V (t), and shifts to step ST16. The speed commanding value vector V contains the advancing-side-by-side speed (t_x, t_y, t_z) and revolving speed ($omega_x$, $omega_y$, $omega_z$) of the robot end point position P, It is expressed $V=(t_x t_y t_z omega_x omega_y omega_z)^T$. And the speed commanding value vector V (t+deltat) in time (t+deltat) is searched for from a formula (4).

[0053]

[Equation 4]

$$V(t+\Delta t)=-\lambda L^{+}e(t)-\widehat{T^{0}}(t) \qquad \cdots (4)$$

[0054]lambda is a speed gain. The rightmost paragraph of the right-hand side of a formula (4) is a point estimate of the motion velocity of the subject 11, and is searched for from a formula (5).

[0055]

[Equation 5]

$$\widehat{T^{0}}(t)=\frac{E(t)-E(t-\Delta t)}{\Delta t}-V(t) \qquad \cdots (5)$$

[0056]The robot controller 5 computes error vector E (t) and the speed commanding value vector V (t) as mentioned above.

[0057]In step ST16, the robot controller 5 generates trajectory generation, and joint angular velocity and angular acceleration based on the computed speed commanding value vector V (t), controls the robot arm 4 according to these, and returns to step ST13.

[0058]In step ST17 when E (t) judges with it being small enough by step ST14, the robot controller 5 judges with the gripper 3 having followed the subject 11, and starts approach to the subject 11. In the following explanation, it is called visual servo by processing the flow chart shown in drawing 7 to make the gripper 3 follow a subject.

[0059]Here, if time which shifted to step ST14 is made into time t_1, as shown, for example in drawing 10, as for a speed commanding value vector, a position vector of V_{actual} (t_1) and a robot end point position will be set to P (t_1).

[0060]In time t_1, since the robot end point position P follows the subject 11, its speed commanding value vector V_{actual} at that time (t_1) is equal to a velocity vector of the subject 11. Therefore, the robot controller 5 generates a speed pattern on which a speed pattern for moving by P_O from the end point position P (t_1) was made to superimpose speed commanding value vector V_{actual} (t_1) mentioned above. P_O is the positional attitude transformation matrix shown by teaching work. A speed pattern for moving by P_O is computable with the conventional techniques, such as a trapezoid speed pattern, for example.

[0061]The robot controller 5 computes P_a according to the following formulas noting that it takes time T_O to carry out P_O part relative displacement.

[0062]

$P_a=P(t_1)+P_O+V_{actual}$ (t_1), T_O, and the robot controller 5 control the robot arm 4 based on computed P_a. Thereby, as shown in drawing 11, a robot hand (gripper 3) can be moved to position P_a which should grasp the subject 11 from the end point position P (t_1). After such approach is completed, it shifts to step ST18.

[0063]In step ST18, the robot controller 5 grasps the subject 11 by the gripper 3, and ends processing.

[0064]As mentioned above, the robot device can memorize the robot end point positions

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Ps and Pd at the time of teaching work, and can follow the subject 11 under conveyance by a visual servo, and can perform grip operations of the subject 11 using the robot end point positions Ps and Pd. Thereby, the robot device can grasp the subject 11 under conveyance easily, without [without it is restrained by attitude position of the subject 11 under conveyance, and] stopping the conveyor 10.

[0065]Since work which searches for beforehand physical relationship the installed position, CCD camera 1, the gripper 3, and between subject 11 is unnecessary, the above-mentioned robot device, For example, even if it is a case where installation requirements of CCD camera 1 change, the subject 11 under conveyance can be grasped only by simple teaching work which was mentioned above. Even if it is a case where the subjects 11 which should be grasped differ when it is going to realize the same work by a different robot device, CCD camera 1, and the gripper 3, only simple teaching work is similarly.

[0066]Thereby, the operator can reduce load in the conventional teaching work and programming substantially. Even if change arises in CCD camera 1, the gripper 3, and the subject 11, it can respond flexibly.

[0067]In an embodiment mentioned above, although it mentioned as an example grasping the subject 11 currently conveyed by conveyor 10 and it was explained, a robot device can be made the same, also when grasping the stationary subject 11.Teaching work is the same as explanation mentioned above.

[0068]In grip operations, in step ST14 shown in drawing 7, when the error vector E (t) becomes small enough, the speed commanding value vector V (t) becomes zero, and speed V_{actual} (t_1) of a actual robot end point position becomes zero similarly.

[0069]Therefore, in step ST17, the robot controller 5 can grasp the subject 11 only using change part P_O of the present robot end point position P (t_1) and a position at the time of instruction. That is, position P_a which should be grasped is calculated by the following formulas.

[0070]$P_a=P(t_1)+P_O$ and the robot controller 5 can control the robot arm 4 based on computed P_a, and can grasp the subject 11 stationary by the gripper 3.

[0071](A 2nd embodiment) Below, a 2nd embodiment of this invention is described. The same numerals are given to the same part as a 1st embodiment, and the statement is omitted about overlapping explanation.

[0072]A 1st embodiment explained a full flattery state where a subject under conveyance and relative physical relationship with the robot end point position P became almost the same as those relative physical relationship at the time of teaching work. On the other hand, by a 2nd embodiment, when it is not in a full flattery state, it explains that a robot device grasps a subject.

[0073]Here, with a flattery state, it is defined as the state where relative position relation was kept constant. For example, in a case where a subject is exercising by speed V_0, the robot end point position P is in a state where it is exercising by speed V_0. Next, two, a "full flattery state" and an "imperfect flattery state", are defined as a flattery state.

[0074]A state which is carrying out fixed time continuation while relative physical relationship of the robot end point position P and a subject has been constant value P_O, i.e., the state of being the same as those relative physical relationship at the time of teaching work, is called "full flattery state." A state which is changing fixed time continuation into an "imperfect flattery state" while relative physical relationship of the robot end point position P and a subject has been constant value P'_0 (!=P_O), That is,

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although there is no change of a position relative between the robot end point position P and a subject, the state of differing from relative physical relationship at the time of teaching work is said. About these two states, a state of speed of a picture error, the robot end point position P, and the robot end point position P and acceleration of the robot end point position P is shown in Table 1.

[0075]

[Table 1]

運 動	完全追従状態				不完全追従状態			
	画像	手先			画像	手先		
	誤差	位置	速度	加速度	誤差	位置	速度	加速度
静 止	微小	一定	0	0	一定	一定	0	0
等速直線	微小	—	一定	0	一定	—	一定	0
等速円	微小	—	一定	一定	一定	—	一定	一定
等加速度直線	微小	—	—	一定	一定	—	—	一定

[0076]"In the state of full flattery", relative physical relationship of the robot end point position P and a subject is P_O, and, moreover, the robot end point position P is moved at the same speed as a subject. For this reason, the approaching operation can perform grip operations by moving approach move P_O, maintaining the following movement V.

[0077]On the other hand, the robot end point position P is moved at the same speed as a subject also "in the state of imperfect flattery." However, relative physical relationship P'_0 of the robot end point position P and a subject differs from physical relationship P_O at the time of teaching work. For example, as shown in drawing 12 (A), the initial picture of the subject 11 at the time of a flattery start is not in agreement with a target image. In order to make it be in a flattery state early at this time, the speed of the robot end point position Ps is large as shown in drawing 13. As shown in drawing 12 (B), the predetermined gap will be maintained the picture of the subject 11 of a flattery state to the target image. The speed of the robot end point position Ps at this time is V_{actual} (t_1) as shown in drawing 13.

[0078]Then, if relative-position-relation P'_0 can be taught, as shown in drawing 12 (C), the completely same effect as a "full flattery state" can be acquired. Physical relationship P'_0 in an "imperfect flattery state" has **** which changes by change of the motion velocity of a subject, change of the gain of a visual servo, etc., and re-instruction is required for it at every time. According to this embodiment, re-teaching work is performed so that it can respond to an "imperfect flattery state."

[0079](Re-teaching work and grip operations) In re-teaching work, first, a visual servo is used and flattery of a subject is performed. And the robot controller 5 extracts image-characteristic-quantity F'i of a subject at this time, and memorizes the coordinates of each image-characteristic-quantity F'i. The extracting processing of image-characteristic-quantity F'i is the same as processing of step ST6 shown in drawing 3.

[0080]Next processings from step ST1 to step ST3 shown in drawing 3 are performed, and the gripper 3 is moved to arbitrary positions (robot end point position Ps). Further, the robot controller 5 performs a visual servo using image-characteristic-quantity Fi', and makes the position of the gripper 3 which reached the flattery state robot end point position P's. And the robot controller 5 computes positional attitude transformation-

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matrix P'_O ($=P'_S{}^{-1}Pd$) in a flattery state, and memorizes this positional attitude transformation-matrix P'_O.
[0081]In grip operations, processings from step ST11 to step ST18 shown in drawing 7 are performed like a 1st embodiment. What is necessary is to replace with the image characteristic quantity Fi and positional attitude conversion P_O which were calculated by a 1st embodiment, and just to use image-characteristic-quantity F'i and positional attitude conversion business sequence P'_O at this time.
[0082]As mentioned above, according to the robot device concerning a 2nd embodiment, even if the robot end point position P does not follow the subject 11 thoroughly, the subject 11 can be grasped only by performing easy teaching work mentioned above without carrying out complicated adjustment.
[0083](A 3rd embodiment) According to 1st and 2nd embodiments, although the case of stillness movement and linear uniform motion was shown as an example, if this invention is used, it is expandable to a linear motion of acceleration or uniform circular motion. And processings from step ST11 to step ST17 shown in drawing 7 are performed like [these grip operations] a 1st embodiment.
[0084]In the case of a linear motion of acceleration, specifically the robot controller 5, In time t_1 to which the error vector E (t) became small enough, Judge with the robot end point position P having been relatively controlled by the position of P_O or P'_O to the subject 11, and V_{actual} (t_1) in this time t_1, Velocity component $V_{estimate}$ (t) generated from hand acceleration acc_{actual} (t_1), The speed commanding value which piled up the speed commanding value generated from P_O or P'_O is generated, the subject 11 is approached from the robot end point position P in time t_1 (t_1), and the subject 11 is grasped by the gripper 3.
[0085]That is, the robot controller 5 is controlled to move the gripper 3 by P_O from the robot end point position Ps when it changes into a flattery state to be shown in drawing 14. The robot controller 5 computes P_a according to the following formulas noting that it takes time T'_O to carry out P_O part relative displacement at this time.
[0086]
[Equation 6]

$$P_a = P(t_1) + P_O + V_{actual}(t_1) \cdot T_O' + \int_0^{T_O'} V_{estimate}(t)\,dt$$

[0087]Although the case where a subject was grasped was mentioned as the example and the embodiment mentioned above explained it, this invention is not limited to this. For example, even if it is a case where attachment of parts, etc. are carried out to the subject 11, it is applicable similarly.
[0088]
[Effect of the Invention]According to a robot device concerning this invention, and a method for controlling the same, the operator should just perform the following two things as teaching work. A gripping mechanism is moved to the 1st end point position, and a subject is made 1st to grasp here. From a gripping mechanism, a subject is made to release and a gripping mechanism is moved [2nd] to the 2nd end point position into an imaging range. The coordinates of the characteristic quantity of the subject in the 1st and 2nd end point positions and the 2nd end point position which are memorized at this time

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are used in order to follow a subject and to grasp this. That is, an operator only performs easy teaching work and can make the subject under movement to a robot device grasp.

TECHNICAL FIELD

[Field of the Invention]This invention relates to a robot device and a method for controlling the same, and relates to a robot device which grasps the object under movement especially, and a method for controlling the same.

PRIOR ART

[Description of the Prior Art]When working to a subject using a robot (for example, objective grasping), information, including the position of a subject, a posture, etc., is acquired by a sensor, and many examples which work based on the sensor information are put in practical use. As such an equipment configuration, it divides roughly and, generally there are the following two methods.

[0003]For example, there are some which detect the position of a subject and a posture from the picture acquired by picturizing with the camera which had the subject which has a conveyor top conveyed fixed, and transmit the information to a robot as indicated to JP,8-63214,A. This robot is working grasping etc. from the position information on a subject.

[0004]Sensors, such as a camera, are attached to the hand of a robot, the target positional attitude is detected from the picture from a camera as mentioned above, and there are some which follow the subject which moves based on the information, and work grasping etc.

EFFECT OF THE INVENTION

[Effect of the Invention]According to a robot device concerning this invention, and a method for controlling the same, the operator should just perform the following two things as teaching work. A gripping mechanism is moved to the 1st end point position, and a subject is made 1st to grasp here. From a gripping mechanism, a subject is made to release and a gripping mechanism is moved [2nd] to the 2nd end point position into an imaging range. The coordinates of the characteristic quantity of the subject in the 1st and 2nd end point positions and the 2nd end point position which are memorized at this time are used in order to follow a subject and to grasp this. That is, an operator only performs easy teaching work and can make the subject under movement to a robot device grasp.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]However, when realizing the work of grasping of a subject, etc. using the camera installed apart from the robot like the former, the work

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which asks for the installed position of a robot and a camera correctly beforehand is needed. It is necessary to perform the camera calibration which computes a focal distance, a lens strain coefficient, etc. of the camera beforehand.
[0006]In addition, in the example in JP,8-63214,A etc., it is necessary to install so that the optic axis of a camera may generally become vertical still more nearly parallel to the transportation direction of a conveyor at a conveyor flat surface in the x axis or the y-axis in a screen. Since the subject is running by the band conveyor etc., in addition to the position attitude information of the subject detected by the picture from a camera, another means (for example, encoder of a conveyor) needs to detect the speed information of a conveyor, etc., and it is necessary to generate the command value to a robot based on both information. The orbit at the time of a robot grasping a subject from the installation position information of a camera and a robot, the position information on a subject, and the speed information of a conveyor must be generated. Therefore, there are problems, like the procedure for teaching work and trajectory generation becomes very complicated.
[0007]It can say such a problem that the same may be said of the example of the latter which installed the camera to the hand of the robot in conventional technology. That is, when a subject is grasped by the gripper etc. which were attached to the hand of a robot based on the position attitude information of the subject detected from the picture from a camera, What is called a hand eye calibration that needs to change the position attitude information of the subject acquired from the camera into the position attitude information seen from the standard coordinates of the robot, and searches for the physical relationship of a robot hand and a camera precisely beforehand is needed. When sensors, such as a camera, are especially installed in a robot hand, a camera position relation with a robot hand frequently changes with the malfunctions under work, etc., and it is necessary to do calibration work again in that case. When the subject is moving like the former example, since the position attitude information of the subject seen from the robot normal coordinate changes every moment, it becomes very complicated [the trajectory generation for grasping].
[0008]In the former, even if the method of the former and the latter changes neither a component (the installation condition of a conveyor, a bearer rate, or the installed position relation between a camera and a robot), nor the shape of a subject which should be grasped, Whenever the robot and sensor to be used changed, the above-mentioned highly precise calibration and complicated teaching work needed to be performed.
[0009]This invention is proposed in order to cancel the problem mentioned above, and it is a thing.
The purpose is to provide a robot device which can save the time and effort which performs work and a calibration, and can make predetermined work do on a subject easily, and a method for controlling the same.

MEANS

[Means for Solving the Problem]A holding means from which the invention according to claim 1 has a gripping mechanism which grasps a subject and which said gripping mechanism comprised movable, An imaging means which is fixed movable with a gripping mechanism of said holding means, and picturizes a subject, A feature amount

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extracting means which extracts coordinates of one or more characteristic quantity from a picture of a subject which said imaging means picturized, A position of a gripping mechanism at a time of making said gripping mechanism grasp said subject is memorized as the 1st end point position, A position of said gripping mechanism when moving said gripping mechanism within limits which can make said subject able to open wide and in which said imaging means can picturize a subject is memorized as the 2nd end point position, A memory measure which memorizes coordinates of each characteristic quantity of said subject which said imaging means picturized in said 2nd end point position, and said feature amount extracting means extracted, A calculating means which computes a move procession for moving from said 2nd end point position to said end point position of 1, Coordinates of each characteristic quantity of a subject under movement extracted by said feature amount extracting means by moving said holding means so that it may be in agreement with coordinates of each characteristic quantity memorized by said memory measure. When a follow-up control means which carries out control which said gripping mechanism is made to follow to a subject under said movement, and a subject while said gripping mechanism is exercising are followed, Based on a move procession which said calculating means computed, said gripping mechanism is brought close to a subject under said movement, and it has a grasping control means which controls said holding means to make said subject grasp.

[0011]The robot device according to claim 1 grasps a subject which exercises relatively to the robot device concerned. Therefore, a case where said robot device exercises and said subject is being fixed, when said robot device and said subject are exercising at a speed different, respectively, and not only when said robot device is fixed and said subject exercises, but when, it can apply. Although said subject may be carrying out the acceleration straight-line motion of linear uniform motion, the uniform circular motion, etc. relatively to said robot device, it may be standing it still relatively.

[0012]First, the operator needs to perform the following two things as teaching work. A gripping mechanism is moved to the 1st end point position, and a subject is made 1st to grasp here. A subject is made to release from a gripping mechanism and an imaging means moves [2nd] a gripping mechanism within limits which can picturize a subject to the 2nd end point position. Such teaching work is performed and a memory measure is made to memorize the 1st and 2nd end point positions. A memory measure is made to also memorize coordinates of one or more characteristic quantity extracted from a picture which an imaging means picturized in the 2nd end point position. An imaging means serves as a sensor of a gripping mechanism, and it is being fixed so that it may move with a holding means. A move procession for moving from the 2nd end point position to the 1st end point position is computed.

[0013]If such teaching work is completed, grip operations which grasp a subject under movement can be performed. A gripping mechanism is moved so that coordinates of each characteristic quantity of a subject under movement may be in agreement with coordinates of each characteristic quantity memorized by said memory measure. That is, what is called a visual servo is performed so that a subject while a gripping mechanism is exercising may be followed. Relative physical relationship of a subject at this time and a gripping mechanism is the same as a subject at the time of teaching work, and that relative of a gripping mechanism. When a subject while said gripping mechanism is exercising is followed, based on the 1st move procession that said calculating means

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computed, said gripping mechanism is brought close to a subject under said movement, and said subject is made to grasp.
[0014]It is desirable for a gripping mechanism to follow a subject under movement thoroughly in a case where a visual servo is being performed. However, a gripping mechanism may follow, separating prescribed distance to a subject under movement. In such a case, it is preferred that re-teaching work which is indicated to claim 2 is performed. While said gripping mechanism separates said memory measure prescribed distance to a subject under said movement by said follow-up control means, when it follows, specifically, Coordinates of each characteristic quantity of said subject which said feature amount extracting means extracted are newly memorized, What is necessary is just to memorize a position of said gripping mechanism when said follow-up control means makes said gripping mechanism follow a subject thoroughly from said 2nd end point position using coordinates of each newly memorized characteristic quantity as the 2nd new end point position.
[0015]The invention according to claim 3 is the control method of a robot device which grasps a subject by a gripping mechanism constituted movable, A position of a gripping mechanism at a time of making said gripping mechanism grasp said subject is memorized as the 1st end point position, A position of said gripping mechanism when making said subject open wide and moving said gripping mechanism within limits which can picturize a subject is memorized as the 2nd end point position, In said 2nd end point position, picturize said subject, and coordinates of one or more characteristic quantity are extracted from a picture of said picturized subject, In the state where memorized coordinates of each of said extracted characteristic quantity, computed a move procession for moving from said 2nd end point position to said end point position of 1, and it was fixed movable with said gripping mechanism. Picturize a subject under movement and coordinates of one or more characteristic quantity are extracted from a picture of a subject under said picturized movement, Coordinates of each characteristic quantity of a subject under said extracted movement by moving said gripping mechanism so that it may be in agreement with coordinates of each of said characteristic quantity memorized. When said gripping mechanism is made to follow a subject under said movement and a subject while said gripping mechanism is exercising is followed, based on said computed move procession, said gripping mechanism is brought close to a subject under said movement, Said gripping mechanism is made to grasp said subject.
[0016]This invention is a method for controlling a robot device indicated to claim 1, and the operator should just perform two things mentioned above as teaching work. That is, only by an operator performing two easy teaching work, a gripping mechanism can be made to be able to follow a subject which is exercising and the subject can be grasped.
[0017]It is desirable for a gripping mechanism to follow a subject under movement thoroughly in a case where a visual servo is being performed. However, a gripping mechanism may follow, separating prescribed distance to a subject under movement. In such a case, it is preferred that re-teaching work which is indicated to claim 4 is performed. While said gripping mechanism specifically separates prescribed distance to a subject under said movement, when it makes said gripping mechanism follow a subject under said movement, and it follows, it is in a state fixed movable with said gripping mechanism, Picturize a subject under movement and coordinates of one or more characteristic quantity are extracted from a picture of a subject under said picturized

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movement, Newly memorize coordinates of each characteristic quantity of said said extracted subject, and coordinates of each of said newly memorized characteristic quantity are used, What is necessary is just to memorize a position of said gripping mechanism as the 2nd new end point position, when said gripping mechanism is moved so that said gripping mechanism may follow a subject thoroughly from said 2nd end point position, and followed thoroughly.
[0018]
[Embodiment of the Invention]Hereafter, it explains in detail, referring to drawings for an embodiment of the invention.
[0019](A 1st embodiment) As shown in drawing 1, the robot device concerning this embodiment grasps the subject 11 currently conveyed by conveyor 10 in the state where it was fixed. This invention is not limited to such an embodiment, and if the subject 11 is exercising relatively to a robot device, it is applicable. That is, they may be a case where a robot device exercises and the subject 11 is standing it still, and a case where it is exercising at the speed from which a robot device and the subject 11 differ. 2nd and 3rd embodiments are also the same.
[0020]A robot device is provided with the following.
CCD camera 1 which picturizes the subject 11.
The sensor controller 2 which extracts characteristic quantity from the picture which CCD camera 1 picturized.
The gripper 3 which grasps the subject 11.
The robot controller 5 which performs the robot arm 4 which moves the gripper 3 in the direction of a three dimension, coordinate conversion, trajectory generation, etc., has a servo circuit, amplifier, etc. which are not illustrated, and controls operation of the gripper 3 or the robot arm 4.

[0021]CCD camera 1 has adhered near the gripper 3 which is a tip of the robot arm 4. The robot controller 5 computes error vector E (t) and the speed commanding value vector V (t) based on the image characteristic quantity Fi obtained with the sensor controller 2, and controls movement of the robot arm 4, and grasping of the subject 11 by the gripper 3 according to these values. The conveyor 10 conveys the subject 11 at a fixed speed.
[0022]Before the robot device of such composition actually grasps the subject 11 currently conveyed, teaching work for grasping the subject 11 is performed.
[0023](Teaching work) First, an operator makes a robot device grasp the subject 11, and teaches the robot end point position P. The position which should be grasped may be restricted by the shape of gripping mechanisms, such as the gripper 3, and the subject 11. The position which should be grasped for next processing (for example, attach other parts to the subject 11, or supply to a parts box) may be specified beforehand.
[0024]Here, as shown, for example in drawing 2, the subject 11 was formed in 7 prismatic forms, and is provided with the seven sides 111-117. Six attachment holes (for example, tapped hole) for attaching the parts which are not illustrated are formed in the upper surface 118 of the subject 11. Such an attachment hole is not formed in the undersurface 119 of the subject 11. As for the portion by which the subject 11 is grasped, it is preferred that they are the side 111,115 in which it faces among seven sides in consideration of stability when grasped, or the side 113,116. Although the subject 11 of

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the above-mentioned shape was used in this embodiment, this invention may not be limited to this shape and the subjects 11 may be other shape. And teaching work is specifically performed according to processing of step ST1 to step ST6 shown in drawing 3.

[0025]In step ST1, an operator shifts to step ST2, as the gripper 3 grasps the side 111,115 or the side 113,116 of the subject 11 using the teaching pendant etc. which are not illustrated.

[0026]In step ST2, as shown in drawing 4, the gripper 3 is in the state which grasped the subject 11, and the robot controller 5 memorizes, the position, i.e., robot end point position Pd, of the gripper 3 in robot standard coordinates, and shifts to step ST3. The "position" said here is expressed with the parameter of 6 flexibility including a posture. The parameter of 6 flexibility including a posture is called "position" like the following.

[0027]In step ST3, the robot controller 5 makes the subject 11 which the gripper 3 grasped release, and moves the gripper 3 to arbitrary positions, and shifts to step ST4.

[0028]It requires that the position which the gripper 3 moves is in the visual field range of CCD camera 1. That is, it is a position where the characteristic quantity of the subject 11 is extracted from the picture picturized with CCD camera 1. It is a position where characteristic quantity which should be extracted, such as a position to which the subject 11 is not settled in the view of CCD camera 1, and a position in which CCD camera 1 picturizes the subject 11 from just beside, is specifically suitably obtained from a picture.

[0029]In step ST4, the robot controller 5 memorizes, as shown in drawing 5, the position Ps, i.e., the robot end point position, of the gripper 3 in the present robot standard coordinates, and it shifts to step ST5.

[0030]Here, the following formulas will be realized if the positional attitude transformation matrix for changing into Pd from the robot end point position Ps is made into P_O.

[0031]$Ps\text{-}P_O=Pd$ therefore $P_O=Ps^{-1}$ and the Pd robot controller 5 compute positional attitude transformation-matrix P_O at this time, and memorizes this. The robot controller 5 may compute positional attitude transformation-matrix P_O in the case of the grip operations mentioned later.

[0032]In step ST5, CCD camera 1 picturizes the subject 11 in the robot end point position Ps, and supplies this picture to the sensor controller 2. The sensor controller 2 extracts image characteristic quantity based on the picture from CCD camera 1, and shifts to step ST6. Here, CCD camera 1 acquires the picture of the subject 11 as shown, for example in drawing 6.

[0033]In step ST6, six attachment holes processed into the upper surface 118 of the subject 11 are extracted as the image characteristic quantity Fi (i= 1-6), the center position of each image characteristic quantity Fi carries out coordinate value (Xi, Yi) memory, and the sensor controller 2 ends processing of teaching work.

[0034]What is necessary is just to use publicly known techniques, such as binarization image processing and edge processing, as an instrumentation method of the center position of the attachment hole in a picture. Although it attached here and the center position of the hole was made into the image characteristic quantity Fi, the area center of gravity of the isolated field of a line segment corner point, a corner, and a binarization picture, etc. may use other image characteristic quantity. An operator may give a definition artificially by the input means in which neither a mouse nor a keyboard

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illustrates the image characteristic quantity Fi at the time of instruction.
[0035](Grip operations) A robot device grasps the subject 11 under conveyance using the coordinates of the image characteristic quantity Fi memorized on the occasion of the work, and the robot end point positions Pd and Ps, after teaching work is completed. In these grip operations, processings from step ST11 to step ST18 shown in drawing 7 are performed.
[0036]In step ST11, as shown in drawing 8, CCD camera 1 picturizes a transportation area [of the subject 11] 10, i.e., conveyor, top, and shifts to step ST12.
[0037]In step ST12, the sensor controller 2 judges whether the subject 11 was detected. In order to detect the subject 11 and to extract characteristic quantity from the picture, it is required for the subject 11 whole to enter within the limits of the view of CCD camera 1. Here, the luminosity of a picture is used for detection of the subject 11. For example, when the subject 11 is upstream of the conveyor 10 and there is into the visual field range of CCD camera 1, the luminosity of the picture acquired with CCD camera 1 hardly changes. [no] On the other hand, if the subject 11 is conveyed by conveyor and it enters in the visual field range of CCD camera 1, the luminosity will change. Then, it judges with the sensor controller 2 providing the window which is not illustrated in the suitable position in a picture, and the subject 11 being in a visual field range, when the luminosity in the window is beyond a predetermined threshold, and when luminosity is less than a predetermined threshold, it judges with there being nothing within the limits of the view. And when the sensor controller 2 detects the subject 11, it shifts to step ST13, and when it does not detect, it returns to step ST11.
[0038]image-characteristic-quantity fi(t) (i=1 in the time T from a picture when CCD camera 1 picturized the sensor controller 2 in step ST13, and 2 ...) -- it extracts and shifts to step ST14. Here, drawing 9 is a figure showing the picture picturized at the time of execution of grip operations. It is necessary to extract the image characteristic quantity fi (t) from the picture picturized at the time t at the time of grip operations. However, there is a thing which should extract essentially by a certain cause and for which the image characteristic quantity f3 (t) is extracted for example, it does not come out. Then, the characteristic quantity f1 (t) - f7 (t) need to perform corresponding point searching which asks for any of F1 - F6 which show drawing 6 are supported.
[0039]This corresponding point searching can be performed with what is called checking methods, such as dynamic programming, a largest faction method, etc. which various methods are proposed, for example, are indicated to "robot vision" (Masahiko Yanaida work, Shokodo, 1990). If F1 - the thing corresponding to F6 are obtained out of f1-f7, the following image characteristic quantity can once be calculated easily.
[0040]What is necessary is just to specifically extract the image characteristic quantity fi (t+deltat) in the next time (t+deltat) of the time t near the image characteristic quantity fi in the inside of a previous picture (t), if cycle time of the repetition processings from step ST13 to step ST16 is set to deltat. Thereby, the stability of characteristic quantity extraction can ease increase and the burden of computation.
[0041]In step ST14, the sensor controller 2, It judges whether the error vector E (t) in the time t is small enough, or the judging standard of ||E(t) ||<epsilon is specifically met, when small enough, it shifts to step ST17, and when not small enough, it shifts to step ST15.
[0042]Here, the error vector E (t) is searched for based on the image characteristic

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quantity fi (t) extracted from the picture of present CCD camera 1, and the image characteristic quantity Fi memorized by step ST6 mentioned above.
[0043]In this invention, literature B.Espiau et al., A New Approach to Visual Servoing in Robotics, IEEE Trans.Robotics and Automation, 8 (3), and 313-326-1992, Literature F.Bensalha et al. and Real Time Visual Tracking using the Generalized Likelihood Ratio Test,Int.Conf.Automation,Robotics and. Based on Computer Vision and the technique indicated to 1379-1383-1994, the error vector E (t) and the speed commanding value vector V (t) mentioned later are computed.
[0044]It asks for characteristic quantity deviation vector e (t) by the following formulas (1) using image-characteristic-quantity fi (t) = (Xi (t), Yi (t)) obtained from the picture picturized at image-characteristic-quantity Fi= at the time of instruction (Xi, Yi), and the time t.
[0045]
[Equation 1]

$$e(t)=\begin{pmatrix} x_1(t)-x_1 \\ y_1(t)-y_1 \\ x_2(t)-x_2 \\ y_2(t)-y_2 \\ \vdots \\ x_N(t)-x_N \\ y_N(t)-y_N \end{pmatrix} \quad \cdots (1)$$

[0046](xi, yi) and (xi(t), and yi (t)) are expressed with a pixel value (Xi, Yi), and change (Xi(t) and Yi (t)) into the value in a camera coordinate system, respectively. N expresses the number of image characteristic quantity.
[0047]The error vector E (t) is expressed with a formula (2) using above-mentioned characteristic quantity deviation vector e (t).
[0048]
[Equation 2]

$$E(t)=L^{T+}e(t) \quad \cdots (2)$$

[0049]Here, L^{T+} is a false inverse matrix of picture Jacobian L^T calculated from the image characteristic quantity F and F (t).
[0050]It judges with the sensor controller 2 having followed the subject 11 which exercises, when the judging standard of ||E(t) ||<epsilon was met. epsilon is scalar quantity beforehand given by an operator. Or as long as it expresses E=(E1 E2 E3 E4 E5 E6) ^{T}, the judging standard shown in a formula (3) may be used.
[0051]
[Equation 3]

$$\max_i E_i < \varepsilon \quad \cdots (3)$$

[0052]In step ST15, the robot controller 5 computes the speed commanding value vector V (t), and shifts to step ST16. The speed commanding value vector V contains the advancing-side-by-side speed (t_x, t_y, t_z) and revolving speed ($omega_x$, $omega_y$, $omega_z$) of the robot end point position P, It is expressed V=($t_x t_y t_z omega_x omega_y omega_z$) ^{T}. And the

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speed commanding value vector V (t+deltat) in time (t+deltat) is searched for from a formula (4).
[0053]
[Equation 4]

$$V(t+\Delta t)=-\lambda L^{+}e(t)-\widehat{T^{0}}(t) \qquad \cdots (4)$$

[0054]lambda is a speed gain. The rightmost paragraph of the right-hand side of a formula (4) is a point estimate of the motion velocity of the subject 11, and is searched for from a formula (5).
[0055]
[Equation 5]

$$\widehat{T^{0}}(t)=\frac{E(t)-E(t-\Delta t)}{\Delta t}-V(t) \qquad \cdots (5)$$

[0056]The robot controller 5 computes error vector E (t) and the speed commanding value vector V (t) as mentioned above.
[0057]In step ST16, the robot controller 5 generates trajectory generation, and joint angular velocity and angular acceleration based on the computed speed commanding value vector V (t), controls the robot arm 4 according to these, and returns to step ST13.
[0058]In step ST17 when E (t) judges with it being small enough by step ST14, the robot controller 5 judges with the gripper 3 having followed the subject 11, and starts approach to the subject 11. In the following explanation, it is called visual servo by processing the flow chart shown in drawing 7 to make the gripper 3 follow a subject.
[0059]Here, if time which shifted to step ST14 is made into time t_1, as shown, for example in drawing 10, as for a speed commanding value vector, a position vector of V_{actual} (t_1) and a robot end point position will be set to P (t_1).
[0060]In time t_1, since the robot end point position P follows the subject 11, its speed commanding value vector V_{actual} at that time (t_1) is equal to a velocity vector of the subject 11. Therefore, the robot controller 5 generates a speed pattern on which a speed pattern for moving by P_O from the end point position P (t_1) was made to superimpose speed commanding value vector V_{actual} (t_1) mentioned above. P_O is the positional attitude transformation matrix shown by teaching work. A speed pattern for moving by P_O is computable with the conventional techniques, such as a trapezoid speed pattern, for example.
[0061]The robot controller 5 computes P_a according to the following formulas noting that it takes time T_O to carry out P_O part relative displacement.
[0062]
$P_a=P(t_1)+P_O+V_{actual}$ (t_1), T_O, and the robot controller 5 control the robot arm 4 based on computed P_a. Thereby, as shown in drawing 11, a robot hand (gripper 3) can be moved to position P_a which should grasp the subject 11 from the end point position P (t_1). After such approach is completed, it shifts to step ST18.
[0063]In step ST18, the robot controller 5 grasps the subject 11 by the gripper 3, and ends processing.
[0064]As mentioned above, the robot device can memorize the robot end point positions Ps and Pd at the time of teaching work, and can follow the subject 11 under conveyance by a visual servo, and can perform grip operations of the subject 11 using the robot end point positions Ps and Pd. Thereby, the robot device can grasp the subject 11 under

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conveyance easily, without [without it is restrained by attitude position of the subject 11 under conveyance, and] stopping the conveyor 10.
[0065]Since work which searches for beforehand physical relationship the installed position, CCD camera 1, the gripper 3, and between subject 11 is unnecessary, the above-mentioned robot device, For example, even if it is a case where installation requirements of CCD camera 1 change, the subject 11 under conveyance can be grasped only by simple teaching work which was mentioned above. Even if it is a case where the subjects 11 which should be grasped differ when it is going to realize the same work by a different robot device, CCD camera 1, and the gripper 3, only simple teaching work is similarly.
[0066]Thereby, the operator can reduce load in the conventional teaching work and programming substantially. Even if change arises in CCD camera 1, the gripper 3, and the subject 11, it can respond flexibly.
[0067]In an embodiment mentioned above, although it mentioned as an example grasping the subject 11 currently conveyed by conveyor 10 and it was explained, a robot device can be made the same, also when grasping the stationary subject 11.Teaching work is the same as explanation mentioned above.
[0068]In grip operations, in step ST14 shown in drawing 7, when the error vector E (t) becomes small enough, the speed commanding value vector V (t) becomes zero, and speed V_{actual} (t_1) of a actual robot end point position becomes zero similarly.
[0069]Therefore, in step ST17, the robot controller 5 can grasp the subject 11 only using change part P_O of the present robot end point position P (t_1) and a position at the time of instruction. That is, position P_a which should be grasped is calculated by the following formulas.
[0070]$P_a=P(t_1)+P_O$ and the robot controller 5 can control the robot arm 4 based on computed P_a, and can grasp the subject 11 stationary by the gripper 3.
[0071](A 2nd embodiment) Below, a 2nd embodiment of this invention is described. The same numerals are given to the same part as a 1st embodiment, and the statement is omitted about overlapping explanation.
[0072]A 1st embodiment explained a full flattery state where a subject under conveyance and relative physical relationship with the robot end point position P became almost the same as those relative physical relationship at the time of teaching work. On the other hand, by a 2nd embodiment, when it is not in a full flattery state, it explains that a robot device grasps a subject.
[0073]Here, with a flattery state, it is defined as the state where relative position relation was kept constant. For example, in a case where a subject is exercising by speed V_0, the robot end point position P is in a state where it is exercising by speed V_0. Next, two, a "full flattery state" and an "imperfect flattery state", are defined as a flattery state.
[0074]A state which is carrying out fixed time continuation while relative physical relationship of the robot end point position P and a subject has been constant value P_O, i.e., the state of being the same as those relative physical relationship at the time of teaching work, is called "full flattery state." A state which is changing fixed time continuation into an "imperfect flattery state" while relative physical relationship of the robot end point position P and a subject has been constant value P'_0 (!=P_O), That is, although there is no change of a position relative between the robot end point position P and a subject, the state of differing from relative physical relationship at the time of teaching work is said. About these two states, a state of speed of a picture error, the robot

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end point position P, and the robot end point position P and acceleration of the robot end point position P is shown in Table 1.

[0075]

[Table 1]

運 動	完全追従状態				不完全追従状態			
	画像	手先			画像	手先		
	誤差	位置	速度	加速度	誤差	位置	速度	加速度
静 止	微小	一定	0	0	一定	一定	0	0
等速直線	微小	—	一定	0	一定	—	一定	0
等速円	微小	—	一定	一定	一定	—	一定	一定
等加速度直線	微小	—	—	一定	一定	—	—	一定

[0076]"In the state of full flattery", relative physical relationship of the robot end point position P and a subject is P_O, and, moreover, the robot end point position P is moved at the same speed as a subject. For this reason, the approaching operation can perform grip operations by moving approach move P_O, maintaining the following movement V.

[0077]On the other hand, the robot end point position P is moved at the same speed as a subject also "in the state of imperfect flattery." However, relative physical relationship P'_0 of the robot end point position P and a subject differs from physical relationship P_O at the time of teaching work. For example, as shown in drawing 12 (A), the initial picture of the subject 11 at the time of a flattery start is not in agreement with a target image. In order to make it be in a flattery state early at this time, the speed of the robot end point position Ps is large as shown in drawing 13. As shown in drawing 12 (B), the predetermined gap will be maintained the picture of the subject 11 of a flattery state to the target image. The speed of the robot end point position Ps at this time is V_{actual} (t_1) as shown in drawing 13.

[0078]Then, if relative-position-relation P'_0 can be taught, as shown in drawing 12 (C), the completely same effect as a "full flattery state" can be acquired. Physical relationship P'_0 in an "imperfect flattery state" has **** which changes by change of the motion velocity of a subject, change of the gain of a visual servo, etc., and re-instruction is required for it at every time. According to this embodiment, re-teaching work is performed so that it can respond to an "imperfect flattery state."

[0079](Re-teaching work and grip operations) In re-teaching work, first, a visual servo is used and flattery of a subject is performed. And the robot controller 5 extracts image-characteristic-quantity F'i of a subject at this time, and memorizes the coordinates of each image-characteristic-quantity F'i. The extracting processing of image-characteristic-quantity F'i is the same as processing of step ST6 shown in drawing 3.

[0080]Next processings from step ST1 to step ST3 shown in drawing 3 are performed, and the gripper 3 is moved to arbitrary positions (robot end point position Ps). Further, the robot controller 5 performs a visual servo using image-characteristic-quantity Fi', and makes the position of the gripper 3 which reached the flattery state robot end point position P's. And the robot controller 5 computes positional attitude transformation-matrix P'_O $(=P'_S{}^{-1}Pd)$ in a flattery state, and memorizes this positional attitude transformation-matrix P'_O.

[0081]In grip operations, processings from step ST11 to step ST18 shown in drawing 7

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are performed like a 1st embodiment. What is necessary is to replace with the image characteristic quantity Fi and positional attitude conversion P_O which were calculated by a 1st embodiment, and just to use image-characteristic-quantity F'i and positional attitude conversion business sequence P'_O at this time.

[0082]As mentioned above, according to the robot device concerning a 2nd embodiment, even if the robot end point position P does not follow the subject 11 thoroughly, the subject 11 can be grasped only by performing easy teaching work mentioned above without carrying out complicated adjustment.

[0083](A 3rd embodiment) According to 1st and 2nd embodiments, although the case of stillness movement and linear uniform motion was shown as an example, if this invention is used, it is expandable to a linear motion of acceleration or uniform circular motion. And processings from step ST11 to step ST17 shown in drawing 7 are performed like [these grip operations] a 1st embodiment.

[0084]In the case of a linear motion of acceleration, specifically the robot controller 5, In time t_1 to which the error vector E (t) became small enough, Judge with the robot end point position P having been relatively controlled by the position of P_O or P'_O to the subject 11, and V_{actual} (t_1) in this time t_1, Velocity component $V_{estimate}$ (t) generated from hand acceleration acc_{actual} (t_1), The speed commanding value which piled up the speed commanding value generated from P_O or P'_O is generated, the subject 11 is approached from the robot end point position P in time t_1 (t_1), and the subject 11 is grasped by the gripper 3.

[0085]That is, the robot controller 5 is controlled to move the gripper 3 by P_O from the robot end point position Ps when it changes into a flattery state to be shown in drawing 14. The robot controller 5 computes P_a according to the following formulas noting that it takes time T'_O to carry out P_O part relative displacement at this time.

[0086]

[Equation 6]

$$P_a = P(t_1) + P_0 + V_{actual}(t_1) \cdot T_0' + \int_0^{T_0'} V_{estimate}(t)dt$$

[0087]Although the case where a subject was grasped was mentioned as the example and the embodiment mentioned above explained it, this invention is not limited to this. For example, even if it is a case where attachment of parts, etc. are carried out to the subject 11, it is applicable similarly.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1]It is a figure showing the composition of the robot device concerning a 1st embodiment of this invention.

[Drawing 2]It is an appearance perspective view of the subject grasped by a robot device.

[Drawing 3]It is a flow chart which shows the contents of processing in the teaching work of a robot device.

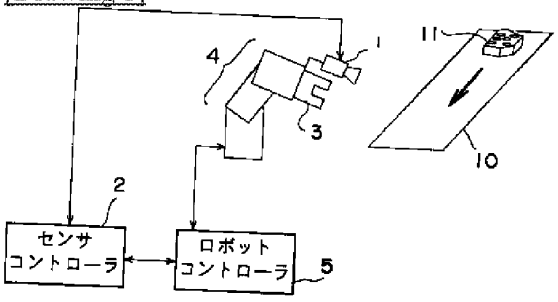
[Drawing 4]In teaching work, it is a figure showing the rough composition which shows robot end point position Pd in the state where the subject was grasped.

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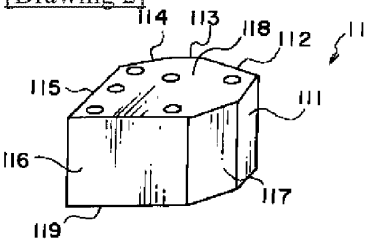
[Drawing 5]In teaching work, it is a figure showing the rough composition which shows the robot end point position Ps when a subject is released.
[Drawing 6]It is a figure showing the image pick of the camera in teaching work.
[Drawing 7]It is a flow chart which shows the contents of processing in the grip operations of a robot device.
[Drawing 8]In grip operations, it is a figure for explaining that the camera is picturizing the conveyor top which conveys a subject.
[Drawing 9]It is a figure showing the image pick of the camera in grip operations.
[Drawing 10]It is a figure for explaining the robot end point position P in time t_1 (t_1), and speed commanding value vector V_{actual} (t_1).
[Drawing 11]It is a figure explaining a state when grasping a subject.
[Drawing 12]It is a figure showing the picture of an initial state, a flattery state, and the subject at the time of re-instruction in the robot device concerning a 2nd embodiment.
[Drawing 13]It is a figure explaining the speed commanding value vector V (t) of the robot end point position P.
[Drawing 14]It is a figure explaining the state where the subject which the robot device concerning a 3rd embodiment of this invention is conveying was grasped.
[Description of Notations]
1 Camera
2 Sensor controller
3 Gripper
4 Robot arm
5 Robot controller

DRAWINGS

[Drawing 1]

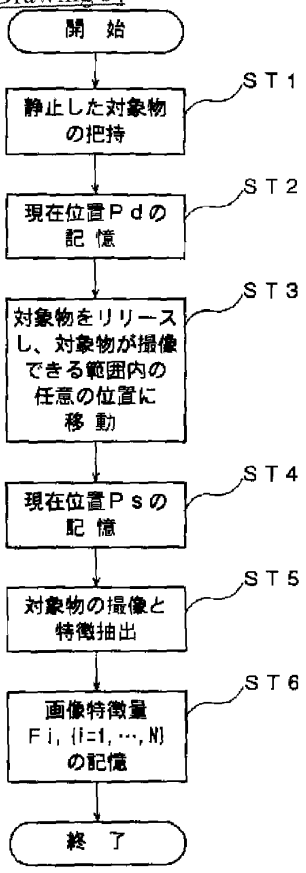


[Drawing 2]

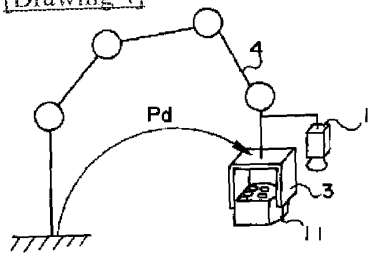


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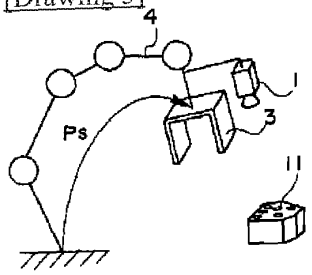
[Drawing 3]



[Drawing 4]

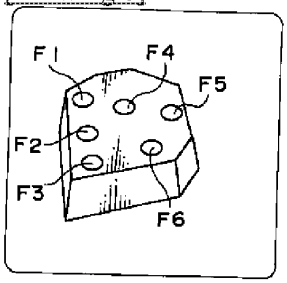


[Drawing 5]

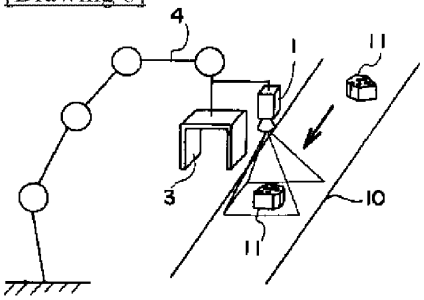


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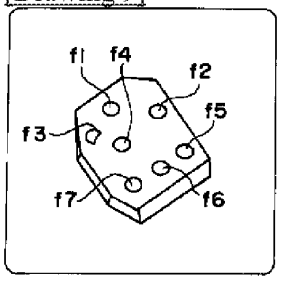
[Drawing 6]



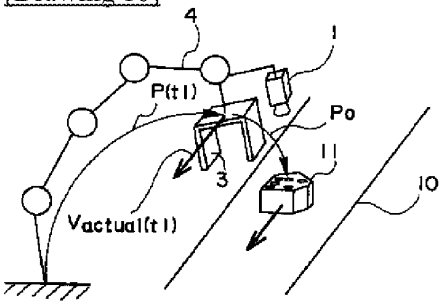
[Drawing 8]



[Drawing 9]

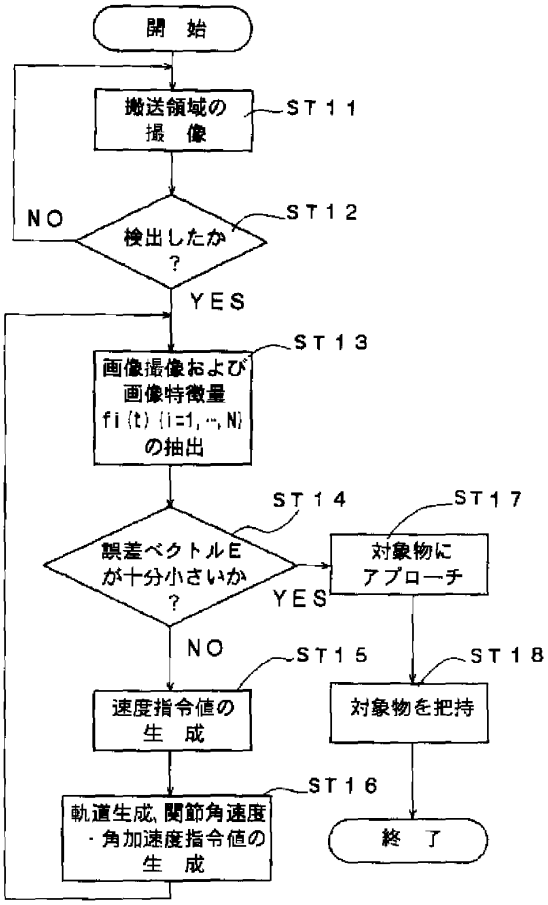


[Drawing 10]

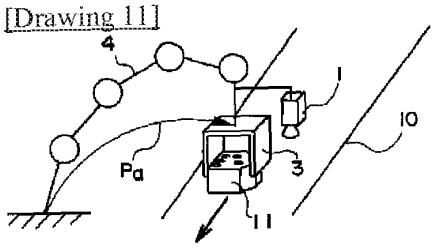


[Drawing 7]

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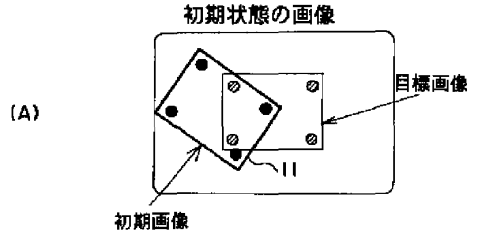


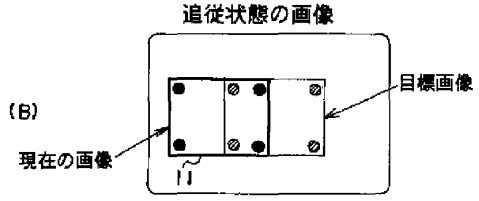
[Drawing 11]

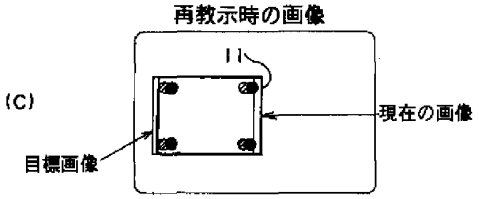


[Drawing 12]

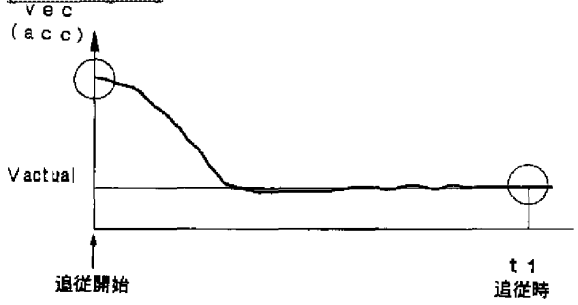
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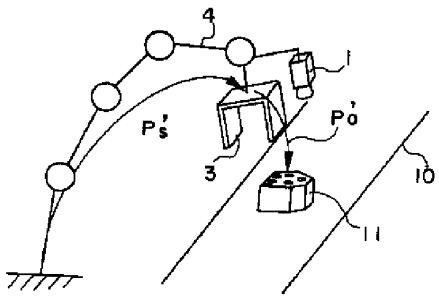


[Drawing 13]



[Drawing 14]

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[Translation done.]

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EP1345099

Publication Title:

Method for determining the spatial position of an object and a workpiece for automatically mounting the workpiece on the object

Abstract:

10fd Abstract of EP1345099

A robot (7) and clamp arm (7') holds the workpiece (6) over the object (1) and cameras (3,3',3'') establish the coordinates of reference object and workpiece and compares these to those of workpieces delivered from a store (9) to accurately apply them.

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(54) Verfahren zur Bestimmung der Lage eines Objektes und eines Werkstücks im Raum zur automatischen Montage des Werkstücks am Objekt

(57) Die Erfindung betrifft ein Verfahren zur Bestimmung der Lage eines Objektes (1) und Werkstücks (6) im Raum zur Montage des Werkstücks (6) am Objekt (1) mittels eines Roboters (7) mit Greifer (7'), mit einem Bildverarbeitungssystems mit Sensoren (3,3',3"), wie Kameras, und Rechner. Roboter (7), Greifer (7') und Kameras (3,3',3") werden im Weltkoordinatensystem (W) vermessen und die Koordinaten im Bildverarbeitungssystem gespeichert. Die Lage eines ersten Objektes (1), Kalibrierobjekt, wird in einer Soll-Montageposition des Objektes (1) ebenfalls im Weltkoordinatensystem (W) vermessen und die Koordinaten im Bildverarbeitungssystem gespeichert. Ein erstes Werkstück (6), Kalibrierwerkstück, wird mittels des Greifers (7') in eine Vorhalteposition gefahren, die einen kleinen Abstand von der Soll-Montageposition zum Kalibrierobjekt besitzt und ebenfalls im Weltkoordinatensystem (W) vermessen und die Koordinaten gespeichert. Die Kameras (3,3',3") sind dergestalt im Weltkoordinatensystem (W) angeordnet und im Weltkoordinatensystem eingemessen, dass sie gleichzeitig sowohl die Soll-Montageposition des Kalibrierobjektes (1) als auch die Soll-Vorhalteposition des Kalibrierwerkstücks (6) erfassen, so dass das Bildverarbeitungssystem die Abweichung zwischen der Soll-Vorhalte- und der Soll-Montageposition berechnen kann. Nun wird ein Objekt (1) "ungenau" in eine Ist-Montageposition des Objektes (1) verbracht, die von der Soll-Montageposition des Kalibrierobjektes abweichen kann; der Greifer (7') entnimmt aus einem Lager (9) ein Werkstück (6) "ungenau" auf und verfährt es in eine Ist-Vorhalteposition, welche von der Soll-Vorhalteposition des Kalibrierwerkstücks abweichen kann, wobei die Kameras (3,3',3") das Werkstück (6) in der Ist-Vorhalteposition und gleichzeitig das Objekt (1) in der Ist-Montageposition erfassen. Das Bildverarbeitungssystem bestimmt die angefahrenen Ist-Positionen von Werkstück (6) und Objekt (1) und errechnet die notwendige Relativbewegung zwischen Werkstück (6) und Objekt (1) sechs-dimensional und gibt dem Greifer (7') des Roboters (7) diese Koordinaten der Ist-Montageposition vor, um welche der Greifer (7') zur genauen Plazierung des Werkstücks (6) am Objekt (1) translatorisch und rotatorisch zu verfahren ist.

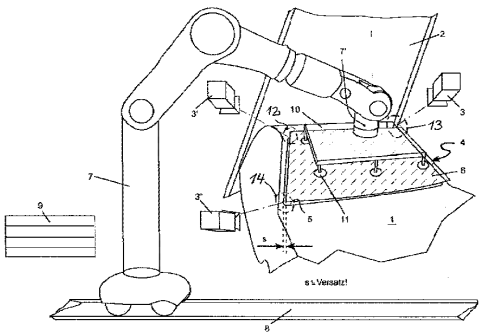


Fig. 1

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Beschreibung

Technisches Gebiet:

[0001] Die Erfindung betrifft ein Verfahren zur Bestimmung der Lage eines Objektes und eines Werkstücks im Raum zur automatischen Montage bzw. Einfügen des Werkstücks am Objekt mittels eines Roboters mit Greifer und unter Verwendung eines digitalen Bildverarbeitungssystems mit wenigstens einer Kamera und einem Rechner gemäß dem Oberbegriff des Anspruchs 1.

Stand der Technik:

[0002] Die schnelle und berührungslose 3D-Vermessung eines dreidimensionalen Körpers besitzt eine Schlüsselfunktion auf dem Weg zur höheren Automatisierung und zur vollständigen Qualitätsüberwachung in vielen Fertigungsprozessen, wobei die SD-Positionserfassung die genaue Kenntnis der Position von Objekten im Raum und deren Lage relativ zueinander liefert. Besonders in der industriellen Produktion kommt der schnellen und berührungslosen 3D-Positions- und 3D-Formerfassung eine große Bedeutung zu, so z. B. für die Maßhaltigkeitskontrolle, die Vollständigkeitsprüfung, Robotervision in der automatischen Montage, Prüfung von Oberflächenstrukturen, Überwachung von Sicherheitszonen, 3D-Objekterkennung und Navigation im Raum, das Abdichten von Fugen oder Nähten, das Sealing, oder das Einsetzen von Scheiben oder anderen Bauteilen an Karossen oder Werkstücken durch Industrieroboter. Die 3D-Formerfassung liefert die absoluten Geometriemaße von Objekten, die unabhängig vom Oberflächenzustand, von der Entfernung, Drehung und Beleuchtung sind, d. h. sie sind rotations-, verschiebungs- und beleuchtungsinvariant.

[0003] Hierzu ist die digitale Bildverarbeitung Voraussetzung und heute Stand der Technik, wobei kalibrierte Kameras, was Grundvoraussetzung ist, das zu bearbeitende Objekt zu erfassen. Methoden und Verfahren der Mustererkennung, der klassischen Bildverarbeitung und der Photogrammetrie werden mit dem Ziel eingesetzt, die Positionen bestimmter Objekte und deren Lage zueinander zu erfassen. Aus den sich ergebenden Pixeldaten bestimmter Objektmerkmale wird hiernach die 3-D-Werkstückpose in einem definierten Koordinatensystem berechnet.

[0004] Durch die DE 100 16 963 A1 ist ein Verfahren zur Bestimmung der Position eines Werkstücks und der Position von Merkmalen des Werkstücks im 3D-Raum unter Verwendung von mindestens zwei elektronischen Kameras und digitaler Bildverarbeitung bekannt geworden, wobei die Kameras auf ein gemeinsames Weltkoordinatensystem kalibriert werden und anschließend das Werkstück in den Raum zwischen den Kameras verbracht wird. Zur Erstellung des gemeinsames Weltkoordinatensystems werden die Kameras einzeln als Lochkameramodelle behandelt, und es erfolgt eine direkte Vermessung der Position und der Orientierung der Lichteintrittsöffnung einer jeden Kamera, indem die Position und die Orientierung der Lichteintrittsöffnung einer jeden Kamera in ihrem passiven Zustand mit einem separaten Meßsystem vermessen wird, welches zur direkten Antastung der Lichteintrittsöffnung imstande ist und welches die Position und die Orientierung der Lichteintrittsöffnung im Weltkoordinatensystem liefert und das in den Raum zwischen den Kameras verbrachte Werkstück durch die nunmehr aktiven Kameras optisch abgebildet und die Videobilder mit einem Rechner zum Auffinden von Merkmalen des Werkstücks ausgewertet werden. Aus der Kenntnis der Position der Kameras bezüglich des Weltkoordinatensystems, der Videobilder und der Koordinaten der Merkmale des Werkstücks in einem Koordinatensystem des Werkstücks durch einen Rechner nach der Methode des Bündelausgleichs die Position des Werkstücks in Weltkoordinaten sowie die Position der Merkmale des Werkstücks in Weltkoordinaten errechnet werden.

[0005] Der Einsatz von Robotern ist in der Regel daran gebunden, daß die Position des zu handhabenden Objektes in engen Grenzen definiert ist. In vielen Produktionsprozessen kann dies entweder nicht sichergestellt werden oder muß durch eine aufwendige, teure und gleichzeitig inflexible Positioniereinheit erreicht werden. Letzteres steht dem Wunsch nach flexiblen Produktionsstraßen entgegen. So werden z. B. Automobilkarossen in bestimmten Abschnitten der Produktion hängend an einem Transportsystem bewegt, das eine Karosse lediglich mit einer Genauigkeit von +/- 30 mm positionieren kann. Eine Bearbeitung durch einen Roboter wird damit unmöglich, wenn für den Arbeitsvorgang selbst eine höhere Genauigkeit gefordert wird.

[0006] Wenn ein Werkstück zu einem Objekt hinzugefügt oder in das Objekt eingebaut werden soll, so kommt es zu sogenannten Fügefehlern, weil sowohl das Objekt als auch das zu fügende Werkstück ungenau positioniert sind. Aufgrund dieser ungenauen Positionierung der Werkstückes und des Objektes, in welches das Werkstück mittels eines Roboters eingefügt werden soll, sowie der Toleranz des Roboters kommt es zu erheblichen Fügefehlern, die sich aus der Summe dieser Einzelfehler berechnen. Denn die Position des Roboters bzw. des Roboterarmes kann entweder über die Zeit oder durch Versehen verändert worden sein oder das Werkstück wird nicht in genau der gleichen Position vom Roboterarm zum Verbau aufgenommen.

[0007] Bisherige Lösungen gehen des Weiteren von der vereinfachenden Annahme aus, daß das Werkstück positionsgenau von Roboter gegriffen wird und vom Greifort bis zur Verbauposition außerdem keine weiteren Fehler mehr auftreten, wie sie zum Beispiel durch Sauggreifer, Roboterfehler und Objekttoleranzen bedingt sind. Es wird dann

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lediglich die Raumlage des Objektes, in welches das Werkstück einzufügen ist, bestimmt. In der Praxis ist dies jedoch nicht erreichbar, zudem das Objekt neben Positionsfehlern selbst in sich Fehler birgt, zum Beispiel Rohbautoleranzen, was eben zu den genannten Fügefehlern führt.

[0008] Als weiterer Stand der Technik hierzu ist noch R. Gerdes, R. Otterbach, R. Kammüller: Kalibrierung eines digitalen Bildverarbeitungssystems mit CCD-Kamera- Teil I und Teil II, in: tm Technisches Messen 60, 1993, 6, S. 255-261 (Teil I) und 60, 1993, 7/8, S. 283-288 (Teil II) zu nennen.

Technische Aufgabe:

[0009] Der Erfindung liegt die Aufgabe zugrunde, ein Verfahren zur Bestimmung der Lage eines Objektes und eines Werkstücks im Raum zur automatischen Montage des Werkstücks am Objekt zu schaffen, mittels welchem ein ungenau positioniertes Werkstück mit einem Roboter gegriffen und positionsgenau in ein ebenfalls ungenau positioniertes Objekt eingefügt werden soll.

Offenbarung der Erfindung sowie deren Vorteile:

[0010] Diese Aufgabe wird durch ein Verfahren zur Bestimmung der Lage eines Objektes und eines Werkstücks im Raum zur automatischen Montage des Werkstücks am Objekt mittels eines Roboters mit Greifer und unter Verwendung eines digitalen Bildverarbeitungssystems mit wenigstens zwei Sensoren, wie optische Sensoren, insbesondere Kameras, wie CCD-Kameras, und einem Rechner gelöst, bei welchem der Roboter mit Greifer und die Sensoren des Bildverarbeitungssystems in ihrer Lage im Weltkoordinatensystem W vermessen und diese Koordinaten dem Bildverarbeitungssystem eingegeben und gespeichert werden,
die Lage eines ersten Objektes, Kalibrierobjekt, wird in einer Soll-Montageposition des Objektes ebenfalls im Weltkoordinatensystem W vermessen und die Koordinaten der Soll-Montageposition ebenfalls im Bildverarbeitungssystem gespeichert, ein erstes Werkstück, Kalibrierwerkstück, wird mittels des Greifers des Roboters in eine Soll-Vorhalteposition gefahren, welche einen kleinen Abstand von der Soll-Montageposition zum Kalibrierobjekt besitzt und ebenfalls im Weltkoordinatensystem W vermessen und die Koordinaten der Soll-Vorhalteposition im Bildverarbeitungssystem gespeichert,
die Sensoren sind dergestalt im Weltkoordinatensystem W angeordnet und in dieser Position im Weltkoordinatensystem eingemessen, dass sie gleichzeitig sowohl die Soll-Montageposition des Kalibrierobjektes als auch die Soll-Vorhalteposition des Kalibrierwerkstücks erfassen, so dass das Bildverarbeitungssystem die Abweichung zwischen der Soll-Vorhalteposition und der Soll-Montageposition berechnen kann, anschließend wird ein nachfolgendes Objekt "ungenau" in eine Ist-Montage- bzw. Fügeposition des Objektes verbracht, welche von der Soll-Montageposition des Kalibrierobjektes abweichen kann,
der Greifer des Roboters entnimmt aus einem Lager ein nachfolgendes Werkstück "ungenau" auf und verfährt es in eine Ist-Vorhalteposition, welche von der Soll-Vorhalteposition des Kalibrierwerkstücks abweichen kann, wobei die Sensoren das Werkstück in der Ist-Vorhalteposition und gleichzeitig das Objekt in der Ist-Montageposition erfassen, nunmehr bestimmt das Bildverarbeitungssystem - in einem oder mehreren Bildern der Sensoren - die angefahrene Ist-Position des Werkstücks sowie die angefahrene Ist-Position des Objektes, und errechnet die notwendige Relativbewegung zwischen Werkstück und Objekt sechs-dimensional und gibt dem Greifer des Roboters diese Koordinaten der Ist-Montageposition vor, um welche der Greifer des Roboters zur genauen Plazierung des Werkstücks am Objekt translatorisch und rotatorisch zu verfahren ist.

[0011] In einer weiteren Ausgestaltung des Verfahrens hält der Roboter das Werkstück in der Ist-Vorhalteposition zur Durchführung des Vermessungsvorgangs kurz an. In
einer weiteren Ausgestaltung des Verfahren wird dasselbe mit einem einzigen Sensor, wie CCD-Kamera, durchgeführt, welcher hinsichtlich der Kalibrierung und Verfahrbarkeit mehrfach positionierbar ist, so dass auch nur mit einem einzigen Sensor, zum Beispiel CCD-Kamera, verfahrensgemäß gearbeitet werden kann.

[0012] In einer weiteren Ausgestaltung des Verfahrens sind die Sensoren, wie CCD-Kameras, am Roboter selbst verteilt angeordnet. Oder die Sensoren, wie CCD-Kameras sind zum Teil am Roboter selbst und zum Teil ortsfest verteilt angeordnet.

[0013] In weiterer Ausgestaltung des Verfahrens werden am Objekt und/oder am Werkstück innerhalb der Ist-Montage oder Fügeposition bzw. der Ist-Vorhalteposition signifikante Merkmale, wie Konturen, Ecken, Aussparungen oder Bohrungen, angetastet. Dadurch ist eine genaue Erfassung von Objekten möglich, welche, wie Scheiben, transparent sind. In weiterer Ausgestaltung des Verfahren werden die signifikanten Merkmale durch Beleuchtung kenntlich gemacht. Dabei kann als Beleuchtung Infrarotlicht oder Laserlicht oder Streifenlicht zur Anwendung gelangen. In weiterer Ausgestaltung des Verfahren werden Laserlichtlinien verwendet.

[0014] Der hervorstechende Vorteil des erfindungsgemäßen Verfahrens besteht darin, dass die Greifposition des Roboters vermessen wird und in die Auswertung eingeht. Das ist ein großer Vorteil, da nicht immer davon ausgegangen

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werden kann, dass einerseits das Werkstück innerhalb kleiner, vorgegebener Grenzen reproduzierbar aufgenommen worden ist, andererseits auch nicht davon ausgegangen werden darf, dass sich das Objekt, in oder an welches das Werkstück zu montieren ist, sich innerhalb kleiner, vorgegebener Grenzen reproduzierbar befindet. In vorteilhafter Weise werden somit durch das Verfahren in automatischer Montage ein ungenau positioniertes Werkstück mit einem Roboter, welcher ebenfalls Verfahrfehler aufweisen kann, gegriffen und positionsgenau in ein ebenfalls ungenau positioniertes Objekt ohne Verfügefehler eingefügt.

[0015] Durch die Erfindung werden deshalb vorteilhaft die folgenden Fehler kompensiert:

- Fehler beim Greifen des Werkstückes
- Fehler in der Positionierung des Objektes
- Fehler in den Toleranzen des Werkstückes und des Objektes
- Roboterfehler, sie spielen praktisch keine Rolle mehr, weil vom Roboter nur noch ein sehr kurzer Weg gefahren werden muss, nämlich der für jeden einzelnen Fügevorgang berechnete Weg, welchen der Roboter zurücklegen muss, um das Werkstück exakt im oder am Objekt zu fügen.

[0016] Die Steuerung des Roboters gibt die Position bzw. die Koordinaten des Roboters an das Bildverarbeitungssystem weiter zur Berechnung der durch den Roboter anzufahrenden Positionen; ebenso sind die Sensoren, wie Digitalkameras, im Weltkoordinatensystem vermessen bzw. kalibriert.

Beispiele der Erfindung sind an Hand einer Zeichnung beschrieben, in der zeigen:

[0017]

Figur 1 eine perspektivische schematische Darstellung eines Roboters mit Greifer, welcher eine Scheibe zum Einbau in eine Karosse hält und
Figur 2 eine schematische Zeichnung der durchzuführenden Vermessungsschritte der am Verfahren beteiligten Komponenten.

Bevorzugte Ausführungsform der Erfindung:

[0018] Das nachfolgend beschriebene Beispiel ist der automatisierten Fahrzeugmontage entnommen. Karossen 1 werden nacheinander auf einer Transportschiene 2 in eine Montage- oder Fügeposition verfahren, wo mittels eines Roboters 7 mit einem Greifer 7' eine vom Greifer 7' getragene Scheibe 6 in eine Karossenaussparung 5 der jeweiligen Karosse 1 eingesetzt wird. Der Roboter 7 ist auf einer Fahrschiene 8 verfahrbar angeordnet und kann zwischen einem Magazin 9, aus welchem die Scheiben 6 nacheinander entnommen werden, und der Karosse 1 hin- und herfahren bzw. schwenken oder beides.

[0019] Zur Aufnahme der Scheiben 6 besitzt der Roboter 7 an seinem Greifer 7' eine Greifplatte 10, an welcher Saugnäpfe 11 zum Ergreifen und Loslassen der Scheiben 6 angeordnet sind. Nachdem der Roboter 7 aus dem Magazin 9 mittels der Greifplatte 10 eine Scheibe 6 aufgenommen hat, fährt er die Scheibe 6 in eine Vorhalteposition 4 der Scheibe 6 kurz vor der Karosse 1.

[0020] Hier nun erblicken, beispielsweise, drei optische Sensoren, wie Digitalkameras 3, 3', 3", welche Teil eines Bildverarbeitungssystems mit einem nicht gezeigten Rechner sind, aus drei verschiedenen Richtungen drei verschiedene Vorhaltebereiche 12, 13, 14, gegeben durch die Vorhalteposition 4, wobei die Sensoren, wie Digitalkameras 3, 3', 3" gleichzeitig sowohl einen - relativ kleinen - Bereich der Füge- bzw. Einbauposition der Karossenaussparung 5 der Karosse 1 als auch einen - ebenfalls relativ kleinen - Bereich der Vorhaltepostion 4 der Scheibe 6 erfassen. Montage- oder Fügungsort und Werkstück werden somit gleichzeitig von den Sensoren, zum Beispiel Digitalkameras 3, 3', 3", erfasst.

[0021] Die optischen Sensoren 3, 3', 3", zum Beispiel Digitalkameras 3, 3', 3", sind entweder ortsfest und kalibriert oder sie sind auf dem Roboter montiert und kalibriert, wobei es auch möglich ist, nur einen oder zwei Sensoren, wie Digitalkameras 3, 3', 3", auf dem Roboter 7, die dritte ortsfest kalibriert, zu montieren. Der Roboter 7 kann die Scheibe 6 in der Vorhalteposition 4 kurzzeitig anhalten, so dass die Sensoren 3, 3', 3", zum Beispiel Digitalkameras 3, 3', 3", eindeutig die Koordinaten der Scheibe 6 und der Karossenaussparung 5 ermitteln können.

[0022] Nunmehr berechnet das Bildverarbeitungssystem anhand der von den drei Digitalkameras 3, 3', 3" ermittelten Koordinaten sowie den vorher ermittelten Soll-Koordinaten der sogenannten Kalibrierkarosse und des sogenannten Kalibrierwerkstücks den Ist-Vektor, um welchen der Greifer 7' bzw. der Roboter 7 in den drei Raumkoordinaten zu verfahren ist, um den Ist-Vektor zu fahren. In der Figur 1 ist zur Veranschaulichung hierzu zweidimensional ein Versatz "s" zwischen Scheibe 6 und Karossenaussparung 5 eingezeichnet. Der Versatz "s" ist in Realität sechs-dimensional, nämlich drei Positionen und drei Orientierungen.

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[0023] Figur 2 zeigt in schematischer Wiedergabe eine Zeichnung, welche die durchzuführenden Vermessungsschritte der am Verfahren beteiligten Komponenten wiedergibt. Diese Abbildung zeigt einen Transformationsgraphen, welcher die Beziehungen zwischen den einzelnen Koordinatensystemen der Anwendung beschreibt. Die Koordinatensysteme sind jeweils mit den einzelnen Komponenten, Objekte, der Anwendung verbunden.

[0024] In Figur 2 bedeutet die Abkürzung "VMT" Bildverarbeitungssystem mit den Komponenten optische Sensoren in Form von Digitalkameras 3, 3', 3" sowie Rechner, welcher nicht gezeigt ist. Die Bezeichnung "RobCon" bedeutet Roboter-Controller, also die Robotersteuerung, was heißt, dass die benötigten Daten von der jeweiligen Robotersteuerung zur Verfügung gestellt werden.

Des Weiteren gelten in Figur 2 die folgenden Benennungen:

[0025]

W	Weltkoordinatensystem, Bezugskoordinatensystem für die gesamte Roboterzelle bzw. Applikation
RB	Roboter-Basiskoordinatensystem, Roboter 7
VMT	Bezugssystem Bildverarbeitungssystem
K (allg)	Karossenkoordinatensystem
K_0	Karossenreferenzposition (Objekt-Kalibrierposition)
K_i	Position der aktuellen i-ten Karosse
G (allg)	Robotergreiferkoordinatensystem
G_0	Greifer-Einbauposition an Referenzkarosse für Referenzscheibe (Position des Greifers 7' des Roboters 7 in Soll-Vorhalteposition des Werkstücks 6)
G_1	Greifer in Vorhalteposition, konstant für alle Scheiben, relativ zu RB
G_i	Greifer in Einbauposition an der aktuellen i-ten Karosse für die aktuelle i-te Scheibe
S (allg)	Scheibenkoordninatensystem
S_0	Referenzscheibe in Einbauposition an Referenzkarosse (Werkstück-Kalibrierposition)
S_{0i}	Aktuelle i-t Scheibe in Einbauposition an aktueller i-ter Karosse
S_1	Referenzscheibe in Vorhalteposition, relativ zu G_1
S_i	Aktuelle i-te Scheibe in Vorhaltepostion, relativ zu G_1
RobCon	Roboter-Controller

[0026] Ein Bildverarbeitungssystem als Sensorsystem, welches entweder auf einem Greifer 7' eines Roboters 7 oder stationär, nämlich außerhalb des Roboters 7, installiert ist, berechnet die Raumlage des Werkstücks 6 und die Raumlage des Objektes 1, in welches das Werkstück 6 gefügt werden soll. Aus diesen beiden Werten wird dann der Ist-Vektor für den Roboter 7 berechnet. Der Ist-Vektor gibt an, welchen Weg der Roboterarm 7 zurücklegen muss, um das Werkstück 6 exakt im Objekt 1 zu fügen; dabei werden auch Ungenauigkeiten des zu fügenden Werkstücks 6, wie auch des Objektes 1 größtenteils durch die dem Verfahren innewohnende Mathematik kompensiert.

[0027] Zunächst wird dem Roboter manuell über seinen Roboter-Controller gelehrt, das Werkstück 6 in die richtige Position, die sogenannte Soll-Einbauposition, an der ersten Karosse, dem Kalibrierobjekt, zu bringen. Diese Position der Karosserie in der Soll-Montageposition oder ersten Phase wird hier K_0 als Karosserie-Referenzposition bezeichnet. Dem Roboter werden die benötigten Daten von der Robotersteuerung, Roboter-Controller, zur Verfügung gestellt.

[0028] Mit Hilfe eines Bildverarbeitungssystems, dem wenigstens zwei, vorzugsweise drei kalibrierte Sensoren, zum Beispiel kalibrierte optische Sensoren, wie Digitalkameras 3, 3', 3", sowie ein nicht gezeigter Rechner angehören, werden danach alle Abweichungen der aktuellen Position der aktuellen Karosse 1 mit diesem Referenzrahmen bzw. Kalibrierobjekt K_0 verglichen, wobei die aktuelle Position der aktuellen Karosse 1 mit K_i bezeichnet ist.

[0029] Der Roboter 7 nimmt dann das erste Werkstück, Kalibrierwerkstück, mit Hilfe des Greifers 7' auf. Der erste Schritt ist nun, den Roboter mit Hilfe seines Roboter-Controllers in eine Position zu kommandieren, in der das Bildverarbeitungssystem, nämlich die drei Kameras 3, 3', 3", gleichzeitig die Referenzpunkte bzw. Referenzbereiche 12, 13, 14 sowohl des Werkstücks als auch der Karosse sehen kann. Dieses Bild des Roboterarms 7' in dieser Position wird hier mit Vorhalteposition G_1 bezeichnet; die entsprechende Scheibenposition der Scheibe sei S_1. Diese Position ist die Referenzposition, bzw. Soll-Vorhalteposition für die Scheibe.

[0030] In einem weiteren Schritt wird nun manuell die Scheibe in die richtige Position an der Karosserie gebracht; diese Einbauposition sei G_0 für den Roboterarm und S_0 für die entsprechende Position der Scheibe; dabei verfährt der Roboter einen Soll-Vektor.

[0031] Nunmehr wird in einem weiteren Schritt der Roboterarm 7' bzw. der Roboter 7 für jede der weiteren aufgenommenen Scheiben 6 in eine Position gebracht, die der von G_1 in etwa entspricht, da diese Position mit Fehlern behaftet sein kann. Das eigentliche Bild dieser Position wird deshalb etwas vom Referenzbild der Scheibe, S_1, abweichen. Mit Hilfe des Bildverarbeitungssystems "VMT" werden diese Abweichungen vom Referenzbild zum aktuellen

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Bild gemessen und in Koordinaten ausgegeben.

[0032] In einem weiteren Schritt werden nun die Transformationen von G_1 zu G_i der Steuerung des Roboterarms 7' zugeführt. G_i bezeichnet hier die Einbauposition in die aktuelle Karosse 1 für die aktuelle Scheibe 6.

[0033] Um diese Transformationen durchführen zu können, benötigt man zwei Abweichungen: die der aktuellen Position der Karosse und die der Scheibe wie diese mit dem Bildverarbeitungssystem "VMT" aufgenommen worden sind sowie die folgenden Grunddaten:

- Die Position und Orientierung der Karossen-Referenzposition K_0 relativ zum Weltkoordinatensystem
- Die Position und Orientierung der Referenzposition bzw. Soll-Vorhalteposition der Scheibe S_1 relativ zum Weltkoordninatensystem
- Die Position und Orientierung des Roboters relativ zum Weltkoordinatensystem.

[0034] Diese mit Grunddaten bezeichneten Transformationen werden vorteilhaft mit einem Meßsystem der Firma LEICA durchgeführt.

[0035] Des Weiteren wird benötigt:

- Die Position und Orientierung des Robotergreifers G_0 relativ zum Roboter.
  Diese letztgenannte Transformation - Position und Orientierung des Robotergreifers G_0 relativ zum Roboter - wird vom Roboter-Controller erhalten.

[0036] Das Verfahren besteht aus zwei Grundschritten oder Modi. Im ersten Modus, Kalibriermodus, werden die folgenden Schritte durchgeführt, wobei das Meßsystem der Firma LEICA nur für diesen Modus des Kalibrierens benötigt wird:

- Schritt 1: Vermessung des Roboters (Roboter-Basiskoordinatensystem) und des VMT-Systems (Koordinaten des Bezugssystems Bildverarbeitung) mittels LEICA
- Schritt 2: Bewegen einer Karosse in die Referenzposition und Vermessen mittels LEICA (Karossenkoordinatensystem)
- Schritt 3: Verfahren des Roboters mit der ersten durch den Greifer aufgenommenen Scheibe (Referenzscheibe) in die Referenzposition der Scheibe, Vermessen der Scheibenposition mittels LEICA und Ermitteln der Robotergreiferposition mittels des Roboter-Controllers
- Schritt 4: Null- bzw. Erst-Vermessung der Karosse und der Scheibe mittels des VMT Bildverarbeitungssystems (im VMT-System)
- Schritt 5: Verfahren des Roboters mit der ersten Scheibe (Referenzscheibe) in die Einbauposition der ersten Karosse und Ermitteln der Robotergreiferposition mittels des Roboter-Controllers (im Roboter-Basiskoordinatensystem)

Im zweiten Modus werden die folgenden Schritte automatisch durchlaufen:

[0037]

- Schritt 1: Anhalten der Karosse in der Montageposition
- Schritt 2: Aufnehmen der Scheibe mittels des Robotergreifers und Verfahren des Roboters in die Greifer-Vorhalteposition G_1
- Schritt 3: Messung der Abweichung der Karosse und der Scheibe von den zugehörigen Referenzpositionen unter Benutzung des VMT Bildverarbeitungssystems
- Schritt 4: Berechnung der Transformation von G_1 - Greifer in Vorhalteposition - zu Gi - Greifer in Einbauposition an der aktuellen i-ten Karosse für die aktuelle i-te Scheibe - und Übermitteln des Ergebnisses an den Roboter bzw. den Roboter-Controller
- Schritt 5: durch den Roboter-Controller nunmehr Verfahren des Roboters entsprechend der so berechneten Transformation, so dass sich die aktuelle Scheibe S_{0i}, das ist die aktuelle i-te Scheibe, in Einbauposition an der aktuellen Karosse, das ist die i-te Karosse, befindet.

[0038] Im Nachfolgenden sei des Weiteren eine mathematische Herleitung des erfindungsgemäßen Verfahrens wiedergegeben:

Schritt 1: es ist die Position aufzufinden, in welche die Scheibe relativ zur kalibrierten Position S_0 der Scheibe, das ist die Soll-Vorhalteposition, zu verfahren ist:

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$$ {}^{S_0}_{i S_0}\mathrm{T} = \left({}^{K_0}_{S_0}\mathrm{T}\right)^{-1} \cdot {}^{K_0}_{K_i}\mathrm{T} \cdot {}^{K_0}_{S_0}\mathrm{T} $$

wobei ${}^{K_0}_{S_0}T = {}^{K_i}_{i S_0}T$ gilt, weil die Scheibe für alle Karossen in der gleichen relativen Position gefügt werden muß.

Schritt 2: es ist die relative Position zwischen dem Roboter bzw. dem Greifer des Roboters und der Vorhalteposition für die erste Referenz-Scheibe aufzufinden:

$$ {}^{G_1}_{S_1}\mathrm{T} = \left({}^{W}_{RB}\mathrm{T} \cdot {}^{RB}_{G_1}\mathrm{T}\right)^{-1} \cdot {}^{W}_{S_1}\mathrm{T} $$

wobei ${}^{G_1}_{S_1}T = {}^{G_0}_{S_0}T$ gilt, weil die relative Position zwischen der Scheibe und dem Greifer des Roboters dieselbe bzw. identisch in der Vorhalteposition G_1 und der Einbauposition G_0 ist.

Schritt 3: es ist die relative Position zwischen der Vorhalteposition der Referenz-Scheiben S_1 und der Einbauposition S_0 der Referenzscheibe an der Referenzkarosse.

$$ {}^{S_1}_{S_0}\mathrm{T} = \left({}^{G_1}_{S_1}\mathrm{T}\right)^{-1} \cdot {}^{G_1}_{G_0}\mathrm{T} \cdot {}^{G_1}_{S_1}\mathrm{T} $$

Schritt 4: es ist die relative Position zwischen der Karosse K_0 und der Scheibe S_0 in ihrer richtigen Fügelage zu finden, die Referenzposition:

$$ {}^{K_0}_{S_0}\mathrm{T} = \left({}^{W}_{K_0}\mathrm{T}\right)^{-1} \cdot {}^{W}_{RB}\mathrm{T} \cdot {}^{RB}_{G_1}\mathrm{T} \cdot {}^{G_1}_{G_0}\mathrm{T} \cdot {}^{S_1}_{S_1}\mathrm{T} $$

Schritt 5: es ist die Transformation von Greifer in Vorhalteposition G_1 zu Greifer in Einbauposition G_i aufzusuchen:

$$ {}^{G_1}_{G_1}\mathrm{T} = {}^{G_1}_{S_1}\mathrm{T} \cdot \left({}^{S_1}_{S_i}\mathrm{T}\right)^{-1} \cdot {}^{S_1}_{S_0}\mathrm{T} \cdot {}^{S_0}_{S_{0i}}\mathrm{T} \cdot \left({}^{G_1}_{S_i}\mathrm{T}\right)^{-1} $$

wobei ${}^{G_1}_{S_1}T = {}^{G_i}_{i S_i}T$ gilt, weil die relative Position zwischen der Scheibe und dem Greifer des Roboters in jeder Greiferposition für ein und dieselbe Scheibe identisch ist.. Die vorstehende letzte Gleichung kann dann wie folgt geschrieben werden:

$$ {}^{G_1}_{G_1}\mathrm{T} = {}^{G_1}_{G_0}\mathrm{T} \cdot \left({}^{W}_{RB}\mathrm{T} \cdot {}^{RB}_{G_1}\mathrm{T}\right)^{-1} \cdot {}^{W}_{S_1}\mathrm{T} \cdot \left(\left({}^{W}_{K_0}\mathrm{T}\right)^{-1} \cdot {}^{W}_{RB}\mathrm{T} \cdot {}^{RB}_{G_1}\mathrm{T}\, {}^{G_1}_{G_0}\mathrm{T} \cdot \left({}^{W}_{RB}\mathrm{T} \cdot {}^{RB}_{G_1}\mathrm{T}\right)^{-1} \cdot {}^{W}_{S_1}\mathrm{T}\right)^{-1} \cdot {}^{K_0}_{K_i}\mathrm{T}^{(VMT)} \cdot $$

$$ \cdot \left({}^{W}_{K_0}\mathrm{T}\right)^{-1} \cdot {}^{W}_{RB}\mathrm{T} \cdot {}^{RB}_{G_1}\mathrm{T}\, {}^{G_1}_{G_0}\mathrm{T} \cdot \left({}^{W}_{RB}\mathrm{T} \cdot {}^{RB}_{G_1}\mathrm{T}\right)^{-1} \cdot {}^{W}_{S_1}\mathrm{T} \cdot \left(\left({}^{W}_{RB}\mathrm{T} \cdot {}^{RB}_{G_1}\mathrm{T}\right)^{-1} \cdot {}^{W}_{S_1}\mathrm{T} \cdot {}^{S_1}_{S_1}\mathrm{T}^{(VMT)}\right)^{-1} $$

wobei ${}^{K_0}_{S_0}T = {}^{K_i}_{S_{0i}}T$ gilt, weil die Scheibe in der gleichen relativen Position in die Karosse gefügt werden muß für alle Karossen.

[0039] Somit wird mit den gleichen Kameras 3, 3', 3", in einem oder mehreren Bildern die Position des Werkstücks, zum Beispiel eine Scheibe im Greifer eines Roboters, und die Position einer Karosse bestimmt, anschließend wird die Relativbewegung ausgerechnet und dem Roboter eine Fügeposition vorgegeben unter Berücksichtigung der Position der Scheibe im Greifer, Messung 1, und der Position der Karosse, Messung 2.

[0040] Anschließend wird der Roboter um den errechneten Ist-Vektor, welcher die tatsächliche Ist-Positionen von

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Karosse und Scheibe berücksichtigt, um die drei Raumkoordinaten verfahren.

[0041] Der Unterschied zu den bisherigen Verfahren liegt darin, das die Greifposition des Roboters mit gemessen wird und in die Auswertung eingeht. Das ist erheblich günstiger und der entscheidende Vorteil, weil nicht immer davon ausgegangen werden kann, dass weder die aktuelle Scheibe innerhalb kleiner Grenzen vom Roboter reproduzierbar aufgenommen wurde noch die aktuelle Karosse innerhalb kleiner Grenzen an den Montage- oder Fügeort verfahren worden ist.

[0042] Die Erfindung betrifft somit ein Verfahren zur Bestimmung der Lage eines Objektes 1 und Werkstücks 6 im Raum zur Montage des Werkstücks 6 am Objekt 1 mittels eines Roboters 7 mit Greifer 7' unter Verwendung eines Bildverarbeitungssystems mit Sensoren, insbesondere Kameras, wie CCD-Kameras 3,3',3" und Rechner. Roboter 7, Greifer 7' und Kameras 3,3',3" werden im Weltkoordinatensystem W vermessen und die Koordinaten im Bildverarbeitungssystem gespeichert. Die Lage eines ersten Objektes 1, Kalibrierobjekt, wird in einer Soll-Montageposition des Objektes 1 ebenfalls im Weltkoordinatensystem W vermessen und die Koordinaten im Bildverarbeitungssystem gespeichert. Ein erstes Werkstück 6, Kalibrierwerkstück, wird mittels des Greifers 7' in eine Vorhalteposition gefahren, die einen kleinen Abstand von der Soll-Montageposition zum Kalibrierobjekt besitzt und ebenfalls im Weltkoordinatensystem W vermessen und die Koordinaten gespeichert. Die Kameras 3,3',3" sind dergestalt im Weltkoordinatensystem W angeordnet und im Weltkoordinatensystem eingemessen, dass sie gleichzeitig sowohl die Soll-Montageposition des Kalibrierobjektes 1 als auch die Soll-Vorhalteposition des Kalibrierwerkstücks 6 erfassen, so dass das Bildverarbeitungssystem die Abweichung zwischen der Soll-Vorhalte- und der Soll-Montageposition berechnen kann. Nun wird ein Objekt 1 "ungenau" in eine Ist-Montageposition des Objektes 1 verbracht, die von der Soll-Montageposition des Kalibrierobjektes abweichen kann; der Greifer 7' entnimmt aus einem Lager 9 ein nachfolgendes Werkstück 6 "ungenau" auf und verfährt es in eine Ist-Vorhalteposition, welche von der Soll-Vorhalteposition des Kalibrierwerkstücks abweichen kann, wobei die Kameras 3,3',3" das Werkstück 6 in der Ist-Vorhalteposition und gleichzeitig das Objekt 1 in der Ist-Montageposition erfassen. Das Bildverarbeitungssystem bestimmt die angefahrenen Ist-Positionen des Werkstücks 6 sowie des Objektes 1 und errechnet die notwendige Relativbewegung zwischen Werkstück 6 und Objekt 1 sechs-dimensional und gibt dem Greifer 7' des Roboters 7 diese Koordinaten der Ist-Montageposition vor, um welche der Greifer 7' des Roboters 7 zur genauen Plazierung des Werkstücks 6 am Objekt 1 translatorisch und rotatorisch zu verfahren ist.

Gewerbliche Anwendbarkeit:

[0043] Der Gegenstand der Erfindung ist beispielsweise für einzufügende Werkstücke im Karosseriebau, im Türenverbau, im Schiebedachverbau, oder im Scheibenverbau u.s.w. gewerblich anwendbar. Denn das Werkstück, beispielsweise die Tür, befindet sich in der Roboterhand und muss in einen Türausschnitt, nämlich das Objekt, der Karosse montiert werden. Oder im Schiebedachverbau befindet sich das Schiebedach in der Roboterhand und muss in einen Dachausschnitt, Objekt, der Karosse montiert werden; oder im Scheibenverbau trägt die Roboterhand eine Fahrzeugscheibe, welche in einen Scheibenausschnitt einer Karosse exakt eingefügt werden muss.

Bezugszeichenliste:

[0044]

1	Karosse
2	Transportschiene
3, 3', 3"	Digitalkameras
4	Annäherungsbereich der Scheibe an die Karosse
5	Karossenaussparung
6	Scheibe
7	Roboter
7'	Roboterarm
8	Fahrschiene
9	Magazin
10	Greifscheibe
11	Saugnäpfe
12, 13, 14	Vorhaltebereiche
s	Versatz zwischen Scheibe 6 und Karossenaussparung 5 (nur zweidimensional dargestellt)

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Patentansprüche

1. Verfahren zur Bestimmung der Lage eines Objektes (1) und eines Werkstücks (6) im Raum zur automatischen Montage bzw. Einfügen des Werkstücks (6) am Objekt (1) mittels eines Roboters (7) mit Greifer (7') und unter Verwendung eines digitalen Bildverarbeitungssystems mit wenigstens einem Sensor (3,3',3"), wie optischer Sensor (3,3',3"), insbesondere Kamera (3,3',3"), und einem Rechner, **gekennzeichnet durch** die folgenden Merkmale:

   der Roboter (7) mit Greifer (7') und die Sensoren (3,3',3"), wie Kameras (3,3',3"), des Bildverarbeitungssystems werden in ihrer Lage im Weltkoordinatensystem (W) vermessen und diese Koordinaten dem Bildverarbeitungssystem eingegeben und gespeichert,
   die Lage eines ersten Objektes (1), Kalibrierobjekt, wird in einer Soll-Montageposition des Objektes (1) ebenfalls im Weltkoordinatensystem (W) vermessen und
   die Koordinaten der Soll-Montageposition ebenfalls im Bildverarbeitungssystem gespeichert,
   ein erstes Werkstück (6), Kalibrierwerkstück, wird mittels des Greifers (7') des Roboters (7) in eine Soll-Vorhalteposition gefahren, welche einen kleinen Abstand von der Soll-Montageposition zum Kalibrierobjekt besitzt und ebenfalls im Weltkoordinatensystem (W) vermessen und die Koordinaten der Soll-Vorhalteposition im Bildverarbeitungssystem gespeichert,
   die Sensoren (3,3',3"), wie Kameras (3,3',3") sind dergestalt im Weltkoordinatensystem (W) angeordnet und in dieser Position im Weltkoordinatensystem eingemessen, dass sie gleichzeitig sowohl die Soll-Montageposition des Kalibrierobjektes (1) als auch die Soll-Vorhalteposition des Kalibrierwerkstücks (6) erfassen, so dass das Bildverarbeitungssystem die Abweichung zwischen der Soll-Vorhalteposition und der Soll-Montageposition berechnen kann,
   anschließend wird ein nachfolgendes Objekt (1) "ungenau" in eine Ist-Montage- bzw. Fügeposition des Objektes (1) verbracht, welche von der Soll-Montageposition des Kalibrierobjektes abweichen kann,
   der Greifer (7') des Roboters (7) entnimmt aus einem Lager (9) ein nachfolgendes Werkstück (6) "ungenau" auf und verfährt es in eine Ist-Vorhalteposition, welche von der Soll-Vorhalteposition des Kalibrierwerkstücks abweichen kann, wobei die Kameras (3,3',3") das Werkstück (6) in der Ist-Vorhalteposition und gleichzeitig das Objekt (1) in der Ist-Montageposition erfassen,
   nunmehr bestimmt das Bildverarbeitungssystem - in einem oder mehreren Bildern der Sensoren (3,3',3"), wie Kameras (3,3',3") - die angefahrene Ist-Position des Werkstücks (6) sowie die angefahrene Ist-Position des Objektes (1), und errechnet die notwendige Relativbewegung zwischen Werkstück (6) und Objekt (1) sechsdimensional und gibt dem Greifer (7') des Roboters (7) diese Koordinaten der Ist-Montageposition vor, um welche der Greifer (7') des Roboters (7) zur genauen Plazierung des Werkstücks (6) am Objekt (1) translatorisch und rotatorisch zu verfahren ist.

2. Verfahren nach Anspruch 1,
   dadurch gekennzeichnet,
   dass der Roboter (7) das Werkstück (6) in der Ist-Vorhalteposition zur Durchführung des Vermessungsvorgangs kurz anhält.

3. Verfahren nach Anspruch 1 oder 2,
   dadurch gekennzeichnet,
   dass dasselbe mit einem einzigen Sensor (3,3',3"), wie Kamera (3,3',3"), durchgeführt wird, welcher hinsichtlich der Kalibrierung und anschließenden Verfahrbarkeit mehrfach positionierbar ist.

4. Verfahren nach Anspruch 1 oder 2,
   dadurch gekennzeichnet,
   dass die Sensoren (3,3',3"), wie Kameras (3,3',3"), am Roboter selbst verteilt angeordnet sind.

5. Verfahren nach Anspruch 1 oder 2,
   dadurch gekennzeichnet,
   dass die Sensoren (3,3',3"), wie Kameras (3,3',3"), am Roboter (7) selbst sowie ortsfest verteilt angeordnet sind.

6. Verfahren nach einem der vorherigen Ansprüche,
   dadurch gekennzeichnet,
   dass an dem Objekt (1) und/oder an dem Werkstück (6) innerhalb der Ist-Montage oder Fügeposition bzw. der Ist-Vorhalteposition signifikante Merkmale, wie Konturen, Ecken, Aussparungen oder Bohrungen, angetastet werden.

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7. Verfahren nach Anspruch 6,
dadurch gekennzeichnet,
dass die signifikanten Merkmale durch Beleuchtung kenntlich gemacht werden.

8. Verfahren nach Anspruch 7,
dadurch gekennzeichnet,
dass als Beleuchtung Infrarotlicht oder Laserlicht oder Streifenlicht zur Anwendung gelangt.

9. Verfahren nach Anspruch 8,
dadurch gekennzeichnet,
dass Laserlichtlinien verwendet werden.

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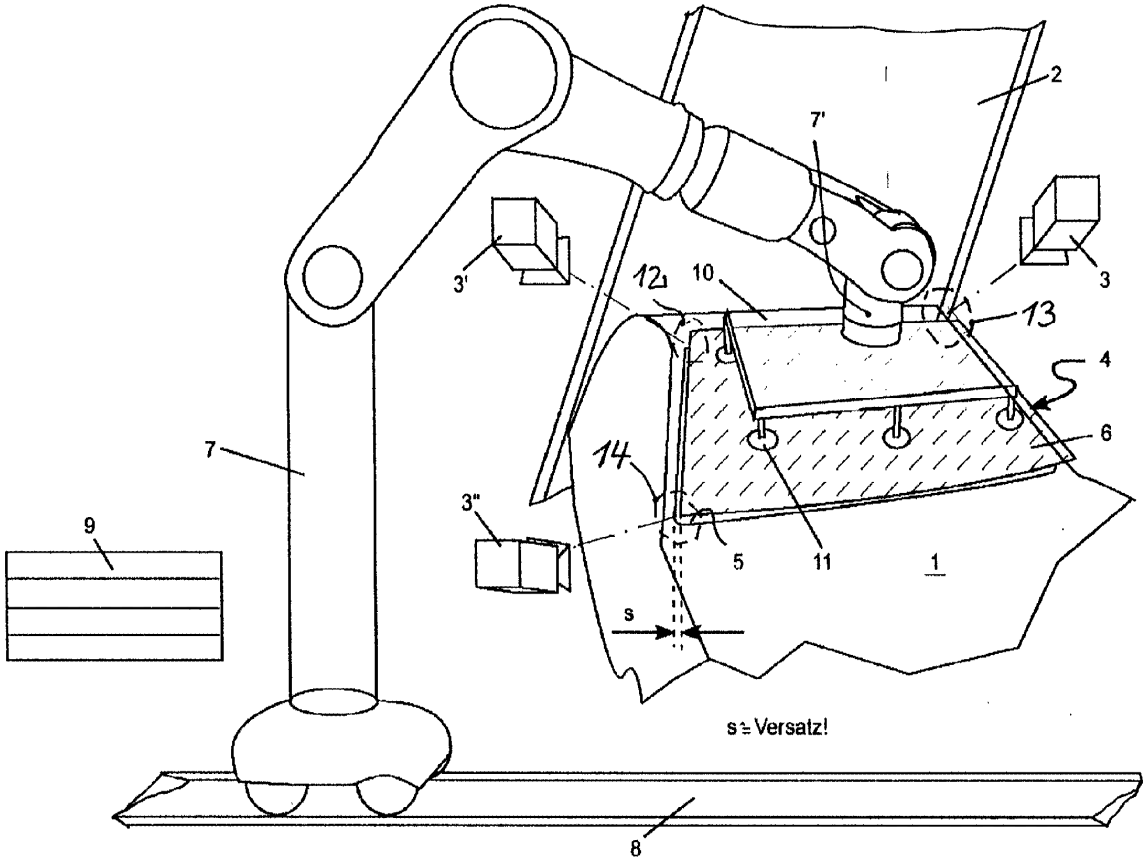


Fig. 1

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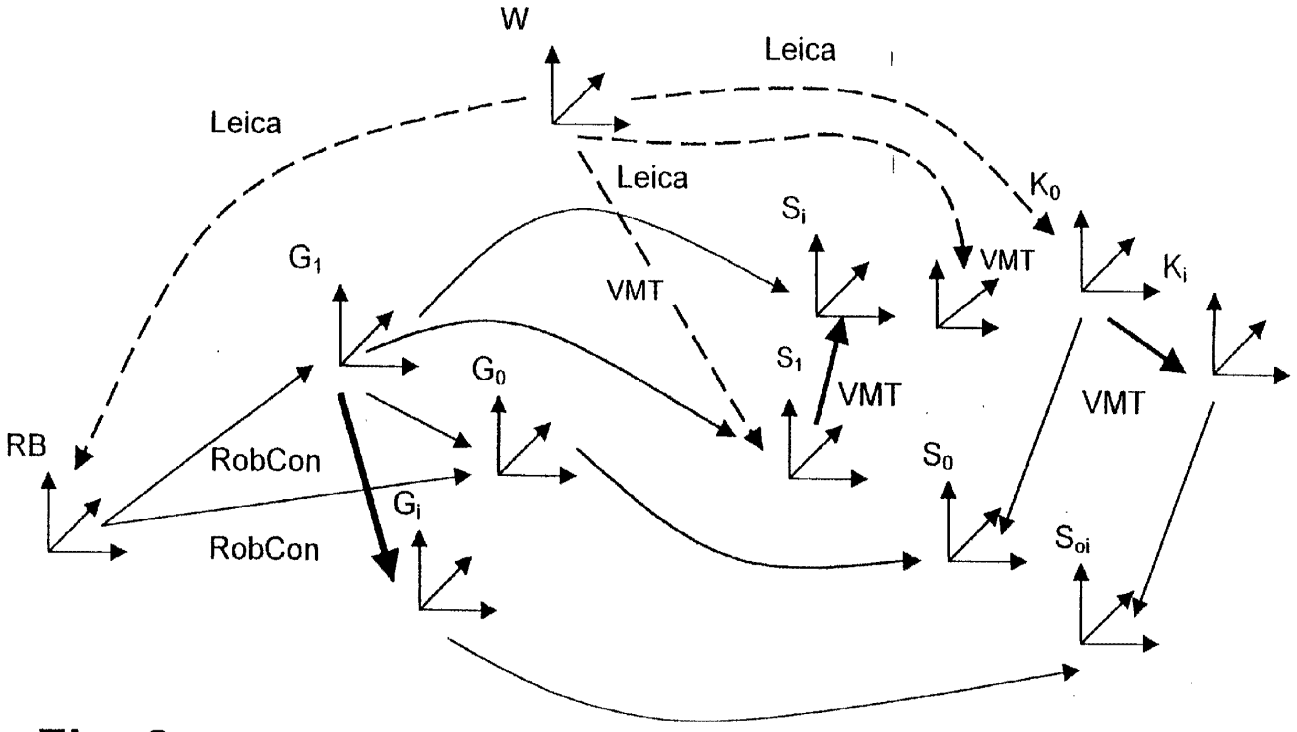


Fig. 2

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DE10319253

Publication Title:

Three-dimensional position-correct component feed uses cameras mounted on robots with component grabs, to monitor deviation from standard positions

Abstract:

Abstract of DE10319253

The components (4) are removed from a container (6) by a robot (1) in a chosen three-dimensional position. Sensors, esp. cameras (2), are fastened directly or indirectly to the robot and moveable with it, to monitor any deviation of the components held by a grab (3), from a standard position. The same sensors are used to localize parts for the purpose of being gripped, and to determine the degree of deviation. The cameras are calibrated relative to a robot-related coordinate system.

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(72) Erfinder:
Antrag auf Nichtnennung

(56) Für die Beurteilung der Patentfähigkeit in Betracht gezogene Druckschriften:
DE 199 30 087 A1
DE 198 49 720 A1
DE 41 15 846 A1
US 61 14 824 A
US 55 79 444 A1
EP 05 28 054 A1
STAVNITZKY, J., CAPSON, D.:"Multiple Camera Model-Based 3-D Visual Servo" In: IEEE Transaction on Robotics and Automation, Vol. 16, No. 6, Dec.2000, S. 732-739;

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

Prüfungsantrag gemäß § 44 PatG ist gestellt.

(54) Bezeichnung: **Dreidimensional lagegerechtes Zuführen mit Roboter**

(57) Zusammenfassung: Zum lagegerechten Zuführen von Teilen, insbesondere von Teilen, die mittels Roboter aus einem Behälter gegriffen wurden, wird über am Roboter direkt oder indirekt befestigte und mit dem Roboter bewegbare Sensoren, vorzugsweise Kameras, in gegriffenem Zustand die Abweichung der aktuellen Teilelage von einer Standardlage bestimmt, vorzugsweise in Bewegung. Hauptvorteil ist die Zeitersparnis, da Bildaufnahme, Bildauswertung, Korrekturrechnung und sogar die Aktualisierung der Roboterbahn während der ohnehin erforderlichen Bewegung durchgeführt werden können. Außerdem entfällt der für einen extra Korrekturschritt erforderliche Platz für eine Ablage und/oder fest montierte Kameras.

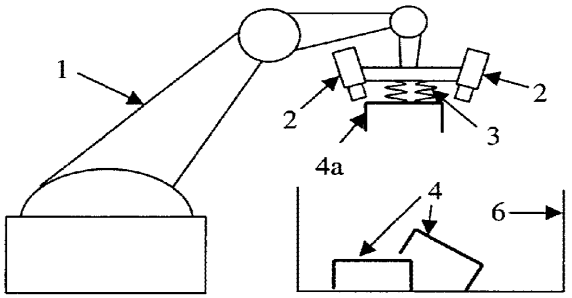


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Beschreibung

[0001] Die Erfindung betrifft das dreidimensional lagegerechte Zuführen von ungenau oder unbekannt gegriffenen Teilen.

[0002] Systeme zur automatischen Bearbeitung oder Montage von Teilen benötigen eine Zuführung der Teile in einer bestimmten gewünschten dreidimensionalen Lage, oft mit kleinen Lagetoleranzen. Zuführsysteme werden aus Flexibilitätsgründen zunehmend mit Robotern realisiert. Ein häufiges Problem bei solchen Anwendungen ist es, daß Teile aufgrund der konkreten Randbedingungen nur ungenau gegriffen werden können.

[0003] Die Aufgabe ist besonders vordringlich beim Greifen von ungeordneten Teilen aus einem Behälter, da aufgrund der Komplexität dieser Aufgabenstellung das genaue Greifen sehr schwierig ist; aber auch in einfacheren Fällen kann die Aufgabe aus konstruktiven Gründen relevant sein, wenn zum Beispiel bei ungenau vorpositionierten Teilen Sauggreifer mit großzügig dimensioniertem Faltenbalg oder Zangengreifer mit großzügig dimensionierter Maulweite verwendet werden müssen.

[0004] Hierfür wurde deshalb als Lösung mehrfach eine mehrschrittige Vorgehensweise vorgeschlagen: das Teil wird in einem ersten Schritt aus der Kiste isoliert herausgeholt, dann auf eine mechanische Ablage gelegt; im zweiten Schritt wird das Teil dann erneut gegriffen, jetzt unter vereinfachten Randbedingungen.

[0005] Nach (H. Geisselmann: Sensor-Roboter-System zum Vereinzeln und Ordnen von Werkstücken; FhG-Berichte 2-80, 1980, S. 26–28) wird beispielsweise ein Stahlgußteil mittels eines flexibel aufgehängten Magnetgreifers blind aus einer Kiste geangelt und dann auf einer Ebene abgelegt. Im zweiten Schritt wird die Lage des so isolierten und vor einem homogenen Hintergrund befindlichen Teil mittels Bildverarbeitung bestimmt, daraufhin vom Roboter erneut gegriffen und der weiteren Bearbeitung zugeführt.

[0006] Teile, die mittels Roboter nur ungenau gegriffen werden können, werden in der Industrie gelegentlich in eine selbstzentrierende Zwischenablage gelegt und dann erneut gegriffen.

[0007] Nach (M. Berger, G. Bachler et al.: A Vision Driven Automatic Assembly Unit: 23th int. Workshop of the Austrian Association for Pattern Recognition, Steyr, Austria, May 1999, Teil A: Robust Bin Picking, pp 205–214. Teil B: Pose Determination from a Single Image. pp 215–224) wurde für den "Griff in die Kiste" demonstriert, wie in einem ersten Schritt über ein Bildverarbeitungssystem gesteuert zunächst lediglich die Lage homogener Flächen bestimmt werden kann, an denen man mittels Sauggreifer ein Teil aus der Kiste holen und isolieren kann, ohne die genaue Lage des Teils bestimmen zu müssen. Das Teil wird dann auf eine ebene Ablage gelegt. Im zweiten Schritt wird über ein Bildverarbeitungssystem die dreidimensionale Lage des so isolierten Teils genau bestimmt, daraufhin vom Roboter erneut gegriffen und der weiteren Bearbeitung zugeführt.

[0008] Es wurde vorgeschlagen, ein gegriffenes Werkstück mit dem Roboter vor einer (zusätzlichen) fest installierten Kamera zu präsentieren und damit die tatsächliche absolute Lage des Werkstücks zu bestimmen, z.B, nach US 4305 130.

[0009] Nachteil der bekannten Vorgehensweisen ist der Platzbedarf für die Ablage und/oder die fest montierten Kameras, und ggf. für zusätzlich erforderliche Beleuchtungen, außerdem der Zeitbedarf für den zweiten Schritt.

[0010] Aufgabe der Erfindung ist es, diese Nachteile zu vermeiden.

[0011] Die Aufgabe wird nach Anspruch 1 gelöst. Die nach Anspruch 1 bestimmte Abweichung wird verwendet, um, durch Korrektur einer vorzugsweise vorab für die Standardlage bestimmten Roboterbewegung, die gewünschte Zuführlage herbeizuführen. Wesentlich dabei ist, daß die Kameras) zur Bestimmung der Lageabweichung am Roboter montiert ist (sind), also mit dem Roboter bewegt werden, wodurch es ermöglicht wird, daß die Messung der Abweichung und die Korrektur der Zuführbewegung während der Bewegung zwischen Greifposition und Zuführposition realisiert werden kann. Die Abweichungsbestimmung geschieht vorzugsweise unter Bezug auf ein roboterbezogenes Koordinatensystem, besonders bevorzugt unter Bezug auf den Effektor, an dem die betreffenden Sensoren befestigt sind, denn dadurch wird die Rechnung von der aktuellen globalen Kameralage entkoppelt und für eine Realisierung in Bewegung vereinfacht.

[0012] Ein Ausführungsbeispiel wird in **Fig.** 1 bis 5 gezeigt; lediglich der einfacheren Darstellung halber ist alles zweidimensional gezeichnet, aus dem gleichen Grund ist der Roboter mit weniger als 6 Freiheitsgraden gezeichnet. Rechts des Roboters sei die Greifposition, links die Zuführposition.

[0013] **Fig.** 1 und 2 zeigen den Einrichtbetrieb, **Fig.** 3 bis 5 den Automatikbetrieb.

[0014] **Fig.** 1 zeigt einen Roboter **1**, an dessen Endeffektor (vor dem Greifer) zwei Kameras **2** befestigt sind. Die Kameras sind so angeordnet, daß aus den Werkstückmerkmalen, die sie erfassen, die dreidimensionale Lage des Werkstücks bestimmt werden

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kann, relativ zu den Kameras bzw. dem Effektor, an dem sie befestigt sind. In dem Behälter **6** befinden sich Werkstücke **4**. Das Werkstück **4a** wurde aus dem Behälter gegriffen; es hängt etwas unsymmetrisch an dem Greifer **3**. Diese Lage des Werkstücks **4a** wird willkürlich als Standardlage definiert, vorzugsweise mit den Kameras vermessen, und gespeichert.

[0015] Der Roboter wird mit Teil in Standardlage in die Zuführposition (hier Montageposition) gebracht, siehe **Fig.** 2. Dort sollen die Werkstücke in ein Werkzeug **5** gesteckt werden. **Fig.** 2 zeigt den Roboter in Montageposition für Standardlage des Werkstücks; die zugehörige Roboterlage wird gespeichert. **Fig.** 3 zeigt das Aufnehmen eines Teils im Automatikbetrieb; das Teil sei trotz Kameraführung zufälligerweise etwas schief gegriffen worden. **Fig.** 4 zeigt die Ablageposition, die sich ohne Korrektur dadurch ergeben würde. Aus Zeitersparnisgründen vorzugsweise während der Bewegung zwischen dem Greifen und dem Zuführen, beispielsweise in der in **Fig.** 3 gezeigten Situation, wird über die Kameras mit Bildverarbeitung die Lageabweichung des Teils **4b** gegenüber der Standardlage (**4a**) bestimmt. Die Montagebewegung des Roboters wird dieser Lageabweichung entprechend korrigiert. **Fig.** 5 zeigt die Systemkomponenten in dementprechend korrigierter Zuführlage.

[0016] Die Lageabweichung wird rechentechnisch vorteilhaft, aber nicht notwendigerweise, ausgedrückt in einem roboterbezogenen Koordinatensystem. Man verwendet vorteilhaft als Bezugspunkt für die rotatorischen Komponenten der Lageabweichung einen Punkt an dem Effektor, an dem die Kameras montiert sind. Dann gestaltet sich die Kamerakalibrierung besonders einfach (s.u.).

[0017] Hauptvorteil ist die Zeitersparnis, da Bildaufnahme, Bildauswertung, Korrekturrechnung und sogar die Aktualisierung der Roboterbahn während der ohnehin erforderlichen Bewegung durchgeführt werden können. Außerdem entfällt der für einen extra Korrekturschritt erforderliche Platz für eine Ablage und/oder fest montierte Kameras.

[0018] Bei Verwendung von Kameras hat die Bildaufnahme in Bewegung den zusätzlichen Vorteil, daß der Hintergrund aufgrund der Bewegungsunschärfe strukturlos wird, die Werkstückkanten sich also einfach vom Hintergrund trennen lassen.

[0019] Die Kameras sind über den Roboter definiert beweglich, also können ohne nennenswerten zusätzlichen Aufwand bekannte Methoden der Kamerakalibrierung verwendet werden, die auf defnierten Bewegungen beruhen, z.B. nach US 6101 455 mit raumfesten Targets. Diese Targets können, irgendwo in Reichweite der Kameras, platzsparend angebracht werden, z.B. an der Decke.

[0020] Je nach Teilegeometrie können Kameras verwendet werden, die ohnehin für die Lokalisierung der Teile im Behälter erforderlich sind; es kann aber auch sinnvoll sein, absichtlich verschiedene Kameras mit unterschiedlichen Bildfeldgrößen und sonstig unterschiedlichen Bildaufnahmeparametern zu verwenden, um z.B. Groblokalisierung der Teile im Behälter einerseits und Feinabgleich während der Bewegung andererseits getrennt optimal gestalten zu können.

[0021] Bevorzugt werden die Kameras an einem Effektor mit 6 Freiheitsgraden (normalerweise der Endeffektor) montiert; die Kameras können Sonderfällen auch an einem anderen Effektor als einem Effektor mit 6 Freiheitsgraden befestigt sein, wenn es die Freiheitsgrade der Montageaufgabe zulassen.

[0022] Unter Roboter ist in dieser Anmeldung ein beliebiges bewegungsgrogrammierbares (steuerbares oder regelbares) System zu verstehen.

[0023] Unter Lage ist in dieser Anmeldung die dreidimensionale Position und Orientierung gemeint (engl.: position and attitude).

[0024] Die Standardlage ist eine in Einrichtbetrieb speziell oder zufällig (s. Beispiel oben) bestimmte Lage des werkstücks im/am Greifer/Effektor. Die spezielle Bestimmung kann explizit durch vorzeigen oder implizit rein konstruktiv erfolgen, z.B. mit Nullpunkt in der Mitte eines Zangengreifers.

[0025] Eine Roboterlage ist die dreidimensionale Lage von beweglichen Roboterkomponenten, bevorzugt einfach die momentane Position und Orientierung des "Tool Center Point".

[0026] Bei dem ungenau oder unbekannt gegriffenen Teil kann es sich natürlich auch um ein vom Roboter gegriffenes Werkzeug handeln, dessen Lage für die anstehende Bearbeitung korrigiert werden muß, z.B. eine Lötspitze.

[0027] Kameras haben gegenüber anderen Sensoren wie z.B. triangulierenden Abstandsmessern den Vorteil höherer Flexibilität und leichterer Projektierbarkeit bei wechselnden Aufgabenstellungen; insbesondere beim Griff in die Kiste ist mit großer Teilevielfalt zu rechnen. Zur dreidimensionalen Lageerkennung von Teilen, mit einer oder mehreren Kameras sind mehrere alternative verfahren bekannt. Speziell vorteilhaft sind zwei oder drei nach außen gerichtete Kameras, die die Außenkonturen des Teils erfassen, gegen bewegten und damit unscharfen Hintergrund oder gegen eine (ohnehin vorhandene) homogene Hallendecke als Hintergrund; dadurch bleibt die Arbeitszelle von allen Seiten frei zugänglich.

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Patentansprüche

1. Verfahren zum lagegerechten Zuführen von Teilen, insbesondere von aus einem Behälter gegriffenen Teilen, in einer gewünschten dreidimensionalen Lage, **dadurch gekennzeichnet**, daß über einen oder mehrere an einem Roboter direkt oder indirekt befestigte und mit dem Roboter bewegbare Sensoren, vorzugsweise eine oder mehrere Kameras, in gegriffenem Zustand die Abweichung der aktuellen Teilelage von einer Standardlage bestimmt wird.

2. Verfahren zum Positionieren von Teilen, die aus einem Behälter gegriffen wurden, nach Anspruch 1, wobei zum Lokalisieren der Teile zum Zweck des Greifens, einerseits, und zum Bestimmen der Abweichung der aktuellen Teilelage von einer Standardlage andererseits, die gleichen Sensoren verwendet werden.

3. Verfahren nach einem der Ansprüche 1 oder 2, dadurch gekennzeichnet, daß die Sensoren relativ zu einem roboterbezogenen Koordinatensystem kalibriert werden.

4. Verfahren nach Anspruch 3, dadurch gekennzeichnet, daß die Sensoren relativ zu den Roboterkomponenten kalibriert werden, an denen sie befestigt sind.

5. Verfahren nach einem der Ansprüche 3 oder 4, dadurch gekennzeichnet, daß die Kalibrierung durch Kamerabewegungen realisiert wird.

6. verfahren nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß die Bestimmung der Abweichung der aktuellen Teilelage von einer Standardlage durchgeführt wird während sich der Roboter bewegt, vorzugsweise mit Kameras als Sensoren.

7. Verfahren nach einem der Ansprüche 1 bis 6, mit einer oder mehreren Kameras als Sensoren, dadurch gekennzeichnet, daß die Kameras während der für die Bestimmung der Lageabweichung realisierten Bildaufnahme zur Decke der Halle oder Arbeitszelle gerichtet sind.

Es folgen 3 Blatt Zeichnungen

ABB Inc. Exhibit 1002, Page 540 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Anhängende Zeichnungen

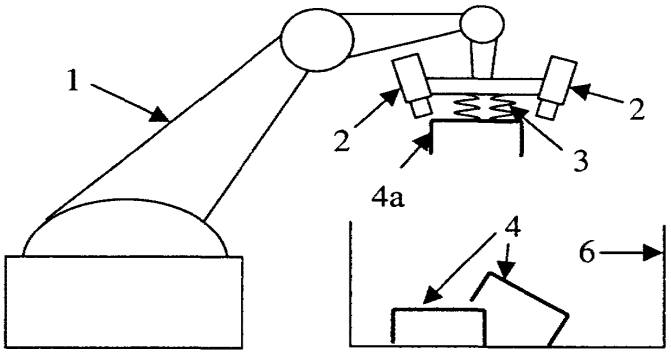


Fig. 1

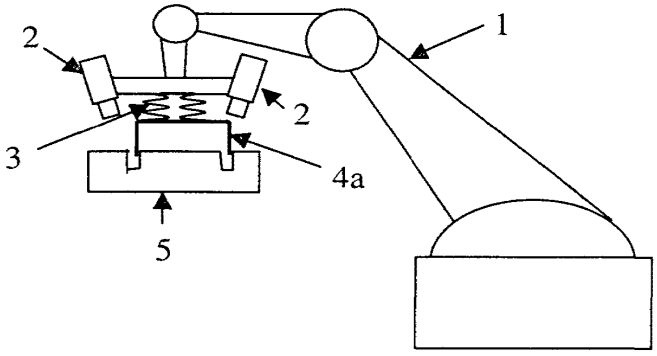


Fig. 2

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ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

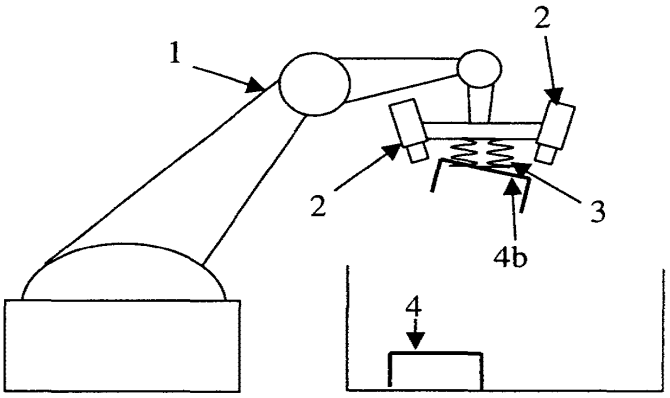


Fig. 3

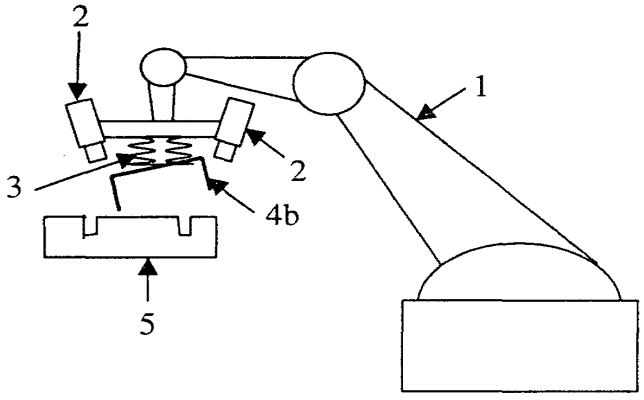


Fig. 4

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ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

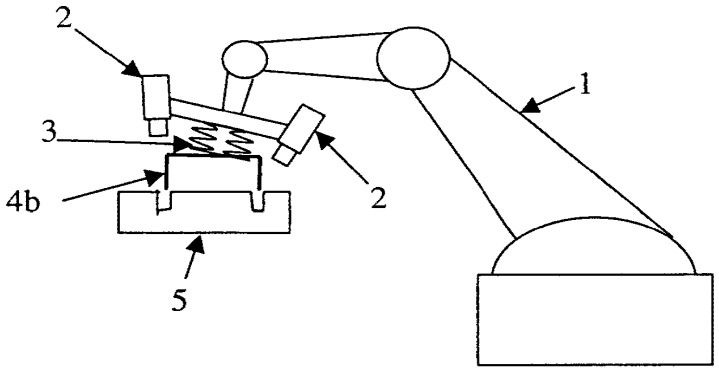


Fig. 5

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ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Electronic Patent Application Fee Transmittal

Application Number:	10634874
Filing Date:	06-Aug-2003
Title of Invention:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS
First Named Inventor/Applicant Name:	Babak Habibi
Filer:	Frank Abramonte/Sandy Clayton
Attorney Docket Number:	170154.401C1

Filed as Small Entity

Utility Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Request for continued examination	2801	1	405	405
		Total in USD ($)		**405**

Electronic Acknowledgement Receipt

EFS ID:	3332699
Application Number:	10634874
International Application Number:	
Confirmation Number:	7619
Title of Invention:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS
First Named Inventor/Applicant Name:	Babak Habibi
Customer Number:	500
Filer:	Frank Abramonte/Sandy Clayton
Filer Authorized By:	Frank Abramonte
Attorney Docket Number:	170154.401C1
Receipt Date:	20-MAY-2008
Filing Date:	06-AUG-2003
Time Stamp:	19:19:08
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$405
RAM confirmation Number	3371
Deposit Account	191090
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes) /Message Digest	Multi Part /.zip	Pages (if appl.)

1	Request for Continued Examination (RCE)	401C1_RCE.pdf	696606 1e6a4adbf4741718c3883b665b650471f4cfab87	no	3
Warnings:					
Information:					
2	Information Disclosure Statement Letter	401C1_IDS_Letter.pdf	68483 d57752cf69007965fa26e7715ab5e640ad4e0ab6	no	2
Warnings:					
Information:					
3	Information Disclosure Statement (IDS) Filed	401C1_IDS_SB08.pdf	857533 800966798e39a319bf4ed4b4cf78d9dd9d4a1cd4	no	5
Warnings:					
Information:					
4	Foreign Reference	EP0114505.pdf	733800 684b843b70243af13a952d96d2169bf9007b067f	no	17
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Information:					
5	Foreign Reference	JP07311610.pdf	187476 7bcc6718aa20cbf0ec348a65ce2f64b55be590d1	no	15
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6	Foreign Reference	DE19515949.pdf	759198 e9b495673ab788c4ed1d289c9255017e32fde72f	no	13
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Warnings:					
Information:					
		Total Files Size (in bytes):	14971282		

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	Babak Habibi et al.
Application No.	:	10/634,874
Filed	:	August 6, 2003
For	:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D GUIDED ROBOTICS

Examiner	:	McDieunel Marc
Art Unit	:	3664
Docket No.	:	170154.401C1
Date	:	May 20, 2008

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Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

INFORMATION DISCLOSURE STATEMENT TRANSMITTAL

Commissioner for Patents:

In accordance with 37 CFR 1.56 and 1.97 through 1.98, applicants wish to make known to the U.S. Patent and Trademark Office the references set forth on the attached Information Disclosure Statement. Copies of cited U.S. patents and published patent applications are not required and accordingly have not been provided. Copies of any other cited references are enclosed. As to any reference cited, applicants do not admit that it is "prior art" under 35 U.S.C. §§ 102 or 103, and specifically reserve the right to traverse or antedate any such reference, as by a showing under 37 CFR 1.131 or other method. Although the aforesaid references are made known to the Patent and Trademark Office in compliance with applicants' duty to disclose all information they are aware of which is believed relevant to the examination of the above-identified application, applicants believe that their invention is patentable.

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ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Please acknowledge receipt of this Information Disclosure Statement and kindly make the cited references of record in the above-identified application.

Applicants believe this Information Disclosure Statement has been timely filed, however, the Director is authorized to charge any fee due by way of this Information Disclosure Statement to our Deposit Account No. 19-1090.

Respectfully submitted,

SEED Intellectual Property Law Group PLLC

/Frank Abramonte/
Frank Abramonte
Registration No. 38,066

FXA:sc

Enclosures:
Information Disclosure Statement
Cited References (13)

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1170045_1.DOC

ABB Inc. Exhibit 1002, Page 551 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

PTO/SB/06 (10-07)
Approved for use through 06/30/2010. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD
Substitute for Form PTO-875

Application or Docket Number: 10/634,874

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A			N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 = *		x =		OR	x =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 = *		x =			x =	
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $260 ($130 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))			N/A			N/A	
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

5/20/08

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 28	Minus	** 32	=	x 26 =		OR	x 50 =	
Independent (37 CFR 1.16(h))	* 3	Minus	*** 3	=	x 105 =		OR	x 210 =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					N/A		OR	N/A	
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)	OR	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x 25 =		OR	x 50 =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x 105 =		OR	x 210 =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					N/A		OR	N/A	
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/634,874	08/06/2003	Babak Habibi	170154.401C1	7619

500 7590 03/05/2009

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

EXAMINER	
MARC, MCDIEUNEL	

ART UNIT	PAPER NUMBER
3664	

MAIL DATE	DELIVERY MODE
03/05/2009	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/634,874	HABIBI ET AL.	
	Examiner	Art Unit	
	MCDIEUNEL MARC	3664	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *20 May 2008*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *33-47 and 49-61* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *33-47 and 49-61* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *06 August 2003* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

1. Claims 33-47 and 49-61 are pending for examination.

2. New corrected drawings in compliance with 37 CFR 1.121(d) are required in this application because figs. 1 and 4 are not clear. Applicant is advised to employ the services of a competent patent draftsperson outside the Office, as the U.S. Patent and Trademark Office no longer prepares new drawings. The corrected drawings are required in reply to the Office action to avoid abandonment of the application. The requirement for corrected drawings will not be held in abeyance.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later

invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

5. Claims 33-47 and 49-61 are rejected under 35 U.S.C. 103(a) as being unpatentable over Parker et al., (U. S. Pat. No. 7,024,280).

As per claims 33-47 and 49-61, Parker et al. teaches a robot having that further comprising an active infrared emitters 115 allows for each emitter 115 to detect an object at a different distance or time. For example, since the top emitter emits a signal substantially parallel to the ground, the top emitter will indicate that an object is in front of the robot 100, but at a distance far away. As the middle emitter emits a signal toward the floor, the middle emitter will indicate that an obstacle is in front of the robot 100 and closer than if the top emitter would have detected the object. Similarly, as the bottom emitter substantially emits a signal toward the ground, the top or middle emitter may not detect an object very close. Thus, the bottom emitter, by not receiving a signal, will indicate that an object is directly in front of the robot 100 and that the obstacle is very near, such as an edge. Some robots have video cameras enabling a user to view the area in front of the robot. However, typically the user may only view the image from the video camera through a computer. Therefore, there is a need for a hand-held remote control device with a video screen that a user can easily transport (see figs. 1 and cols. 3-12). Parker et al. teaches implicitly an algorithm that employs a known or determinable physical relationship between at least some of the located features.

It would have been obvious to one of ordinary skill in the art at the time of the invention to shed light into the features of Parker's et al., in order to recognize object based on known algorithm to measure distance, because this function would definitely allow object detection, thereby explaining the implicit function of the object detection of Parker's et al.

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to MCDIEUNEL MARC whose telephone number is (571)272-6964. The examiner can normally be reached on 6:30-5:00 Mon-Thu.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Khoi Tran can be reached on (571) 272-6919. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/McDieunel Marc/
Examiner, Art Unit 3664
Tuesday, February 10, 2009
MM/
/Khoi H Tran/
Supervisory Patent Examiner, Art Unit 3664

Notice of References Cited	Application/Control No. 10/634,874	Applicant(s)/Patent Under Reexamination HABIBI ET AL.	
	Examiner MCDIEUNEL MARC	Art Unit 3664	Page 1 of 2

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-7,024,280	04-2006	Parker et al.	700/245
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Crowley et al., Maintaining stereo calibration by tracking image points, 1993, IEEE, pg. 483-488
	V	Chandrashaker et al., Robotics and structural dynamics characterization of the space station remote manipulator system using photogrammetric techniques, 1994, IEEE, pg. 691-694
	W	Triboulet et al., Finding 3D polyhedral object attitude using a virtual model for industrial machining, 2001, IEEE, pg. 57-65
	X	Zhaohui et al., Image registration using a 3-D scene representation, 1998, IEEE, pg. 828-832

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

ABB Inc. Exhibit 1002, Page 558 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Notice of References Cited	Application/Control No. 10/634,874	Applicant(s)/Patent Under Reexamination HABIBI ET AL.	
	Examiner MCDIEUNEL MARC	Art Unit 3664	Page 2 of 2

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-			
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Safaee-Rad et al., Three-dimensional location estimation of circular features for machine vision, 1992, IEEE, pg. 624-640.
	V	Safaee-Rad et al., An analytical method for the 3D-location estimation of circular features for an active-vision system, IEEE, pg. 215-220
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

ABB Inc. Exhibit 1002, Page 559 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10634874	HABIBI ET AL.
	Examiner	Art Unit
	Marc, McDieunel	3664

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/22/2007	02/09/2008	02/10/2009						
	1	-	-	-						
	2	-	-	-						
	3	-	-	-						
	4	-	-	-						
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4	35	✓	=	=						
5	36	✓	=	=						

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ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10634874	HABIBI ET AL.
	Examiner	Art Unit
	Marc, McDieunel	3664

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/22/2007	02/09/2008	02/10/2009						
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25	58	✓	=	=						
26	59	✓	=	=						
27	60	✓	=	=						
28	61	✓	=	=						

ABB Inc. Exhibit 1002, Page 561 of 996
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WEST Search History

Hide Items | Restore | Clear | Cancel

DATE: Thursday, June 12, 2008

Hide?	Set Name	Query	Hit Count
		DB=PGPB,USPT,EPAB,JPAB,DWPI,TDBD; PLUR=YES; OP=ADJ	
☐	L12	parameters and L10	84
☐	L11	extrinsic and parameters and L10	0
☐	L10	irobot	263
☐	L9	calibrat$6 and L8	137
☐	L8	reference frame and L7	275
☐	L7	(700/245 |700/246 |700/253 |700/257 |700/258 |700/259 |700/279 or 29/218 |29/702 |29/714 |29/720 |29/407.1 |29/407.04 or 318/568.13 | 318/568.15 |318/568.16 |318/640 or 348/42 |348/94 |348/154 |348/190 | 348/291 |348/287552 or 901/6 |901/14 |901/17 |901/46 |901/47 or 414/730 |414/737 or 382/154).ccls.	12067
☐	L6	('20050233770' |'20050190957' |'20050142293' |'20050045214' |'20040258514' |'20040243320')!.ABPN1,NRPN,PN,TBAN,WKU.	12
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☐	L4	camera and L3	7479
☐	L3	(robot$6 or articulat$3 or automat$6 or autonomous$2 or CNC or machine $2 or mechanical device or mechan$6 or servomechan$4) and L2	31083
☐	L2	calibrat$$ and semiconductor and (correct$3 or fix$3)	36356
☐	L1	10/126493	7

END OF SEARCH HISTORY

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B445 0014
BMG/cnr

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

Inventors: HABIBI, Babak; PESCARU, Simona, SAMMETI, Mohammad, BOCA, Remus Florinel

Title: METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS

Filed: Herewith

Date: 5 August 2003

Commissioner for Patents
Washington, D.C. 20231

Dear Sir/Madam:

LIST OF PATENTS AND PUBLICATIONS FOR APPLICANT'S INFORMATION DISCLOSURE STATEMENT
[Form PTO-1449 (Modified)]

United States Patent Documents

Examiner	ID	Patent No.	Issue Date	Inventor(s)	Class	Sub-Cl	Filing Date
	US: 1	3,986,007	12 Oct 1976	Ruoff, Jr.			
	US: 2	4,146,924	27 Mar 1979	Birk et al.			
	US: 3	4,219,847	26 Aug 1980	Pinkney et al.			
	US: 4	4,305,130	8 Dec 1981	Kelley et al.			
	US: 5	4,334,241	8 Jun 1982	Kashioka et al.			
	US: 6	4,437,114	13 Mar 1984	LaRussa			
	US: 7	4,613,942	23 Sep 1986	Chen			
	US: 8	4,654,949	7 Apr 1987	Pryor			
	US: 9	4,942,539	17 Jul 1990	McGee et al.			
	US: 10	5,696,673	9 Dec 1997	Pryor			
	US: 11	5,956,417	21 Sep 1999	Pryor			
	US: 12	5,959,425	28 Sep 1999	Bieman et al.			
	US: 13	6,044,183	28 Mar 2000	Pryor			
	US: 14	6,141,863	7 Nov 2000	Hara et al.			

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.M./

ABB Inc. Exhibit 1002, Page 563 of 996
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IPR2023-01426

	US: 15	6,167,607	2 Jan 2001	Pryor			
	US: 16	6,211,506	3 Apr 2001	Pryor et al.			
	US: 17	6,301,763	16 Oct 2001	Pryor			

Other Art

Examiner	ID	Author, Title, Date, Pertinent Pages, etc.
	OA: 1	Roger Y. Tsai and Reimar K. Lenz, "A New Technique for Fully Autonomous and Efficient 3D Robotics Hand/Eye Calibration", *IEEE Transactions on Robotics and Automation*, Vol. 5, No. 3, June 1989 p. 345
	OA: 2	Zhengyou Zhang, "A Flexible New Technique for Camera Calibration", http://research.microsoft.com/scripts/pubs/view.asp?TR_ID=MSR-TR-98-71
	OA: 3	Guo-Qing Wei, Klaus Arbter, and Gerd Hirzinger, "Active Self-Calibration of Robotic Eyes and Hand-Eye Relationship with Model Identification", *IEEE Transactions on Robotics and Automation*, Vol 14, No. 1, February 1998 p. 158
	OA: 4	Yuncai Liu, Thomas S. Huang and Olivier D. Faugeras, "Determination of Camera Location from 2-D to 3-D Line and Point Correspondences", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 12, No. 1, January 1990 p. 28
	OA: 5	Chien-Ping Lu, Gregory D. Hager and Eric Mjolsness, "Fast and Globally Convergent Pose Estimation from Video Images", *IEEE Transactions on Pattern Analysis and Machine Intelligence,* Vol. 22, No. 6, June 2000 p. 610
	OA: 6	Thomas Huang, Alfred M. Bruckstein, Robert J. Holt, and Arun N. Netravali, "Uniqueness of 3D Pose Under Weak Perspective: A Geometrical Proof", *IEEE Transactions on Pattern Analysis and Machine Intelligence,* Vol. 17, No. 12, December 1995 p. 1220

Examiner: /Mcdieunel Marc/

Date Considered: 06/11/2008

EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; draw line through citation if not in conformance **and** not considered. Include copy of this form with next communication to applicant.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.M./

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EXPRESS MAIL NO. EV335546775US

FORM PTO-1449 (REV. 7-80)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 170154.401C1	APPLICATION NO. 10/634,874
		APPLICANTS Babak Habibi et al.	
	INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	FILING DATE August 6, 2003	GROUP ART UNIT 3664 ~~3661~~

OIPE JUN 23 2005 JC26 PATENT & TRADEMARK OFFICE

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	AA	4,578,561	03/25/86	Corby, Jr. et al.	219	124.34	
	AB	4,835,450	05/30/89	Suzuki	318	568.13	
	AC	5,083,073	01/21/92	Kato	318	577	
	AD	5,350,269	09/27/94	Azuma et al.	414	416	
	AE	5,454,775	10/03/95	Cullen et al.	483	16	
	AF	6,341,246	01/22/02	Gerstenberger et al.	700	245	
	AG	6,466,843	10/15/02	Bonanni et al.	700	245	
	AH	6,804,416	10/12/04	Bachelder et al.	382	294	
	AI	2004/0114033	06/17/04	Eian et al.	348	42	
	AJ	60/413,180		Eian et al.			09/23/02

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	TRANSLATION YES	TRANSLATION NO
	AK	0151417	08/14/85	EP		
	AL	0493612	07/08/92	EP		
	AM	0951968	10/27/99	EP		
	AN	401124072	05/89	JP		
	AO	0911603 B1	04/28/99	EP (with machine translation)	X	

OTHER PRIOR ART *(Including Author, Title, Date, Pertinent Pages, Etc.)*

	AP		Denzler, J. et al. "Learning, Tracking and Recognition of 3D Objects," *Proceedings of the IEEE/RSJ/GI International Conference on Intelligent Robots and Systems*. (No date available.)
	AQ		"Advanced Robotic Systems and the Real World," *Proceedings of the International Conference on Intelligent Robots and Systems (IROS)*, XP000512662, Vol. 1, Munich, September 12, 1994, pp. 89-96.

EXAMINER	DATE CONSIDERED

* EXAMINER: Initial if reference considered, whether or not criteria is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant(s).

599816_1

Date: June 23, 2005

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.M./

FORM PTO-1449 (REV.7-80)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 170154.401C1	APPLICATION NO. 10/634,874
INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)		APPLICANTS Babak Habibi et al.	
		FILING DATE August 6, 2003	GROUP ART UNIT 3664 ~~3661~~

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	BA	60/587,488		Boca et al.			07/14/04
	BB						
	BC						
	BD						
	BE						
	BF						
	BG						
	BH						
	BI						
	BJ						

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	TRANSLATION YES	TRANSLATION NO
	BK					
	BL					
	BM					
	BN					
	BO					

OTHER PRIOR ART *(Including Author, Title, Date, Pertinent Pages, Etc.)*

	BP		W. Meyer, "One-Eyed Robots With 3D Vision," ISRA Vision Systems AG, Press News, Release No. 16, June 15, 2004, pp 1-7.
	BQ		~~"3D Robot Guidance with a Single Camera," ISRA Vision Systems AG. (No date available.)~~
	BR		3D Vision with One Camera, URL=http://neu.isravision.com/likecms/index.php?site=site.html&dir=isra&nav=162, download date April 12, 2005.

EXAMINER	/Mcdieunel Marc/	DATE CONSIDERED	06/11/2008

* EXAMINER: Initial if reference considered, whether or not criteria is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant(s).

599816_1

Date: June 23, 2005

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.M./

WEST Search History

Hide Items | Restore | Clear | Cancel

DATE: Saturday, June 21, 2008

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☐	L1	marc.xa. and irobot	21

END OF SEARCH HISTORY

ABB Inc. Exhibit 1002, Page 567 of 996
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IPR2023-01426

Key: **IEEE JNL** = IEEE Journal or Magazine, **IEE JNL** = IEE Journal or Magazine, **IEEE CNF** = IEEE Conference, **IEE CNF** = IEE Conference, **IEEE STD** = IEEE Standard

1. **A Calibration Method for MEMS Inertial Sensors Based on Optical Tracking**
   Zhuxin Dong; Guanglie Zhang; Yilun Luo; Chi Chiu Tsang; Guangyi Shi; Sze Yin Kwok; Li, W.J.; Leong, P.H.W.; Ming Yiu Wong;
   Nano/Micro Engineered and Molecular Systems, 2007. NEMS '07. 2nd IEEE International Conference on
   16-19 Jan. 2007 Page(s):542 - 547
   IEEE CNF

2. **Maintaining stereo calibration by tracking image points**
   Crowley, J.L.; Bobet, P.; Schmid, C.;
   Computer Vision and Pattern Recognition, 1993. Proceedings CVPR '93., 1993 IEEE Computer Society Conference on
   15-17 June 1993 Page(s):483 - 488
   IEEE CNF

3. **Automated calibration of a camera sensor network**
   Rekleitis, I.; Dudek, G.;
   Intelligent Robots and Systems, 2005. (IROS 2005). 2005 IEEE/RSJ International Conference on
   2-6 Aug. 2005 Page(s):3384 - 3389
   IEEE CNF

4. **Robotics and structural dynamics characterization of the space station remote manipulator system using photogrammetric techniques**
   Chandrashaker, R.; Kalaycioglu, S.; Graham, W.B.;
   Electrotechnical Conference, 1994. Proceedings., 7th Mediterranean
   12-14 April 1994 Page(s):691 - 694 vol.2
   IEEE CNF

5. **μ IMU-based handwriting recognition calibration by optical tracking**
   Zhuxin Dong,; Guanglie Zhang,; Chi Chiu Tsang,; Guangyi Shi,; Li, Wen J.; Leong, Philip H. W.; Ming Yiu Wong,;
   Robotics and Biomimetics, 2007. ROBIO 2007. IEEE International Conference on
   15-18 Dec. 2007 Page(s):382 - 387
   IEEE CNF

6. **Numerical optimization on the Euclidean group with applications to camera calibration**
   Seungwoong Gwak; Junggon Kim; Park, F.C.;
   Robotics and Automation, IEEE Transactions on
   Volume 19, Issue 1, Feb. 2003 Page(s):65 - 74
   IEEE JNL

7. **Finding 3D polyhedral object attitude using a virtual model for industrial machining**
   Triboulet, J.; Shaheen, M.; Mallem, M.; Fioroni, C.; Passemard, J.R.;
   Emerging Technologies and Factory Automation, 2001. Proceedings. 2001 8th IEEE International Conference on
   15-18 Oct. 2001 Page(s):57 - 65 vol.1
   IEEE CNF

ABB Inc. Exhibit 1002, Page 568 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

8. **Adaptive visual servoing in the presence of intrinsic calibration uncertainty**
Chen, J.; Behal, A.; Dawson, D.M.; Dixon, W.E.;
Decision and Control, 2003. Proceedings. 42nd IEEE Conference on
Volume 5, 9-12 Dec. 2003 Page(s):5396 - 5401 Vol.5
IEEE CNF

9. **Image registration using a 3-D scene representation**
Zhaohui Sun; Tekalp, A.M.;
Image Processing, 1998. ICIP 98. Proceedings. 1998 International Conference on
Volume 1, 4-7 Oct. 1998 Page(s):828 - 832 vol.1
IEEE CNF

10. **Three-dimensional location estimation of circular features for machine vision**
Safaee-Rad, R.; Tchoukanov, I.; Smith, K.C.; Benhabib, B.;
Robotics and Automation, IEEE Transactions on
Volume 8, Issue 5, Oct. 1992 Page(s):624 - 640
IEEE JNL

11. **An analytical method for the 3D-location estimation of circular features for an active-vision system**
Safaee-Rad, R.; Smith, K.C.; Benhabib, B.; Tchoukanov, I.;
Systems, Man and Cybernetics, 1990. Conference Proceedings., IEEE International Conference on
4-7 Nov. 1990 Page(s):215 - 220
IEEE CNF

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IPR2023-01426

PTO/SB/08a (05-07)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	10634874
	Filing Date	2003-08-06
	First Named Inventor	Babak Habibi
	Art Unit	3664
	Examiner Name	Marc McDieunel
	Attorney Docket Number	170154.401C1

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	4402053		1983-08-30	Kelley et al.	
	2	5212738		1993-05-18	Chande et al.	
	3	5978521		1999-11-02	Wallack et al.	
	4	6115480		2000-09-05	Washizawa	
	5	6628819	B1	2003-09-30	Huang et al.	
	6	7061628	B2	2006-06-13	Franke et al.	
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	Examiner Name	Marc McDieunel
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	1	20030007159	A1	2003-01-09	Franke et al.	
	2	20040172164	A1	2004-09-02	Habibi et al.	

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	1	01124072	JP		1989-05-16	Masanobu	(+ abstract)	☐
	2	0763406	EP		1997-03-19	Ersue Enis		☐

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	1	Borotschnig, H., et al., "Appearance-Based Active Object Recognition," Image and Vision Computing, 18:715-727, 2000.	☐
	2	Chen, L., et al., "An investigation on the accuracy of three-dimensional space reconstruction using the Direct Linear Transformation Technique," J. Biomechanics 27(4):493-500, 1994.	☐
	3	Denzler J., et al., "Learning, Tracking and Recognition of 3D Objects," Proceedings of the IEEE/RSJ/GI, International Conference on Intelligent Robots and Systems (IROS) 1:89-96, 1994.	☐

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	4	Ji, Q., et al., "An Integrated Linear Technique for Pose Estimation from different Geometric Features," International Journal of Pattern Recognition and Artificial Intelligence, 13(5):705-733, August 1999.	☐
	5	Jia, Y-B., et al., "Sensing Polygon Poses by Inscription," Proc. of 1994 IEEE International Conference on Robotics and Automation, pp. 1642-1649, May 1994.	☐
	6	Kim, W.S., "Computer vision assisted virtual reality calibration," URL=http://www.robotics.jpl.nasa.gov/publications/Won_Kim/ra98_vrc.pdf., pp. 1-14, 1999.	☐
	7	Kovacic, S., et al., "Planning Sequences of Views for 3-D Object Recognition and Pose Determination," Pattern Recognition 31(10):1407-1417, 1998.	☐
	8	Sanchez, A., et al., "Robot-arm Pick and Place Behavior Programming System Using Visual Perception," in Proceedings of the 15th International Conference on Pattern Recognition 4:507-510, September 2000.	☐
	9	Tsai, R. et al., "An Efficient and Accurate Camera Calibration Technique for 3D Machine Vision," Proceedings of IEEE, Conference on Computer Vision and Pattern Recognition, pp. 364-374, 1986.	☐
	10	Tsai, R., "A Versatile Camera Calibration Technique for High-Accuracy 3D Machine Vision Metrology Using Off-the-Shelf TV Cameras and Lenses," IEEE Journal of Robotics and Automation, RA-3(4):323-344, August 1987.	☐

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Examiner Signature	/Mcdieunel Marc/	Date Considered	06/11/2008

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Doc code :IDS
Doc description: Information Disclosure Statement (IDS) Filed

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Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6236896	B1	2001-05-22	Watanabe et al.	

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	1	20050273202	A1	2005-12-08	Bischoff	

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Examiner Initial*	Cite No	Foreign Document Number[3]	Country Code[2] i	Kind Code[4]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T[5]
	1	0114505	EP	A1	1984-08-01	Pryor		☐
	2	07311610	JP		1995-11-28	Watanabe et al.		☐
	3	19515949	DE	A1	1996-11-14	Siebeneicher et al.	(+ Abstract in English)	☐

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	Art Unit	3664
	Examiner Name	McDieunel Marc
	Attorney Docket Number	170154.401C1

	4	0763406	EP	A1	1997-03-19	Ersu et al.	(+ Abstract in English)	☐
	5	9806015	WO		1998-02-12	Watanabe et al.	(+ Abstract in English)	☐
	6	10049218	JP		1998-02-20	Watanabe et al.		☐
	7	0106210	WO	A1	2001-01-25	Coulombe et al.		☐
	8	1172183	EP	A2	2002-01-06	Kleck	(+ Abstract in English)	☐
	9	2002018754	JP		2002-01-22	Naito et al.		☐
	10	1345099	EP	A2	2003-09-17	Schnell et al.	(+ Abstract in English)	☐
	11	10319253	DE	A1	2004-12-02	Tropf	(+ Abstract in English)	☐

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T[5]
	1	Nelson et al., "Robotic Visual Servoing and Robotic Assembly Tasks," IEEE Robotics & Automation Magazine 3 (2):23-31, 1996.	☐

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	Art Unit	3664
	Examiner Name	McDieunel Marc
	Attorney Docket Number	170154.401C1

	2	Zhang, "A Flexible New Technique for Camera Calibration," Technical Report MSR-TR-98-71, Microsoft Corporation, December 2, 1998, 22 pages.	☐

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EXAMINER SIGNATURE

Examiner Signature	/Mcdieunel Marc/	Date Considered	06/11/2008

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[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10634874	HABIBI ET AL.
	Examiner	Art Unit
	Marc, McDieunel	3664

SEARCHED

Class	Subclass	Date	Examiner
700	245,246,253,257,258,259,279	2/10/09	MM
318	568.13,568.15.568.16,640	2/10/09	MM
901	6,14,17,46,47	2/10/09	MM
29	218,407.1,702,714,720	2/10/09	MM
348	42,94,154,190,,191,287,291,552	2/10/09	MM
382	154,103,106,154,276,293,295,298	2/10/09	MM

SEARCH NOTES

Search Notes	Date	Examiner
Palm inventor search	2/10/09	MM
West search see attached listings	2/10/09	MM
NPL search see attached listings	2/10/09	MM

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	Babak Habibi et al.
Application No.	:	10/634,874
Filed	:	August 6, 2003
For	:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS

Examiner	:	McDieunel Marc
Art Unit	:	3664
Docket No.	:	170154.401C1
Date	:	June 5, 2009

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

AMENDMENT

Commissioner for Patents:

In response to the Office Action dated March 5, 2009, please amend the application as follows:

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Amendments to the Drawings begin on page 9 of this paper and include an attached Replacement Sheet.

Remarks begin on page 10 of this paper.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1.-32. (Canceled)

33. (Previously Presented) The method of claim 50, further comprising:

capturing a number of images of a calibration object by the camera;

determining a set of intrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera; and

determining a set of extrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera, the set of extrinsic parameters comprising a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame.

34. (Previously Presented) The method of claim 33, further comprising:

positioning the camera with respect to the calibration object.

35. (Previously Presented) The method of claim 34 wherein positioning the camera with respect to the calibration object comprises positioning the camera orthogonally with respect to a ruled template with a number of features, where a known or determinable physical relationship exists between at least some of the features.

36. (Previously Presented) The method of claim 34 wherein positioning the camera with respect to the calibration object comprises positioning the camera with respect to a sample of a type of object the robot will manipulate, the sample having a number of features, where a known or determinable physical relationship exists between at least some of the features.

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37. (Previously Presented) The method of claim 34 wherein capturing a number of images of a calibration object by the camera comprises capturing at least one image at each of a plurality of positions spaced perpendicularly from the calibration object.

38. (Previously Presented) The method of claim 34 wherein capturing a number of images of a calibration object by the camera comprises capturing at least one image at each of a plurality of different orientations with respect to the calibration object.

39. (Previously Presented) The method of claim 33 wherein determining a set of intrinsic parameters of the camera from the at least one of the number of images of the calibration object captured by the camera comprises determining at least one of a focal length, a first order radial lens distortion coefficient, a set of coordinates of a center of a radial lens distortion, or a scale factor indicative of a framegrabber scanline resampling uncertainty.

40. (Previously Presented) The method of claim 33 wherein determining a set of extrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera, the set of extrinsic parameters comprising a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame comprises determining a respective translation component along three orthogonal axes, and a respective rotation component about the three orthogonal axes.

41. (Previously Presented) The method of claim 33, further comprising:

determining a camera space-to-tool space transformation based at least in part on at least two of the number of images captured by the camera of the calibration object.

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42. (Previously Presented) The method of claim 33, further comprising:

determining a camera space-to-tool space transformation based on single one of the number of images captured by the camera of the calibration object and on a number of physical coordinates of at least one feature of the calibration object.

43. (Currently Amended) The method of claim 50, further comprising:

capturing an image of a teaching object of a type of object that will be manipulated by the robot;

selecting a number of features from the captured image of the teaching object; and

determining a set of object space coordinates for each of the selected features from the captured image of the teaching object.~~; and~~

44. (Previously Presented) The method of claim 43 wherein selecting a number of features from the captured image of the teaching object comprises selecting six features from the captured image of the teaching object.

45. (Previously Presented) The method of claim 43, further comprising:

determining an object space-to-camera space transformation defining a transformation between an object space reference frame and the camera space reference frame.

46. (Previously Presented) The method of claim 45, further comprising:

determining a position and an orientation of an object frame in the tool frame reference frame based at least in part on the object frame-to-camera space and camera space-to-tool space transformations.

47. (Previously Presented) The method of claim 46, further comprising:

providing the position and orientation of the object frame to the robot; and

training an intended operation path inside the object frame.

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48. (Canceled)

49. (Currently Amended) The method of claim 50, further comprising:

adjusting a position of the movable portion of the robot if the number of features located in the captured image of the target object is determined to be an insufficient number of features; and

capturing another two-dimensional image of the volume containing the target object before ~~determinint~~ determining the object space-to-camera space transformation for the target object.

50. (Currently Amended) A method useful in three-dimensional pose estimation for use with a single camera mounted to a movable portion of a robot, the method comprising:

capturing a two-dimensional image of a volume containing a target object; ~~and~~

locating a number of features in the captured image of the target object; and

determining an object space-to-camera space transformation for the target object based at least in part on a position of at least some of the located features using only the ~~signal~~ single captured image and an algorithm that employs a known or determinable physical relationship between at least some of the located features.

51. (Previously Presented) The method of claim 50, further comprising:

determining at least one movement of the robot that orients the camera orthogonally with respect to the target object based at least on part on the object space-to-camera space transformation.

52. (Previously Presented) The method of claim 51, further comprising:

determining a position of the object frame in the tool space reference frame; and

providing an object frame to the robot.

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53. (Currently Amended) An apparatus useful in robotics, the apparatus comprising:

a single camera operable to capture ~~at~~ a number of images of a calibration object ~~by the camera~~;

means for calibrating the camera, by:

determining a set of intrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera; and

determining a set of extrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera, the set of extrinsic parameters comprising a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame; and

means for estimating a pose of a target object, by:

capturing a two-dimensional image of a volume containing a target object; and

locating at least six features in the captured image of the target object; and

determining an object space-to-camera space transformation based at least in part on a position of at least some of the located features in solely the captured image using an algorithm that employs a known or determinable physical relationship between at least some of the located features.

54. (Previously Presented) The apparatus of claim 53, further comprising:

means for training, comprising:

capturing an image of a teaching object of a type of object that will be manipulated by the robot;

selecting a number of features from the captured image of the teaching object;

determining a set of object space coordinates for each of the selected features from the captured image of the teaching object; and

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determining an object space-to-camera space transformation defining a transformation between an object space reference frame and the camera space reference frame.

55. (Previously Presented) The apparatus of claim 54 wherein the means for calibrating, the means for estimating a pose, and the means for training comprises at least one programmed computer.

56. (Previously Presented) The apparatus of claim 54 wherein the means for calibrating, the means for estimating a pose, and the means for training comprises at least one computer-readable medium storing instructions operating at least one computer.

57. (Previously Presented) The apparatus of claim 53 wherein the pose estimating means estimates the pose of the target object further by:

adjusting a position of the movable portion of the robot if the number of features located in the captured image of the target object is determined to be an insufficient number of features.

58. (Currently Amended) An apparatus useful in robotics, the apparatus comprising:

a single camera operable to capture a number of images of a calibration object ~~by the camera~~;

means for calibrating the camera, by:

determining a set of intrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera; and

determining a set of extrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera, the set of extrinsic parameters comprising a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame; and

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means for estimating a pose of a target object, by:

capturing a two-dimensional image of a volume containing a target object;

locating at least five features in the captured image of the target object; and

determining an object space-to-camera space transformation based at least in part on a position of at least some of the located features using the captured image without any additional captured images and an algorithm that employs a known or determinable physical relationship between at least some of the located features.

59. (Previously Presented) The apparatus of claim 58 wherein the means for calibrating and the means for estimating a pose comprises at least one programmed computer.

60. (Previously Presented) The apparatus of claim 58 wherein the means for calibrating and the means for estimating a pose comprises at least one computer-readable medium storing instructions operating at least one computer.

61. (Previously Presented) The apparatus of claim 58 wherein the pose estimating means estimates the pose of the target object further by:

adjusting a position of the movable portion of the robot if the number of features located in the captured image of the target object is determined to be an insufficient number of features.

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Amendments to the Drawings:

The attached sheets of drawings include changes to Figures 1 and 4. These sheets, which include Figs. 1 and 4, replace the original sheets including Figs. 1 and 4.

Attachment: Replacement Sheets

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REMARKS

This is a Response to the Office Action mailed March 5, 2009, in which a three (3) month Shortened Statutory Period for Response has been set, due to expire June 5, 2009. In this Amendment, claims 43, 49, 50, 53 and 58 have been amended to correct minor errors. No new matter has been added by way of this Amendment.

The Director is authorized to charge any additional fees due by way of this Amendment, or credit any overpayment, to our Deposit Account No. 19-1090. Claims 31-47 and 49-61 are pending.

Objections

The drawings were objected to because Figures 1 and 4 were not clear. Figures 1 and 4 have been amended to improve clarity and 2 sheets of drawings are presented herewith for approval. No new matter has been added.

Rejections Under 35 U.S.C. § 103

Claims 33-47 and 49-61 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Parker et al. (U.S. Patent No. 7,024,280, hereinafter "Parker").

The present rejection does not establish a *prima facie* case of obviousness under 35 U.S.C. § 103(a). "Section 103 forbids issuance of a patent when 'the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.'" *KSR Int'l Co. v. Teleflex Inc.*, 127 S.Ct. 1727, 1734, 82 U.S.P.Q.2d 1385, 1391 (2007). This obviousness determination is made based on underlying factual inquiries, including:

1. the scope and content of the prior art;
2. the differences between the prior art and the claims at issue;
3. the level of ordinary skill in the pertinent art; and
4. secondary considerations.

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Graham v. John Deere Co., 383 U.S. 1, 17-18, 148 U.S.P.Q. 459, 467 (1966). The Examiner should also support an obviousness determination by identifying some reason or motivation that would have prompted a person of ordinary skill in the relevant field at the time of the invention to combine the prior art elements in the way claimed by the application at issue. *KSR*, 127 S.Ct. at 1740-41, 82 U.S.P.Q.2d at 1396. Moreover, a prior art reference must be considered in its entirety, *i.e.,* as a whole, including portions that would lead away from the claimed invention. M.P.E.P. § 2141.02(VI); *W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 U.S.P.Q. 303 (Fed. Cir. 1983), *cert. denied*, 469 U.S. 851 (1984).

Independent Claims 50, 53 and 58

A *prima facie* case of obviousness for claims 50, 53 and 58 has not been established because of substantial differences between the teachings of the cited reference and the limitations recited in these independent claims.

Parker is generally directed to a robot (100) that can be manipulated remotely by a user or operate autonomously. "Robot 100 has several modes by which the robot 100 can operate. Several modes allow the robot 100 to operate autonomously, while other modes require a user to remotely manipulate the robot 100." (Column 6, lines 32-35.) The robot taught by Parker employs passive infrared sensors (114), active infrared emitters (115), and a video device (122).

Importantly, the video device 122 is used to provide video images to a remote control device (500) that enables a user to manipulate the robot. In particular, the remote control device (500) includes a joystick (502), a video display (504), and various control buttons. Parker's robot (100) does not use video images in autonomous mode. Parker merely discloses that video images are provided to the remote control device (500) so that the user can manipulate the robot (100).

It is also important to realize that while the passive infrared sensors (114) and the active infrared emitters (115) "help the robot 100 avoid bumping into obstacles" (column 4, line 56), the passive infrared sensors (114) and the active infrared emitters (115) do not capture an image.

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The robot has three vertically aligned active infrared emitters per leg (106), which are arranged in a pattern that "allows for each emitter 115 to detect an object at a different distance or time." (Column 5, lines 15-17.) In particular, "since the top emitter emits a signal substantially parallel to the ground, the top emitter will indicate that an object is in front of the robot 100, but at a distance far away. As the middle emitter emits a signal toward the floor, the middle emitter will indicate that an obstacle is in front of the robot 100 and closer than if the top emitter would have detected the object. Similarly, as the bottom emitter substantially emits a signal toward the ground, the top or middle emitter may not detect an object very close. Thus, the bottom emitter, by not receiving a signal, will indicate that an object is directly in front of the robot 100 and that the obstacle is very near, such as an edge." (Column 5, lines 17-28.)

Parker discloses that "[t]he [passive infrared] sensor 114 is a separate system from the active infrared emitters 115. The PIR sensor 114 does not emit a signal. Instead, the PIR sensor 114 detects heat." (Column 5, lines 41-43.)

At column 6, lines 37-49, Parker further discloses:

> When the automatic mode is selected, the robot 100 begins to move autonomously throughout the room. As explained above, *the active infrared emitters 115 assist the robot 100 to avoid bumping into obstacles* and traveling off an edge. While the robot 100 is moving throughout the room it will occasionally speak from the auto vocabulary, depending on sensor input. Simultaneously, *the PIR sensor 114 scans the area in front of the robot 100 to detect a heat source*. When the robot 100 detects a heat source, the rotatable platform 124 will turn toward the object and speak from its "roam" vocabulary (e.g., "Nice to see you again.", "How are you.", etc.)

(Emphasis added.)

In contrast to Parker, Applicants' claims are directed to methods and apparatus that employ *single camera* three-dimensional (3-D) vision for robotic guidance.

For example, claim 50 is directed to "[a] method useful in three-dimensional pose estimation for use with *a single camera* mounted to a movable portion of a robot." (Emphasis added.) Claim 50 recites *"capturing a two-dimensional image* of a volume containing a target object; *locating* a number of *features in the captured image* of the target object; and *determining an object space-to-camera space transformation* for the target object based at least in part on a position of at least some of the located features *using only the single captured image* and an

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algorithm that employs a known or determinable physical relationship between at least some of the located features."

As described above, Parker fails to disclose, teach, or suggest at least the aforementioned limitations. Therefore, Applicants respectfully request that the rejection of claim 50 be withdrawn.

Also for example, claim 53 is directed to an apparatus useful in robotics, and recites, *inter alia*, "a *single camera* operable to capture at a number of images of a calibration object; means for calibrating the camera." (Emphasis added.) Similarly, claim 58 is directed to an apparatus useful in robotics, and recites, inter alia, "a *single camera* operable to capture a number of images of a calibration object; means for calibrating the camera." (Emphasis added.)

Parker discloses that "the arms 104 are calibrated by moving them through a range of motion that the robot 100 can track their position from the starting position" when the robot is turned on (column 3, lines 44-47), but Parker fails to discuss calibration of the video device 122 (or any other part of the robot). Thus, Parker fails to disclose, teach, or suggest at least "means for calibrating the camera," and therefore, Applicants respectfully request that the rejection of claims 53 and 58 be withdrawn.

Further, the dependent claims recite many limitations which are not taught or suggested by Parker. For example, a number of the dependent claims recite specific acts and structures to determine transformations. Such acts or structures do not appear to be disclosed or suggested by Parker.

As one example, claim 43 recites, *inter alia*, "capturing an image of a teaching object of a type of *object that will be manipulated by the robot*," and claim 54 recites a similar, but not identical limitation. While Parker's robot is capable of gripping objects, there is no indication that the robot can grip objects in autonomous mode. At column 10, lines 1-19, Parker discloses the following:

> To grip an object, the second finger element 108 can move to a width opening of approximately 75 millimeters away from the first finger element 110. The second finger element 108 can be opened and closed via the hand control button 544 on the remote control 500. Similar to the direction buttons, by quickly depressing the hand control button 544, the second finger element 108 will move to the next preset position. As the motor 150 that controls the movement of the second finger

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> element 108 only rotates in one direction, the second finger element 108 simply cycles through an open and close position. By holding down the hand control button 544 is also divided into a left and right portion. The left half of the hand control button 544 controls the left hand and the right half of the hand control button 544 controls the right hand grip. Thus, the hand grips can be controlled independently. Thus, holding down the hand control button 544 cycles the second finger element 108 through the entire range of motion. The second finger element 108 is also clutched in both directions.

(Column 10, lines 1-19).

In other words, Parker's robot relies on user control/manipulation of the robot to grip an object. In contrast, Applicants' capture an image of an object so that the robot may manipulate the object. Parker fails to disclose, teach, or suggest at least the aforementioned limitation, and therefore Applicants respectfully request that the rejection of claims 43 and 54 be withdrawn.

Failure to State a *Prima Facie* Case of Obviousness

At page 3, the Office Action concludes that "Parker et al. teaches implicitly an algorithm that employs a known or determinable relationship between at least some of the located features," where the features are located in a two-dimensional image of a target object.

It is well established that "rejections on obviousness grounds cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness." *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006). See also *KSR*, 127 S.Ct. 1727, at 1740-41, citing *In re Kahn* with approval. The Office Action has failed to articulate reasoning with some rational underpinning to support the conclusion that Parker teaches an algorithm that locates features in a two-dimensional image. As previously stated above, Parker's video images are provided to a user. There is no disclosure of the robot doing anything with an image. Therefore, Applicants respectfully submit that the Examiner has failed to meet his burden for establishing a *prima facie* case of obviousness, and Applicants request that the rejection of the pending claims be withdrawn.

Further, Applicants respectfully note that the rejection cannot be sustained based on an alleged "implicit" teaching. The Examiner has the burden of showing that the reference or references, expressly or inherently, disclose all of the claim limitations. Inherency may not be

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established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient. See MPEP 2112.

Stated Rejections Are Not In Compliance With M.P.E.P. § 707

In the Office Action, each rejected claim must be specified and "[a] plurality of claims should **never** be grouped together in a common rejection, unless that rejection is equally applicable to all claims in the group." (See, M.P.E.P. 707.07(d)) (emphasis added). The Examiner has provided a single rejection that groups all of the pending claims together. Applicants submit that the claims cannot be grouped together because of the limitations of the individual claims are different. Therefore, in the event that the rejections are not withdraw, Applicants respectfully submit any claims that might be rejected in a subsequent Office Action cannot be grouped into one rejection and respectfully request that the Examiner individually explain the rationale of any rejected claim. Unless the Examiner provides a fact-based, reasoned analysis for all of the rejected claims, the Examiner is "leaving the applicant to shoot arrows into the dark hoping to somehow hit a secret objection harbored by the examiner, which is not permissible. *In re Oetiker*, supra.

Furthermore, in the event that the rejections are not withdrawn, Applicants respectfully request that any subsequent Office Action be Non-Final. Applicants submit that the deficiencies of the current Office Action have denied Applicants of a fair opportunity to meet the objections with evidence and argument.

Conclusion

Overall, the cited reference does not teach or suggest the claimed features of the embodiments recited in the independent claims, and thus such claims are allowable. Because the remaining claims depend from the allowable independent claims, and also because they include additional limitations, such claims are likewise allowable. If the undersigned attorney has overlooked a relevant teaching in any of the references, the Examiner is requested to point out specifically where such teaching may be found.

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In light of the above amendments remarks, Applicants respectfully submit that all pending claims are allowable. Applicants, therefore, respectfully request that the Examiner reconsider this application and timely allow all pending claims. Examiner Marc is encouraged to contact Mr. Ringer by telephone to discuss the above and any other distinctions between the claims and the applied reference, if desired. If the Examiner notes any informalities in the claims, the Examiner is encouraged to contact Mr. Ringer by telephone to expediently correct such informalities.

Respectfully submitted,

SEED Intellectual Property Law Group PLLC

/Eric M. Ringer, Ph.D./
Eric M. Ringer, Ph.D.
Registration No. 47,028

EMR:sc

Enclosures:
2 Sheet(s) of Drawings (Figures. 1 and 4)

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1359226_1.DOC`

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ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

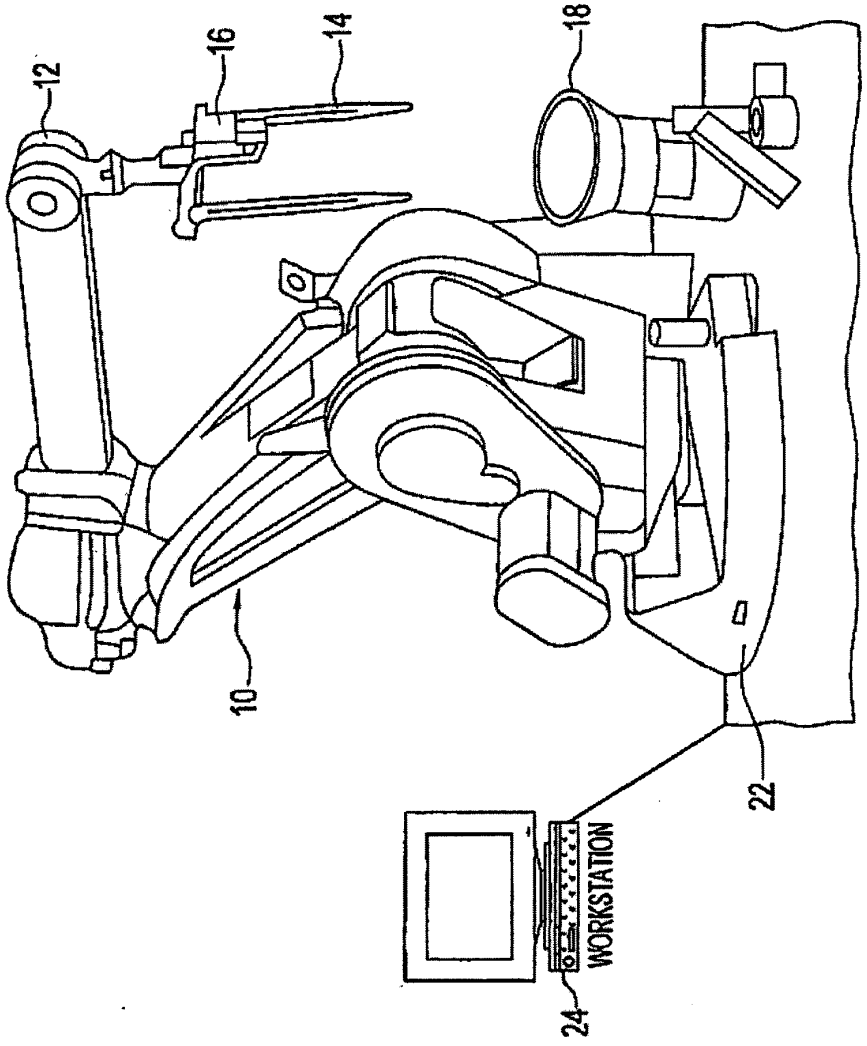


FIG. 1

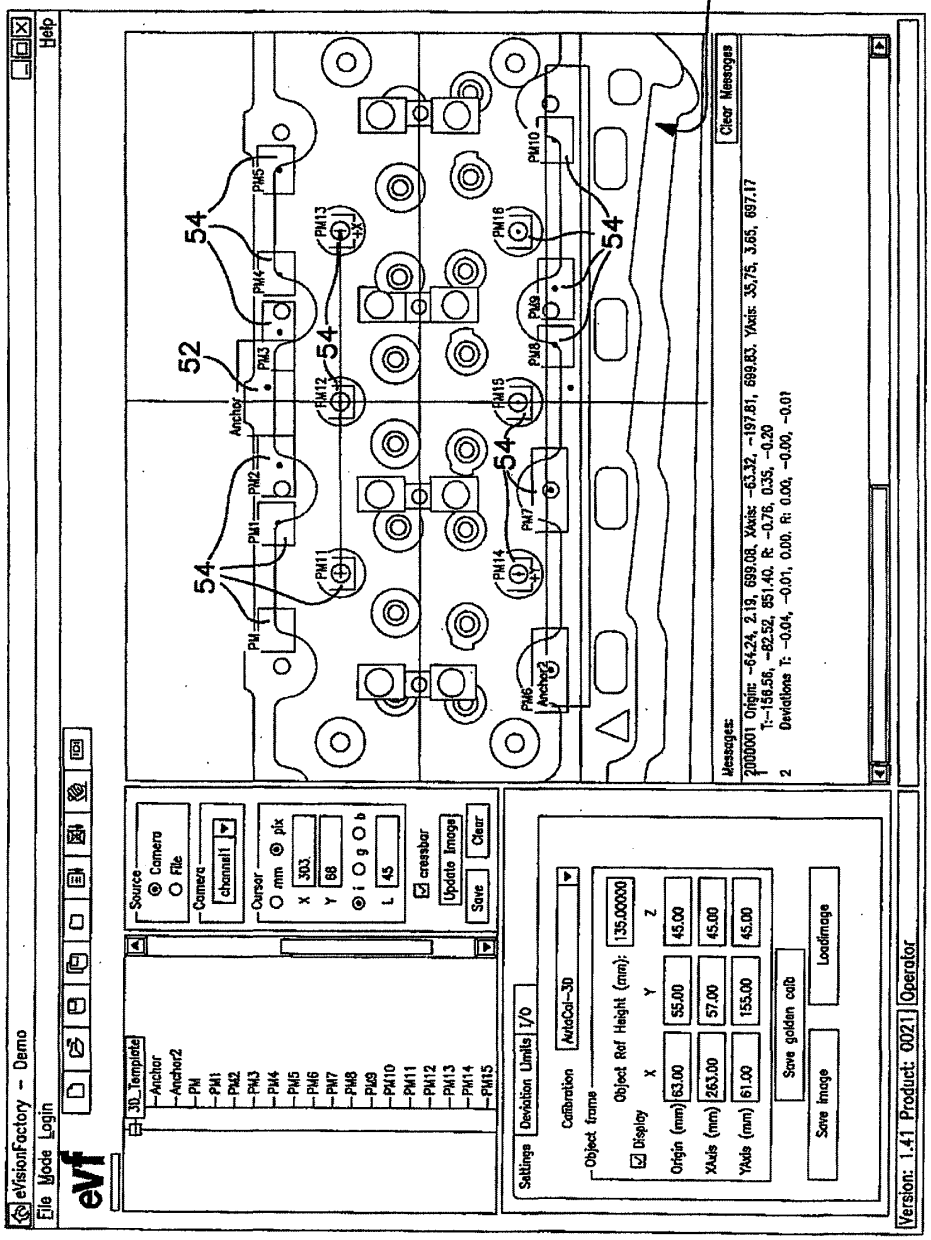


FIG. 4

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IPR2023-01426

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	Babak Habibi et al.
Application No.	:	10/634,874
Filed	:	August 6, 2003
For	:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS

Examiner	:	McDieunel Marc
Art Unit	:	3664
Docket No.	:	170154.401C1
Date	:	June 5, 2009

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

FEE DEFICIENCY AUTHORIZATION FORM

Commissioner for Patents:

Applicants hereby authorize the Director to charge any deficiencies in fees due by way of the enclosed papers only under 37 CFR 1.16 and 1.17 to Deposit Account No. 19-1090.

Respectfully submitted,

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ABB Inc. Exhibit 1002, Page 595 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	Babak Habibi et al.
Application No.	:	10/634,874
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Examiner	:	McDieunel Marc
Art Unit	:	3664
Docket No.	:	170154.401C1
Date	:	June 5, 2009

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INFORMATION DISCLOSURE STATEMENT TRANSMITTAL

Commissioner for Patents:

In accordance with 37 CFR 1.56 and 1.97 through 1.98, applicants wish to make known to the U.S. Patent and Trademark Office the references set forth on the attached Information Disclosure Statement. Copies of cited U.S. patents and published patent applications are not required and accordingly have not been provided. Copies of any other cited references are enclosed. As to any reference cited, applicants do not admit that it is "prior art" under 35 U.S.C. §§ 102 or 103, and specifically reserve the right to traverse or antedate any such reference, as by a showing under 37 CFR 1.131 or other method. Although the aforesaid references are made known to the Patent and Trademark Office in compliance with applicants' duty to disclose all information they are aware of which is believed relevant to the examination of the above-identified application, applicants believe that their invention is patentable.

Please acknowledge receipt of this Information Disclosure Statement and kindly make the cited references of record in the above-identified application.

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ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

A fee of $180 is submitted in accordance with 37 CFR 1.97(c). The Director is authorized to charge any other fees which may be required, or credit any overpayment to Deposit Account No. 19-1090.

Respectfully submitted,

SEED Intellectual Property Law Group PLLC

/Eric M. Ringer, Ph.D./
Eric M. Ringer, Ph.D.
Registration No. 47,028

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Enclosures:
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Cited References (2)

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PTO/SB/08a (03-08)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Not for submission under 37 CFR 1.99)

Application Number	10634874
Filing Date	2003-08-06
First Named Inventor	Babak Habibi
Art Unit	3664
Examiner Name	McDieunel Marc
Attorney Docket Number	170154.401C1

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	10634874
	Filing Date	2003-08-06
	First Named Inventor	Babak Habibi
	Art Unit	3664
	Examiner Name	McDieunel Marc
	Attorney Docket Number	170154.401C1

	1	Wilson, et al., "Relative End-Effector Control Using Cartesian Position Based Visual Servoing," IEEE Transactions on Robotics and Automation, 12(5):684-696, October 1996.	☐
	2	"3D Robot Guidance with a Single Camera," ISRA Vision Systems AG, Machine Vision for Robot Guidance, Nashville, Tennessee, October 5, 2004.	☐

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

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	Application Number	10634874
	Filing Date	2003-08-06
	First Named Inventor	Babak Habibi
	Art Unit	3664
	Examiner Name	McDieunel Marc
	Attorney Docket Number	170154.401C1

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ Fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ None

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Eric M. Ringer, Ph.D./	Date (YYYY-MM-DD)	2009-06-05
Name/Print	Eric M. Ringer, Ph.D.	Registration Number	47028

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

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ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Electronic Patent Application Fee Transmittal

Application Number:	10634874
Filing Date:	06-Aug-2003
Title of Invention:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS
First Named Inventor/Applicant Name:	Babak Habibi
Filer:	Eric Ringer/Sandy Clayton
Attorney Docket Number:	170154.401C1

Filed as Large Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

Electronic Acknowledgement Receipt	
EFS ID:	5467353
Application Number:	10634874
International Application Number:	
Confirmation Number:	7619
Title of Invention:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS
First Named Inventor/Applicant Name:	Babak Habibi
Customer Number:	00500
Filer:	Eric Ringer/Sandy Clayton
Filer Authorized By:	Eric Ringer
Attorney Docket Number:	170154.401C1
Receipt Date:	05-JUN-2009
Filing Date:	06-AUG-2003
Time Stamp:	19:01:37
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$180
RAM confirmation Number	5172
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1		401C1_Amendment.pdf	138388 29e27431ff6efe415c6b4eea56f1013ee9b8abf7	yes	16

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1
	Claims	2	8
	Drawings-only black and white line drawings	9	9
	Applicant Arguments/Remarks Made in an Amendment	10	16

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2	Drawings-only black and white line drawings	401C1_Rep_Drawings.pdf	89269 9720a20ac5f5bbfda356cf0260f9008c5b517a65	no	2

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3	Miscellaneous Incoming Letter	401C1_FDA.pdf	51427 aa72f1bae37867991e9f152ad4b6090115451401	no	1

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4	Transmittal Letter	401C1_IDS_Letter.pdf	54400 11cf2a05240ecb47130a353b3945acb1f5d61df6	no	2

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5	Information Disclosure Statement (IDS) Filed (SB/08)	401C1_IDS_SB08.pdf	734036 8dff35a3ccf916b97be8c4a6017905be7ae8601e	no	4

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6	NPL Documents	REF_Wilson.pdf	1141125 28145a1a18a82683f2173391cdf71a2b13b4f846	no	13

Warnings:

Information:

7	NPL Documents	REF_3D_Robot.pdf	5551304 c57285818d5301c728efa102d768aa0bf8543725	no	23
Warnings:					
Information:					
8	Fee Worksheet (PTO-875)	fee-info.pdf	30329 20791259503b1aa68abcebb8b229114567e3f460	no	2
Warnings:					
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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
10/634,874	08/06/2003	

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)	SMALL ENTITY ☒		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT		(Column 1)		(Column 2)	(Column 3)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
	06/05/2009	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 28	Minus	** 32	= 0	X $26 =	0	OR	X $ =	
	Independent (37 CFR 1.16(h))	* 3	Minus	***3	= 0	X $110 =	0	OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE	0	OR	TOTAL ADD'L FEE	

AMENDMENT		(Column 1)		(Column 2)	(Column 3)					
		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/ROSALIND BALL/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PLUS Search Results for S/N 10634874, Searched Wed Aug 19 09:12:17 EDT 2009

The Patent Linguistics Utility System (PLUS) is a USPTO automated search system for U.S. Patents from 1971 to the present PLUS is a query-by-example search system which produces a list of patents that are most closely related linguistically to the application searched. This search was prepared by the staff of the Scientific and Technical Information Center, SIRA.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/634,874	08/06/2003	Babak Habibi	170154.401C1	7619

500 7590 08/25/2009

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
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SEATTLE, WA 98104

EXAMINER	
MARC, MCDIEUNEL	

ART UNIT	PAPER NUMBER
3664	

MAIL DATE	DELIVERY MODE
08/25/2009	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/634,874	HABIBI ET AL.	
	Examiner	Art Unit	
	MCDIEUNEL MARC	3664	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *05 June 2009*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *33-61* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *all* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

1. Claims 33-47 and 49-61 are pending.

2. The rejection to c Claims 33-47 and 49-61 are rejected under 35 U.S.C. 103(a) as being unpatentable over Parker et al. (US 7024280) is withdrawn in view of new applied prior art.

Claim Rejections - 35 USC § 102

3. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

4. Claims 33-47 and 49-61 are rejected under 35 U.S.C. 102(b) as being anticipated by **Wei et al.** (***Multisensory Visual servoing by a Neural Network*, 1999**).

As per claim 33, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a capturing a number of images of a calibration object (see fig. 4) by the camera; determining a set of intrinsic parameters (see page 1, col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered) of the camera (see figs. 2-3) from at least one of the number of images of the calibration object (see fig. 4) captured by the camera; and determining a set of extrinsic parameters (see page 1, col. 1, second paragraph, wherein both

intrinsic and extrinsic parameters have been covered) of the camera (see figs. 2-3) from at least one of the number of images of the calibration object (see fig. 4) captured by the camera, the set of extrinsic parameters (see page 1, col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered) comprising a camera (see figs. 2-3) space-to-training space transformation defining a transformation between a camera (see figs. 2-3) space reference flame and a training space reference frame (see page 2, col. 1, wherein reference frame has been considered as position frame) .

As per claim 34, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a positioning the camera (see figs. 2-3) with respect to the calibration object (see fig. 4).

As per claim 35, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method wherein positioning the camera (see figs. 2-3) with respect to the calibration object (see fig. 4) comprises positioning the camera (see figs. 2-3) orthogonally with respect to a ruled template with a number of features (see page 5, table II, which has been considered as template), where a known or determinable physical relationship exists between at least some of the features (see page 2, col. 1).

As per claim 36, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method wherein positioning the camera (see figs. 2-3) with respect to the calibration object (see fig. 4) comprises positioning the camera (see figs. 2-3) with respect to a sample of a type of object (see fig. 4) the robot (see fig. 3) will manipulate, the sample having a number of features, where a known or determinable physical relationship exists between at least some of the features (see page 2, col. 1).

As per claim 37, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method wherein capturing a number of images of a calibration object (see fig. 4) by the camera (see figs. 2-3) comprises capturing at least one image at each of a plurality of positions spaced perpendicularly from the calibration object (see fig. 4).

As per claim 38, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method wherein capturing a number of images of a calibration object (see fig. 4) by the camera (see figs. 2-3) comprises capturing at least one image at each of a plurality of different orientations with respect to the calibration object (see fig. 4).

As per claim 39, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method wherein determining a set of intrinsic parameters (see page 1, col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered) of the camera (see figs. 2-3) from the at least one of the number of images of the calibration object (see fig. 4) captured by the camera (see figs. 2-3) comprises determining at least one of a focal length, a first order radial lens distortion coefficient, a set of coordinates of a center of a radial lens distortion, or a scale factor indicative of a framegrabber scanline resampling uncertainty.

As per claim 40, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method wherein determining a set of extrinsic parameters (see page 1, col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered) of the camera (see figs. 2-3) from at least one of the number of images of the calibration object (see fig. 4) captured by the camera, the set of extrinsic parameters (see page 1, col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered) comprising a camera (see figs. 2-3) space-to- training space transformation defining a transformation between a camera (see figs. 2-3)

space reference frame (see page 2, col. 1, wherein reference frame has been considered as position frame) and a training space reference frame (see page 2, col. 1, wherein reference frame has been considered as position frame) comprises determining a respective translation component along three orthogonal axes, and a respective rotation component about the three orthogonal axes.

As per claim 41, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method that further comprising: determining a camera (see figs. 2-3) space-to-tool space transformation based at least in part on at least two of the number of images captured by the camera (see figs. 2-3) of the calibration object (see fig. 4).

As per claim 42, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method that further comprising: determining a camera (see figs. 2-3) space-to-tool space transformation based on single one of the number of images captured by the camera (see figs. 2-3) of the calibration object (see fig. 4) and on a number of physical coordinates of at least one feature of the calibration object (see fig. 4).

As per claim 43, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method that further comprising: capturing an image of a teaching object (see fig. 4) of a type of object (see fig. 4) that will be manipulated by the robot; selecting a number of features (see page 2, col. 1) from the captured image of the teaching object (see fig. 4); determining a set of object (see fig. 4) space coordinates for each of the selected features (see page 2, col. 1) I from the captured image of the teaching object (see fig. 4).

As per claim 44, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method wherein selecting a number of features (see page 2, col. 1) from the captured

image of the teaching object (see fig. 4) comprises selecting six features (see page 2, col. 1) from the captured image of the teaching object (see fig. 4).

As per claim 45, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method that further comprising:

determining an object (see fig. 4) space-to-camera (see figs. 2-3) space transformation defining a transformation between an object (see fig. 4) space reference frame (see page 2, col. 1, wherein reference frame has been considered as position frame) and the camera (see figs. 2-3) space reference frame (see page 2, col. 1, wherein reference frame has been considered as position frame).

As per claim 46, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method that comprising: determining a position and an orientation of an object (see fig. 4) frame in the tool frame reference frame (see page 2, col. 1, wherein reference frame has been considered as position frame) based at least in part on the object (see fig. 4) frame-to-camera (see figs. 2-3) space and camera (see figs. 2-3) space-to- tool space transformations (see abstract, pages 1-2 and fig. 2).

As per claim 47, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method that further comprising: providing the position and orientation of the object (see fig. 4) frame to the robot; and training an intended operation path inside the object frame (see abstract and fig. 4).

As per claim 49, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method that further comprising: adjusting a position of the movable portion of the robot (see fig. 3) if the number of features (see page 2, col. 1) located in the captured image of

the target object (see fig. 4) is determined to be an insufficient number of features; and capturing another two-dimensional image of the volume containing the target I object (see fig. 2-4, wherein image taken by the camera being considered has having the capacity to do two- or three-dimensional images) before determining the object (see fig. 4) space-to-camera (see figs. 2-3) space transformation for the target object (see fig. 4).

As per claim 50, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method that useful in three-dimensional pose estimation for use with a single camera (see figs. 2-3) mounted to a movable portion of a robot, the method comprising:
capturing a two-dimensional image of a volume containing a target object (see fig. 4); locating a number of features (see page 2, col. 1) in the captured image of the target object (see fig. 4); and determining an object (see fig. 4) space-to-camera (see figs. 2-3) space transformation for the target object (see fig. 4) based at least in part on a position of at least some of the located features (see page 2, col. 1) using only the captured image and an algorithm that employs a known or determinable physical relationship between at least some of the located features (see page 2, col. 1).

As per claim 51, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method that further comprising: determining at least one movement of the robot (see fig. 3) that orients the camera (see figs. 2-3) orthogonally with respect to the target object (see fig. 4) based at least on part on the object (see fig. 4) space-to-camera (see figs. 2-3) space transformation (see abstract, pages 1-2 and fig. 2).

As per claim 52, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method that comprising: determining a position of the object (see fig. 4) frame in the

tool space reference frame (see page 2, col. 1, wherein reference frame has been considered as position frame); and providing an object (see fig. 4) frame to the robot (see fig. 3).

As per claim 53, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a system that useful in robotics, the apparatus comprising: a single camera (see figs. 2-3) operable to capture at a number of images of a calibration object (see fig. 4) means for calibrating the camera, by: determining a set of intrinsic parameters (see page 1, col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered) of the camera (see figs. 2-3) from at least one of the number of images of the calibration object (see fig. 4) captured by the camera; and determining a set of extrinsic parameters (see page 1, col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered) of the camera (see figs. 2-3) from at least one of the number of images of the calibration object (see fig. 4) captured by the camera, the set of extrinsic parameters (see page 1, col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered) comprising a camera (see figs. 2-3) space-to-training space transformation defining a transformation between a camera (see figs. 2-3) space reference frame (see page 2, col. 1, wherein reference frame has been considered as position frame) and a training space reference frame (see page 2, col. 1, wherein reference frame has been considered as position frame); and means for estimating a pose of a target object (see fig. 4), by: capturing a two-dimensional image of a volume containing a target object (see fig. 4); and locating at least six features (see page 2, col. 1) in the captured image of the target object (see fig. 4); and determining an object (see fig. 4) space-to-camera (see figs. 2-3) space transformation based at least in part on a position of at least some of the located features (see page 2, col. 1) in solely the captured image using an algorithm that employs a known or

determinable physical relationship between at least some of the located features (see page 2, col. 1).

As per claim 54, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a system that comprising: means for training, comprising:
capturing an image of a teaching object (see fig. 4) of a type of object (see fig. 4) that will be manipulated by the robot; selecting a number of features (see page 2, col. 1) from the captured image of the teaching object (see fig. 4); determining a set of object (see fig. 4) space coordinates for each of the selected features (see page 2, col. 1) from the captured image of the teaching object (see fig. 4); an determining an object (see fig. 4) space-to-camera (see figs. 2-3) space transformation defining a transformation between an object (see fig. 4) space reference frame (see page 2, col. 1, wherein reference frame has been considered as position frame) and the camera (see figs. 2-3) space reference frame (see page 2, col. 1, wherein reference frame has been considered as position frame).

As per claim 55, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a system wherein the means for calibrating, the means for estimating a pose, and the means for training comprises at least one programmed computer (see abstract, page 1, col. 1 and page 4, col. 2, second paragraph).

As per claim 56, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a system wherein the means for calibrating, the means for estimating a pose, and the means for training comprises at least one computer-readable medium (see abstract, page 1, col. 1 and page 4, col. 2, second paragraph) storing instructions operating at least one computer (see abstract, page 1, col. 1 and page 4, col. 2, second paragraph).

As per claim 57, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a system wherein the pose estimating means estimates the pose of the target object (see fig. 4) further by: adjusting a position of the movable portion of the robot (see fig. 3) if the number of features (see page 2, col. 1) located in the captured image of the target object (see fig. 4) is determined to be an insufficient number of features (see page 2, col. 1).

As per claim 58, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a system that useful in robotics, the apparatus comprising:
a single camera (see figs. 2-3) operable to capture a number of images of a calibration object (see fig. 4) means for calibrating the camera, by: determining a set of intrinsic parameters (see page 1, col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered) of the camera (see figs. 2-3) from at least one of the number of images of the calibration object (see fig. 4) captured by the camera; and determining a set of extrinsic parameters (see page 1, col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered) of the camera (see figs. 2-3) from at least one of the number of images of the calibration object (see fig. 4) captured by the camera, the set of extrinsic parameters (see page 1, col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered) comprising a camera (see figs. 2-3) space-to-training space transformation defining a transformation between a camera (see figs. 2-3) space reference frame (see page 2, col. 1, wherein reference frame has been considered as position frame) and a training space reference frame (see page 2, col. 1, wherein reference frame has been considered as position frame) ; and means for estimating a pose of a target object (see fig. 4), by: capturing a two-dimensional image of a volume containing a target object (see fig. 4); locating at least five features (see page 2, col. 1) in the captured image of the target object

(see fig. 4); and determining an object (see fig. 4) space-to-camera (see figs. 2-3) space transformation based at least in part on a position of at least some of the located features (see page 2, col. 1) using the captured image without any additional captured images and an algorithm that employs a known or determinable physical relationship between at least some of the located features (see page 2, col. 1).

As per claim 59, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a system wherein the means for calibrating and the means for estimating a pose comprises at least one programmed computer (see abstract, page 1, col. 1 and page 4, col. 2, second paragraph).

As per claim 60, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a system wherein the means for calibrating and the means for estimating a pose comprises at least one computer-readable medium (see abstract, page 1, col. 1 and page 4, col. 2, second paragraph) storing instructions operating at least one computer (see abstract, page 1, col. 1, wherein "traditional computer" inherently works with computer-readable medium, and page 4, col. 2, second paragraph).

As per claim 53, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a system wherein the pose estimating means estimates the pose of the target object (see fig. 4) further by: adjusting a position of the movable portion of the robot (see fig. 3) if the number of features (see page 2, col. 1) located in the captured image of the target object (see fig. 4) is determined to be an insufficient number of features (see page 2, col. 1).

Response to Arguments

5. As to the reference dos not use video images in autonomous mode (see figs. 2-3);

As to the sensor 114 not emit a signal (see fig. 2);

As to the reference not teaching a calibration of the video device 122 "or any other part of the robot" (see abstract);

As to the reference not teaching a robot (see fig. 3) that can grip object (see figs. 2-4)s in autonomous mode (see fig. 3);

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to MCDIEUNEL MARC whose telephone number is (571)272-6964. The examiner can normally be reached on 6:30-5:00 Mon-Thu.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Khoi Tran can be reached on (571) 272-6919. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

/McDieunel Marc/
Examiner, Art Unit 3664
August 24, 2009

/KHOI TRAN/
Supervisory Patent Examiner, Art Unit 3664

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10634874	HABIBI ET AL.
	Examiner	Art Unit
	Marc, McDieunel	3664

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/22/2007	02/09/2008	02/10/2009	08/12/2009					
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	2	-	-	-	-					
	3	-	-	-	-					
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	32	-	-	-	-					
2	33	✓	=	=	✓					
3	34	✓	=	=	✓					
4	35	✓	=	=	✓					
5	36	✓	=	=	✓					

ABB Inc. Exhibit 1002, Page 623 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10634874	HABIBI ET AL.
	Examiner	**Art Unit**
	Marc, McDieunel	3664

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
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☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/22/2007	02/09/2008	02/10/2009	08/12/2009					
6	37	✓	=	=	✓					
7	38	✓	=	=	✓					
8	39	✓	=	=	✓					
9	40	✓	=	=	✓					
10	41	✓	=	=	✓					
11	42	✓	=	=	✓					
12	43	✓	=	=	✓					
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15	46	✓	=	=	✓					
16	47	✓	=	=	✓					
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26	59	✓	=	=	✓					
27	60	✓	=	=	✓					
28	61	✓	=	=	✓					

ABB Inc. Exhibit 1002, Page 624 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 170154.401C1	APPLICATION NO. 10/634,874
INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	APPLICANTS Babak Habibi et al.	
	FILING DATE August 6, 2003	GROUP ART UNIT 3664

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	AA	4,011,437	03/08/77	Hohn	235	151.11	
	AB	4,187,454	02/05/80	Ito et al.	318	568	
	AC	4,294,544	10/13/81	Altschuler et al.	356	376	
	AD	4,523,809	06/18/85	Taboada et al.	350	163	
	AE	4,687,325	08/18/87	Corby, Jr.	356	1	
	AF	4,791,482	12/13/88	Barry et al.	358	107	
	AG	4,879,664	11/07/89	Suyama et al.	364	518	
	AH	4,985,846	01/15/91	Fallon	364	513	
	AI	5,160,977	11/03/92	Utsumi	356	376	
	AJ	5,208,763	05/04/93	Hong et al.	364	551.02	
	AK	5,325,468	06/28/94	Terasaki et al.	395	97	
	AL	5,446,835	08/29/95	Iida et al.	395	133	
	AM	5,461,478	10/24/95	Sakakibara et al.	356	375	
	AN	5,499,306	03/12/96	Sasaki et al.	382	291	
	AO	5,521,830	05/28/96	Saito	364	474.34	
	AP	5,568,593	10/22/96	Demarest et al.	395	82	
	AQ	5,608,818	03/04/97	Chini et al.	382	153	
	AR	5,715,166	02/03/98	Besl et al.	364	474.24	
	AS	5,745,523	04/28/98	Dent et al.	375	216	
	AT	5,784,282	07/21/98	Abitbol et al.	364	474.28	
	AU	5,802,201	09/01/98	Nayar et al.	382	153	
	AV	5,809,006	09/15/98	Davis et al.	369	275.4	
	AW	5,870,527	02/09/99	Fujikawa et al.	395	80	

EXAMINER	DATE CONSIDERED

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant

1509406

Date: November 25, 2009

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U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	AA	5,974,169	10/26/99	Bachelder	382	151	
	AB	6,004,016	12/21/99	Spector	364	167.02	
	AC	6,064,759	05/16/00	Buckley et al.	382	154	
	AD	6,278,906	08/21/01	Piepmeier et al.	700	250	
	AE	6,392,744	05/21/02	Holec	356	4.03	
	AF	6,463,358	10/08/02	Watanabe et al.	700	253	
	AG	6,490,369	12/03/02	Beiman	382	153	
	AH	6,516,092	02/04/03	Bachelder et al.	382	181	
	AI	6,529,627	03/04/03	Callari et al.	382	154	
	AJ	6,546,127	04/08/03	Seong et al.	382	152	
	AK	6,549,288	04/15/03	Migdal et al.	356	603	
	AL	6,580,971	06/17/03	Bunn et al.	700	259	
	AM	6,721,444	04/13/04	Gu et al.	382	154	
	AN	6,724,930	04/20/04	Kosaka et al.	382	154	
	AO	6,741,363	05/25/04	Kaupert	356	602	
	AP	6,748,104	06/08/04	Bachelder et al.	382	151	
	AQ	6,836,702	12/28/04	Brogårdh et al.	700	245	
	AR	6,970,802	11/29/05	Ban et al.	702	153	
	AS	7,006,236	02/28/06	Tomasi et al.	356	614	
	AT	7,009,717	03/07/06	Van Coppenolle et al.	356	603	
	AU	7,084,900	08/01/06	Watanabe et al.	348	94	
	AV	7,177,459	02/13/07	Watanabe et al.	382	151	

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	AA	2002/0019198	02/14/02	Kamono	451	41	
	AB	2002/0156541	10/24/02	Yutkowitz	700	28	
	AC	2003/0182013	09/25/03	Moreas et al.	700	145	
	AD	2004/0037689	02/26/04	Watanabe et al.	414	730	
	AE	2004/0041808	03/04/04	Ban et al.	345	419	
	AF	2004/0073336	04/15/04	Huang et al.	700	245	
	AG	2004/0081352	04/29/04	Ban et al.	382	154	
	AH	2004/0193321	09/30/04	Anfindsen et al.	700	257	
	AI	2005/0002555	01/06/05	Kumiya et al.	382	153	
	AJ	2005/0097021	05/05/05	Behr et al.	705	36	
	AK	2005/0126833	06/16/05	Takenaka et al.	180	8.1	
	AL	2005/0233816	10/20/05	Nishino et al.	473	131	
	AM	2005/0246053	11/03/05	Endou et al.	700	188	
	AN	2006/0025874	02/02/06	Huffington et al.	700	44	
	AO	2006/0088203	04/27/06	Boca et al.	382	153	
	AP	2006/0119835	06/08/06	Rastegar et al.	356	28	
	AQ	2006/0210112	09/21/06	Cohen et al.	382	103	
	AR	2007/0073439	03/29/07	Habibi et al.	700	213	
	AS	11/754,218		Habibi et al.			05/25/07
	AT	11/779,812		Habibi			07/18/07
	AU	11/833,187		Boca et al.			08/02/07
	AV	11/857,680		Boca et al.			09/19/07
	AW	60/719,765		Habibi et al.			09/23/05

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U.S. PATENT DOCUMENTS

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	AA	60/808,903		Habibi et al.			05/26/06
	AB	60/832,356		Habibi			07/20/06
	AC	60/845,932		Boca et al.			09/19/06
	AD	60/875,073		Beis et al.			12/16/06

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	TRANSLATION	
					YES	NO
	AE	1 043 126	10/11/00	EP		
	AF	1 043 642	10/11/00	EP		
	AG	1 043 689	10/11/00	EP		
	AH	1 484 716	12/08/04	EP		
	AI	102 36 040	02/19/04	DE (+ abstract in English)		
	AJ	2000024973	01/25/00	JP (+ abstract in English)		
	AK	2005/074653	08/18/05	WO		
	AL	63288683	11/25/88	JP (+ abstract in English)		
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	AP					
	AQ					
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	AS					
	AT					

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	APPLICANTS Babak Habibi et al.	
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OTHER PRIOR ART *(Including Author, Title, Date, Pertinent Pages, Etc.)*

	AA		Aloimonos, J., et al., "Active Vision," *IEEE*, pp. 35-54, 1987.
	AB		Anonymous, "Precise Length Measurement at VSM (Vereinigte Schmirgel-Und Maschinen-Fabriken AG)," *News of the Astech GMBH 2001*(4), December 31, 2001.
	AC		Bajcsy, R., "Active Perception," *Proc. IEEE 76*(8):996-1005, 1988
	AD		Bakhtari, A., et al., "Active-Vision Based Multi-Sensor Surveillance – An Implementation," *IEEE Transactions on Systems, Man and Cybernetics, Part C: Applications and Reviews, 36*(5):668-680, September 2006.
	AE		Borotschnig, H., et al., "Active Object Recognition in Parametric Eigenspace," *Proc. 9th British Machine Vision Conference*, pp. 629-638, 1998.
	AF		Bouthemy, P., "A Maximum Likelihood Framework for Determining Moving Edges," *IEEE Trans. Pattern Analysis and Machine Intelligence 11*(5):499-511, 1989.
	AG		Brown, M., et al., "3D Model Acquisition by Tracking 2D Wireframes," *Proc. 11th British Machine Vision Conference*, pp. 656-665, 2000.
	AH		Callari, F., et al., "Active Recognition: Using Uncertainty to Reduce Ambiguity," *Proc. 13th International Conference on Pattern Recognition*, pp. 925-929, 1996.
	AI		Chaumette, F., "Potential Problems of Stability and Convergence in Image-Based and Position-Based Visual Servoing," in D. Kriegman, G. Hager and S. Morse, editors, *The Confluence of Vision and Control, Vol. 237* of Lecture Notes in Control and Information Sciences, pp. 66-78, Springer-Verlag, 1998.
	AJ		Chaumette, F., et al., "Structure from Controlled Motion," *IEEE Trans. Pattern Analysis and Machine Intelligence 18*(5):492-504, May 1996.
	AK		Constantinescu, D., et al., "Smooth and Time-Optimal Trajectory Planning for Industrial Manipulators along Specified Paths," *Journal of Robotic Systems 17*(5):233-249, 2000.
	AL		Corke, P.I., et al., "A New Partitioned Approach to Image-Based Visual Servo Control," *IEEE Trans. On Robotics and Automation 17*(4):507-515, August 2001.
	AM		Deguchi, K., "Optimal Motion Control for Image-Based Visual Servoing by Decoupling Translation and Rotation," in *Proc. Int. Conf. Intelligent Robots and Systems*, pp.705-711, October 1998.
	AN		Drummond, T., et al., "Real-time Tracking of Complex Structures with On-line Camera Calibration," *Proceedings of British Machine Vision Conference*, pp. 574-583, 1999.

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OTHER PRIOR ART *(Including Author, Title, Date, Pertinent Pages, Etc.)*

	AA		Eriksen, R.D., et al., "Classification and pose estimation of unconstrained 3D objects," *34th International Symposium on Robotics*, June 2-5, 2003, 7 pages.
	AB		Hartley et al., *Multiple View Geometry in Computer Vision,* Cambridge University Press, Cambridge, 2000
	AC		Holliday et al., "Demonstration of Automated Robotic Workcell for Hazardous Waste Characterization," *Proceedings of the International Conference on Robotics and Automation 3*(10):788-794, May 2, 1993.
	AD		Hutchinson, S.A., et al., "Planning Sensing Strategies in a Robot Work Cell with Multi-Sensor Capabilities," *IEEE Trans. Robotics and Automation 5*(6):765-783, 1989
	AE		Hutchison et al., "A Tutorial on Visual Servo Control," *IEEE Transactions on Robotics and Automation 12*(5), October 1996
	AF		Lowe, D.G., "Robust Model-based Motion Tracking Through the Integration of Search and Estimation," *International Journal of Computer Vision 8*(2):113-122, 1992.
	AG		Macfarlane, S., et al., "Jerk-Bounded Manipulator Trajectory Planning: Design for Real-Time Applications," *IEEE Trans. Robotics and Automation 19*(1):42-52, 2003.
	AH		Marjanovic et al., "Self-Taught Visually-Guided Pointing for a Humanoid Robot," XP-002220054, pp. 35-44, 1996.
	AI		Miura, J., et al., "Task-Oriented Generation of Visual Sensing Strategies in Assembly Tasks," CMU School of Computer Science Tech Report CMU-CS-95-116, 42 pages, 1995.
	AJ		Motai, Y., et al., "Concatenate Feature Extraction for Robust 3D Elliptic Object Localization," *Proc. Of the 19th ACM Symposium on Applied Computing*, pp. 21-28, 2004.
	AK		Murase, H., et al., "Visual Learning and Recognition of 3-D Objects from Appearance," *International Journal of Computer Vision 14*(1):5-24, 1995.
	AL		Naish, M.D., et al., "Coordinated dispatching of proximity sensors for the surveillance of manoeuvring targets," *Journal of Robotics and Computer Integrated Manufacturing 19*(3):283-299, 2003.
	AM		Nomura et al., "Integrated Visual Servoing System to Grasp Industrial Parts Moving on Conveyer by Controlling 6D0F Arm," *Systems, Man, and Cybernetics, 2000 IEEE International Conference 3*:1768-1775, October 2000.
	AN		Papanikolopoulos et al., "Six Degree-of-Freedom Hand/Eye Visual Tracking with Uncertain Parameters," *IEEE Transactions on Robotics and Automation 11*(5):725-732, October 1995.

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	APPLICANTS Babak Habibi et al.	
	FILING DATE August 6, 2003	GROUP ART UNIT 3664

OTHER PRIOR ART *(Including Author, Title, Date, Pertinent Pages, Etc.)*

	AA		Sang, T., et al., "Vision Assisted Robotic Tele-training," *IEEE International Conference on Mechatronics and Automation*, pp. 1288-1293, July 2005.
	AB		Tarabanis, K.A., et al., "A Survey of Sensor Planning in Computer Vision," *IEEE Transactions on Robotics and Automation 11*(1):86-104, February 1995.
	AC		Tarabanis, K.A., et al., "The MVP Sensor Planning System for Robotic Vision Tasks," *IEEE Transactions on Robotics and Automation 11*(1):72-85, February 1995.
	AD		Vincze, M., "Robust tracking of ellipses at frame rate," *The Journal of Pattern Recognition 34*(2):487-498, 2001.
	AE		Whaite, P., et al., "From Uncertainty to Visual Exploration," *IEEE Transactions on Pattern Analysis and Machine Intelligence 13*(10):1038-1049, 1991.
	AF		Wilson et al., "Relative End-Effector Control Using Cartesian Position Based Visual Servoing," *IEEE Transactions 12*(5):684-696, 1996.
	AG		Zhou, F., et al., "Complete calibration of a structured light stripe vision sensor through planar target of unknown orientations," *Image and Vision Computing 23*:59-67, 2005.
	AH		Office Action for U.S. Application No. 11/183,228, 12 pages, Mail Date 12/06/2006.
	AI		Amendment filed in U.S. Application No. 11/183,228, 24 pages, Mail Date 04/05/2007.
	AJ		Office Action for U.S. Application No. 11/183,228, 14 pages, Mail Date 06/08/2007.
	AK		Amendment filed in U.S. Application No. 11/183,228, 8 pages, Mail Date 09/04/2007.
	AL		
	AM		
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	AR		
	AS		
	AT		

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1509406

Date: November 25, 2009

Electronic Acknowledgement Receipt	
EFS ID:	6525546
Application Number:	10634874
International Application Number:	
Confirmation Number:	7619
Title of Invention:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS
First Named Inventor/Applicant Name:	Babak Habibi
Customer Number:	00500
Filer:	Frank Abramonte/Sandy Clayton
Filer Authorized By:	Frank Abramonte
Attorney Docket Number:	170154.401C1
Receipt Date:	25-NOV-2009
Filing Date:	06-AUG-2003
Time Stamp:	15:32:56
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	NPL Documents	REF_OA_120606.pdf	431586 890c159155234b5cd12881d30ceea9debc388de4	no	12
Warnings:					
Information:					

2	NPL Documents	REF_Amend_040507.pdf	1091510 e393ba084f52906af40cc4bb5918a0b133342a25	no	24
Warnings:					
Information:					
3	NPL Documents	REF_OA_060807.pdf	546797 c92a034b6e320de85afcdfa23659c2a6c34a75e1	no	14
Warnings:					
Information:					
4	NPL Documents	REF_Amend_090407.pdf	357140 b260792ced5642f04e44a83197ac376225a62129	no	8
Warnings:					
Information:					
5	Information Disclosure Statement (IDS) Filed (SB/08)	401C1_IDS_1449.pdf	143756 3d69f9ffed43f42828cbd666fe6c8f45c189c3cf	no	7
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
			Total Files Size (in bytes):	2570789	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	Babak Habibi et al.
Application No.	:	10/634,874
Filed	:	August 6, 2003
For	:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS

Examiner	:	McDieunel Marc
Art Unit	:	3664
Docket No.	:	170154.401C1
Date	:	November 25, 2009

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

RESPONSE

Commissioner for Patents:

In response to the Office Action dated August 25, 2009, please consider the following remarks:

Remarks begin on page 2 of this paper.

REMARKS

This is a Response to the Office Action mailed August 25, 2009, in which a three (3) month Shortened Statutory Period for Response has been set, due to expire November 25, 2009. Thirty-two (32) claims, including four (4) independent claims, were paid for in the application. No new matter has been added to the application. No fee for additional claims is due by way of this Amendment. The Director is authorized to charge any additional fees due by way of this Amendment, or credit any overpayment, to our Deposit Account No. 19-1090. Claims 33-47 and 49-61 are pending.

Information Disclosure Statement

Applicants filed a Supplemental IDS on June 5, 2009. It is respectfully requested that an initialed copy of the IDS be provided to Applicants to confirm consideration thereof.

35 U.S.C. §102(b) Rejections

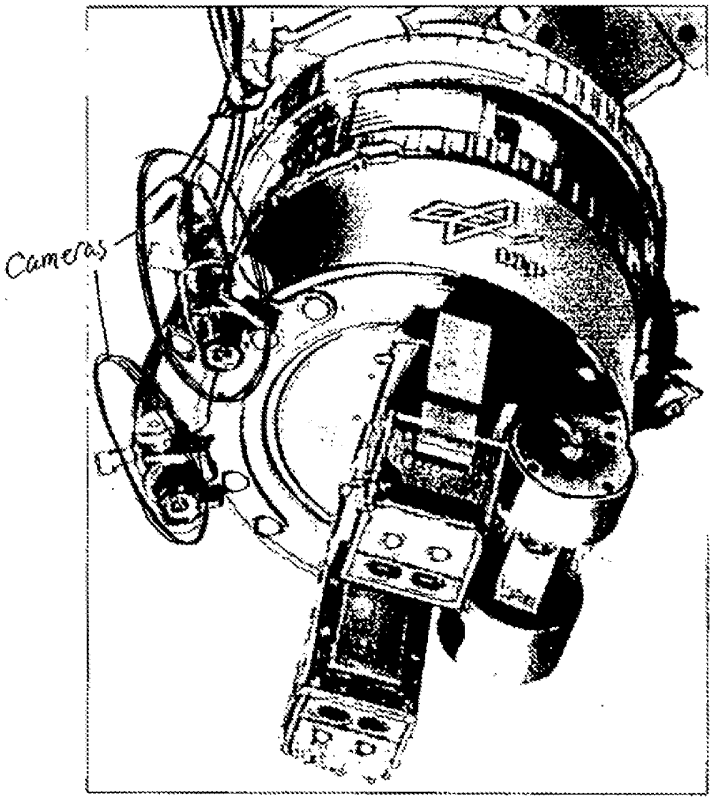
Claims 33-47 and 49-61 were rejected under 35 U.S.C. §102(b) as being anticipated by Multisensory Visual Servoing by a Neural Network by Wei et al. (hereinafter "Wei").

Claim 50 is independent so will be discussed before the claims that depend therefrom. Claim 50 recites:

> A method useful in three-dimensional pose estimation for use with a single camera mounted to a movable portion of a robot, the method comprising: capturing a two-dimensional image of a volume containing a target object; locating a number of features in the captured image of the target object; and determining an object space-to-camera space transformation for the target object based at least in part on a position of at least some of the located features using only the single captured image and an algorithm that employs a known or determinable physical relationship between at least some of the located features.

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The Office alleges that Wei teaches all of the elements recited by claim 50, relying on Figures 2-3 of Wei. However, Figure 2 refers to cameras in the plural. Figure 3 shows two cameras. See Wei, at page 4 bottom of first column-top of second column, Figure 3, and page 1, second column. Figure 3 is reproduced below, in which circles have been added to identify the two stereo cameras.



The Office also relies on Figure 4 of Wei. However Figure 4 illustrates *stereo* images produced from the two cameras.

It is clear that Wei does not teach or suggest "[a] method useful in three-dimensional pose estimation for use with a *single camera* mounted to a movable portion of a robot, as recited by claim 50. (Emphasis added.) It is also clear that Wei does not teach or suggest "determining an object space-to-camera space transformation for the target object based at least in part on a position of at least some of the located features *using only the single captured*

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image and an algorithm that employs a known or determinable physical relationship between at least some of the located features." (Emphasis added).

Claim 33 is dependent from claim 50 and further recites "capturing a number of images of a calibration object by the camera; determining a set of intrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera; and determining a set of extrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera, the set of extrinsic parameters comprising a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame." The Office alleges that such is taught by Wei, relying on page 1, column 1. However, the cited portion of Wei actually appears to teach away from such (*e.g.* "On the contrary, a neural network approach for doing the same job can avoid all such calibrations and provides convenient sensor fusion framework. The network learns the direct transformation from (multi-) sensory data to the required motions based on a set of examples. The effects of sensor calibration, geometric transformation, and the relative importance of each sensor are all absorbed in a single network.").

Claim 35 is indirectly dependent from claim 50 and further recites "positioning the camera orthogonally with respect to a ruled template with a number of features, where a known or determinable physical relationship exists between at least some of the features." The Office contends that Wei teaches such, relying in particular on table II, and by interpreting table II to be a template. Applicants respectfully contend that a table in a printed publication cannot be reasonably interpreted to constitute a ruled template with a number of features. In any case, Wei clearly does not teach or suggest positioning a camera orthogonally with respect to such table.

Claim 37 is indirectly dependent from claim 50 and further recites "capturing a number of images of a calibration object by the camera comprises capturing at least one image at each of a plurality of positions spaced perpendicularly from the calibration object." The Office alleges that Wei teaches such, replying on Figures 2-4. Figure 2 illustrates the overall system, while Figure 3 shows an end effecter with two cameras in a stereoscopic arrangement and

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number of laser range finders. Figure 4 illustrates stereo images as captured by the two cameras. (Note, since the two cameras are not parallel, than it is impossible for both cameras to be perpendicular to an object at a same time.) The positions of the cameras do not appear to be perpendicular with respect to the object. In any case, Wei clearly does not teach capturing a number of images at *a plurality of positions spaced perpendicularly from the calibration object*" (emphasis added) as recited by claim 37.

Claim 39 is indirectly dependent from claim 50 and further recites "determining at least one of a focal length, a first order radial lens distortion coefficient, a set of coordinates of a center of a radial lens distortion, or a scale factor indicative of a framegrabber scanline resampling uncertainty." The Office alleges that such is taught by Wei, but does not identify any specific portion of Wei. Upon review of Wei, Applicant's attorney has not found any teaching of such in the cited reference. Applicants respectfully ask that the Office specifically point out such teaching, if the Office persists in this rejection.

Claim 40 is indirectly dependent from claim 50 and further recites that "determining a set of extrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera, the set of extrinsic parameters comprising a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame comprises determining a respective translation component along three orthogonal axes, and a respective rotation component about the three orthogonal axes." The Office alleges that such is taught by Wei, relying on page 1, col. 1, second paragraph, and figures 2-3. However, the cited portion of Wei actually appears to teach away from such (*e.g.* "On the contrary, a neural network approach for doing the same job can avoid all such calibrations and provides convenient sensor fusion framework. The network learns the direct transformation from (multi-) sensory data to the required motions based on a set of examples. The effects of sensor calibration, geometric transformation, and the relative importance of each sensor are all absorbed in a single network.").

Claim 41 is indirectly dependent from claim 50 and further recites "determining a camera space-to-tool space transformation based at least in part on at least two of the number of

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images captured by the camera of the calibration object." The Office alleges Wei teaches such, relying on Figures 2-4. Figure 2 illustrates the overall system, Figure 3 shows an end effecter carrying a pair of cameras and laser range finders, and Figure 4 shows a stereo images captured by the pair of cameras. Applicant does not see how the Office could possible infer such details of operation (*i.e.,* determining a camera space-to-tool space transformation based at least in part on at least two of the number of images captured by the camera of the calibration object) from such high level Figures.

Claim 42 is indirectly dependent from claim 50 and further recites "determining a camera space-to-tool space transformation based on single one of the number of images captured by the camera of the calibration object and on a number of physical coordinates of at least one feature of the calibration object." The Office alleges Wei teaches such, relying on Figures 2-4. Figure 2 illustrates the overall system, Figure 3 shows an end effecter carrying a *pair of cameras* and laser range finders, and Figure 4 illustrates *stereo* images captured by the *pair of cameras*. Such cannot possibly teach or suggest , "determining a camera space-to-tool space transformation based on *single one of the number of images captured by the camera* of the calibration object and on a number of physical coordinates of at least one feature of the calibration object" as recited in claim 42 (emphasis added). Wei simply does not teach or suggest a single camera single image approach to robotic machine-revision.

Claim 43 is dependent from claim 50 and further recites, *inter alia*, "selecting a number of features from the captured image of the teaching object; and determining a set of object space coordinates for each of the selected features from the captured image of the teaching object." The Office alleges Wei teaches such, relying on page 2, col. 1 and Figure 4. However, the cited portion does not appear to refer to features, let alone "selecting features and determining object space coordinates for each of the selected features" as recited in claim 43. The cited portion is directed to training and with dealing with inexactness of mapping through a recursive method.

Claim 44 is indirectly dependent from claim 50 and further recites "selecting a number of features from the captured image of the teaching object comprises selecting six features from the captured image of the teaching object." The Office alleges Wei teaches such,

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again relying on page 2, col. 1 and Figure 4. However, the cited portion does not appear to refer to features, let alone "selecting six features from the captured image of the teaching object" as recited in claim 44.

Claim 45 is indirectly dependent from claim 50 and further recites "determining an object space-to-camera space transformation defining a transformation between an object space reference frame and the camera space reference frame." The Office alleges that Wei teaches such relying on page 2, col. 1, and Figures 2-4, "wherein reference frame has been considered as position frame." It appears that the Office is employing the "position frame" to be both the object space reference frame and the camera space reference frame. Such is of course incorrect since two different reference frames have been recited, and the Office cites to at most a single reference frame in its rejection.

Claim 46 is indirectly dependent from claim 50 and further recites "determining a position and an orientation of an object frame in the tool frame reference frame based at least in part on the object frame-to-camera space and camera space-to-tool space transformations." The Office alleges that Wei teaches such relying on pages 1-22, the abstract, and Figures 2-4. While Wei mentions a transformation, the cited passages do not appear to describe the various transformations or various reference frames recited in claim 46.

Claim 47 is indirectly dependent from claim 50 and further recites "providing the position and orientation of the object frame to the robot; and training an intended operation path inside the object frame." The Office alleges that Wei teaches such relying on Figure 4 and the abstract. As previously explained, Figure 4 illustrates stereoscopic images captured by a pair of cameras. The abstract discuss camera calibration and sensor to hand calibration (*e.g.*, camera to end effecter). The abstract further discusses supplying sensor data to a multilayer feed forward neural network to associate the direct transformation for the sensory data to required motions, which avoids the need for network retaining. There is no discussion of providing position and orientation of an object frame to the robot or of training an intended operation path inside the object frame, as opposed to any other possible reference frame. In fact, it appear that only small portions of motions M are provided to the robot, and without more, one can only assume that those are in a robot frame of reference.

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Claim 49 is dependent from claim 50 and further recites "adjusting a position of the movable portion of the robot if the number of features located in the captured image of the target object is determined to be an insufficient number of features; and capturing another two-dimensional image of the volume containing the target object before determining the object space-to-camera space transformation for the target object." The Office alleges that Wei teaches such relying on page 2, col. 1, and Figure 2-4. Applicant's attorney has carefully reviewed the cited passage, and cannot find any reference to features or to the number of located features, let alone adjusting a position in response to the number of features being insufficient or capturing an additional image in response to the same.

Claim 51 is dependent from claim 50 and further recites "determining at least one movement of the robot that orients the camera orthogonally with respect to the target object based at least on part on the object space-to-camera space transformation." The Office alleges that such is taught by Figure 4 of Wei. However, Figure 4 illustrates stereo images which appear to have a random orientation with respect to the workpiece. There is nothing in Figure 4 that would suggest an orthogonal orientation between the camera and the workpiece.

Claim 52 is dependent from claim 50 and further recites "determining a position of the object frame in the tool space reference frame; and providing an object frame to the robot." The Office alleges that such is taught by Wei, relying on page 2, col. 1, and Figures 3 and 4. While Figure shows an image of an object, such is not the same as the recited "object frame" not the recited "providing an object frame to the robot." Likewise, while Figure 3 shows an end effecter portion of a robot, such is not the same as the recited "providing an object frame to the robot." In column 1 of page 2, Wei discusses training a neural network and dealing with inexactness of mapping. According to the cited passage, only a small portion of M_1 is sent to the robot, where M_1 is an amount of motion of the robot hand with respect to the reference position and the sensory data which was recorded after each motion. Wei, page 2, col. 1. Thus, there is no basis to allege that Wei teaches "determining a position of the object frame in the tool space reference frame; and providing an object frame to the robot" as recited by claim 52.

Claim 53 is independent and recites, *inter alia,* "a single camera operable to capture a number of images of a calibration object" "determining an object space-to-camera

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space transformation based at least in part on a position of at least some of the located features in solely the captured image using an algorithm that employs a known or determinable physical relationship between at least some of the located features." The Office alleges that Wei teaches such. As previously explained, Wei is clearly teaches the use of two cameras to produce stereo images. Thus, Wei is inapposite with respect to the single camera approach recited in claim 53.

Claim 54 is dependent from claim 53 and further recites, *inter alia,* "determining a set of object space coordinates for each of the selected features from the captured image of the teaching object" and "determining an object space-to-camera space transformation defining a transformation between an object space reference frame and the camera space reference frame." The cited passage of Wei (*i.e.*, page 2, col. 1) does not each such. The cited passage at most teaches sending only a small portion of M_1 to the robot, where M_1 is an amount of motion of the robot hand with respect to the reference position and the sensory data which was recorded after each motion. Wei, page 2, col. 1.

Claim 57 is dependent from claim 53 and further recites "adjusting a position of the movable portion of the robot if the number of features located in the captured image of the target object is determined to be an insufficient number of features." The Office alleges such is taught is page 2, col. 1 of Wei. Applicant's attorney has carefully reviewed the cited passage, and cannot find any reference to features or to the number of located features, let alone adjusting a position in response to the number of features being insufficient.

Claim 58 is independent recites, *inter alia*, "a single camera operable to capture a number of images of a calibration object;" and "determining an object space-to-camera space transformation based at least in part on a position of at least some of the located features using the captured image without any additional captured images and an algorithm that employs a known or determinable physical relationship between at least some of the located features."

As previously explained, Wei is clearly teaches the use of two cameras to produce stereo images. Thus, Wei is inapposite with respect to the single camera approach recited in claim 58.

Claim 61 is dependent from claim 58 and further recites "adjusting a position of the movable portion of the robot if the number of features located in the captured image of the

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target object is determined to be an insufficient number of features." The Office alleges such is taught is page 2, col. 1 of Wei. Applicant's attorney has carefully reviewed the cited passage, and cannot find any reference to features or to the number of located features, let alone adjusting a position in response to the number of features being insufficient.

Conclusion

Applicants respectfully submit that the pending claims are in condition for allowance. Any remarks in support of patentability of one claim should not be imputed to any other claim, even if similar terminology is used. Any remarks referring to only a portion of a claim should not be understood to base patentability on that portion; rather, patentability must rest on each claim taken as a whole. A number of clarifying amendments have also been made to the above claim set. Applicants do not acquiesce to each of the Examiner's rejections and to each of the Examiner's assertions regarding what the cited references show or teach, even if not expressly discussed herein. Although changes to the claims have been made, no acquiescence or estoppel is or should be implied thereby; such amendments are made only to expedite prosecution of the present application and are without prejudice to the presentation or assertion, in the future, of claims relating to the same or similar subject matter.

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If the undersigned attorney has overlooked a relevant teaching in any of the references, the Examiner is requested to point out specifically where such teaching may be found. In light of the above amendments and remarks, Applicants respectfully submit that all pending claims are allowable. Applicants, therefore, respectfully request that the Examiner reconsider this application and timely allow all pending claims. The Examiner is encouraged to contact the undersigned by telephone to discuss the above and any other distinctions between the claims and the applied references, if desired. If the Examiner notes any informalities in the claims, the Examiner is encouraged to contact the undersigned by telephone to expediently correct such informalities.

Respectfully submitted,

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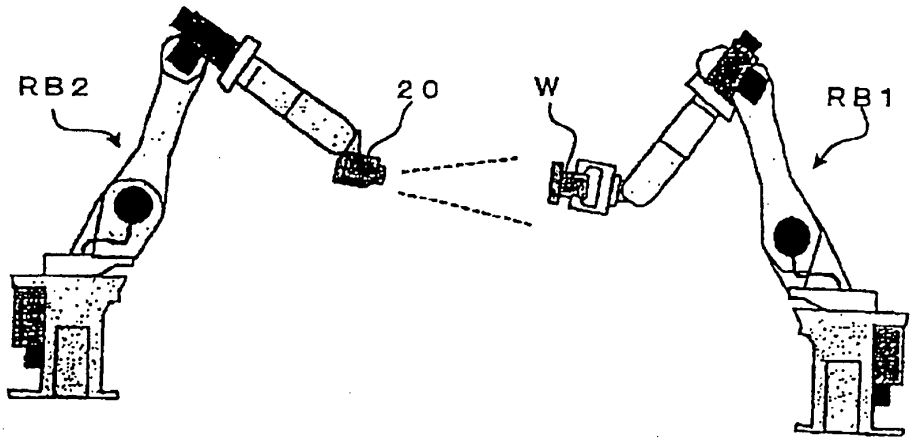
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(54) Teaching model generating device

(57) A workpiece W serving as an object for detection is fixed in place. A camera 20 is mounted to the end of a robot RB. The camera is turned about an axis, which passes through the center position of the workpiece W and is perpendicular to the optical axis of the camera, to take an image of the workpiece W at a plurality of positions in different directions. A teaching model is generated on the basis of each produced image data. The relative position and posture of the workpiece to the camera 20 is also stored in association with the teaching model. Thus, it is possible to easily generate the teaching model of the workpiece regardless of three-dimensional variations in posture.

FIG. 3



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Description

[0001] This invention relates to a device for generating a teaching model applied to a method of detecting the position and posture of an object through pattern matching. More particularly the present invention relates to a device for generating a teaching model for making it possible to detect an object regardless of three-dimensional variations in position and posture of the object for detection.

[0002] with a well-known method and device for detecting the position and posture of an object set on a plane by storing a two-dimensional image of the object for detection is stored as a teaching model, prior to pattern matching of the teaching model with image data produced by taking an image of the object with an image pickup means such as a camera. The above method and device for detecting the object is applied to conveying or like jobs, of machine parts and articles or like workpieces grasped with a robot, to a predetermined position in an automatic mode.

[0003] However, picking-out of an individual workpiece from a pile of disordered same-shaped workpieces or a set of same-shaped workpieces housed within a predetermined range in any three-dimensionally different position and posture is not suited for the robot, and therefore, requires manual operation. In the case of allowing the robot to pick out such an individual workpiece, there is the need for the manual operation of picking out the workpieces one by one from the pile of disordered workpieces for reoriented alignment such that the robot may pick out the individual workpiece directly.

[0004] For allowing the robot to grasp each workpiece for picking out from a large number of same-shaped workpieces piled up disorderly or housed within the predetermined range in any three-dimensionally different position and posture, it is necessary for the robot to recognize the position and posture (direction) of each of the above workpieces.

[0005] In this connection, a device for detecting the three-dimensional position and posture (direction) of the individual workpiece among the workpieces has been developed. This device performs the following operations.

(1) To produce image data in advance by taking an image of one of same-shaped workpieces for detection with a camera from different directions

(2) To store a plurality of teaching models based on the produced image data, together with the relative position and posture of each teaching model to the workpiece

(3) To select a teaching model of a high matching value by carrying out pattern matching of each teaching model with image data produced by taking an image of the piled same-shaped workpieces with the camera

(4) For this selected teaching model, to detect the position and posture (direction) of the target workpiece for detection to the selected teaching model on the basis of the relative position and posture of each teaching model to the workpiece, stored in the above operation (2).

[0006] The above device requires a plurality of teaching models generated by taking the image of the workpiece from the plurality of directions as shown in the above operation (1).

[0007] It is an object of the present invention to provide a device for generating a teaching model applied to an image processing device for detecting the three-dimensional position and posture of an object.

[0008] The present invention relates to a teaching model generating device for image processing, in which an object or an article having the same shape as that of the object is selected as a reference object, and three-dimensional position and/or posture of the object is recognized by carrying out matching processing of a plurality of teaching models, which were generated and stored in advance on the basis of the respective image data produced by taking the image of the reference object from a plurality of directions, with the image data including the object.

[0009] According to the first mode of the invention, one of the reference object and the image pickup means is fixed in place, while the other is fixed to a movable part of a robot or is grasped with a hand of the robot, and the robot is operated for positioning to a plurality of image pickup positions where direction of the optical axis of the image pickup means with respect to the reference object is different from one another respectively so that the image data respectively obtained at each of the image pickup positions is stored as a teaching model.

[0010] According to the second mode of the invention, the reference object is fixed to a movable part of a first robot or is grasped with a hand of the first robot, and an image pickup means is fixed to a movable part a second robot or is grasped with a hand of the second robot, and any one of or both of these first and second robots is operated for positioning to a plurality of image pickup positions where direction of the optical axis of the image pickup means with respect to the reference object is different from one another respectively, so that the image data respectively obtained at each of said image pickup positions is stored as a teaching model.

[0011] Preferably, the teaching model is a part of the image data of the reference object.

[0012] Preferably, the teaching model is composed of data obtained by performing a image processing on the image data of the reference object.

[0013] Preferably, the teaching model is generated for every direction in which the image pickup means took the image of the reference object and the teaching model is stored in association with the information on the direction.

[0014] Preferably, the image pickup means is a cam-

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era.

[0015] Preferably the image pickup means is a three dimensional visual sensor whose image pickup means measures the distance between the image pickup means and a plurality of points on the object.

[0016] According to the present invention, the robot may be used to simply generate teaching models which are applied to an image processing device or the like for detecting the position and posture of an object through identification of the object regardless of three -dimensional variation in position and posture of the object.

[0017] For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Fig. 1 is view for explaining the outline of a first embodiment according to the present invention;
Fig. 2 is a view for explaining the outline of a second embodiment according to the present invention;
Fig. 3 is a view for explaining the outline of a third embodiment according to the present invention;
Fig. 4 is a view showing teaching models in each of the above embodiments;
Fig. 5 is a block diagram showing an essential part of a robot controller in each of the above embodiments;
Fig. 6 is a block diagram showing an essential part of an image processing device in each of the above embodiments;
Fig. 7 is a flow chart showing the procedure to generate teaching models in the first embodiment;
Fig. 8 is a flow chart showing the procedure to generate teaching models in the second embodiment:
Fig. 9 is a flow chart showing the procedure to generate teaching models in the third embodiment;
Fig. 10 is a flow chart showing the procedure of picking job:
Fig. 11 is a view for explaining the operation of a visual sensor for measurement of distance data for use in the embodiments according to the present invention;
Fig. 12 is a view for explaining two-dimensional array data composed of distance data as image data produced by the above visual sensor for measurement of distance data; and
Fig. 13 is a flow chart showing the procedure to produce two-dimensional array data as the above image data.

[0018] A teaching model generating device configured by a robot system will be described below as an embodiment according to the present invention.

[0019] Fig. 1 is a schematic view showing the first embodiment for generation of a teaching model according to the present invention. As shown in Fig. 1, a workpiece W is fixed in place to take an image of the workpiece W from a plurality of directions with an image pickup device 20 grasped with a hand of a robot RB (or fixed to a movable part of the robot RB). A teaching model of an object (the workpiece W) is generated on the basis of image data produced by taking the image of the workpiece. For instance, four teaching models are respectively generated on the basis of four image data produced by taking the image of the workpiece W from four directions as shown in Fig. 4.

[0020] Fig. 5 is a block diagram showing an essential part of a controller of the robot RB in the present embodiment, and this controller has the same configuration as a robot controller in the prior art.

[0021] As shown in Fig. 5, connected to a bus designated by reference numeral 8 are a main processor (which will be hereinafter simply referred to as a processor) 1, a memory 2 composed of a RAM, a ROM and a non-volatile memory (EEPROM or the like), a teaching operation panel interface 3, an external device interface 6, a communication interface 7 for communication with an image processing device and a servo control unit 5. A teaching operation panel 4 is connected to the teaching operation panel interface 3.

[0022] A system program for supporting basic functions of the robot and the robot controller is stored in the ROM of the memory 2. An operation program and its related set data of the robot taught according to an application are stored in the non-volatile memory of the memory 2. The RAM of the memory 2 is used for a storage area for temporary storage of data in various processing executed by the processor 1.

[0023] The servo control unit 5 is equipped with servo controllers 5a1 to 5an (n being a number resulting from adding the number of movable axes of a tool mounted to a robot wrist to the total number of robot axes). Each servo controller is composed of a processor, a ROM and a RAM or the like to perform loop control of position and speed of a servo motor for driving each axis and also loop control of current. This servo controller constitutes a digital servo controller performing loop control of position, speed and current in software.

[0024] Output from the servo controllers 5a1 to 5an is provided through servo amplifiers 5b1 to 5bn to axis servo motors M1 to Mn to control the drive of these servo motors. Incidentally, although not shown, a position/speed detector is mounted to each of the servo motors M1 to Mn to detect the position and speed of each servo motor, and the detected position and speed are allowed to be fed back to the servo controllers 5a1 to 5an.

[0025] The input/output interface 6 is connected to sensors mounted to the robot, together with actuators and sensors of the peripheral equipment.

[0026] Fig. 6 is a block diagram showing an image processing device 30 connected to an interface of the robot controller. The image processing device 30 has a processor 31, and the processor 31 is connected through a bus 40 to a ROM 32 for storage of a system program or the like executed by the processor 31, an image processor 33, an image pickup device interface

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34 connected to the image pickup device, an MDI 35 with display such as a CRT and a liquid crystal display for input and output of various commands and data, an image memory 36, a non-volatile memory 37, a RAM 38 for temporary storage and so on of data and a communication interface 39 connected to the robot controller 10.

[0027] An image produced by the image pickup device 20 is stored in the image memory 26. The image processor 33 conducts processing of the image stored in the image memory according to a command from the processor 31 to recognize the object. The image processing device 30 is similar in configuration and function to an image processing device in the prior art. However, according to the present invention, the image processing device 30 is characterized in that teaching models (described later) are stored in the non-volatile memory 37, and pattern matching is carried out by using the stored teaching models, for the image data of the pile of workpieces photographed by the image pickup device 20 to obtain three-dimensional position and posture of the workpiece.

[0028] As will be described later, the image pickup device 20 is to produce the image data, and a CCD camera for producing a two-dimensional image or a visual sensor permitting the measurement of distance data is available for the image pickup device 20. The CCD camera produces the image data from the two-dimensional image according to a conventionally known method, while the visual sensor for measurement of distance data is to produce, as image data, two-dimensional array data composed of distance data representing the distance between the sensor and the object. Since a three-dimensional visual sensor of spotlight scan type or the like disclosed in Japanese Patent Application Laid-open No. 7-270137 is well known as the visual sensor for measurement of distance data, a description will now be given of the three-dimensional visual sensor briefly.

[0029] The three-dimensional visual sensor is adapted for measuring the position of a beam spot irradiated onto the object with two scanners in arbitrary directions (X- and Y-directions) by using a detector (PSD) of position detection type. Thus, this three-dimensional visual sensor is effective in finding the three-dimensional position of the object irradiated with the beam by calculation on the basis of mirror deflection angles θx, θy of two scanners together with a light detecting position on the PSD.

[0030] A description will now be simply given of a method of producing, as image data, two-dimensional array data composed of distance data with this three-dimensional visual sensor with reference to Figs. 11 to 13.

[0031] The range of scan over the object (the range of measurement) is determined in advance, and in this state, the three-dimensional visual sensor makes measurement of the three-dimensional position in each point on the X-Y plane in the predetermined range of scan to find the distance Z (i, j) in each point (i, j) between the sensor and the point of the beam irradiated onto the object in the manner of making a scan over the object in sequence of points (1, 1) to (1, n), (2, 1) to (2, n), ... (m, 1) to (m, n) on the above X-Y plane under discrete control of the mirror deflection angles θx, θy of the scanners, as shown in Fig. 11. Then, this distance data Z (i, j) is stored in the RAM 38 of the image processing device 30.

[0032] With the above operation, the three-dimensional visual sensor may produce, as image data, the two-dimensional array data composed of the distance data Z (i, j) between the sensor and the point of the beam irradiated onto the object, as shown in Fig. 12.

[0033] Fig. 13 is a flow chart showing the processing performed by the processor 31of the image processing device 30 to produce the image data.

[0034] Firstly, indexes i, j are set at "1" (Step 500) to issue a command to irradiate to the sensor 20, together with commanded mirror deflection angles θx, θy corresponding to the start points y1, x1 (the point (1, 1) in Fig. 11) in the predetermined range of measurement (Steps 501 to 503). The sensor 20 irradiates optical beams after the mirrors are set at these deflection angles. Then, the sensor 20 outputs a signal produced by the PSD to the image processing device 30.

[0035] The processor 31 of the image processing device 30 calculates the position of a beam spot formed on the object on the basis of the signal from the PSD and the commanded mirror deflection angles θx, θy to find the distance Z (i, j) between the sensor and the beam spot position, and then stores the distance data in the RAM 28 as two-dimensional array data [i, j] (Steps 504 and 505). Instead of the processor 31, the sensor 20 may be applied to calculation of finding the position of the beam spot formed on the object and also that of finding the distance Z (i, j) on the basis of the above beam spot position.

[0036] Subsequently the processor 31 increments the index i by "1" to increase the mirror deflection angle θx in X-axial scanning by a predetermined amount Δx (Steps 506, 507), and decides whether or not the index i exceeds a set value n (Step 508). If not exceeding, the processing is returned to Step 503 to find the distance Z (i, j) in the next point by repeating the processing in Steps 503 to 508. Subsequently, the processing in Steps 503 to 508 is executed for finding and storing the distance Z (i, j) at each point from (1, 1) to (1, n) in Fig. 11 until the index i exceeds the set value n.

[0037] When it is decided in Step 508 that the index i exceeds the set value n, the processor 31 sets the index i at "1", and increments the index j by "1" to increase the mirror deflection angle θy in Y-axial scanning by a predetermined amount Δy (Steps 509 to 511). Subsequently, the processor 31 decides whether or not the index j exceeds a set value m (Step 512). If not exceeding, the processing is returned to Step 502 to repeat the processing in Steps 502 to 512.

[0038] As described above, the processing in Steps

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502 to 512 is performed repeatedly until the index j exceeds the set value m. The measurement of all the points in the range of measurement (the range of scan) shown in Fig. 11 is considered to be finished as of the time when the index j exceeds the set value m. Then, the distance data Z (1, 1) to Z (m, n) serving as the two-dimensional array data is stored in the RAM 28, resulting in the completion of the processing to produce the image data.

[0039] The above processing is applied to produce the two-dimensional array data as the image data with the visual sensor for measurement of distance data.

[0040] The two-dimensional array data produced as described above may be used as the image data to generate teaching models. However, for simplification, a description will now be given of the procedure to generate teaching models on the basis of the image data produced by taking in the image of the object with the CCD camera 20 serving as an image pickup device for taking in image data.

[0041] A description will be given of the procedure to generate teaching models by using the teaching model generating device according to the present embodiment configured by the robot controller 10 and the image processing device 30 with reference to the flow chart shown in Fig. 7.

[0042] An operator sets a work coordinate system as to the workpiece fixed in place in the robot controller 10 through the teaching operation panel 4. The work coordinate system is stored in the robot controller (Step 100). In this place, the meaning of setting of the work coordinate system is that a coordinate transformation matrix of the work coordinate system as seen from a world coordinate system provided in the robot is set in the robot controller.

[0043] Then, calibration of the camera mounted to the robot wrist is performed and camera mounting position and posture based on the center of the flange surface of the robot wrist is set in the robot control device 10. As a result, a camera coordinate system is set in the robot (Step 101).

[0044] Then, for specifying the first (0th) position and posture of the camera mounted to the end of the robot wrist for the image-taking operation with respect to the workpiece W and subsequent positions and postures, a turning axis and a turning angle for turning the camera from the first position and posture is set, and also the number N of positions and postures which the camera assumes for the image-taking operation is set (Step 103).

[0045] For instance, four teaching models are generated on the basis of four image data produced by taking the image of the workpiece W from four directions (N=4) as shown in Fig. 4.

[0046] Fig. 4(a) shows a first teaching model generated through the image-taking operation with the camera in the 0th position and posture. The first teaching model is generated on the basis of the image data produced by taking the image of the top of the workpiece W with the camera from the Z-axis direction of the world coordinate system.

[0047] Subsequently, the robot is operated to turn the camera by a certain angle about an axis, which passes through a specific point (an origin of the work coordinate system) on the workpiece W and is perpendicular to the center axis of the camera, to the first position and posture for the image-taking operation. Incidentally when the Z-axis of the world coordinate system is set to be parallel to the center axis of the camera in the first (0th) position and posture, the first position and posture next to the 0th position and posture for the image-taking operation assume to be the position and posture provided by turning the camera by a certain angle (for instance, 30 degrees) about an axis parallel to the axis (for instance, the X-axis) perpendicular to the Z-axial direction as shown in Fig. 4(b). Then, the second teaching model is generated on the basis of the image data (see Fig. 4 (b)) produced by taking the image of the workpiece W with the camera in the above first position and posture.

[0048] Thereafter, in the same way the camera is caused to turn by 60 and 90 degrees respectively from the position shown in Fig. 4(a) about the axis, which passes through the specific point on the workpiece and is parallel to the X-axis, to the second and third positions and postures for the image-taking operation to take the image of the workpiece W respectively. Then, the third and fourth teaching models are generated on the basis of the image data (see Figs. 4(c) and 4(d)) obtained from the images the camera took at the respective positions and postures.

[0049] In this place, a description will be given of one example of generating four teaching models in the above manner with respect to the workpiece serving as the object and application of these models. Incidentally in the above embodiment, camera is caused to turn by 0, 30, 60 and 90 degrees about the workpiece serving as the object to generate four teaching models by taking the image of the workpiece with the camera from the respective positions. Alternatively, if the turning angle of the robot to turn the camera is set at a smaller pitch for generation of more teaching models, it is possible to detect the three-dimensional position and posture of the workpiece with higher accuracy.

[0050] As described above, the position and posture of the robot where the first (0th) image-taking operation is performed with the camera 20 mounted to the end of the robot wrist are taught together with the axis serving as the center axis of turning and the turning angle, and the number N of positions and postures for the image-taking operation is set. For easy understanding, it is assumed that the position in which the center axis of the camera is parallel to the Z-axis of the world coordinate system and which has the same coordinate values of the X- and Y-axes, other than the Z-axis, on the world coordinate system as those of the workpiece W put in predetermined position and posture is taught as the po-

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sition and posture for generating the 0th teaching model. Further, the positions turned by 30, 60 and 90 degrees about the axis, which passes through the position of the workpiece W and is parallel to the X-axis of the world coordinate system, are set as the first, second and third positions and postures for the image-taking operation. It is also assumed that the number N of positions for the image-taking operation is set at "4".

[0051] When a command to generate the teaching model is supplied through the teaching operation panel 4, the processor 1 of the robot controller 10 initializes a counter M for counting the image-taking times to "0" (Step 103), and outputs a command to take the image with the camera to the image processing device 30 after operating the robot to move the camera to the Mth (=0) position and posture (Step 104). The image processing device 30, in response to the above command, causes the camera to take the image of the workpiece W and stores the image data in the image memory 36. In addition to the above operation, the image processing device 30 generates the Mth teaching model on the basis of the image data and stores the generated Mth teaching model in the non-volatile memory 37 (Step 105),

[0052] Further, the image processing device 30 calculates the position and posture of the work coordinate system as a coordinate transformation matrix as seen from the camera coordinate system to find the relative position and posture of the camera to the workpiece, and then stores the found relative position and posture in the non-volatile memory 37 as the relative position and posture of the Mth teaching model and outputs a data acquisition signal to the robot controller (Step 106). For instance, the above relative position and posture are stored in the form of [x0, y0, z0, α0, β0, γ0,] c as the position and posture of the camera coordinate system, where α, β and γ represent the turning angles about the X-, Y- and Z-axes, respectively and "C" represents the camera coordinate system.

[0053] Subsequently, the processor 1 of the robot controller 10 increments the counter M by "1" in response to the data acquisition signal (Step 107), and decides whether or not the value of the counter M is smaller than the set value N (=4) (Step 108). When the counter value is smaller than the set value, the processing is returned to Step 104 to move the robot to the Mth position and posture. That is, in the above embodiment shown in Fig. 4, the cam is caused to turn by 30 degrees about the axis, which passes through the position of the workpiece and is parallel to the X-axis of the world coordinate system, to store the teaching model and the relative position and posture of the camera to the workpiece at that time.

[0054] In the following operation, the processing in Steps 104 to 108 is executed for storing the generated teaching model and the relative position and posture of the camera to the workpiece in the non-volatile memory until the value of the counter M reaches the set value N (=4). In the above example, the teaching models to be stored are those produced from the image of Figs. 4(a) to 4(d). For the above four teaching models, the relative position and posture of the camera to the workpiece are stored in the form of [x0, y0, z0, α0, β0, γ0]c, [x1, y1, z1, α1, β1, γ1]c, [x2, y2, z2, α2, β2, γ2]c and [x3, y3, z3, 3α, β3, γ3]c as the positions and postures of the workpiece W of the camera coordinate system.

[0055] With the above operation, the teaching model and the relative position of the camera to the workpiece are stored in the non-volatile memory 37 of the image processing device 30.

[0056] Fig. 2 is a schematic view showing the second embodiment according to the present invention. The second embodiment is different from the first embodiment shown in Fig. 1 in that the camera 20 is fixed in place, and the workpiece W serving as the object is grasped with the hand mounted to the end of the robot wrist or is fixed to the movable part of the robot for generation and storage of the teaching modeL The robot controller 10 and the image processing device 30 in the second embodiment are similar in configuration to those in the first embodiment, except for the processing for generation of the teaching modeL Fig. 8 shows the flow of the procedure to generate the teaching modeL

[0057] After calibration of the camera 20 fixed in place, the camera coordinate system is set in the robot controller 10 and stored in the memory 2 (Step 200). Accordingly, the coordinate transformation matrix of the camera coordinate system as seen from the world coordinate system may be produced.

[0058] Then, the operator sets, in the robot controller 10, the position and posture of the robot wrist, as seen from the center of the flange surface of the robot wrist in the coordinate system (the work coordinate system) supposed on the workpiece grasped with the robot hand (or fixed to the movable part of the robot) are measured and the measured data is set in the robot controller 10 and stored in the memory 2. As a result, the robot is allowed to recognize the position and posture in the coordinate system (the work coordinate system) supposed on the workpiece when the robot is at any position.

[0059] Then, similarly to the first embodiment, the operator sets the first (0th) position and posture of the workpiece W grasped with the robot hand for the image-taking operation with the camera 20 fixed in place, together with the turning axis and turning angle of the robot to turn the workpiece with respect to the camera 20 fixed in place from the first position and posture in order to specify the positions and postures for the subsequent image-taking operations (Step 202).

[0060] The positions and postures resulting from turning the workpiece grasped with the robot hand by 30, 60 and 90 degrees about the axis passing through the camera 20 and being parallel to the X-axis of the work coordinate system are set as the first, second and third positions for the image-taking operation in the similar manner to the first embodiment. As long as the number N of positions for the image-taking operation is set at

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"4", it is possible to generate the similar teaching models to the first embodiment as shown in Fig. 4.

[0061] When a command to generate the teaching model is supplied through the teaching operation panel 4, the processor 1 of the robot controller 10 initializes the counter M to "0", operates the robot so that the workpiece W moves to the Mth (=0) position and posture and issues a command to take the image with the camera 20 to the image processing device 30 (Steps 203, 204).

[0062] The image processing device 30 takes the image of the workpiece W with the camera in response to the above command and generates the Mth teaching model on the basis of the image data produced from the image, and stores the generated teaching models in the non-volatile memory 37. Further, the image processing device 30 calculates the position and posture of the coordinate system (the work coordinate system) supposed on the workpiece as the coordinate transformation matrix as seen from the camera coordinate system, stores the calculated position and posture in the non-volatile memory 37 as the Mth teaching model for the relative position and posture of the camera to the workpiece and outputs a data acquisition signal to the robot controller (Steps 204 to 206).

[0063] The processor 1 of the robot controller 1 increments the counter M by "1" in response to the data acquisition signal (Step 207), and decides whether or not the value of the counter M is smaller than the set value N (=4). When the value of the counter M is smaller than the set value N, the processing is returned to Step 204 to move the robot to the Mth position and posture.

[0064] In the following operation, the processing in Steps 204 to 208 is executed for storing the teaching model and the relative position and posture of the camera to the workpiece in the non-volatile memory 37 in the same way as in the first embodiment until the value of the counter M reaches the set value N (=4).

[0065] Fig. 3 is a schematic view showing the third embodiment according to the present invention. According to the third embodiment, both the workpiece and the camera are respectively fixed to the movable parts of the robots or are grasped with the hands thereof for generation of the teaching model. The robot controllers of robots RB1, RB2 in the third embodiment are substantially similar in configuration to that shown in Fig. 5, except that two robot controllers are connected together through the communication interface and that the image processing device 30 is connected to only the second robot controller. The image processing device 30 is also similar in configuration to that shown in Fig. 6.

[0066] The workpiece W serving as the object is grasped with the hand of the first robot RB1 and the camera 20 is mounted to the wrist of the second robot RB2. The position and posture of the second robot RB2 in the world coordinate system as seen from the world coordinate system of the first robot RB1 is measured to find the coordinate transformation matrix (A), which is then stored in the first robot controller (Step 300).

[0067] Further, the coordinate transformation matrix (B) of the position and posture of the coordinate system (the work coordinate system) supposed on the workpiece W grasped with the hand of the first robot RB1, as seen from the center of the flange surface of the robot wrist, are set and stored in the robot controller of the first robot RB1 (Step 301). Calibration of the camera 20 mounted to the wrist of the second robot RB2 is performed and the transformation matrix (C) from the center of the flange surface of the second robot wrist to the camera coordinate system is set and stored in the robot controller of the first robot RB1 (Step 302).

[0068] Further, like the first and second embodiments, the position and posture of each of the first and second robots are set in each of the robot controllers such that the camera 20 and the workpiece W of which image the camera 20 first takes to assume the first (0th) relative position and posture for the image-taking operation. Subsequently the first, second,... and ith positions and postures for the image-taking operation are set together with the number N of positions and postures for the image-taking operation. According to the third embodiment, the relative position and posture of the camera to the workpiece are set by turning any one or both of the camera and the workpiece by a predetermined turning angle relatively to each other in a manner such that the second robot RB2 mounted with the camera is operated to turn the camera relatively to the workpiece W without shifting the position and posture of the first robot RB1 grasping the workpiece W from the first position and posture, or that the first robot RB1 is operated to turn the workpiece W while the camera 20 is fixed in place without shifting the position and posture of the second robot RB2.

[0069] Further, the turning axis of each of the robots is set to be an axis which is orthogonal to the center axis of the camera 20 parallel to an axis of each world coordinate system and also passes through the center position (the origin of the camera coordinate system or the origin of the work coordinate system) of the other party. For instance, in the embodiment shown in Fig. 3, the angles the workpiece W or camera 20 turns about Z axis (vertical axis) of each of the world coordinate system which passes through the camera 20 or the workpiece W is set. For simple setting of the turning axis and turning angle, one of the workpiece W and the camera 20 is turned with the other fixed in place. However, in the case where the robot operated for turning the workpiece or the camera is prevented from moving, the other robot for keeping the camera or the workpiece fixed is driven such that the camera and the workpiece assume the relative position and posture set in advance (Step 303).

[0070] When the command to generate the teaching model is supplied through the teaching operation panel 4 any of one of the robot controllers, the processor 1 of the robot controller 10 of each of the robots RB1,RB2 initializes the counter M to "0" operates the robot to move the workpiece W to the Mth (0th) position and pos-

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ture and issues a command to take the image with the camera 20 to the image processing device 30 (Steps 304, 305). The image processing device 30 takes the image of the workpiece W with the camera in response to the above command, generates the Mth teaching model on the basis of the image data produced from the image and stores the generated teaching model in the non-volatile memory 37 (Step 306).

[0071] Further, the position and posture of the coordinate system supposed on the workpiece W is obtained as the coordinate transformation matrix (D) as seen from the world coordinate system of the first robot, on the basis of the position and posture of the first robot as of the time of image-taking operation and also the coordinate transformation matrix (B) set in Step 301. In addition, the position and posture as seen from the camera coordinate system is obtained as the coordinate transformation matrix (E) as seen from the world coordinate system of the second robot, on the basis of the position and posture of the second robot and also the coordinate transformation matrix (C) set in Step 302 (Step 307). The position and posture supposed on the workpiece W is transformed into the coordinate transformation matrix (F) as seen from the camera coordinate system through the operation of the following expression (1) on the basis of the coordinate transformation matrices (D), (E) found as described above and also the coordinate transformation matrix (A) set in Step 300, and is stored as the Mth relative position and posture, and then the data acquisition signal is outputted to both the robot controllers.

$$(F) = (E)^{-1} (A)^{-1} (D) \qquad (1)$$

[0072] The processor 1 of each robot controller 10 increments the counter M by "1" in response to the data acquisition signal (Step 308), and decides whether or not the value of the counter M is smaller than the set value N (=4) (Step 309). When the value of the counter M is smaller than the set value, the processing is returned to Step 305 to move the robot to the Mth position and posture.

[0073] In the following operation, the processing in Steps 305 to 310 is executed for storing the teaching model and the relative position and posture of the camera 20 to the workpiece W in the non-volatile memory 37 in the same manner as in the above first and second embodiments until the value of the counter M reaches the set value N.

[0074] In addition to the above three kinds of embodiments for generation of the teaching models, a description will now be given of the application of the teaching models to the case of starting a picking job to pick out the individual workpiece from the pile of workpieces W, for instance.

[0075] The robot wrist is mounted with the camera together with the hand. When a command to pick a workpiece is supplied through the teaching operation panel or the like to the robot controller 10, the processor 1 starts the procedure of the picking job as shown in Fig. 10.

[0076] After operating the robot to move the camera mounted to the wrist of the taught robot to the image pickup position where the piled workpieces are in the field of vision of the camera, the processor 1 firstly outputs the three-dimensional position and posture of the camera on the world coordinate system to the image processing device 30 together with a command to take the image of the workpiece (Steps 400, 401).

[0077] The processor 31 of the image processing device 30 takes the image of the pile of workpiece in response to the image pickup command, data obtains the image data of several workpieces, and stores in the image memory 36 (Step 402).

[0078] Subsequently, the processor 31 detects a workpiece by performing pattern matching by using one (the 0th teaching model) of the teaching models stored in the non-volatile memory 37 (Step 403). In the above pattern matching, variations in position, turning and scale of the image of the workpieces are detected. Then, the processor 31 decides whether or not the detected workpiece has a matching value of not less than a reference value (Step 404). When the workpiece having the matching value of not less than the reference value is not found, the processor 31 further decides whether or not the pattern matching was completed for all the teaching models (the 0th to 3rd teaching models) (Step 405). If not completed yet, the processor 31 makes the pattern matching of the image data with the other teaching model (Step 406).

[0079] When the image data of the workpiece having the matching value of not less than the certain reference value is detected through the pattern matching of the image data with any of the teaching models in Step 404, pattern matching of the detected image data of the workpiece is carried out with all the other teaching models. That is, the processor 31 carries out the pattern matching of the detected image data of the workpiece with all the stored teaching models (Step 407).

[0080] The processor 31 selects the teaching model of the highest matching value obtained by the above pattern matching to obtain the ultimate relative position and posture of the camera to the workpiece on the basis of the relative position and posture of the camera to the workpiece stored in association with the selected teaching model and also the amount of variations in position, turning and scale within the image in the pattern matching of the image data with respect to the selected teaching model.

[0081] Then, the processor 31 finds the position and posture of the workpiece on the world coordinate system on the basis of the above ultimate relative position and posture and also the position and posture of the camera in the world coordinate system sent through the processing in Step 401 and outputs the above found po-

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sition and posture. That is, since the relative position and posture of the workpiece to the camera is the position and posture of the workpiece as seen from the camera coordinate system, the position and posture of the detected workpiece on the work coordinate system may be found through operation of coordinate transformation on the basis of the data of the above position and posture and also the data of the position and posture of the camera in the world coordinate system (Step 409).

[0082] The robot controller 10 actuates the robot on the basis of the transmitted three-dimensional position and posture of the detected workpiece W, picks the detected workpiece and move the workpiece to a predetermined taught position in the manner similar to the prior art (Step 410). Then, the processing is returned to Step 402 to repeat the processing from Step 402.

[0083] When all the workpieces are picked from the pile of workpieces, a matching value of not less than the certain reference value can not be detected any more by conducting the pattern matching of the image data with all the teaching models in the processing in Steps 403 to 406, so that the picking job is finished.

Claims

1. A teaching model generating device for image processing, in which an object or an article having the same shape as that of the object is selected as a reference object, and three-dimensional position and/or posture of said object is recognized by carrying out matching processing of a plurality of teaching models, which were generated and stored in advance on the basis of the respective image data produced by taking the image of said reference object from a plurality of directions, with the image data including the object,

   wherein one of the reference object and the image pickup means is fixed in place, while the other is fixed to a movable part of a robot or is grasped with a hand of the robot, and said robot is operated for positioning to a plurality of image pickup positions where direction of the optical axis of said image pickup means with respect to the reference object is different from one another respectively, so that the image data respectively obtained at each of said image pickup positions is stored as a teaching modeL

2. A teaching model generating device for image processing, in which an object or an article having the same shape as that of the object is selected as a reference object, and three- dimensional position and/or posture of said object is recognized by carrying out matching processing of a plurality of teaching models, which were generated and stored in advance on the basis of the respective image data produced by taking the image of said reference object from a plurality of directions, with the image data including the object,

   wherein the reference object is fixed to a movable part of a first robot or is grasped with a hand of the first robot, and an image pickup means is fixed to a movable part a second robot or is grasped with a hand of the second robot, and any one of or both of said first and second robots is operated for positioning to a plurality of image pickup positions where direction of the optical axis of said image pickup means with respect to the reference object is different from one another respectively, so that the image data respectively obtained at each of said image pickup positions is stored as a teaching model.

3. A teaching model generating device according to claims 1 or 2, wherein said teaching model is a part of the image data of the reference object.

4. A teaching model generating device according to any preceding claim, wherein said teaching model is composed of data obtained by performing a image processing on the image data of the reference object.

5. A teaching model generating device according to any preceding claim, wherein said teaching model is generated for every direction in which said image pickup means took the image of said reference object and said teaching model is stored in association with the information on the direction.

6. A teaching model generating device according to any preceding claim, wherein said image pickup means is a camera.

7. A teaching model generating device according to any preceding claim, wherein said image pickup means is a three-dimensional visual sensor whose image pickup means measures the distance between the image pickup means and a plurality of points on the object.

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FIG. 1

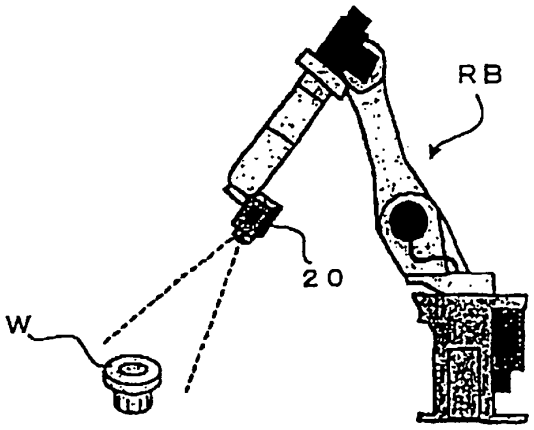


FIG. 2

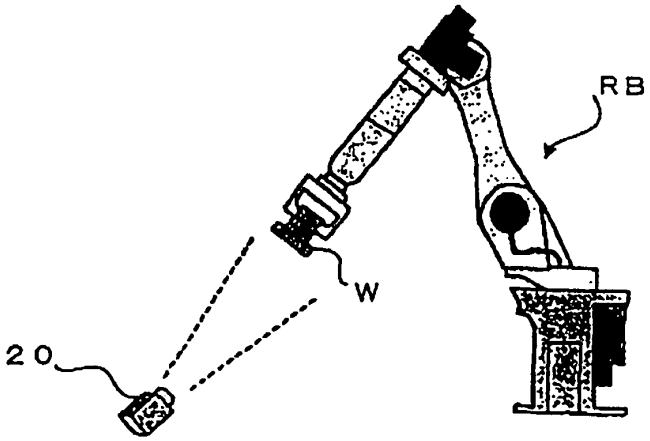


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FIG. 3

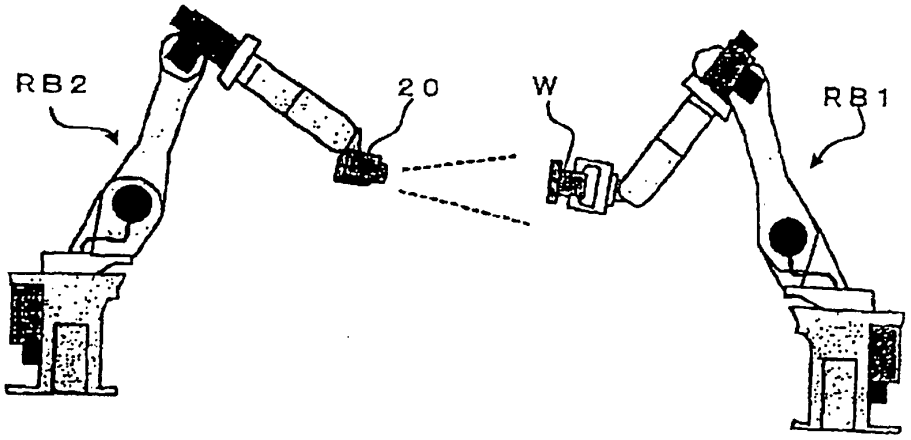


FIG. 4

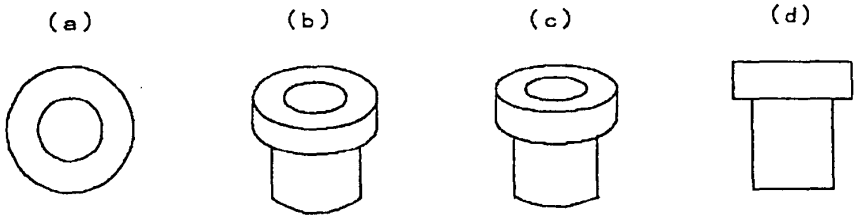


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FIG. 5

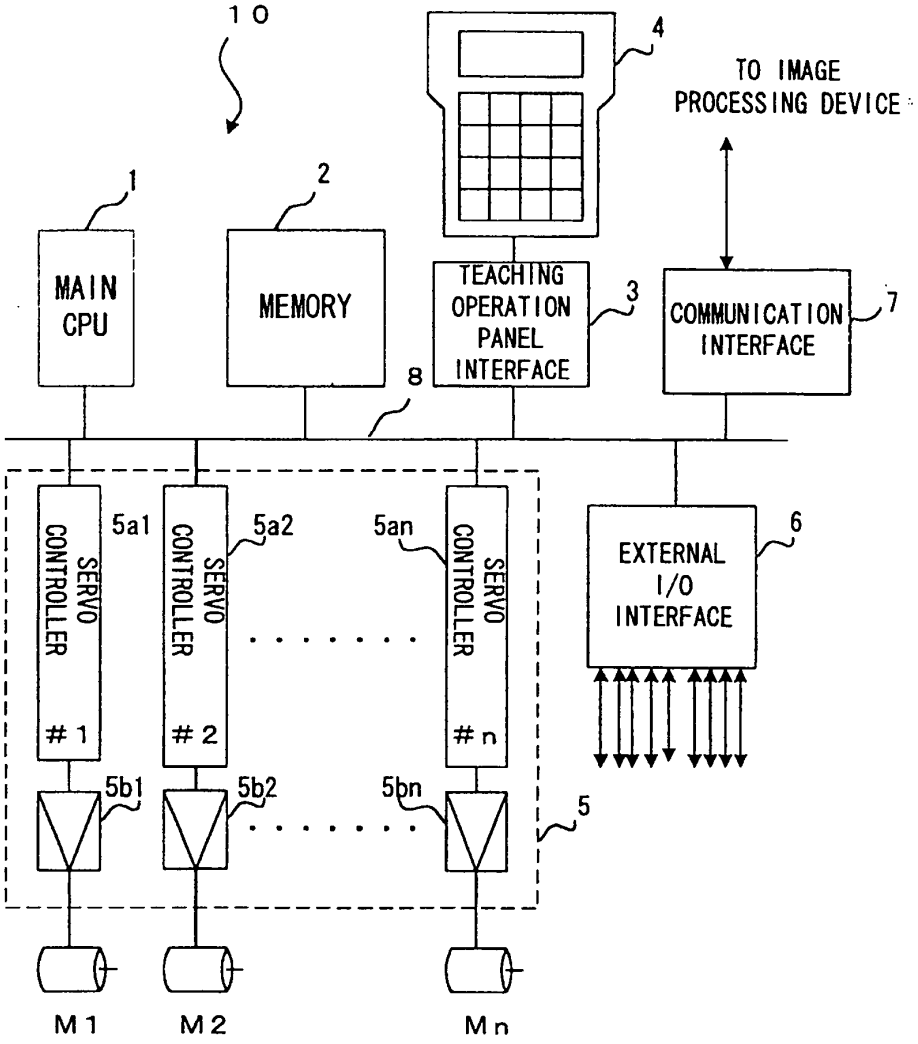


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FIG. 6

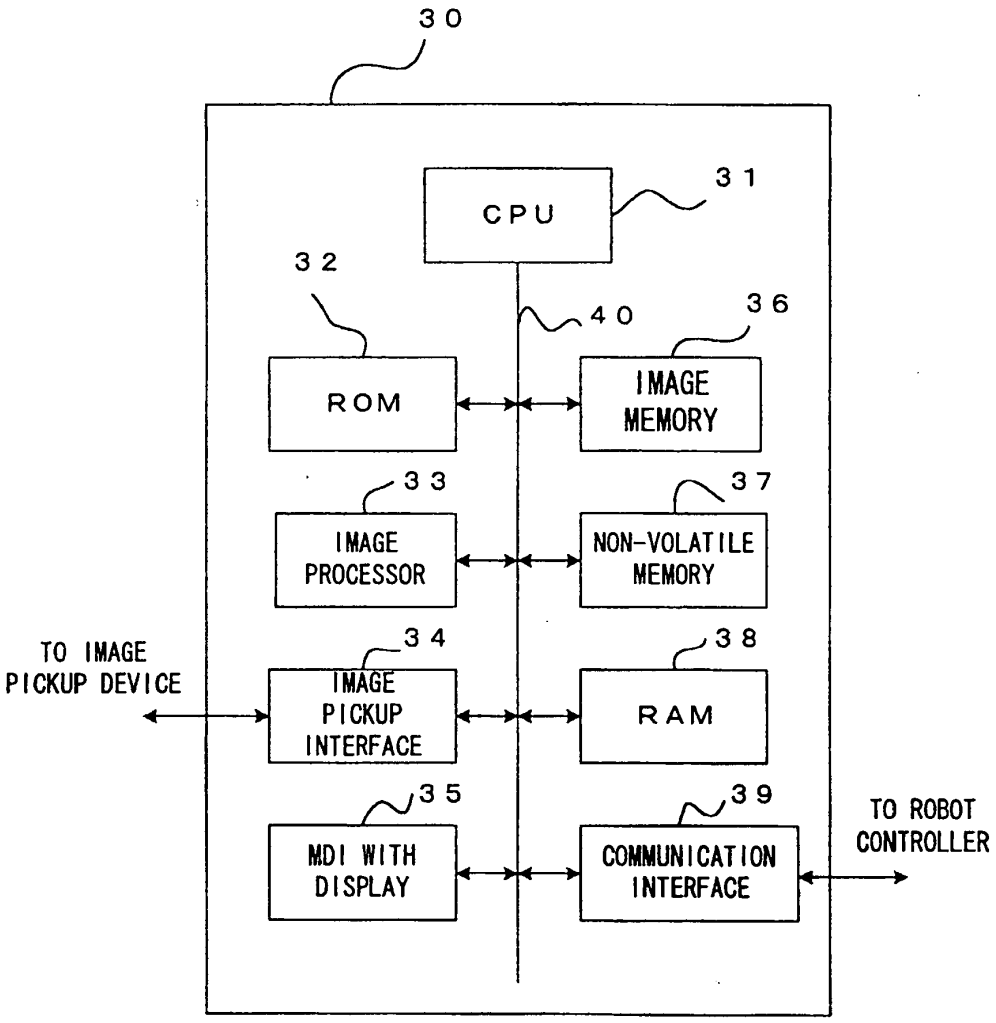


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FIG. 7

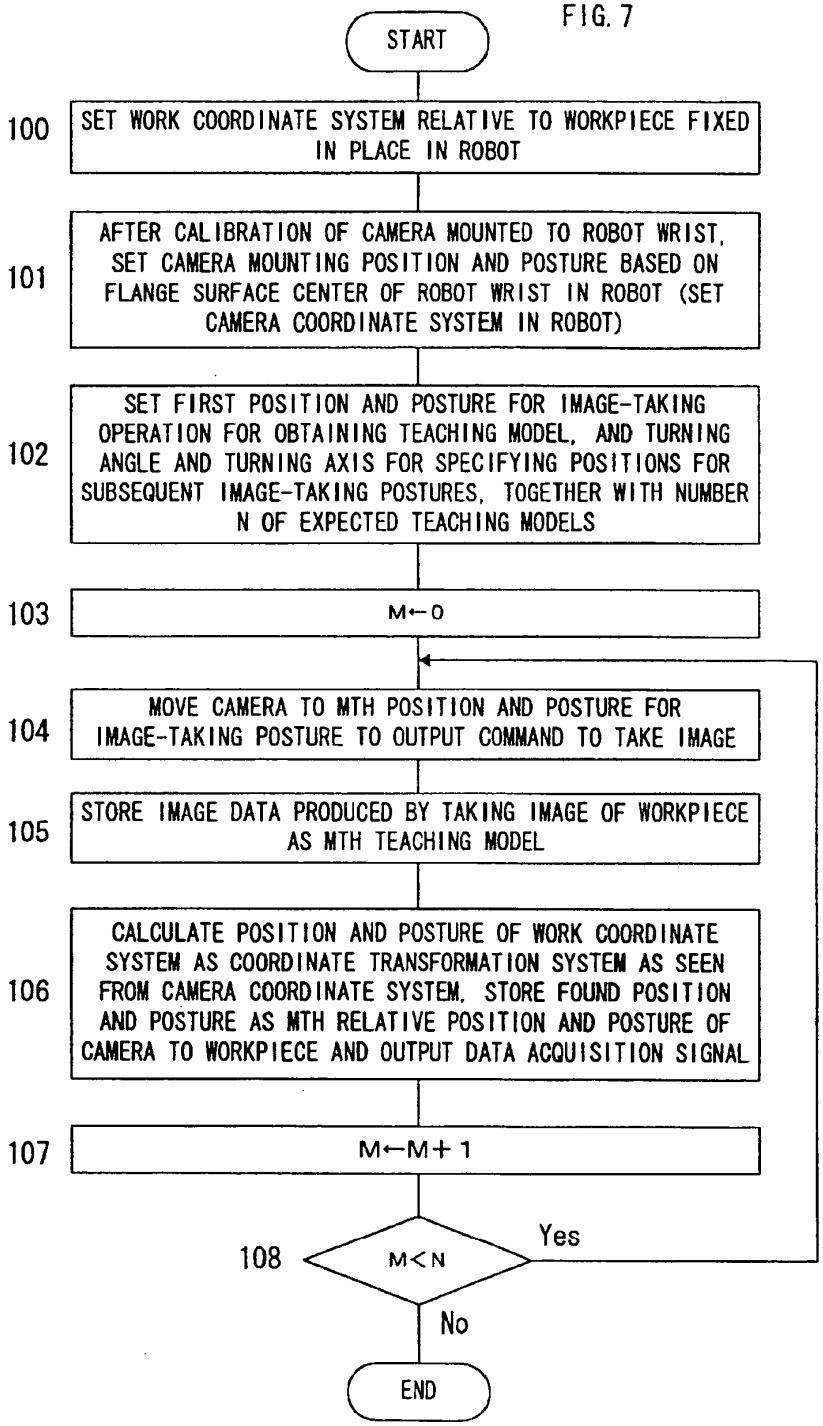


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FIG. 8

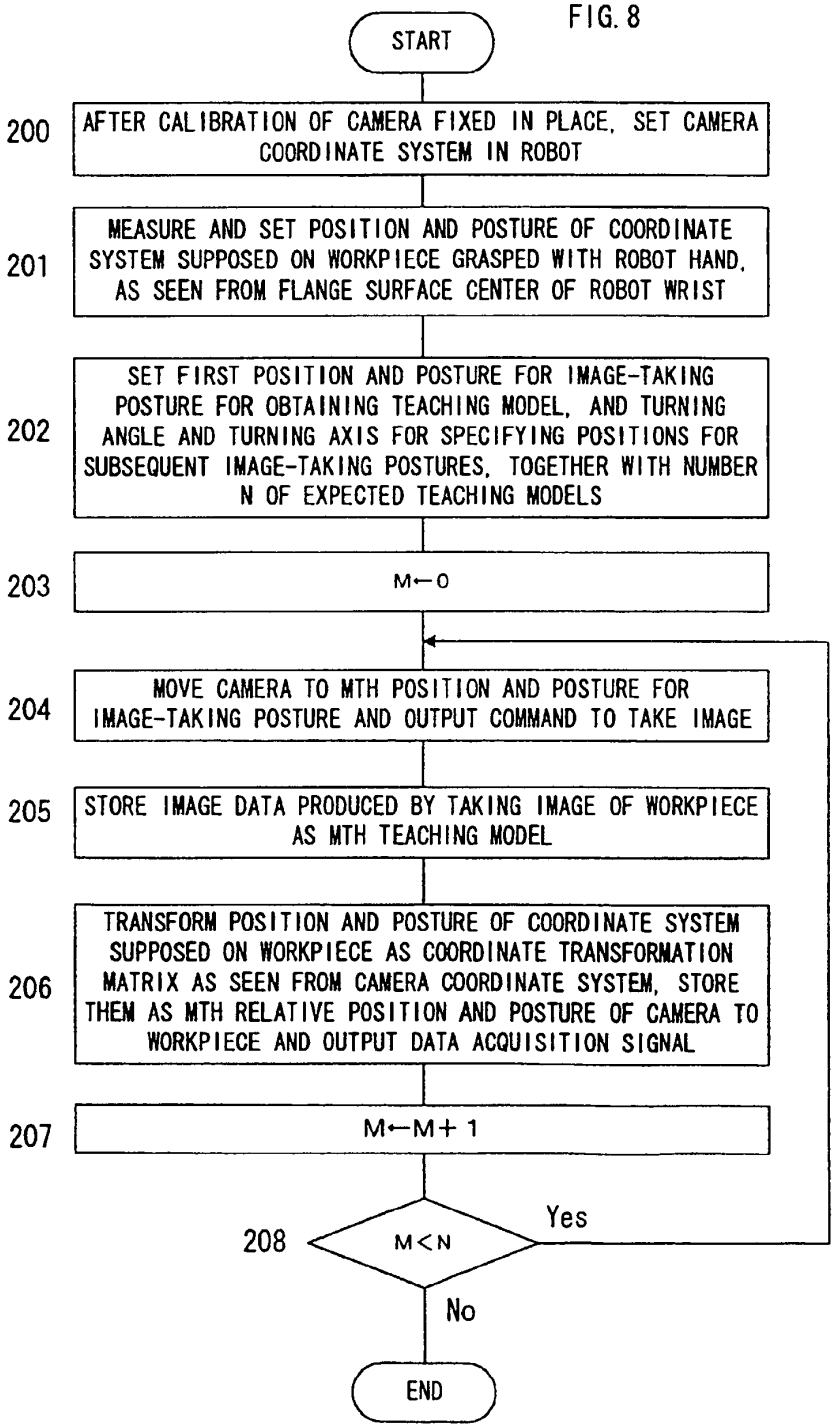


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FIG. 9

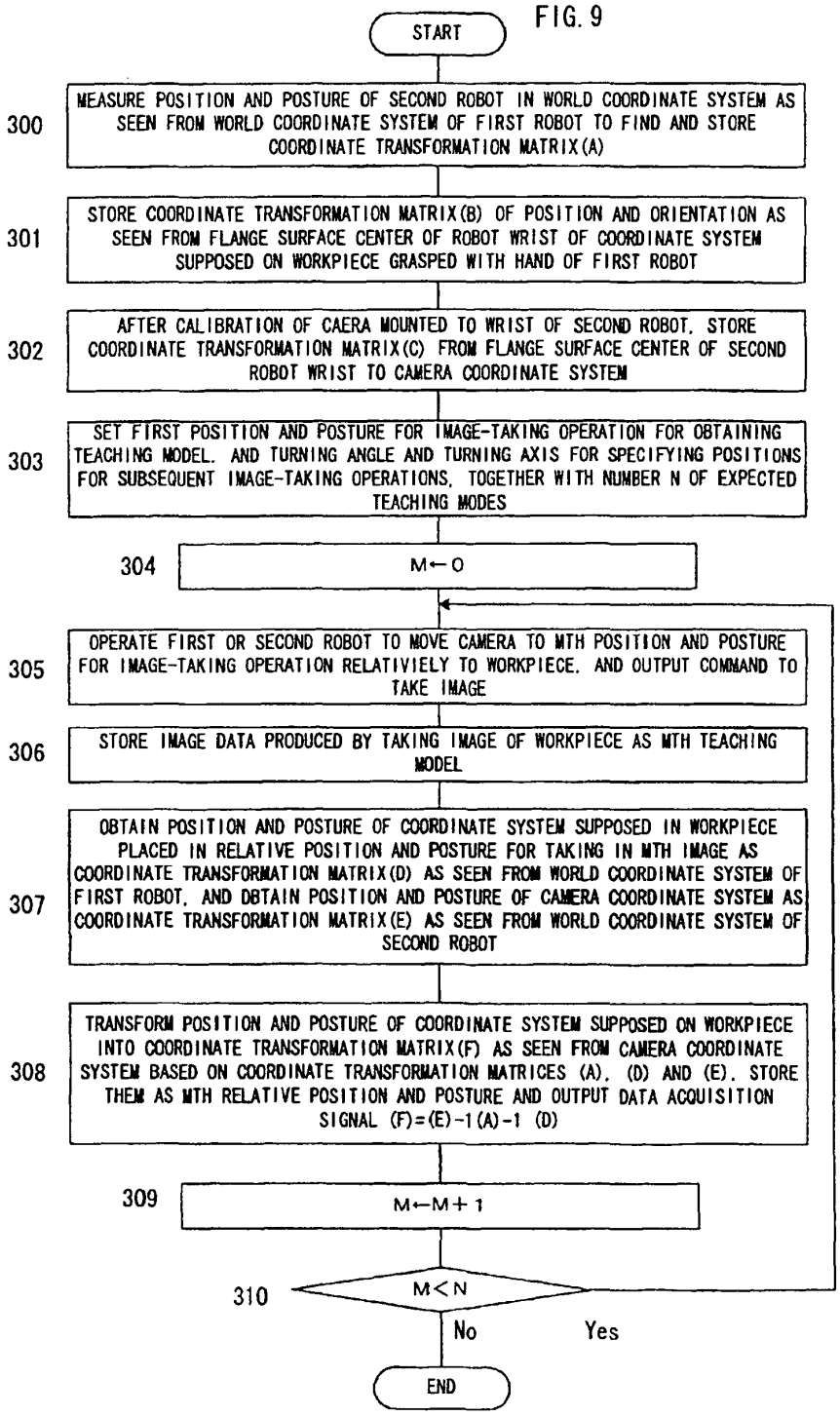


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FIG. 10

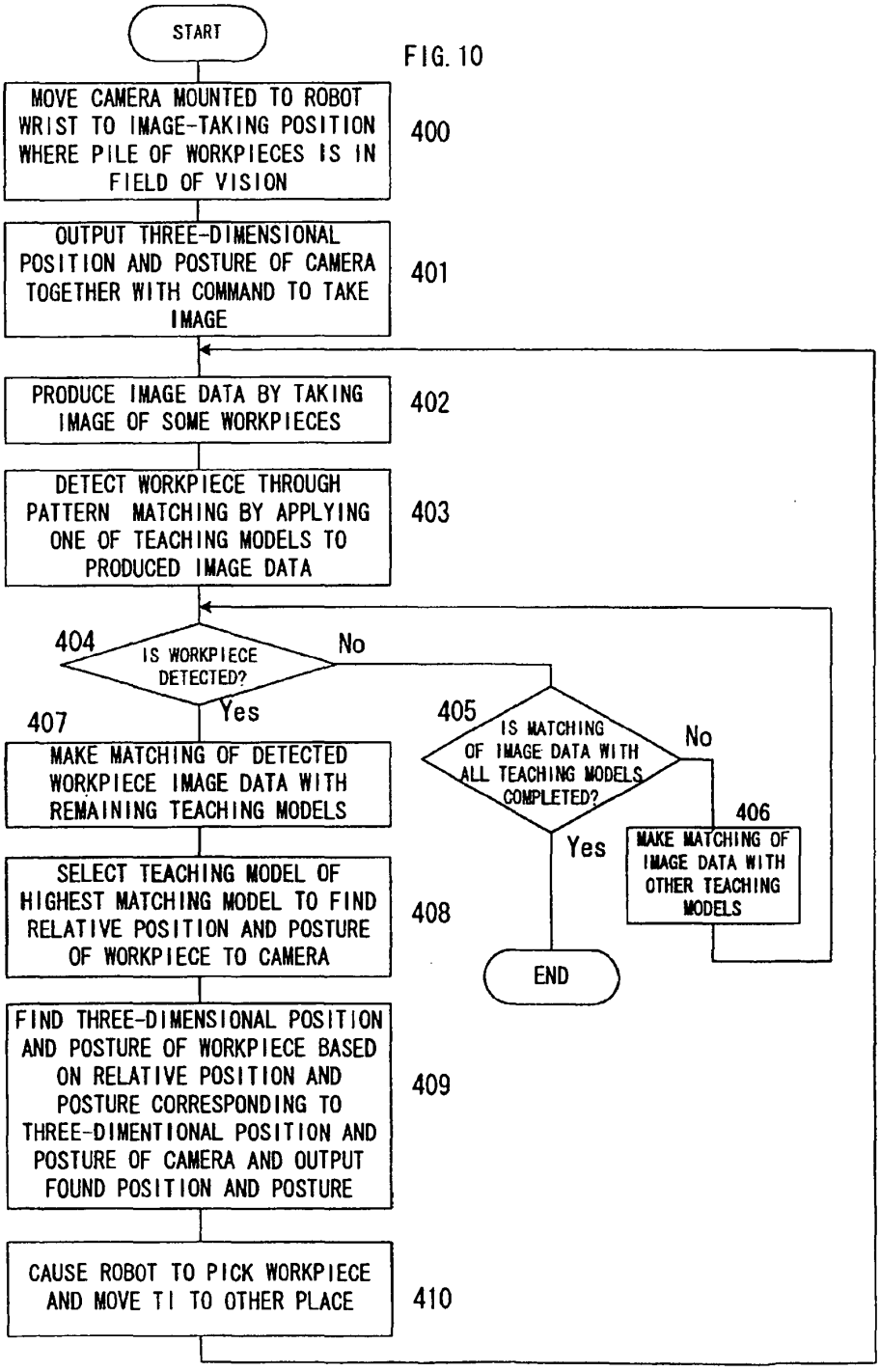


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FIG. 11

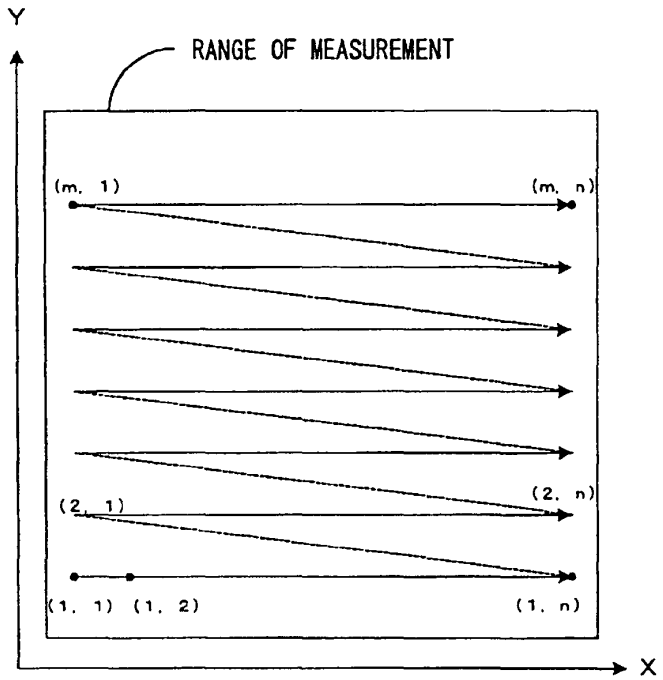


FIG. 12

Z(m, 1)	• • •	• • •	• • •	• • •	Z(m, n)
• • •	• • •	• • •	• • •	• • •	• • •
• • •	• • •	• • •	• • •	• • •	• • •
• • •	• • •	Z(i, j)	• • •	• • •	• • •
• • •	• • •	• • •	• • •	• • •	• • •
Z(1, 1)	Z(1, 2)	• • •	• • •	• • •	Z(1, n)

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FIG. 13

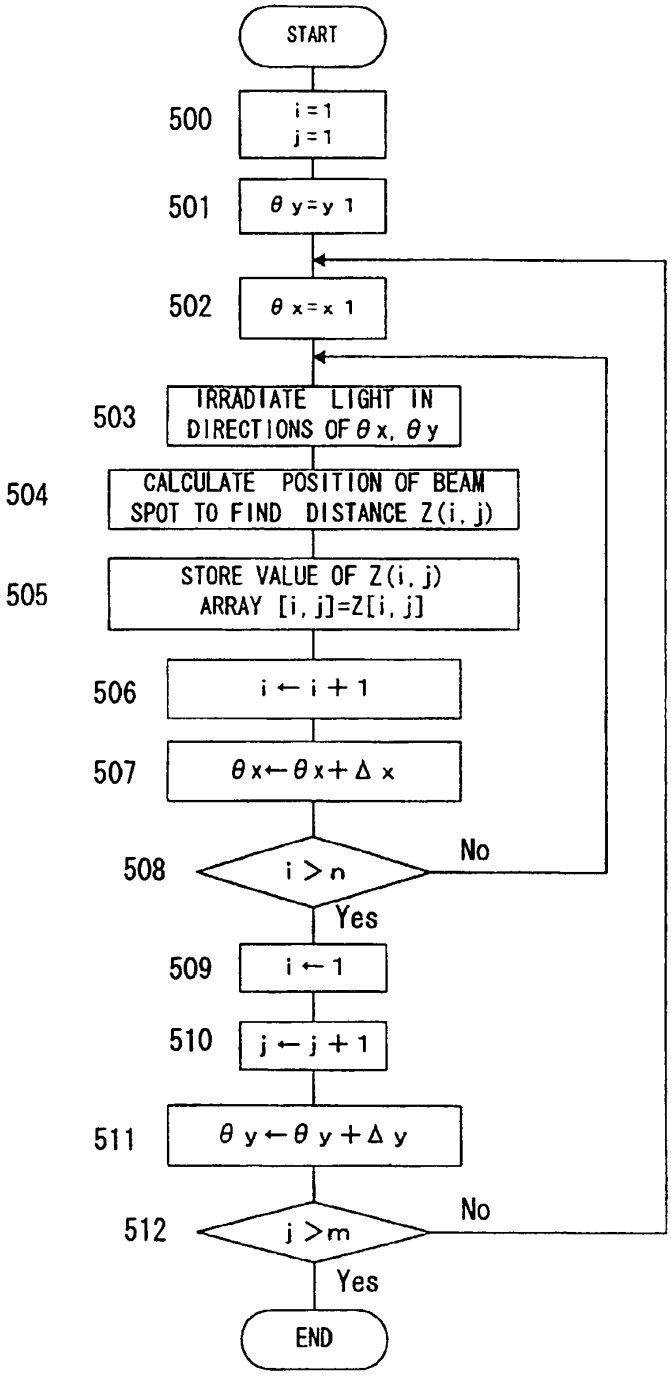


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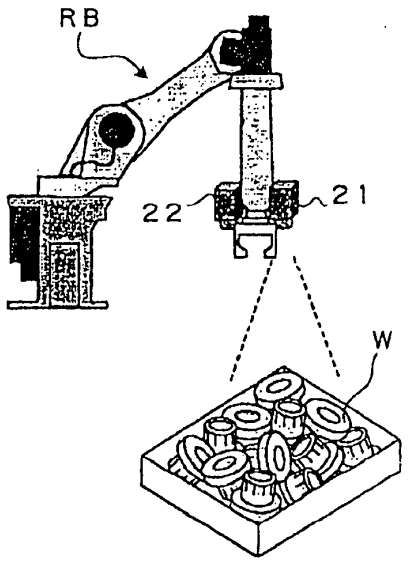
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(54) Robot system having image processing function

(57) A robot system has an image processing function capable of detecting position and/or posture of individual workpieces randomly arranged in a pile to determine posture, or posture and position of a robot operation suitable for the detected position and/or posture of the workpiece. Reference models are created from two-dimensional images of a reference workpeace captured in a plurality of directions by a first visual sensor and stored. Also, the relative positions/postures of the first visual sensor with respect to the workpiece at the respective image capturing, and relative position/posture of a second visual sensor to be situated with respect to the workpiece are stored. Matching processing between an image of a pile of workpieces captured by the camera and the reference models are performed and an image of a workpiece matched with one reference model is selected. A three-dimensional position/posture of the workpiece is determined from the image of the selected workpiece, the selected reference model and position/posture information associated with the reference model. The position/posture of the second visual sensor to be situated for measurement is determined based on the determined position/posture of the workpiece and the stored relative position/posture of the second visual sensor, and precise position/posture of the workpiece is measured by the second visual sensor at the determined position/posture of the second visual sensor. A picking-up operation for picking out a respective workpiece from a randomly arranged pile can be performed by a robot, based on the measuring results of the second visual sensor

FIG.1



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Description

[0001] The present invention relates to a robot system having an image processing function for detecting three-dimensional position and posture (orientation) of an object, and in particular to a robot system having an image processing function suitable for a bin-picking operation for taking out workpiece one by one from a randomly arranged pile of workpieces.

[0002] The operation of taking out an individual workpiece from a randomly arranged pile of workpieces or an aggregation of workpieces contained in a container of a predetermined size, which workpieces have identical shapes and different three-dimensional positions/postures, has been performed manually. In storing workpieces on a pallet or placing workpieces at a predetermined position in a machine or a device using a (dedicated) robot, since it has been impossible to directly take out individual workpieces one by one from the randomly arranged pile of workpieces by the dedicated robot, it has been necessary to rearrange the workpieces in advance so as to be picked out by the robot. In this rearrangement operation, it has been necessary to take out an individual workpiece from the pile manually.

[0003] The reason why individual workpieces having identical shapes and different three-dimensional positions/postures cannot be picked out by a robot from a randomly arranged pile of workpieces or an aggregation of workpieces contained in a container is that the position/posture of individual workpieces in the pile or the aggregation cannot be recognised, so that a robot hand cannot be placed to a suitable position/posture at which the robot hand can hold the individual workpiece.

[0004] An object of the present invention is to provide a robot system having an image processing function capable of determining an orientation and/or a position of a robot for performing an operation on an object by precisely detecting three-dimensional position and posture of individual objects in a randomly arranged pile or an aggregation in a container in a predetermined region, which have identical shapes and different three-dimensional positions/postures.

[0005] A robot system of the present invention having an image processing function comprises a robot, a first image capturing device, a memory and a processor. The memory stores reference models created according to image data of a reference object captured by the image capturing device in a plurality of directions, and stores information of the capturing directions to be respectively associated with the reference models and information of orientation of the robot operation with respect to the object. The reference object is the object for detection or an object having a shape identical to that of the object for detection. The processor performs matching processing on image data containing an image for the object of detection captured by the first image capturing device with said reference models to select an image of an object matched with one of the reference models, and determines orientation, or orientation and position, of an operation to be performed by the robot based on the selected image of the object, said one reference model and information about the capturing direction and information about the orientation of the robot operation with respect to the object associated with said one reference model.

[0006] With a robot system of the present invention, a robot operation can be performed on an individual object in a pile or on an aggregation of plural kinds of objects. In this case, image data of plural kinds of reference objects are captured by the first image data capturing device to create the reference models based on the captured image data, and relevant information is additionally stored to be associated with each reference model. Each of the reference objects is the object of each kind of operation or an object having a shape identical to that of the object of operation of each kind. The processor determines orientation, or orientation and position, of the robot operation based on the image of the object and one reference model selected in the matching processing, and the information of the kind associated with said one. reference model and the information of the orientation of the robot operation with respect to the object associated with said one reference model.

[0007] The image capturing device may be a camera for capturing two-dimensional images and in this case the image data of the reference model are captured by the camera from a predetermined distance.

[0008] The robot may situate the second image data capturing device to have the determined orientation or to have the determined orientation and the determined position with respect to the object, and the processor may process second image data captured by the second image capturing device to detect position and/or posture of the object with respect to the second image data capturing device.

[0009] The robot may also situate the second image data capturing device to have the determined orientation or to have the determined orientation and the determined position with respect to the object, so that the second image data capturing device is directed to a characterising portion of the object, and the processor may detect three-dimensional position and/or posture of the object based on three-dimensional position of said characterising portion obtained by the second image capturing device.

[0010] The first image data capturing device can be used as the second image data capturing device.

[0011] The second image capturing device may comprise a three-dimensional visual sensor of spot-light scanning type capable of measuring distance between the sensor and an object, or may comprise a structured-light unit for irradiating a structured light on an object and capturing an image of the object including the irradiated light on the object.

[0012] The robot operation may be an operation for picking up at least one object from a plurality of objects

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whose positions overlap.

[0013] For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

FIG. 1 is a diagram for showing a picking-up operation by a robot to take out an individual workpiece from a pile of workpieces using an image processing apparatus according to an embodiment of the present invention;

FIGS. 2a-2d show an example of reference models;

FIG. 3 is a block diagram of a principal part of a robot controller;

FIG. 4 is a block diagram of the image processing apparatus according to an embodiment of the present invention;

FIG. 5 -is a flowchart of the processing for creating reference models;

FIG. 6 is a flowchart of the processing for the picking-up operation;

FIG. 7 is a table showing relative positions/postures of the workpiece relative to the first visual senor and the positions/postures of the second visual sensor to be situated relative to the workpiece in the case of four reference models;

FIG. 8 is a diagram showing an example of scanning motion of a visual sensor capable of obtaining distance data;

FIG. 9 is a diagram of the two-dimensional arrangement data containing distance data as image data obtained by the visual sensor;

FIG. 10 is a flowchart of processing for obtaining the two-dimensional arrangement data.

[0014] A robot system having an image processing function according to an embodiment of the present invention will be described. As shown in FIG. 1, a two-dimensional visual sensor 21 such as a CCD camera, is attached to a wrist of a robot RB as an image capturing device. In this embodiment, an image of a pile of workpieces, which are objects for detection having identical shapes and randomly arranged as shown in FIG. 1, is captured by the two dimensional visual sensor 21, and orientation, or orientation and position, of an operation to be performed by the robot RB is determined based on the captured image. Further, rough position and posture of the individual workpieces are detected to determine the orientation of the robot based on the captured image and then precise position and posture of the workpiece are detected by the two-dimensional visual sensor 21 or a three-dimensional visual sensor 22.

[0015] For this purpose, images of a reference object, which is one of workpieces W subjected to a picking-up operation or an object having a shape identical to that of the workpiece W are captured in different directions by the image capturing device and reference models are created from the image data obtained by the image capturing and stored in advance. Matching processing between the image data obtained by capturing the image of the pile of workpieces and the reference models is executed to select an image of one workpiece matched with one of reference models, and the position/posture of the selected workpiece is determined based on the selected image of the workpiece in the image field of view, the selected one of reference modes and the position/posture information associated with the selected one of the reference models.

[0016] FIG. 3 is a block diagram showing a principal part of a robot controller 10 for use in an embodiment of the present invention. A main processor 1, a memory 2 including a RAM, a ROM and a nonvolatile memory (such as an EEPROM), an interface 3 for a teaching operating panel, an interface 6 for external devices, an interface 7 for an image processing apparatus and a servo control section 5 are connected to a bus 8. A teaching operating panel 4 is connected to the interface 3.

[0017] A system program for supporting basic functions of the robot RB and robot controller 10 are stored in the ROM of the memory 2. Robot operation programs and their related determined data which are taught in accordance with various operations are stored in the nonvolatile memory of the memory 2. The RAM of the memory 2 is used for temporary storage of data for various arithmetical operations performed by the processor 1.

[0018] The servo control section 5 comprises servo controllers 5al to San (n: sum of the number of all the axes of the robot including additional movable axes of a tool attached to the wrist of the robot), each composed of a processor, a ROM, a RAM, etc. Each servo controller performs position/velocity loop control and also current loop control for its associated servomotor for driving the axis, to function as a so-called digital servo controller for performing loop control of position, velocity and current by software. Each servomotor M1-Mn for driving each axis is drivingly controlled according to outputs of the associated servo controller 5al-5an through the associated servo amplifier 5bl-5bn. Though not shown in FIG. 3, a position/velocity detector is attached to each servomotor Ml-Mn, and the position and velocity of each servomotor detected by the associated position/velocity detector is fed back to the associated servo controller 5al-5an. To the input/output interface 6 are connected sensors of the robot, and actuators and sensors of peripheral devices.

[0019] FIG 4 is a block diagram of the image processing apparatus 30 connected to an interface 7 of the robot controller 10. The image processing apparatus 30 comprises a processor 31 to which are connected through a bus 42 a ROM 32 for storing a system program to be executed by the processor 31, an image processor 33, a camera interface 34 connected to a CCD camera 21 which is a first visual sensor serving as a first image data capturing device, a three-dimensional sensor interface 35 connected to a three-dimensional sensor 22 as a

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second visual sensor as a second image data capturing device, a MDI 36 with a display such as a CRT or a liquid crystal display for inputting and outputting various commands and data, a frame memory 37, a nonvolatile memory 38, a RAM 39 for temporary storage of data, a communication interface 40 for the robot controller and a console interface 41 for a console 43. An image captured by the CCD camera 21 is converted into a light and shade grey scale image and stored in the frame memory 37. The image processor 33 performs image processing of images stored in the frame memory 37 on demand by the processor 31 so as to recognise an object. The architecture and function of the image processing apparatus 30 itself is in no way different from the conventional image processing apparatus. The image processing apparatus 30 of the present invention is different from the conventional one in that reference models as described later are stored in the nonvolatile memory 38 and pattern matching processing is performed on an image of a pile of workpieces W captured by the first visual sensor 21 using the reference models to obtain position and posture of a workpiece W and thus orientation, or orientation and position, of an operation to be performed by the robot RB. Further, the image processing apparatus of the present invention differs from the conventional one in that approach orientation/position for more precise detection of the position/posture of the workpiece W by the second visual sensor of the three-dimensional visual sensor 22 is determined based on the detected position/posture of the workpiece W using the first visual sensor 21.

[0020] The CCD camera for obtaining two-dimensional images data is well known in the art and thus detailed explanation thereof is omitted here. The three-dimensional visual sensor 22 for detecting a three-dimensional position of an object by irradiating structured light (slit beam) on the object is known and used in various fields. This type of sensor may be used as the three dimensional visual sensor 22. Further, a three-dimensional visual sensor of a spot-light scanning type as disclosed in Japanese Patent Publication No. 7-270137 may be used as the three-dimensional visual sensor 22, and the summary of such three-dimensional visual sensor is described below.

[0021] This visual sensor detects a three-dimensional position of an object by irradiating a light beam to form a light spot on the object for scanning the object in two different directions (X direction and Y direction) and by detecting the light reflected on the object by a position sensitive detector (PSD). The three dimensional position of the object is measured by a calculation using the respective inclination angles $\theta x, \theta y$ of mirrors for scanning and incident positions of the reflected light beam on the PSD.

[0022] Referring to FIGS. 8-10, a method of obtaining two-dimensional arrangement data including distance data using the three-dimensional visual sensor will be explained briefly.

[0023] The scanning range (measuring range) on an object is set in advance, and an inclination angle $\theta x, \theta y$ of the mirrors is controlled discretely. As shown in FIG. 7, the scanning is performed from a point (1,1) to a point (1, n), from a point (2,1) to a point (2, n), ..., from a point (m, 1) to a point (m, n) on the X-Y plane within the scanning range, to measure the three-dimensional positions of each reflected point on the object. Also, a distance Z (i, j) between the sensor and the reflection point (i, j) on the object is obtained and stored in the RAM38 of the image processing apparatus 30. Thus, the image data is obtained as two-dimensional arrangement data including the distance data Z (i, j) between the sensor and the reflection point on the object, as shown in FIG. 9.

[0024] FIG. 10 is a flowchart of processing to be executed by the processor 31 of the image processing apparatus 30 for obtaining the image data.

[0025] First, indexes i and j are respectively set to "1" (Step 300) and the inclination angle $(\theta x, \theta y)$ of the mirrors is set to (x1, yl) to direct to the start point (1, 1) and an irradiation command with the inclination angle is sent to the sensor 20 (Steps 301-303). The sensor irradiates a light beam with the mirrors set at the inclination angle. The signal representing the image captured by the PSD is sent to the image processing apparatus 30. The processor 31 of the image processing apparatus 30 calculates the position of the reflection point on the object from the signal from the PSD and the inclination angle $(\theta x, \theta y)$ of the mirrors to obtain the distance Z (i, j) between the sensor and the position of the reflection point on the object. This value Z (i, j) is stored in the RAM 38 as the two-dimensional arrangement data [i, j] (Step 304, 305). The calculation for obtaining the position of the reflection point and the distance Z (i, j) may be performed by the sensor 20.

[0026] Then, the index i is incrementally increased by "1" and the inclination angle Dx of the mirror for X-axis direction scanning is increased by the predetermined amount Ax (Step 306, 307). It is determined whether or not the index i exceeds the set value n (Step 308). If the index i does not exceed the set value n, the procedure returns to Step 303 and the processing from Step 303 to Step 308 is executed to obtain the distance Z (i, j) of the next point. Subsequently, the processing of Steps 303-308 is repeatedly executed until the index i exceeds the set value n to obtain and store the distance Z (i, j) of the respective points (1, 1) to (1, n) shown in FIG. 8.

[0027] If it is determined that the index i exceeds the set value n in Step 308, the index i is set to "1" and the index j is incrementally increased by "l" to increase the inclination angle θy of the mirror for Y-axis direction scanning (Steps 309-311). Then, it is determined whether or not the index j exceeds the set value m (Step 312) and if the index j does not exceed the set value m, the procedure returns to Step 302 to repeatedly execute the processing of Step 302 and the subsequent Steps.

[0028] Thus, the processing from Step 302 to Step 312 is repeatedly executed until the index j exceeds the

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set value m. If the index j exceeds the set value m, the points in the measurement range (scanning range) shown in FIG. 8 have been measured entirely, the distance data Z (1, 1) - Z (m, n) as two-dimensional arrangement data are stored in the RAM 39 and the image data obtaining processing is terminated. A part of the image data of two-dimensional arrangements or a plurality of distance data can be obtained by appropriately omitting the measurement of the distance for the index i.

[0029] The foregoing is a description on the processing for obtaining two-dimensional arrangement data as image data using the visual sensor capable of measuring the distance. Using the two-dimensional arrangement data obtained in this way as image data, creation of reference models and detection of position and posture (orientation) of an object can be performed.

[0030] In order to simplify the explanation, the following description will be made assuming that a CCD camera is used as the two-dimensional visual sensor 21 and the two-dimensional image data obtained by capturing image of the object by the CCD camera is used.

[0031] Processing for creating reference models will be explained referring to FIGS. 2a-2d and FIG. 5. FIG. 5 is a flowchart showing processing for teaching reference models to the image processing apparatus 30 according to the present invention.

[0032] One reference workpiece (one of the workpieces W as objects of robot operation or a workpiece having a three-dimensional shape identical to that of the workpiece W) is arranged at a predetermined position with predetermined posture for creating reference models. A first (0-th) position and orientation (posture) of the CCD camera 21 for capturing the image of the object is set, and an axis of rotation and rotation angles with respect to the first (0-th) position and orientation (posture) are set in order to determine the subsequent positions and orientations (postures) of the camera 21 from the teaching operation panel 4 of the robot controller 10. In addition, the number of the positions and orientations (postures) of the workpiece at which the camera 21 captures the image of the object are set.

[0033] As shown in FIGS. 2a to 2d, in this example, images of the reference workpiece are captured from four different directions and reference models are created based on the four image data. As shown in FIG. 2a, an image of the reference workpiece is captured from the direction of a Z-axis of a world coordinate system at 0-th position/orientation (posture) to create 0-th reference model. For setting the subsequent positions/orientations (postures), an axis perpendicular to an optical axis of the camera and passing a central point of the workpiece (an origin of a world coordinate system set to the workpiece) and rotation angles along the rotation axis are set. Since the optical axis of the camera is set parallel to the Z axis of the world coordinate system, an axis parallel to either the X-axis or the Y-axis of the world coordinate system, which is perpendicular to the Z axis, can be selected and the workpiece is rotated around the rotation axis at the workpiece position.

[0034] In the example, an axis parallel to the X-axis of the world coordinate system is set as the rotation axis, and for the position/posture shown in FIG. 2b, the rotation angle of 30° is set to rotate the camera by 30° with respect to the workpiece along the rotation axis. A first reference model is created based on the image data of the workpiece at the position/orientation (posture) shown in FIG. 2b. Similarly, as shown in FIGS. 2c and 2d, the camera 21 is rotated by 60° and 90°, respectively, along the rotation axis for capturing images of the workpiece to create second and third reference models. Only posture (orientation) information may be stored to be associated with each reference model in the case where the relative position between the camera and the reference workpiece is not changed, as in this example.

[0035] Further, in this example, rotation angles of zero degree, 30 degrees, 60 degrees and 90 degrees are set for creating four reference models. The dividing range of the rotation angles may be set more finely and/or range of the rotation angle may be set greater to create more reference models for more precise detection of the position/posture of the workpiece.

[0036] Processing for creating the four reference models will be explained referring to flowchart of FIG. 5.

[0037] As described above, the 0-th position/posture of the robot at which the camera 20 captures the image of the object, and the rotation axis and the rotation angles with respect to the 0-th position/posture are set in advance in order to determine the subsequent positions/postures of the reference workpiece, and also the number of the subsequent positions/postures of the workpiece are set. For intelligible explanation, it is assumed that the optical axis of the camera is parallel to the Y-axis of the world coordinate system and that a position where the X-axis and Y-axis coordinate values are identical to those of the reference workpiece arranged at a predetermined position with a predetermined posture and only the Z-axis coordinate value is different form that of the position of the reference workpiece taught to the robot as the 0-th image capturing position for obtaining the 0-th reference model. Further, the positions of the robot where the camera is rotated with respect to the reference workpiece by 30 degrees, 60 degrees and 90 degrees along the axis passing the central point of the reference workpiece and parallel to the X-axis of the world coordinate system are set as the 1st, 2nd and 3rd image capturing positions, and the number N of the image capturing positions is set "4."

[0038] When a command for creating reference models is inputted from teaching operation panel 4, the processor 1 of the robot controller 10 sets a counter M for counting the number of the image capturing to "0" (Step 100). The robot is operated to have the M-th position/posture and a command for image capturing is outputted to the image processing apparatus 30 (Step 101). In response to this command, the image processing apparatus 30 performs capturing of an image of the refer-

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ence workpiece with the camera 20 and the captured image data is stored in the frame memory 37. Further, relative position/orientation (posture) of the workpiece with respect to the camera is obtained and stored in the nonvolatile memory 37 as relative position/orientation (posture) of M-th reference model (Step 103). This relative position/posture is hereinafter referred to as "first-sensor relative position/posture". Thus, position/posture of the workpiece in a camera coordinate system set to the camera is obtained from the position/posture of the camera and the position/posture of the reference workpiece in the world coordinate system when capturing the image by the camera, and is stored as the relative position/posture of the workpiece with respect to the camera (the first-sensor relative position/posture). For example, the position/posture of the workpiece in the camera coordinate system is stored as [x0, y0, z0, α0, β0, γ0]c, where α, β and γ mean rotation angle around X-, Y-, Z- axes, and "c" means the camera coordinate system. Further, as described above, in the case where the position of the camera relative to the workpiece is not changed, only the orientation(posture) of the camera [x0, y0, z0, α0, β0, γ0]c is stored to be associated with each reference model as the relative position/posture of the first sensor.

[0039] The relative position/posture of (the tool center point of) the robot to be situated with respect to the workpiece, or the relative position/posture of the second visual sensor 22 to be situated with respect to the workpiece is stored to be associated with M-th reference model, for a subsequent operation performed by the robot, i.e., a precise detection of position/posture of the workpiece by the second visual sensor 22. This relative position/posture is hereinafter referred to as "workpiece-robot (second sensor) relative position/posture". Then, a data-captured signal is sent to the robot controller 10 (Step 104).

[0040] The workpiece-robot (second sensor) relative position/posture is for determining orientation and/or position of a subsequent operation of the robot RB, i.e., the orientation/position of the robot at which the three-dimensional sensor 22 can detect the object or a characteristic portion of the object, more precisely. Alternatively, in the case where the precise detection of the workpiece by the three-dimensional sensor 22 is omitted, the workpiece-robot relative position/posture may be set to the relative position/posture between the tool center point and the workpiece which is most suitable for picking up the workpiece by a robot hand.

[0041] The workpiece-robot (second sensor) relative position/posture is stored as position/posture of the tool center point or the three-dimensional visual sensor 22 in a workpiece coordinate system set to the workpiece. The following explanation is given assuming that the relative position/posture of the three-dimensional visual sensor 22 is stored. The workpiece-robot (second sensor) relative position/posture is represented by an approach vector for determining approach position/posture of the three-dimensional visual sensor 22 with respect to the workpiece in precise measuring position/posture of the workpiece W by the three-dimensional visual sensor 22. One approach vector may be commonly set to reference models created for one kind of reference workpiece, since the optimal position/posture of the tool center point with respect to the workpiece can be determined unequivocally in accordance with a kind of the workpiece for precisely measuring the position/posture of the workpiece by the three-dimensional visual sensor 22 or picking up the workpiece by the robot hand. The approach vector may be selected from a plurality of patterns prepared in advance and may include orientation (posture) information only.

[0042] The workpiece-robot (second sensor) relative position/posture can be expressed by three components (X, Y, Z)wp for parallel motion and three components (α, β, γ)wp for rotation, where wp means the workpiece coordinate system. In this embodiment, the workpiece-robot (second sensor) relative position/posture is commonly set for all the reference models. Further, The information to be stored in Steps 103 and 104 may be gathered as the relative position/posture of the second visual sensor to be situated with respect to the CCD camera 21.

[0043] Upon receipt of the data-captured signal, the processor 1 of the robot controller 10 incrementally increases the value of the counter M by "1" (Step 105) and determines whether or not the value of the counter M is less than a set value N (=4) (Step 106). If the value of the counter M is less than the set value N, the procedure returns to Step 101 to move the robot to the M-th image-capturing position/posture. Processing of Steps 101 and the subsequent Steps are repeatedly executed until the value of the counter M equals the set value N(=4).

[0044] Thus, the reference models are stored in the nonvolatile memory 38 and also the first-sensor relative position/posture, which is the relative position/posture of the first visual sensor 21 and the workpiece W and the workpiece-robot (second sensor) relative position/posture, which is the position/posture of the second visual sensor 22 (or the robot) to be situated with respect to the workpiece W are stored in the nonvolatile memory 38.

[0045] The reference models may be created from a part of the image data of the reference object, and may be created by processing the image data of the reference object.

[0046] FIG. 7 shows an example of the first-sensor relative position/posture and the workpiece-robot (second sensor) relative position/posture in the case of four reference models.

[0047] The first-sensor relative position/posture is expressed as position/posture of the workpiece W in the camera coordinate system (X, Y, Z, α, β, γ)c set for the CCD camera 21. The relative positions of the workpiece W, i.e., the positions of the 0-th to 3rd reference models are the same, being expressed as (X, Y, Z)=(10.50,

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-20.80, 50.50) and, the rotation angles a for 0-th to 3rd reference models for the rotation around the X-axis being set to 0, 60 and 90 degrees, respectively. The CCD camera is rotated around the axis parallel to the X-axis of the world coordinate system with a center of rotation set to the origin of the workpiece coordinate system, and since the X-axis of the camera coordinate system is set parallel to the X-axis of the world coordinate system, only the rotation angles a in the camera coordinate system are changed.

[0048] The workpiece-robot (second sensor) relative position/posture is expressed as the position/posture of the second visual sensor 22 in the workpiece coordinate system (X, Y, Z, α, β, γ)wp set to the workpiece, and the approach vector (30.5, 20.5, 60.9, 0.0, 0.0, 0.0)wp is set to represent constant orientation with respect to the workpiece W.

[0049] The reference models and the relative position/posture of the workpiece W and the camera 20 are stored in the nonvolatile memory 38 of the image processing apparatus 30. In the above described embodiment, the reference models are created using a robot, although the reference models may be created by a manual operation without using a robot. In this case, the reference workpiece is arranged within a field of view of the camera connected to the image processing apparatus 30, and the images of the workpiece with different postures are captured by the camera. The reference models are created based on the image data and the relative positions/postures of the camera and the workpiece at the image capturing are manually inputted, and are stored with the respective relative positions/postures.

[0050] Hereinafter, a picking-up operation for taking out an individual workpiece by a robot from a pile of workpieces each having a shape identical to that of the reference workpiece will be described, as an example of a method of detecting three-dimensional position/posture of an object, using the image processing apparatus 30 storing the reference models.

[0051] FIG. 6 is a flowchart of processing for the picking-up operation using the reference models.

[0052] When a picking-up command is inputted into the robot controller 10 from the teaching operation panel 4, the processor 1 operates the robot RB to move the camera attached to the robot wrist to an image capturing position where a pile of workpieces are within a field of view of the CCD camera 21 (Step 200). Three-dimensional position/posture of the camera 21 on the world coordinate system at this image capturing position is outputted to the image processing apparatus 30, and an image capturing command is outputted (Step 201). Upon receipt of the image capturing,command, the processor 31 of the image processing apparatus 30 captures an image of the pile of the workpieces W to obtain image data of some workpieces W and store the data in the frame memory 37 (Step 202).

[0053] Then, pattern matching processing is performed for the image data stored in the frame memory 37 using one of the reference models (first reference model) stored in the nonvolatile memory 37 so as to detect a workpiece W (Step 203). In this pattern matching processing, matching of the image data of the reference model with the image data of workpieces is performed on the basis of position, turn and scale. A determination I made as to whether or not an object has a matching value equal to or greater than the set value (Step 204). If an object having a matching value equal or greater than the set value is not detected, the procedure proceeds to Step 205 to determine whether or not the pattern matching is performed using all the reference models (first to fourth reference models). If the pattern matching using all the reference models has not yet been achieved, further pattern matching is performed using another reference model (Step 206).

[0054] If it is determined in Step 204 that an object having a matching value equal or greater than the set value with respect to any of the reference models is detected, the procedure proceeds to Step 207 to perform matching processing on the two-dimensional data of the detected workpieces W. using every taught mode. In Step 208, the reference model having the largest matching value in the pattern matching processing is selected, and the relative position/posture of the workpiece W with respect to the camera 21 is determined based on the first-sensor relative position/posture, i.e., the relative position/posture of the camera and the reference workpiece stored for the selected reference model, and position, rotation angle and scale of the image of the workpiece in the matching processing as well as data of the workpiece-robot (second sensor) relative position/posture associated with the selected reference model, which represent the position/posture of the second sensor 22 to be situated with respect to the workpiece are read from the nonvolatile memory 37 (Step 208).

[0055] The reference model having the highest matching value is selected in this embodiment, although a reference model of the rotation angle of zero degree (the O-th reference model) may be selected with precedence, or an object having the highest expansion rate of scale (the object which is nearest to the camera, i.e. located at the top of the pile in this example) may be selected with precedence.

[0056] The position and posture (orientation) of the detected workpiece on the world coordinate system is determined from the position and posture of the camera 21 in the world coordinate system, which has been sent in Step 201, and the relative position/posture of the workpiece W with respect to the camera 21, and is outputted (Step 209). Thus, since the relative position/posture of the workpiece W. with respect to the camera 21 is the position/posture of the workpiece W in the camera coordinate system, the position and posture (orientation) of the detected workpiece W in the world coordinate system is obtained by an arithmetical operation of coordinate transformation using the data of the position/

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posture of the workpiece W in the camera coordinate system and the position/posture of the camera 20 in the world coordinate system (Step 209).

[0057] The position/posture of the second visual sensor 22 to be situated for a subsequent operation in the world coordinate system is determined based on the determined position/posture of the detected workpiece W in the world coordinate system and the workpiece-robot (second sensor) relative position/posture data (approach vector) (Step 210). The processor 1 operates the robot to situate the second visual sensor 22 to have the determined position/posture, and outputs a measuring command to the second visual sensor 22 (Step 211).

[0058] Upon receipt of the measuring command, the three-dimensional sensor 22 measures a three-dimensional position/posture of the workpiece W. Since the second visual sensor 22 is situated at a suitable position/posture with respect to the workpiece W designated by the approach vector, the three-dimensional position/posture of the workpiece W can be precisely measured. The processor 31 of the image processing apparatus 30 outputs the result of measurement to the robot controller 10 (Step 212).

[0059] The robot controller 10 operates the robot to perform a picking-up operation to grip and hold the detected workpiece W and move the held workpiece W to a predetermined position, based on the result of measurement by the three-dimensional visual sensor 22 (Step 213). Then, the procedure returns to Step 202 to repeatedly execute the processing of Step 202 and subsequent Steps.

[0060] When all the workpieces have been picked up from the pile of the workpieces, a matching value equal to or greater than the set reference value cannot be obtained in the pattern matching processing for all reference models in Steps 203-206, and the picking-up operation is terminated.

[0061] In the case where a pile of the workpieces cannot fall within the field of view of the camera 20, or in the case where it is not necessary to capture an image of a workpiece behind other workpieces by changing the orientation of the camera, the procedure may return to Step 200 when it is determined "Yes" in Step 205, to move the camera to another position/posture at which an image of the objective workpiece can be captured.

[0062] In the foregoing embodiment, the three-dimensional sensor 22 is adopted as the second visual sensor for precisely detecting the position/posture of the workpiece, although the two-dimensional sensor may be adopted instead of the three-dimensional sensor. In the case where the two-dimensional sensor is adopted as the second visual sensor, the second sensor may be provided in addition to the first visual sensor, or the first visual sensor may function as the second visual sensor.

[0063] The position/posture of the individual workpiece in the pile of workpieces is roughly detected by the first visual sensor and the precise position/posture of the detected workpiece is detected by the second visual sensor situated at the suitable position/posture which is nearer to the workpiece W, to improve the precision of detection. Therefore, when the first visual sensor takes place of the second visual sensor, precise position/posture of the workpiece can be detected by capturing the image of the detected workpiece W from the shorter distance and performing the matching processing by the CCD camera as the second sensor.

[0064] Further, in the case where a wide-angle lens is installed in the CCD camera as the image capturing device, for example there is possibility of judging the inclination angle to be 30 degrees by influence of parallax when a workpiece of zero degree inclination is at a corner of a field of view of the camera. In such a case, the camera may be moved in parallel in accordance with the position of the workpiece in the field of view of the camera to a position right above the workpiece to lose the influence of parallax, and at this position the image capturing processing of Step 201 and the subsequent Steps in FIG. 6 is performed so that false judgment is prevented.

[0065] Furthermore, in the foregoing embodiment, the first visual sensor is mounted on the distal end of the robot wrist, although the first visual sensor may be a stationary camera fixed at a place above the pile of the workpieces. In this arrangement, the distance between the camera and the workpieces is lengthened to prevent the influence of parallax. Also, it is not necessary to operate the robot to capture the image of the workpieces by the first visual sensor to shorten the cycle time.

[0066] In the foregoing embodiment, one kind of object (workpieces) are detected and picked up, although, the robot system can be modified to detect and pick up plural kinds of objects (workpieces).

[0067] In this case, Ma is the number of reference models created from a reference workpiece of a kind A and Mb is the number of reference models created from a reference workpiece of a kind B and information of the workpiece kinds A or B are additionally stored to be associated with each reference model. Then, matching processing is carried out between the captured image and the (Ma+Mb) number of reference models to select the matched reference model, and the workpiece kind information, in addition to the orientation and/or position for the subsequent operation, are determined. In this way, it is not necessary to separate the workpieces according to the kind of workpieces in advance, so that the mixed kinds of workpiece can be picked up one by one to reduce the operational cost.

[0068] In the foregoing embodiment, the position/posture of the object is roughly determined based on image data captured by the first visual sensor and the precise position/posture of the detected workpiece is measured by the second visual sensor, although, the second image capturing device may be omitted and the orientation and/or position of the robot operation can be determined using the first image data capturing device only. In this case, the relative position/posture of the robot (tool cent-

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er point) to be situated with respect to the workpiece is stored as the workpiece-robot relative position/posture.

[0069] According to the present invention, a position/posture of an objective workpiece in a randomly arranged pile of workpieces of one kind or a plurality of kinds, or an aggregation of workpieces of one kind or a plurality of kinds gathered in a predetermined region, which have different three-dimensional positions/postures, is-detected, and an orientation/position for an operation on the detected workpiece by a robot is determined. Further, the second image data capturing device measures the position/posture of the workpiece more precisely at the determined position/posture (approach vector) for the robot operation. Therefore, the robot can securely perform a picking-up operation of picking up an individual workpiece from such a pile or an aggregation.

Claims

1. A robot system having an image processing function for determining posture, or posture and position of a robot operation on an object comprising:

   a robot;
   a first image capturing device;
   a memory storing reference model created according to image data of a reference object captured by said image capturing device in a plurality of different directions, and storing information of the capturing directions to be respectively associated with said reference models, and information of orientation of the robot operation with respect to the object, said reference object being the object for detection or an object having a shape identical to that of the object for detection; and
   a processor to perform matching processing on image data containing an image of the object for detection captured by said image capturing device with said reference models to select an image of an object matched with one of said reference models, and to determine orientation, or orientation and position, of an operation to be performed by the robot based on the selected image of the object, said one reference model and the information about the capturing direction and information about the orientation of the robot operation with respect to the object associated with said one reference model.

2. A robot system having an image processing function for determining posture, or posture and position of a robot operation on an object comprising:

   a robot;
   a first image capturing device;
   a memory storing reference model created according to image data of different kinds of reference objects captured by said first image capturing device, and storing information of the kinds respectively associated with said reference models, and information about orientation of the robot operation with respect to the object of each kind, each of said reference objects being an object of operation of one such kind or an object having a shape identical to that of the object of operation of one such kind; and
   a processor to perform matching processing on image data containing an image of the object for operation captured by said first image capturing device with said reference models to select an image of an object matched with one of said reference models, and to determine orientation, or orientation and position of the robot operation based on the selected image of the object, said one reference model, the information about the kind of information associated with said one reference model and the information of the orientation about the robot operation respect to the object associated with said one reference model.

3. A robot system having an image processing function according to claim 1 or 2, wherein said reference models are obtained from a part of the image data of the reference object.

4. A robot system having an image processing function according to claim 1 or 2, wherein said reference models are obtained by processing the image data of the reference object.

5. A robot system having an image processing function according to any preceding claim, wherein said first image capturing device comprises a camera for capturing two-dimensional image data.

6. A robot system having an image processing function according to claim 5, wherein said image data of the reference object are captured by said camera from a predetermined distance.

7. A robot system having an image processing function according to any preceding claim, wherein said robot system further comprises a second image capturing device and

   said robot situates said second image data capturing device to have said determined orientation or to have said determined orientation and said determined position with respect to the object, and
   said processor processes second image data captured by said second image capturing de-

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vice to detect position and/or posture of the object with respect to said second image data capturing device

8. A robot system having an image processing function according to any one of claims 1 to 6, wherein said robot system further comprises a second image capturing device for obtaining three-dimensional position;

said robot situates said second image data capturing device to have said determined orientation or to have said determined orientation and said determined position with respect to the object, so that said second image data capturing device is directed to a characterising portion of the object; and
said processor detects three-dimensional position and/or posture of the object based on three-dimensional position of said characterising portion obtained by said second image capturing device.

9. A robot system having an image processing function according to claim 7 or 8, wherein said first image data capturing device is used as said second image data capturing device.

10. A robot system having an image processing function according to claim 7, 8 or 9, wherein said second image capturing device comprises a three-dimensional visual sensor of spot-light scanning type capable of measuring distance between the sensor and an object.

11. A robot system having an image processing function according to claim 7, 8 or 9, wherein said second image data capturing device comprises a structured-light unit for irradiating a structured light on an object and capturing an image of the object including the irradiated light on the object.

12. A robot system having an image processing function according to any preceding claim, wherein said, robot operation is an operation for picking up at least one object from a plurality of objects overlapped with each other.

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FIG. 1

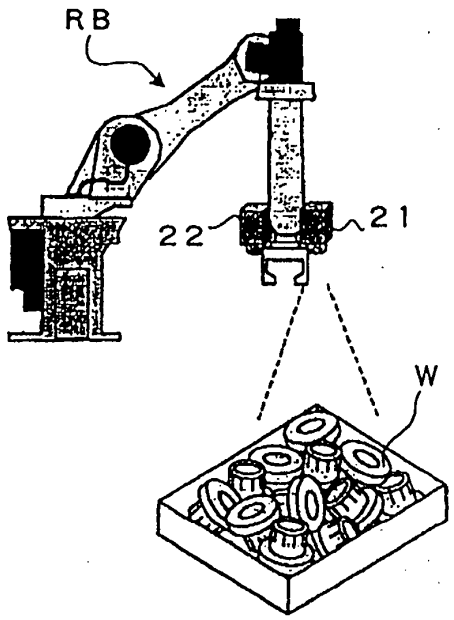


FIG. 2a

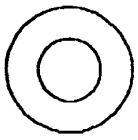


FIG. 2b

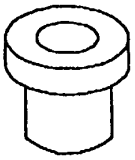


FIG. 2c

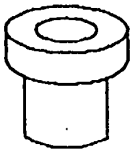


FIG. 2d

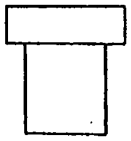


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FIG.3

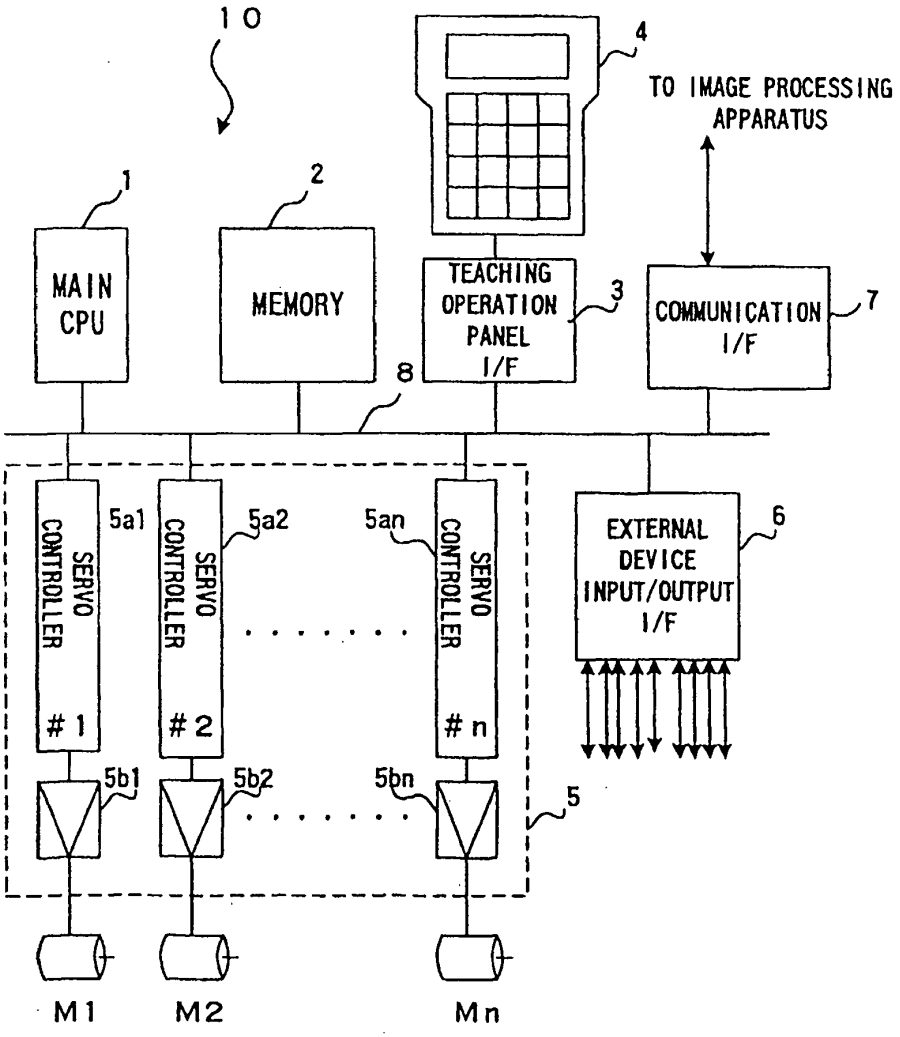


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FIG.4

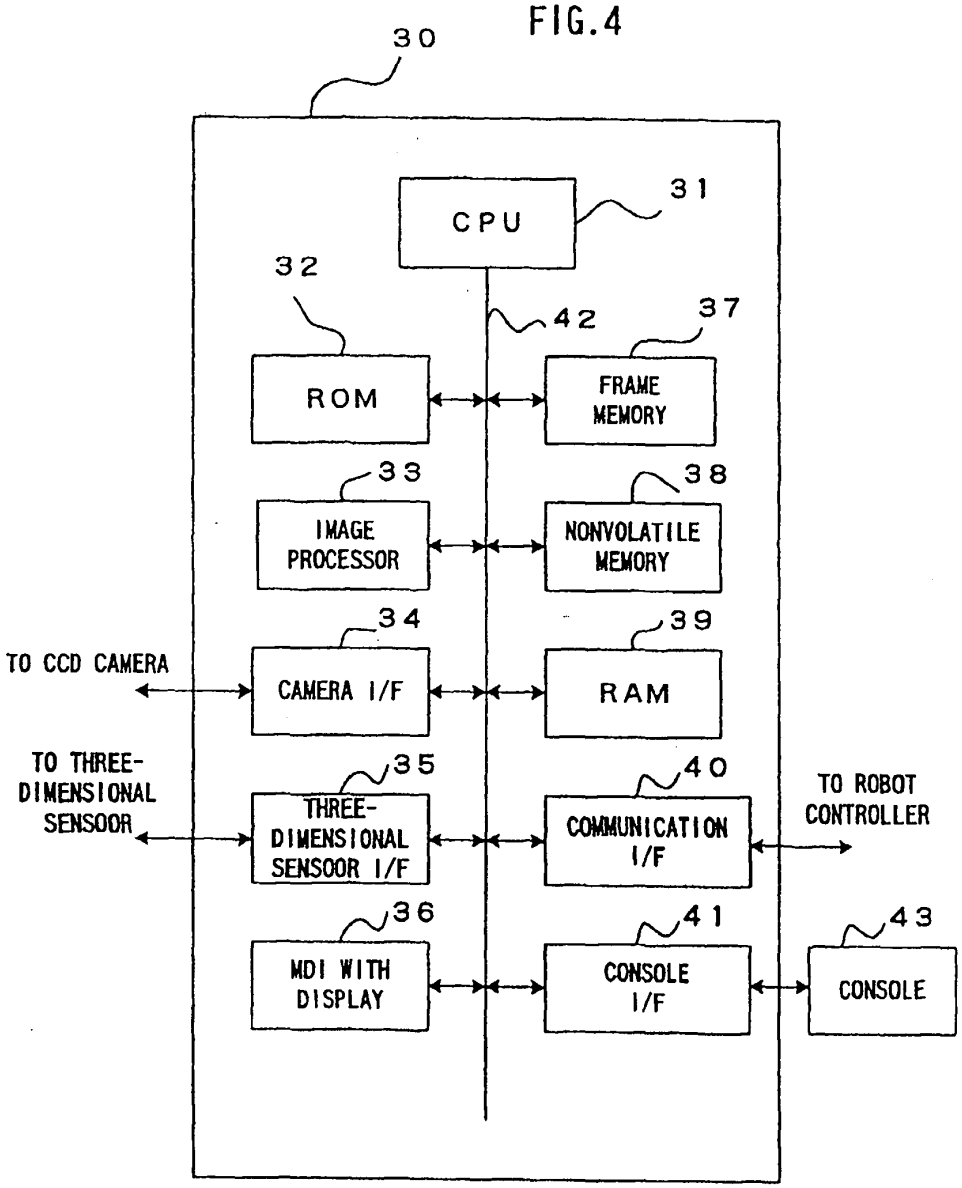


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FIG.5

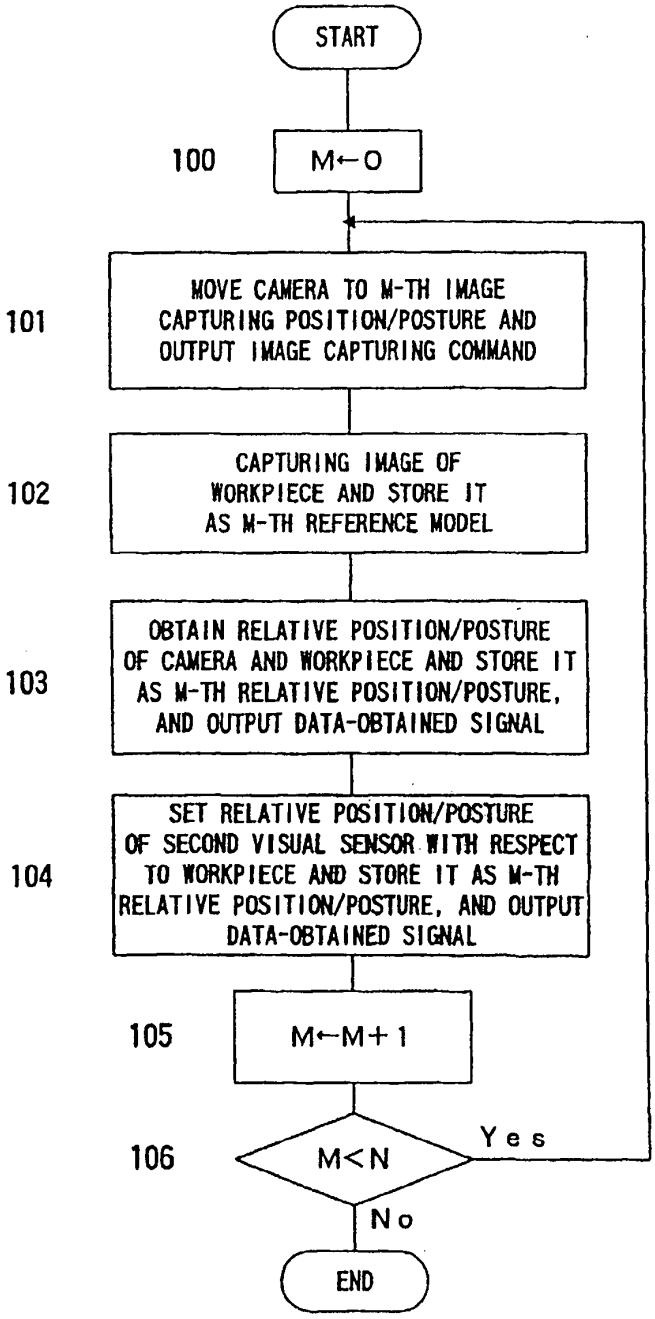


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FIG.6

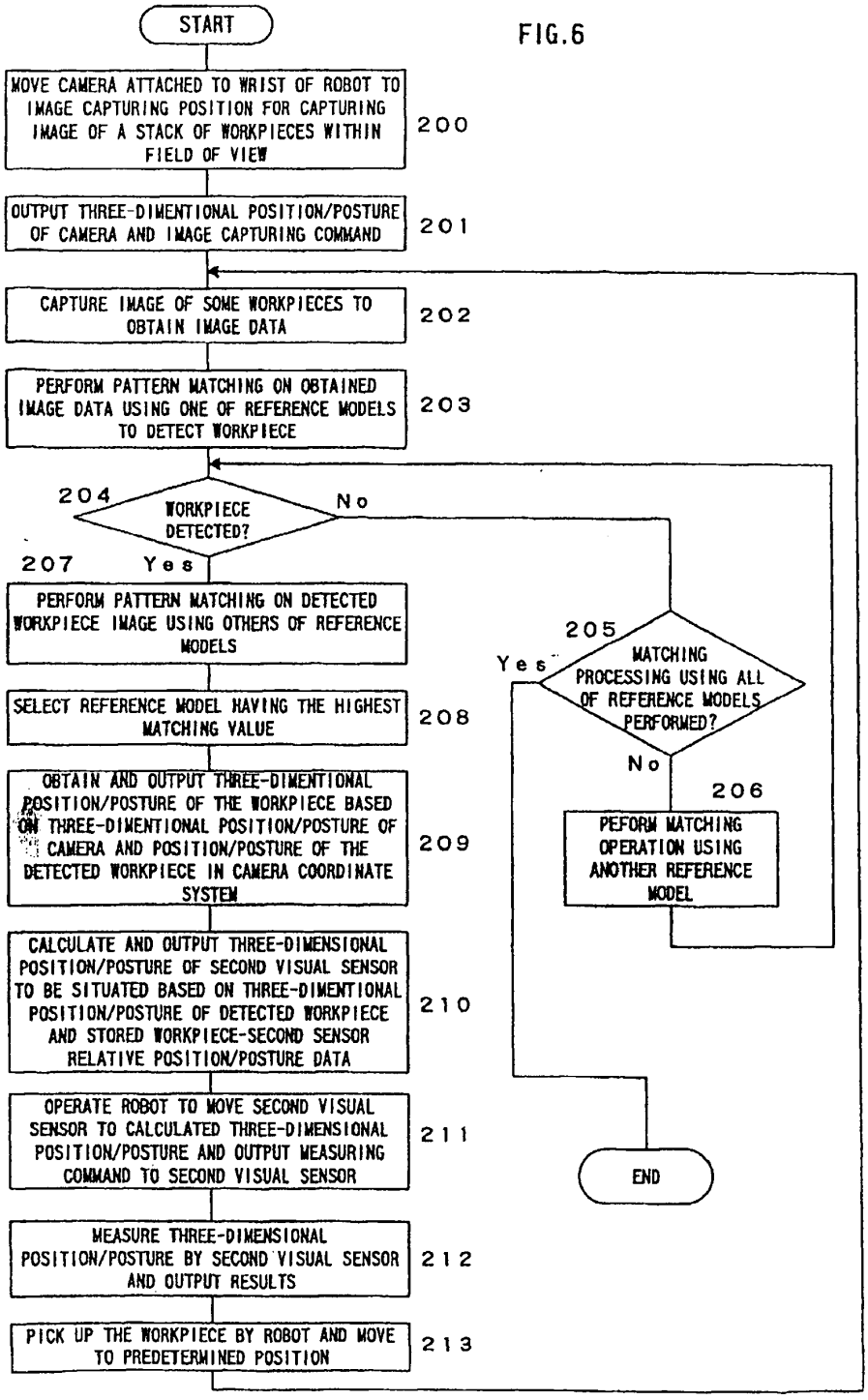


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FIG.7

REFERENCE MODEL NO. (M)	FIRST-SENSOR RELATIVE POSITION/POSTURE [RELATIVE POSITION POSTURE OF WORKPIECE WITH RESPECT TO CAMERA] (X、Y、Z、α、β、γ) c	WORKPIECE-ROBOT RELATIVE POSITION/POSTURE [RELATIVE POSITION POSTURE OF SECOND VISUAL SENSOR TO BE SITUATED WITH RESPECT TO WORKPIECE] (X、Y、Z、α、β、γ) wk
0	10.0, -20.8, 50.5, 0.0, 0.0, 0.0	35.5, 20.5, 60.9, 0.0, 0.0, 0.0
1	10.0, -20.8, 50.5, 30.0, 0.0, 0.0	35.5, 20.5, 60.9, 0.0, 0.0, 0.0
2	10.0, -20.8, 50.5, 60.0, 0.0, 0.0	35.5, 20.5, 60.9, 0.0, 0.0, 0.0
3	10.0, -20.8, 50.5, 90.0, 0.0, 0.0	35.5, 20.5, 60.9, 0.0, 0.0, 0.0

FIG.8

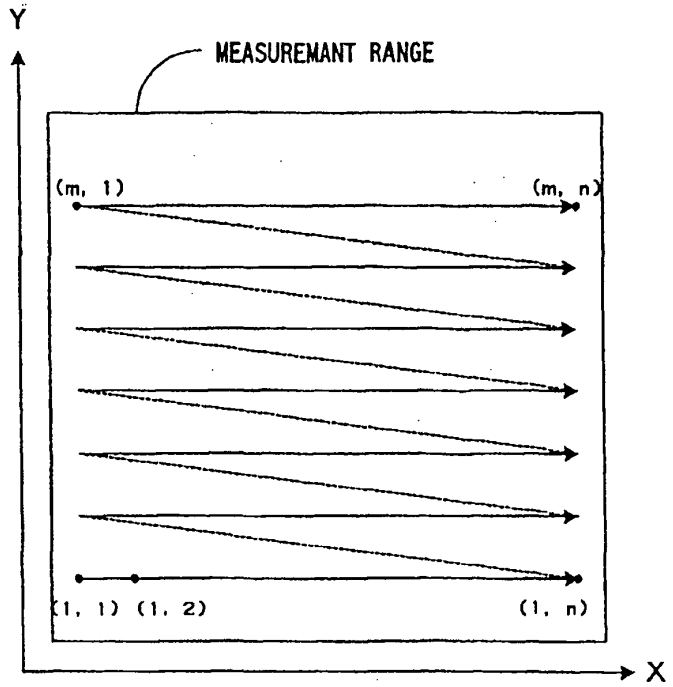


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FIG.9

Z(m,1)	. . .	. . .	. . .	. . .	Z(m,n)
. . .	. . .	. . .	. . .	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .
. . .	. . .	Z(i,j)	. . .	. . .	. . .
. . .	. . .	. . .	. . .	. . .	. . .
Z(1,1)	Z(1,2)	. . .	. . .	. . .	Z(1,n)

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FIG.10

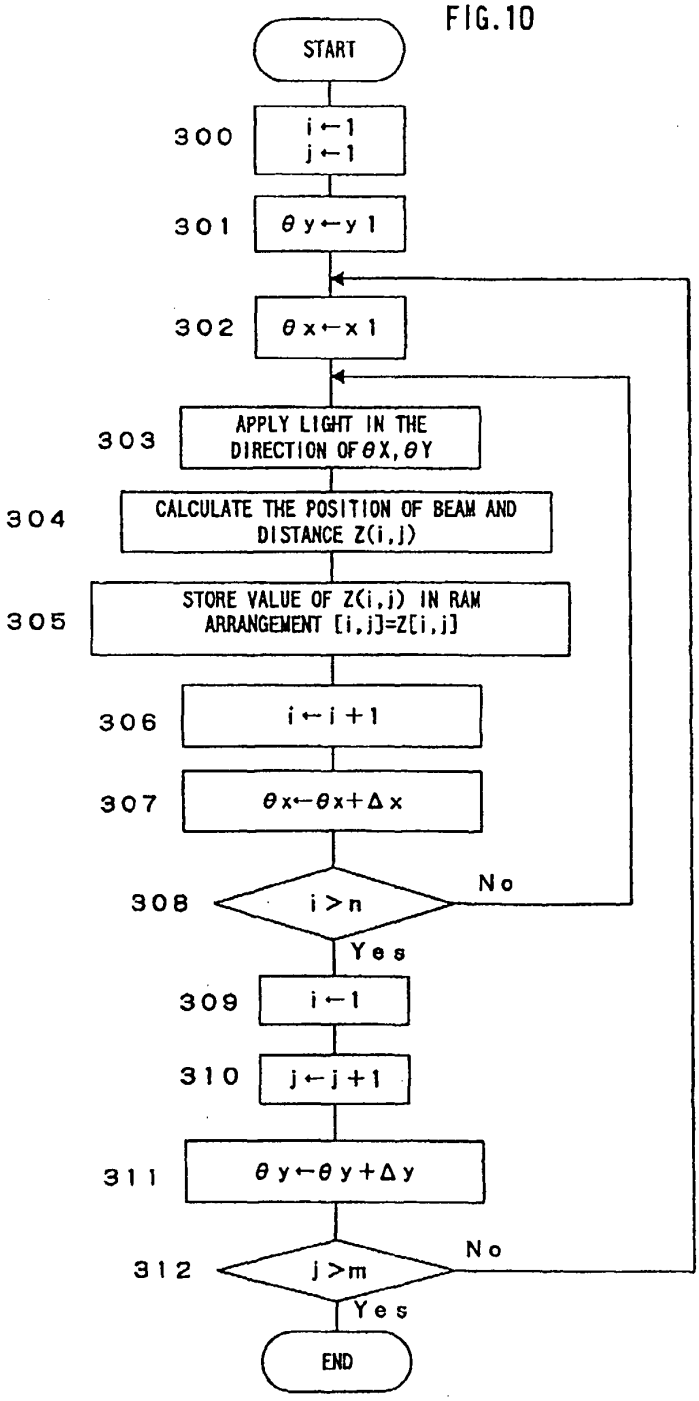


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(54) Image processing apparatus

(57) An image processing apparatus is capable of detecting position and posture of individual workpieces randomly arranged in a pile and having identical shapes. Reference models are created from two-dimensional images of a reference workpiece captured in a plurality of directions by a camera and stored. Also, the relative positions/postures of the workpiece with respect to the camera at the respective image capturing are stored. An image of a pile of workpieces is captured by the camera to obtain a two-dimensional image and the position/posture of the camera at the image capturing is stored. An image of a workpiece matched with one reference model is selected by matching processing of the reference model with the captured image A three-dimensional position/posture of the workpiece with respect to the camera is obtained from the image of the selected workpiece, the selected reference model and position/posture information associated with the reference model. A picking-up operation for picking out a respective workpiece from a randomly arranged pile can be performed by a robot, based on the position/posture of the workpiece.

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Description

[0001] The present invention relates to an image processing apparatus for detecting three-dimensional position and posture (orientation) of an object, and in particular to an image processing apparatus suitable for use in a bin-picking operation for taking out a workpiece one by one from a pile of workpieces using an industrial machine such as a robot.

[0002] The operation of taking out an individual workplace from a randomly arranged pile of workpieces or an aggregation of workpieces contained in a container of a predetermined size, which workpieces have identical shapes and different three-dimensional positions/postures, has been performed manually. In storing workpieces in a pallet or placing workpieces at a predetermined position in a machine or a device using a (dedicated) robot, since it has been impossible to directly take out individual workpieces one by one from the randomly arranged pile of workpieces by the dedicated robot, it has been necessary to rearrange the workpieces in advance so as to be picked out by the robot. In this rearrangement operation, it has been necessary to take out an individual workpiece from the pile manually.

[0003] The reason why individual workpieces having identical shapes and different three-dimensional positions/postures cannot be picked out by a robot from a randomly arranged pile of workpieces or an aggregation of workpieces contained in a container is that the position/posture of individual workplaces in the pile or the aggregation cannot be recognised, so that a robot hand cannot be placed to a suitable position/posture at which the robot hand can hold the individual workpiece.

[0004] An object of the present invention is to provide an image processing apparatus capable of detecting three-dimensional position and posture of individual objects in a randomly arranged pile or an aggregation in a container of a predetermined region, which have identical shapes and different three-dimensional positions/postures.

[0005] An image processing apparatus of the present invention comprises an image capturing device; and a memory storage reference model based on image data of a reference object captured by the image capturing device in a plurality of directions, and storing information of the capturing directions to be respectively associated with the reference models. The reference object may be an object for detection itself or an object having a shape identical to that of the object for detection.

[0006] The image processing apparatus also comprises a processor for performing matching processing of image data containing an image of the object for detection captured by the image capturing device with image data for reference models to select an image of an object matched with one of the reference models, and to obtain posture, or posture and position, of the object based on the selected image of the object, said one reference model and the information of the direction associated with said one reference model.

[0007] The reference models may be a part of the image data of the reference object or obtained by processing the image data of the reference object.

[0008] The image capturing device may be a camera for capturing two-dimensional image data, and in this case the image data of the reference object are captured by the image capturing device from a predetermined distance. Alternatively, the image capturing device may be a visual sensor for capturing three-dimensional image data, and when the three-dimensional visual sensor is adopted the image data containing an image of the object of detection may be two-dimensional arrangement data including distance information from the object of detection to the image capturing device, a part of said two dimensional arrangement data or a set of distance data.

[0009] The image capturing device may be attached to a wrist of a robot. Further, the image data of the reference object can be captured in a place different from a place where the detection of the object is performed, and supplied to the image processing apparatus on line or off line.

[0010] For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

FIG. 1 is a diagram for showing a picking-up operation by a robot to take out an individual workplace from a pile of workpieces using an image processing apparatus according to an embodiment of the present invention;

FIGS. 2a-2d show examples of reference models;

FIG. 3 is a block diagram of a principal part of a robot controller;

FIG. 4 is a block diagram of the image processing apparatus according to an embodiment of the present invention;

FIG. 5 is a flowchart of the processing for creating reference models;

FIG. 6 is a flowchart of the processing for the picking-up operation;

FIG. 7 is a diagram showing an example of scanning motion of a visual sensor capable of obtaining distance data;

FIG. 8 is a diagram of the two-dimensional arrangement data containing distance data as image data obtained by the visual sensor;

FIG. 9 is a flowchart of processing for obtaining the two-dimensional arrangement data.

[0011] An embodiment in which an image processing apparatus of the present invention is used in combination with a robot system will be described. In this embodiment, an image of a pile of workpieces, which are objects for detection having identical shapes and randomly arranged as shown in FIG 1, is captured by an

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image capturing device (camera or visual sensor) 20, which is attached to a wrist of a robot RB and position and posture (orientation) of the individual workplaces are detected based on the captured image. For this purpose, images of a reference object, which is one of workplaces W, subjected to a picking-up operation or an object having a shape identical to that of the workpiece W are captured in different directions by the image capturing device and reference models are created from the image data obtained by the image capturing and stored in advance. Matching processing between the image data obtained by capturing the image of the pile of workplaces and the reference models is executed to select an image of one workpiece matched with one of reference models, and a position/posture of the selected workpiece is determined based on the selected image of the workpiece in the image field of view, the selected one of taught modes and the position/posture information being associated with the selected one of the reference models.

[0012] FIG. 3 is a block diagram showing a principal part of a robot controller 10 for use in the embodiment of the present invention. A main processor 1, a memory 2 including a RAM, a ROM and a nonvolatile memory (such as an EEPROM), an interface 3 for a teaching operating panel, an interface 6 for external devices, an interface 7 for an image processing apparatus and a servo control section 5 are connected to a bus 8. A teaching operating panel 4 is connected to the interface 3 for a teaching operating panel. ,

[0013] A system program for supporting basic functions of the robot RB and robot controller 10 are stored in the ROM of the memory 2. Robot operation programs and their related determined data which are taught in accordance with various operations are stored in the nonvolatile memory of the memory 2. The RAM of the memory 2 is used for temporary storage of data for various arithmetic operations performed by the processor 1.

[0014] The servo control section 5 comprises servo controllers 5al to 5an (n:sum of the number of all the axes of the robot including additional movable axes of a tool attached to a wrist of the robot), each composed of a processor, a ROM, a RAM, etc. Each servo controller performs position/velocity loop control and also current loop control for its associated servomotor for driving the axis, to function as a so-called digital servo controller for performing loop control of position, velocity and current by software. Each servomotor M1-Mn for driving each axis has its drive controlled according to outputs of the associated servo controller 5al-5an through the associated servo amplifier 5bl-5bn. Though not shown in FIG. 3, a position/velocity detector is attached to each servomotor Ml-Mn, and the position and velocity of each servomotor detected by the associated position/velocity detector is fed back to the associated servo controller 5al-5an. Connected to the input/output interface 6 are sensors of the robot, and actuators and sensors of peripheral devices.

[0015] FIG 4 is a block diagram of the image processing apparatus 30 connected to an interface 7 of the robot controller 10. The image processing apparatus 30 comprises a processor 31 to which a ROM 32 for storing a system program to be executed by the processor 31, an image processor 33, an image-capturing- device interface 34 connected to the image capturing device 20, a MDI 35 with a display such as a CRT or a liquid crystal display for inputting and outputting various commands and data, a frame memory 36, a nonvolatile memory 37, a RAM 38 for temporary storage of data and a communication interface 39 for the robot controller are connected. An image captured by the camera 20 is stored in the frame memory 36. The image processor 33 performs image processing from images stored in the frame memory 36 on demand of the processor 31 so as to recognise an object. The architecture and function of the image processing apparatus 30 itself is no way different form the conventional image processing apparatus. The image processing apparatus 30 of the present invention is different form the conventional one in that reference models as described later are stored in the nonvolatile memory 37 and pattern matching processing is performed on an image of a pile of workpieces W captured by the image capturing device 20 using the reference models to obtain the position and posture of a workpiece W.

[0016] The image capturing device 20 is used for obtaining image data, as described later, and may be a CCD camera for obtaining two-dimensional images data or a visual sensor capable of obtaining three-dimensional image data including distance data. In the case of using the CCD camera, the image data is obtained by a conventional method based on two-dimensional images captured by the CCD camera, but in the case of the visual sensor capable of obtaining three-dimensional data including distance data, two-dimensional arrangement data with distance data between the sensor and an object is obtained. A visual sensor for obtaining the three-dimensional data including distance data is known, for example, from three-dimensional visual sensors of a spot light scanning type disclosed in Japanese Patent Publication No. 7-270137, and the summary of the three-dimensional visual sensor is described below.

[0017] This visual sensor detects a three-dimensional position of an object by irradiating a light beam to form a light spot on the object for scanning the object in two different directions (X direction and Y direction) and by detecting the light reflected on the object by a position sensitive detector (PSD). Three dimensional position of the object is measured by a calculation using the respective inclination angles θx,θy of mirrors for scanning and an incident positions of the reflected light beam on the PSD.

[0018] Referring to FIGS. 7-9, a method of obtaining two-dimensional arrangement data including distance data using the three-dimensional visual sensor will be

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explained briefly.

[0019] Scanning range (measuring range) on an object is set in advance, and an inclination angle θx, θy of the mirrors is controlled discretely. As shown in FIG. 7, the scanning is performed from a point (1,1) to a point (1, n), from a point (2,1) to a point (2, n), ..., from a point (m, 1) to a point (m, n) on the X-Y plane within the scanning range, to measure three-dimensional positions of each reflected point on the object. Also, a distance Z (i, j) between the sensor and the reflection point (i, j) on the object is obtained and stored in the RAM38 of the image processing apparatus 30. Thus, the image data is obtained as two-dimensional arrangement data including the distance data Z (i, j) between the sensor and the reflection point on the object, as shown in FIG. 8.

[0020] FIG. 9 is a flowchart of processing to be executed by the processor 31 of the image processing apparatus 30 for obtaining the image data.

[0021] First, indexes i and j are respectively set to "1" (Step 300) and the inclination angle (θx, θy) of the mirrors is set to (x1, y1) to direct to the start point (1, 1) and an irradiation command with the inclination angle is send to the sensor 20 (Steps 301-303). The sensor irradiates a light beam with the mirrors set at the inclination angle. The signal representing the image captured by the PSD is sent to the image processing apparatus 30. The processor 31 of the image processing apparatus 30 calculates the position of the reflection point on the object of the signal from the PSD and the inclination angle (θx, θy) of the mirrors to obtain the distance Z (i, j) between the sensor and the position of the reflection point on the object. This value Z (i, j) is stored in the RAM 38 as the two-dimensional arrangement data [i, j] (Step 304, 305). The calculation for obtaining the position of the reflection point and the distance Z (i, j) may be performed by the sensor 20.

[0022] Then, the index i is incrementally increased by "1" and the inclination angle θx of the mirror for X-axis direction scanning is increased by the predetermined amount Δx (Step 306, 307). It is determined whether or not the index i exceeds the set value n (Step 308). If the index i does not exceed the set value n, the procedure returns to Step 303 and the processing from Step 303 to Step 308 is executed to obtain the distance Z (i, j) of the next point. Subsequently, the processing of Steps 303-308 are repeatedly executed until the index i exceeds the set value n to obtain and store the distance Z (i, j) of the respective points (1, 1) to (1, n) shown in FIG. 7.

[0023] If it is determined that the index i exceeds the set value n in Step 308, the index i is set to "1" and the index j is incrementally increased by "1" to increase the inclination angle θy of the mirror for Y-axis direction scanning (Steps 309-311). Then, it is determined whether or not the index j exceeds the set value m (Step 312) and if the index j does not exceed the set value m, the procedure returns to Step 302 to repeatedly executes the processing of Step 302 and the subsequent Steps.

[0024] Thus, the processing from Step 302 to Step 312 is repeatedly executed until the index j exceeds the set value m. If the index j exceeds the set value m, the points in the measurement range (scanning range) shown in FIG. 7 have been measured entirely, the distance data Z (1, 1) - Z (m, n) as two dimensional arrangement data are stored in the RAM28 and the image data obtaining processing is terminated. A part of the image data of two dimensional arrangements or a plurality of distance data can be obtained by appropriately omitting the measurement of the distance for the index i.

[0025] The foregoing is a description on the processing for obtaining two dimensional arrangement data as image data using the visual sensor capable of measuring the distance. Using the two-dimensional arrangement data obtained in this way as image data, creation of reference models and detection of position and posture (orientation) of an object can be performed. In order to simplify the explanation, the following description will be made assuming that a CCD camera 20 is used as an image capturing device and the two dimensional image data obtained by capturing image of the object by this camera 20 is used.

[0026] Processing for creating reference models will be explained referring to FIGS. 2a-2d and FIG. 5. FIG. 5 is a flowchart showing processing for teaching reference models to the image processing apparatus 30 according to the present invention.

[0027] One reference workpiece (one of the workpieces W as object for robot operation or a workpiece having a three-dimensional shape identical to that of the workpiece W) is prepared for creating reference models. A first (0-th) position/posture of the reference workpiece at which the camera 20 attached to a distal end of a robot wrist captures the image of the object is set, and an axis of rotation and rotation angles with respect to the first (0-th) position/posture are set in order to determine the subsequent positions/postures of the reference workpiece. In addition, the number of positions/postures of the workpiece at which the camera 20 captures the image of the object is set. In this example, information of both position and posture is used. However it is sufficient for creating reference models to use only posture (orientation) information if the demanded precision of position is not high.

[0028] As shown in FIGS. 2a to 2d, in this example, images of the reference workpiece are captured from four different directions and reference models are created based on the four image data. As shown in FIG. 2a, an image of the reference workpiece is captured from the direction of a Z-axis of a world coordinate system at 0-th position/posture to create 0-th reference model. For setting the subsequent positions/postures, an axis perpendicular to an optical axis of the camera and passing a central point of the workpiece (origin of a work coordinate system set to the workpiece) and rotation angles of the workpiece along the rotation axis are set for this camera position. Since the optical axis of the

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camera is set parallel to the Z axis of the world coordinate system, an axis parallel to either the X-axis or the Y-axis of the world coordinate system, which is perpendicular to the Z axis, can be selected and the workpiece is rotated around the rotation axis at the workpiece position.

[0029] In the example, an axis parallel to the X-axis of the world coordinate system is set as the rotation axis, and for the position/posture shown in FIG. 2b, the rotation angle of 30° is set to rotate the workpiece by 30° with respect to the camera along the rotation axis. A first reference model is created based on the image data of the workpiece at the position/posture shown in FIG. 2b. Similarly, as shown in FIGS. 2c and 2d, the workpiece is rotated by 60° and 90°, respectively, along the rotation axis for capturing images of the workpiece to create 2nd and 3rd reference models.

[0030] In this example, rotation angles of zero degree, 30 degrees, 60 degrees and 90 degrees are set for creating four reference models. The dividing range of the rotation angles may be set more finely and/or range of the rotation angle may be set greater to create more reference models for more precise detection of the position/posture of the workpiece.

[0031] The processing for creating the four reference models will be explained referring to flowchart of FIG. 5.

[0032] As described above, the 0-th position/posture of the robot at which the camera 20 captures the image of the object, and the rotation axis and the rotation angles with respect to the 0-th position/posture are set in advance in order to determine the subsequent positions/postures of the reference workpiece, and also the number of the subsequent positions/postures of the workpiece are set. For intelligible explanation, it is assumed that an optical axis of the camera is parallel to the Y-axis of the world coordinate system and that a position where the X-axis and Y-axis coordinate values are identical to those of the reference workpiece and only the Z-axis coordinate value is different from that of the position of the reference workpiece is taught to the robot as the 0-th image capturing position for obtaining the 0-th reference model. Further, the positions of the robot where the camera is rotated with respect to the reference workpiece by 30 degrees, 60 degrees and 90 degrees along the axis passing the central point of the reference workpiece and parallel to the X-axis of the world coordinate system are set as the 1st, 2nd and 3rd image capturing position, and the number N of the image capturing positions is set to "4."

[0033] When a command for creating reference models is inputted from teaching operation panel 4, the processor 1 of the robot controller 10 sets a counter M for counting the number of the image capturing to "0" (Step 100). The robot is operated to have the M-th position/posture and a command for image capturing is outputted to the image processing apparatus 30 (Step 101). In response to this command, the image processing apparatus 30 performs capturing of an image of the reference workpiece with the camera 20 and the captured image data is stored in the frame memory 36. Further, relative position/posture of the workpiece with respect to the camera is obtained and stored in the nonvolatile memory 37 as relative position/posture of M-th reference model, and a data-captured signal is sent to a robot controller (Step 103). Thus, position/posture of the workpiece in a camera coordinate system set to the camera is obtained from the position/posture of the camera and the position/posture of the reference workpiece in the world coordinate system when capturing the image by the camera, and is stored as the relative position/posture of the workpiece with respect to the camera. For example, the position/posture of the workpiece in the camera coordinate system is stored as [x0, y0, z0, α0, β0, γ0]c, where α, β and γ mean rotation angle around X-, Y-, Z- axes, and "c" means the camera coordinate system.

[0034] Upon receipt of the data-captured signal, the processor 1 of the robot controller 10 incrementally increases the value of the counter M by " 1 "(Step 104) and determines whether or not the value of the counter M is less than a set value N (=4) (Step 105). If the value of the counter M is less than the set value N, the procedure returns to Step 101 to move the robot to the M-th image-capturing position/posture. Thus, in the example as shown in FIGS. 2a-2d, the camera is successively turned by 30 degrees around the axis parallel to X axis of the world coordinate system and passing the workpiece position, and successively captures the image of the workpiece, and reference models and relativity positions/postures of the camera with respect to the workpiece at the image capturing are stored.

[0035] Processing of Steps 101-105 is repeatedly executed until the value of the counter M equals to the set value N (=4), and the reference models and the relative positions/postures of the camera and the workpiece are stored in the nonvolatile memory 37. Thus, the reference models created from the image data of the workpiece at the positions/postures shown in FIGS. 2a-2d are stored, and the relative positions/postures between the camera and the workpiece for respective reference models are stored as positions/postures of the workpiece W in the camera coordinate system as [x 0, y 0, z 0, α0, β0, γ0]c,[x 1, y 1, z 1, α1, β1, γ1]c, [x 2, y 2, z 2, α2, β2, γ2]c, and [x 3, y 3, z 3, α3, β3, γ3]c.

[0036] The reference models and the relative position/posture of the workpiece W and the camera 20 are stored in the nonvolatile memory 37 of the image processing apparatus 30. In the above described embodiment, the reference models are created using a robot, however, the reference models may be created by a manual operation without using a robot. In this case, the reference workpiece is arranged within the field of view of the camera connected to the image processing apparatus 30, and the images of the workpiece with different postures are captured by the camera. The reference models are created based on the image data and

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the relative positions/postures of the camera and the workpiece at the image capturing manually inputted, and are stored with the respective relative positions/postures.

[0037] The reference models may be created from a part of the image data of the reference object, and may be created by processing the image data of the reference object.

[0038] In addition, the reference models may be created based on the stored image data of the reference workpiece when detecting the position/posture of the objective workpiece, without creating and storing the reference models in advance.

[0039] Hereinafter, a picking-up operation for taking out an individual workpiece by a robot from a pile of workpieces each having a shape identical to that of the reference workpiece will be described, as an example of a method of detecting three-dimensional position/posture of an object, using the image processing apparatus 30 storing the reference models.

[0040] FIG. 6 is a flowchart of the carrying out of the picking-up operation. When a picking-up command is inputted into the robot controller 10 from the teaching operation panel 4, the processor 1 operates the robot RB to move the camera attached to the robot wrist to an image capturing position where a pile of workpieces is within a field of view of the camera 20 (Step 200). The three dimensional position/posture of the camera 20 on the world coordinate system at this image capturing position is outputted to the image processing apparatus 30, and an image capturing command is outputted (Step 201). Upon receipt of the image capturing command, the processor 31 of the image processing apparatus 30 captures an image of the pile of the workpieces W. to obtain image data of some workpieces W and store the data in the frame memory 36 (Step 202).

[0041] Then, pattern matching processing is performed for the image data stored in the frame memory 36 using one of the reference models (the first reference model) stored in the nonvolatile memory 37 so as to detect a workpiece W (Step 203). In this pattern matching processing, matching of the image data of the reference model with the image data of workpieces is performed on the basis of position, turn and scale. It is determined whether or not an object has a matching value equal or greater than the set value (Step 204). If an object having a matching value equal or greater than the set value is not detected, the procedure proceeds to Step 205 to determine whether or not the pattern matching is performed using all the reference models (1st to 4th reference models). If the pattern matching using all the reference models is not yet performed, further pattern matching is performed using another reference model (Step 206).

[0042] If it is determined in Step 204 that an object having a matching value equal or greater than the set value with respect to any of the reference models is detected, the procedure proceeds to Step 207 to perform matching processing on the two-dimensional data of the detected workpieces W using every taught mode. In Step 208, the reference model having the largest matching value in the pattern matching processing is selected, and the relative position/posture of the workpiece W with respect to the camera 20 is determined based on the relative position/posture of the camera and the reference workpiece stored for the selected reference model, and position, rotation angle and scale of the image of the workpiece in the matching processing, (Step 208). The position and posture (orientation) of the detected workpiece on the world coordinate system is determined from the position and posture of the camera 20 in the world coordinate system, which has been sent in Step 201, and the relative position/posture of the workpiece W with respect to the camera 20, and is outputted (Step 209). Thus, since the relative position/posture of the workpiece W with respect to the camera 20 is the position/posture of the workpiece W in the camera coordinate system, the position and posture (orientation) of the detected workpiece W in the world coordinate system is obtained by an arithmetic operation of coordinate transformation using the data of the position/posture of the workpiece W in the camera coordinate system and the position/posture of the camera 20 in the world coordinate system (Step 209).

[0043] The reference model having the highest matching value is selected in this embodiment, although a reference model of the rotation angle of zero degree (the O-th reference model) may be selected in accordance with precedents, or an object having the highest expansion rate of scale (the object which is nearest to the camera, i.e. located at the suit of the pile in this example) may be selected in accordance with precedents.

[0044] The robot controller 10 operates the robot to perform a picking-up operation to grip and hold the detected workpiece W and move the held workpiece W to a predetermined position, based on the three-dimensional position/posture of the workpiece W (Step 210). Then, the procedure returns to Step 202 to repeatedly execute the processing of Step 202 and subsequent Steps.

[0045] When all the workpieces have been picked-up from the pile of the workpieces, a matching value equal to or greater than the set reference value cannot be obtained in the pattern matching processing for all reference models in Steps 203-206, and the picking-up operation is terminated.

[0046] In the case where a pile of the workpieces cannot fall within the field of view of the camera 20, or in the case where it is not necessary to capture an image of a workpiece behind other workpieces by changing the orientation of the camera, the procedure may return to Step 200 when "Yes" is determined in Step 205, to move the camera to another position/posture at which an image of the object workpiece can be captured.

[0047] In addition, in the case where the robot and the image processing apparatus 30 are used in combination

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as in the foregoing embodiment, the robot controller 10 may store the three-dimensional position/posture of the camera without outputting it to the image processing apparatus 30 in Step 201 and the relative position/posture of the workpiece and the camera may be outputted from the image processing apparatus 30 to the robot controller 10 in Step 208 to execute the processing of Step 209 in the robot controller 10.

[0048] Further, in the case where a wide-angle lens is installed in the CCD camera as the image capturing device, for example, there is possibility of judging the inclination angle to be 30 degrees by influence of parallax when a workpiece of zero degree inclination is at a corner of a field of view of the camera. In such a case, the camera may be moved parallelly in accordance with the position of the workpiece in the field of view of the camera to a position right above the workpiece so that the effect of parallax is lost, and at this position the image capturing processing of Step 201 and the subsequent Steps in FIG. 6 is performed so that a false judgment is prevented.

[0049] Furthermore, in order to obtain three-dimensional position/posture of an object workpiece whose three-dimensional position/posture is unknown without using a robot, the camera is arranged to capture an image of a pile of workpieces or a region containing the objective workpiece within a field of view of the camera, and the position/posture of the camera in the world coordinate system is inputted to the image processing apparatus 30 and an object detection command is issued to the image processing apparatus 30, to make the image processing apparatus 30 execute Steps 202-209 of FIG. 6.

[0050] The image data for creating the reference models may be obtained at a place different form the place where the robot is installed. In this case, the image data may be supplied to the image processing apparatus on line through a communication interface provided in the image processing apparatus, or may be supplied offline through a disc driver for reading a floppy disk, etc.

[0051] According to the present invention, the position/posture of an object workpiece in a randomly arranged pile of workpieces or an aggregation of workpieces gathered in a predetermined region which have identical shapes and different three-dimensional positions/postures is detected, to thereby enable a robot to automatically pick out an individual workpiece from such a pile or an aggregation.

Claims

1. An image processing apparatus for detecting posture, or posture and position, of an object comprising:

   an image capturing device;
   a memory storage reference model created based on image data of a reference object captured by said image capturing device in a plurality of directions, and storing information of the capturing directions to be respectively associated with said reference models, said reference object being the object for detection or an object having a shape identical to that of the object for detection; and
   a processor to perform matching processing of image data containing an image of the object for detection captured by said image capturing device with image data for said reference models to select an image of an object matched with one of said reference models, and to obtain posture, or posture and position, of the object based on the selected image of the object, said one reference model and the information of the direction associated with said one reference model.

2. An image processing-apparatus according to claim 1, wherein said reference models comprises a part of the image data of the reference object.

3. An image processing apparatus according to claim 1 or 2, wherein said reference models are obtained by processing the image data of the reference object.

4. An image processing apparatus according to any preceding claim, wherein said image capturing device comprises a camera for capturing two-dimensional image data.

5. An image processing apparatus according to claim 4, wherein said image data of the reference object are captured by said image capturing device from a predetermined distance.

6. An image processing apparatus according to any one of claims 1 to 3, wherein said image capturing device comprises a visual sensor for capturing three-dimensional image data.

7. An image processing apparatus according to claim 6, wherein said image data containing an image of the object for detection captured by said visual sensor are two-dimensional arrangement data including distance information from the object of detection to the image capturing device, a part of said two-dimensional arrangement data or a set of distance data.

8. An image processing apparatus according to an one of claims 1 through 7, wherein said image capturing device is attached to a robot.

9. An image processing apparatus according to claim

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1, wherein said image data of the reference object are captured in a place different from a place where the detection of the object is performed, and supplied to the image processing apparatus on line or off line.

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FIG. 1

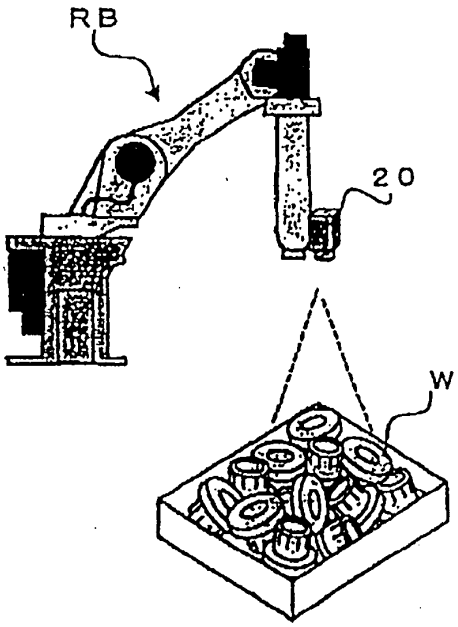


FIG. 2a

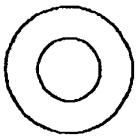


FIG. 2b

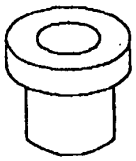


FIG. 2c

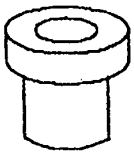


FIG. 2d

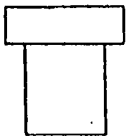


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FIG.3

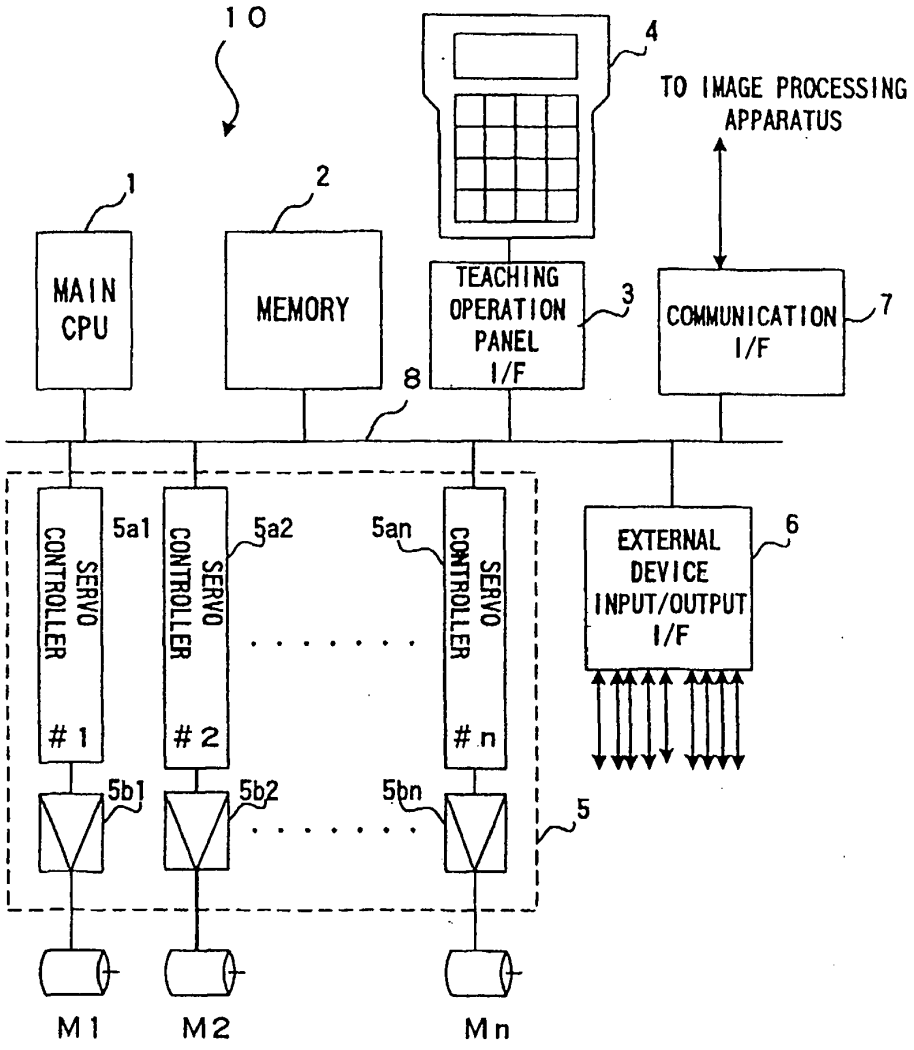


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FIG. 4

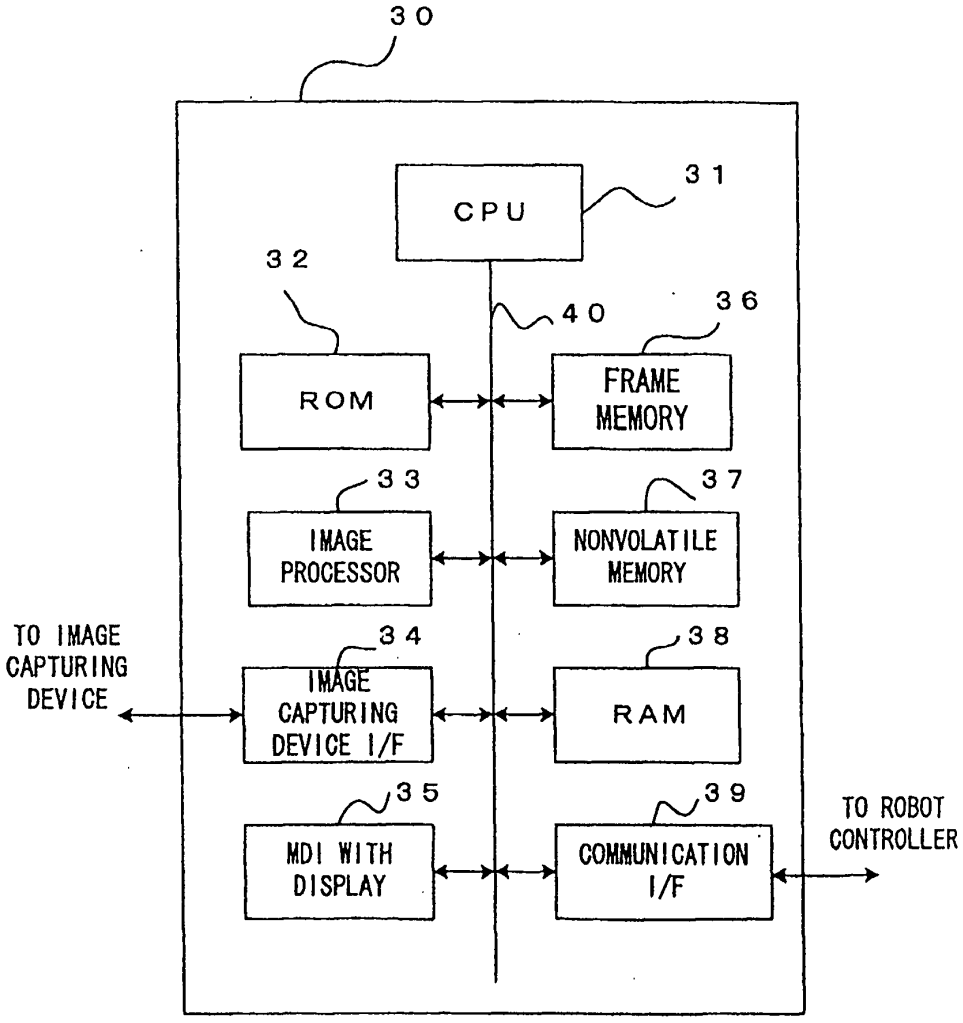


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FIG. 5

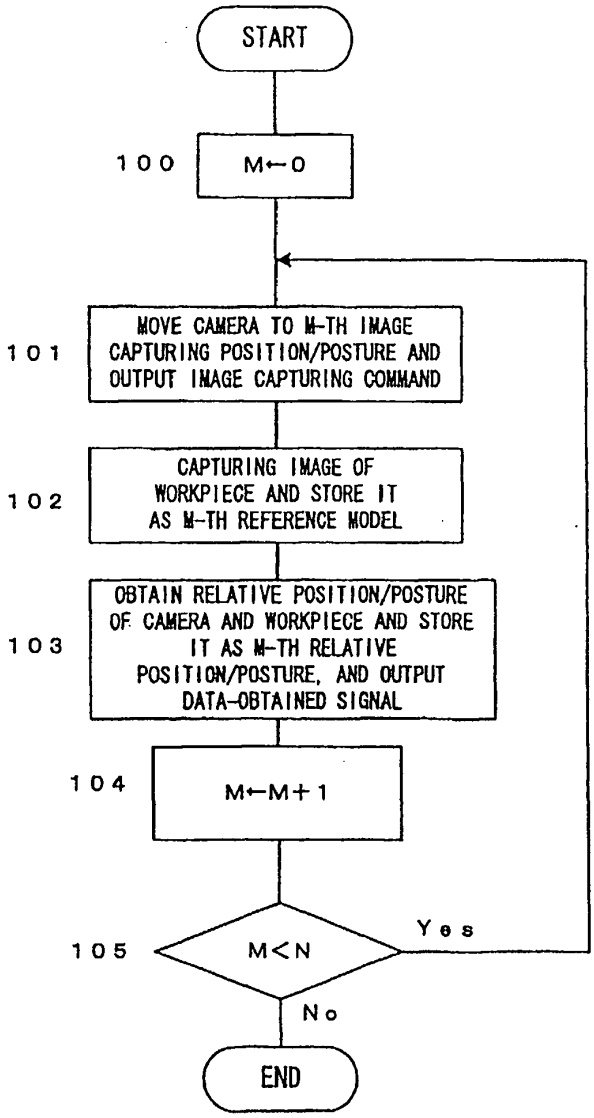


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FIG. 6

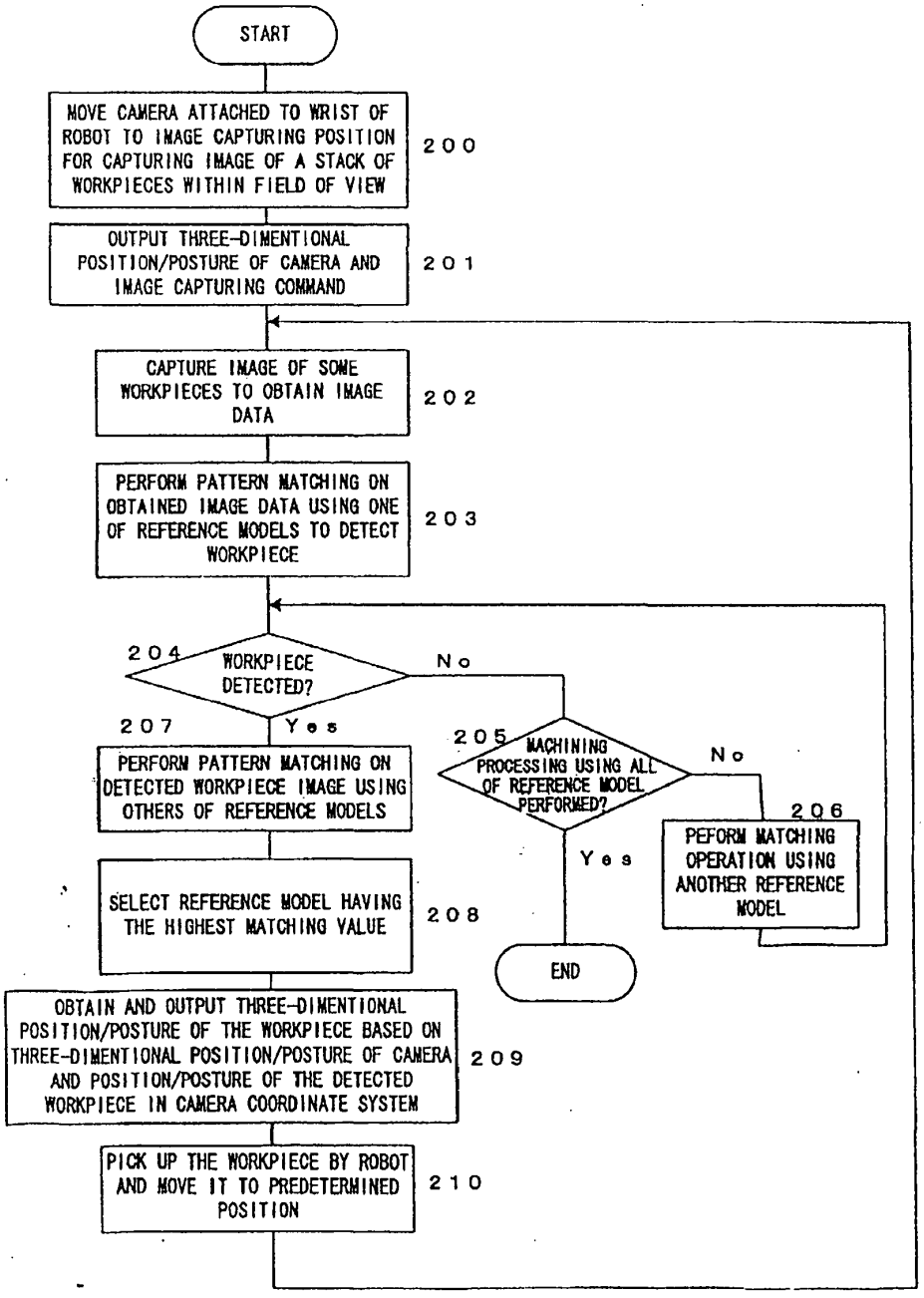


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FIG. 7

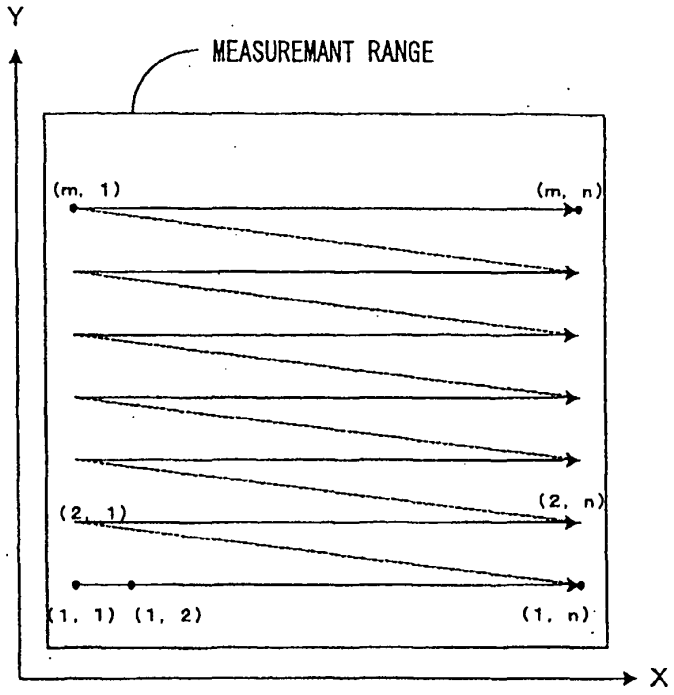


FIG. 8

Z(m, 1)	• • •	• • •	• • •	• • •	Z(m, n)
• • •	• • •	• • •	• • •	• • •	• • •
• • •	• • •	• • •	• • •	• • •	• • •
• • •	• • •	Z(i, j)	• • •	• • •	• • •
• • •	• • •	• • •	• • •	• • •	• • •
Z(1, 1)	Z(1, 2)	• • •	• • •	• • •	Z(1, n)

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FIG. 9

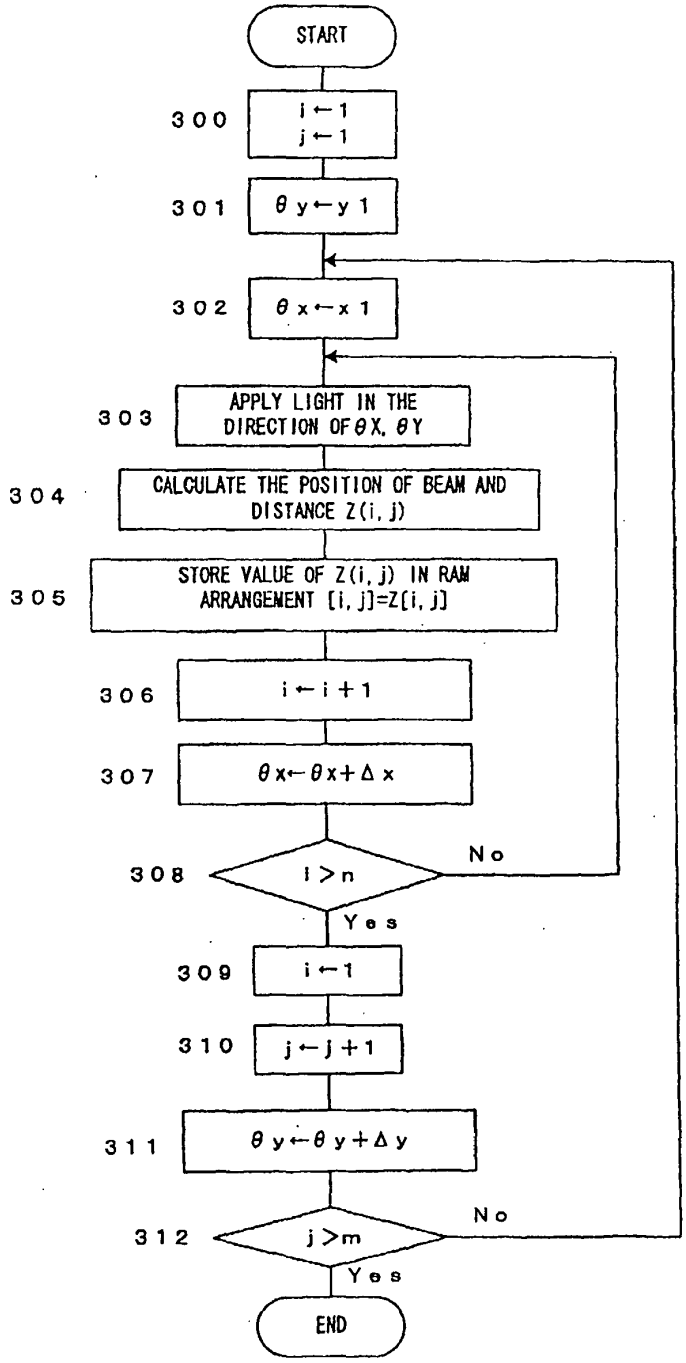


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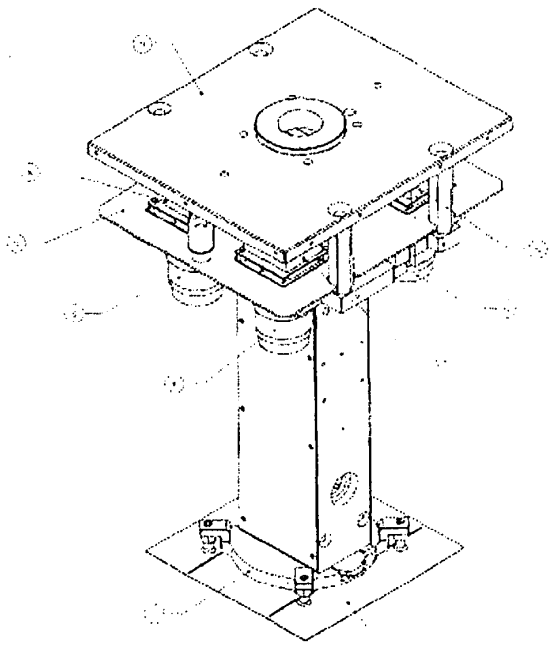
EXPRESS MAIL NO.
EM035615557US

Gripper or handling device for picking up an object and moving it from one location to another comprises an array of cameras linked to an evaluation and control unit for determination of the object position relative to the gripper

Patent number:	DE10236040
Publication date:	2004-02-19
Inventor:	MANZ DIETER (DE)
Applicant:	MANZ AUTOMATION AG (DE)
Classification:	
- international:	***B25J9/16;*** **B25J9/16**; (IPC1-7): B25J13/08; G06T9/20
- european:	B25J9/16H; B25J9/16V1
Application number:	DE20021036040 20020806
Priority number(s):	DE20021036040 20020806

Abstract of **DE10236040**

Device has a gripper (11) with a controllable manipulator for handling workpieces or components (12) whose position relative to the gripper is undefined. The gripper also has at least one optical recording device (16) which, after picking up of the component and during its movement, makes one or more recordings of it. The images are evaluated by an evaluation and control unit that controls movement of the gripper based on the image information.



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Deutsches Patent- und Markenamt

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(51) Int Cl.[7]: **B25J 13/08**
G06T 9/20

(71) Anmelder:
Manz Automation AG, 72768 Reutlingen, DE

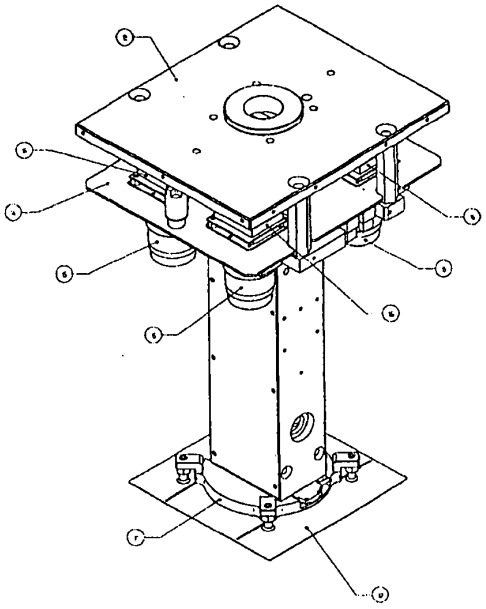
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Möbus, D., Dr.-Ing. Dipl.-Ing., Pat.-Anw., 72764 Reutlingen

(72) Erfinder:
Manz, Dieter, 72141 Walddorfhäslach, DE

Die folgenden Angaben sind den vom Anmelder eingereichten Unterlagen entnommen

(54) Bezeichnung: **Greifvorrichtung**

(57) Zusammenfassung: Eine Greifvorrichtung (10) mit mindestens einem Greifer (11) mit steuerbarem Manipulator für Bauteile (12) oder dergleichen, deren Position beim Aufnehmen durch den Greifer (11) undefiniert ist, mit mindestens einer optischen Aufnahmevorrichtung (16), die nach dem Ergreifen des Bauteils (12) und während der Bewegung des Bauteils (12) durch den Greifer (11) zur Ermittlung der Lage des Bauteils (12) innerhalb des Greifers (11) eine oder mehrere Aufnahmen des Bauteils (12) macht und die mit einer Auswerte- und Steuereinrichtung verbunden ist, die die Bildinformation der mindestens einen optischen Aufnahmevorrichtung (16) auswertet und die Bewegung des Greifers (11) in Abhängigkeit von der Bildinformation beeinflusst.



Beschreibung

[0001] Die Erfindung betrifft eine Greifvorrichtung mit mindestens einem Greifer mit steuerbarem Manipulator für Bauteile oder dergleichen, deren Position beim Aufnehmen durch den Greifer undefiniert ist, mit mindestens einer optischen Aufnahmevorrichtung.

[0002] Beim Handhaben von Bauteilen, Werkstücken oder dergleichen kann das Problem auftreten, dass die ankommenden Bauteile in ihrer Position beispielsweise auf einem Transportband oder dergleichen nicht exakt definiert sind. In der Regel wird in solchen Fällen die Position des zu ergreifenden Bauteils optisch kontrolliert. Dazu sind auch bereits Greifer mit integrierten Kameras vorgeschlagen worden. Die Greifer fahren über das Bauteil und machen mit der Kamera eine Aufnahme vom Bauteil. Die Bildinformation wird anschließend ausgewertet. In Abhängigkeit von der detektierten Position des Bauteils wird dann der Greifer derart über dem Bauteil positioniert, dass er es in einer definierten Lage zu sich selbst aufnehmen kann. Bei anderen Greifvorrichtungen wird das Werkstück vom Greifer in der gerade vorhandenen Position aufgenommen, was beispielsweise bei Vakuumgreifern, Saugvorrichtungen und dergleichen möglich ist. Anschließend verfährt der Greifer mit dem Werkstück über eine Kamera, mit deren Hilfe die Position des Werkstücks im Greifer feststellbar ist. Abhängig davon wird dann der Greifer so gesteuert, dass er das Werkstück am Zielort in einer definierten Position absetzen kann.

[0003] Die bisher bekannten Greifvorrichtungen zur Handhabung von Werkstücken aus einer undefinierten Übergabeposition heraus haben jedoch alle den Nachteil, dass sie für die Feststellung der Position des Werkstückes relativ viel Zeit benötigen und die Positioniergenauigkeit nur gering ist, da sich Positionierfehler beim Aufnehmen des Bauteils und beim Bewegen über die Kamera addieren.

[0004] Der vorliegenden Erfindung liegt die Aufgabe zugrunde, eine Greifvorrichtung zu schaffen, mit der eine rasche Handhabung von Gegenständen möglich ist, deren Aufnahmeposition undefiniert ist.

[0005] Die Aufgabe wird durch eine Greifvorrichtung der eingangs genannten Art erfindungsgemäß dadurch gelöst, dass die mindestens eine optische Aufnahmevorrichtung nach dem Ergreifen des Bauteils und während der Bewegung des Bauteils durch den Greifer zur Ermittlung der Lage des Bauteils innerhalb des Greifers eine oder mehrere Aufnahmen des Bauteils macht und mit einer Auswerte- und Steuereinrichtung verbunden ist, die die Bildinformation der mindestens einen optischen Aufnahmevorrichtung auswertet und die Bewegung des Greifers in Abhängigkeit von der Bildinformation beeinflusst.

[0006] Mit der erfindungsgemäßen Greifvorrichtung ist nun eine Überprüfung der Position des Bauteils im Greifer während der Bewegung des Greifers möglich, sodass keinerlei Zeitverlust durch die Erfassung der Lage des Bauteils auftritt. Auch eine Bestimmung der Zielkoordinaten des Greifes in Abhängigkeit von der Bildinformation ist während der Bewegung des Greifers möglich. Damit arbeitet die erfindungsgemäße Greifvorrichtung mit der gleichen Geschwindigkeit wie eine Greifvorrichtung für Bauteile, deren Aufnahmeposition genau definiert ist.

[0007] Die mindestens eine optische Aufnahmevorrichtung kann vorzugsweise derart an der Greifvorrichtung angeordnet sein, dass die Kontur des Bauteils erfassbar ist. Es ist dann möglich, dass die Auswerte- und Steuereinrichtung anhand der Form der Kontur eine Beschädigungsüberprüfung des Bauteils durch Vergleich mit der Kontur eines unbeschädigten Bauteils durchführt. Damit kann die Greifvorrichtung auch gleichzeitig zur Erkennung von Ausschussware eingesetzt werden. Wird eine Beschädigung des im Greifer befindlichen Bauteils detektiert, so kann der Greifer sofort zu einer Ablageposition für Ausschussteile bewegt werden. Auf diese Weise ist sowohl für die Detektierung eines Ausschussbauteils als auch zu dessen Aussortieren nur ein minimaler Zeitaufwand nötig. Mit der Erfassung der Kontur des Bauteils ist außerdem eine Bauteilidentifikation möglich, sodass bei einer Handhabung verschiedener Bauteile diese eindeutig identifiziert werden können.

[0008] Die erfindungsgemäße Greifvorrichtung lässt sich insbesondere für größere, seitlich über die Greifvorrichtung vorstehende Bauteile einsetzen. In einem solchen Fall ist es zweckmäßig, vier Kameras vorzusehen, die derart angeordnet sind, dass die gesamten seitlich über den Greifer vorstehenden Bereiche des Bauteils erfassbar sind. Auf diese Weise ist neben der Detektion der Lage des Bauteils im Greifer auch eine Überprüfung auf Beschädigungen in zuverlässiger Weise möglich. Insbesondere lässt sich die Greifvorrichtung für sehr bruchempfindliche Bauteile wie Solarzellen oder Wafer einsetzen. Solche Bauteile können vom Greifer beispielsweise aus einer Übergabevorrichtung, die die Bauteile durch Einblasen von Luft aus einem Bauteilestapel vereinzelt, aufgenommen werden. Zur Vermeidung einer Beschädigung solch empfindlicher Bauteile lässt sich vorzugsweise ein Bernoulli-Greifer einsetzen, der ein berührungsloses Erfassen der Bauteile ermöglicht. Hier macht das Vorsehen der erfindungsgemäßen Greifvorrichtung besonderen Sinn, da das Vereinzeln der Bauteile durch Luft und die berührungslose Aufnahme mittels eines Bernoulli-Greifers dazu führen, dass die Lage des aufgenommenen Bauteils im Greifer nicht vorhersagbar ist.

[0009] Der Greifer kann die Bauteile – je nach Einsatzzweck – beispielsweise auf einem Transportband zur Weiterleitung an Bearbeitungsstationen oder direkt in einer Bearbeitungsstation absetzen.

[0010] Nachfolgend wird ein bevorzugtes Ausführungsbeispiel einer erfindungsgemäßen Greifvorrichtung anhand der Zeichnung näher beschrieben.

[0011] Es zeigen:

[0012] **Fig.** 1 eine perspektivische Ansicht einer erfindungsgemäßen Greifvorrichtung;

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[0013] **Fig.** 2 eine Frontansicht auf die Greifvorrichtung aus **Fig.** 1;
[0014] **Fig.** 3 eine Draufsicht auf die Greifvorrichtung aus **Fig.** 1.
[0015] Die Greifvorrichtung **10** nach **Fig.** 1 weist einen Bernoulli-Greifer **11** für ein flächiges, rechteckiges Werkstück **12**, hier eine Solarzelle, auf. Mit dem Bernoulli-Greifer **11** ist dabei eine berührungslose Aufnahme des Werkstücks **12** möglich, um einen Bruch des Werkstücks **12** beim Aufnehmen oder Absetzen zu vermeiden. Der Bernoulli-Greifer **11** kann über eine Koppelplatte **13** an einem hier nicht näher dargestellten Greifarm eines Industrieroboters (Manipulators) befestigt werden. Unterhalb der Koppelplatte **13** ist eine Aufnahmeplatte **13** für die Objektive **15** von insgesamt vier Kameras **16** angeordnet. Der gegenseitige Abstand der Koppelplatte **13** und der Aufnahmeplatte **14** kann veränderlich sein, um die Brennweite der Objektive **15** verändern zu können. Die vier Kameras **16** mit den Objektiven **15** sind so angeordnet, dass sie alle Bereiche des Werkstücks **12**, die seitlich über den Greifer **11** hinausragen, erfassen können. Dadurch ist mit Hilfe der Kameras **16** nicht nur eine exakte Bestimmung der Lage des Werkstücks **12** im Greifer **11**, sondern auch eine Überprüfung des Werkstücks **12** auf Beschädigungen möglich. Diese Anordnung der Kameras **16** außerhalb des Bereichs des Greifers **11** ist insbesondere auch aus der Draufsicht aus **Fig.** 3 ersichtlich.
[0016] Die Bildsignale der vier Kameras **16** werden von einer hier nicht näher dargestellten Auswerte- und Steuereinrichtung ausgewertet, die entweder in der Greifvorrichtung **10** oder aber auch außerhalb davon, beispielsweise im Industrieroboter (Manipulator), angeordnet sein kann. In Abhängigkeit von der detektierten Lage des Bauteils **12** im Greifer **11** und/oder der Feststellung eventueller Beschädigungen wird von der Auswerte- und Steuereinrichtung die Bewegung des Greifers **11** derart beeinflusst, dass der Greifer **11** das Bauteil **12** exakt an der gewünschten Position und dort in der richtigen Lage absetzt. Dies kann beispielsweise ein Transportband oder eine Bearbeitungsstation sein. Wird eine Beschädigung des Werkstückes **12** detektiert, so wird der Greifer zu einer Ablageposition für Ausschussware umgelenkt.
[0017] Die erfindungsgemäße Greifvorrichtung kann selbstverständlich auch andere Arten von Greifer als Bernoulli-Greifer aufweisen und lässt sich auch für andere Bauteile oder Werkstücke als dünne oder flächige Elemente einsetzen.

Patentansprüche

1. Greifvorrichtung mit mindestens einem Greifer (**11**) mit steuerbarem Manipulator für Bauteile (**12**) oder dergleichen, deren Position beim Aufnehmen durch den Greifer (**11**) undefiniert ist, mit mindestens einer optischen Aufnahmevorrichtung (**16**), **dadurch gekennzeichnet**, dass die mindestens eine optische Aufnahmevorrichtung (**16**) nach dem Ergreifen des Bauteils (**12**) und während der Bewegung des Bauteils (**12**) durch den Greifer (**11**) zur Ermittlung der Lage des Bauteils (**12**) innerhalb des Greifers (**11**) eine oder mehrere Aufnahmen des Bauteils (**12**) macht und mit einer Auswerte- und Steuereinrichtung verbunden ist, die die Bildinformation der mindestens einen optischen Aufnahmevorrichtung (**16**) auswertet und die Bewegung des Greifers (**11**) in Abhängigkeit von der Bildinformation beeinflusst.

2. Greifvorrichtung nach Anspruch 1, dadurch gekennzeichnet, dass die Auswerte- und Steuereinrichtung die Zielposition der Bewegung des Greifers (**11**) in Abhängigkeit von der Bildinformation der mindestens einen optischen Aufnahmevorrichtung (**16**) bestimmt.

3. Greifvorrichtung nach Anspruch 1 oder 2, dadurch gekennzeichnet, dass die mindestens eine optische Aufnahmevorrichtung (**16**) derart an der Greifvorrichtung (**10**) angeordnet ist, dass die Kontur des Bauteils (**12**) erfassbar ist.

4. Greifvorrichtung nach Anspruch 3, dadurch gekennzeichnet, dass die Auswerte- und Steuereinrichtung anhand der Form der Kontur eine Beschädigungsüberprüfung und/oder Identifikation des Bauteils durch Vergleich mit der Kontur eines unbeschädigten Bauteils (**12**) durchführt.

5. Greifvorrichtung nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, dass die mindestens eine optische Aufnahmevorrichtung (**16**) eine Kamera, eine CCD-Kamera oder ein anderer Pixelmatrix-Fotodetektor ist.

6. Greifvorrichtung nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, dass die Bauteile (**12**) nach dem Ergreifen seitlich über den Greifer (**11**) vorstehen.

7. Greifvorrichtung nach Anspruch 6, dadurch gekennzeichnet, dass sie vier Kameras (**16**) aufweist, die derart angeordnet sind, dass die gesamten seitlich über den Greifer (**11**) vorstehenden Bereiche des Bauteils (**12**) erfassbar sind.

8. Greifvorrichtung nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, dass die Bauteile (**12**) flächige Elemente, insbesondere Solarzellen oder Wafer, sind.

9. Greifvorrichtung nach einem der Ansprüche 1 bis 8, dadurch gekennzeichnet, dass der mindestens eine Greifer (**11**) ein Bernoulli-Greifer ist.

10. Greifvorrichtung nach einem der Ansprüche 1 bis 9, dadurch gekennzeichnet, dass der Greifer (**11**)

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die Bauteile (**12**) aus einer Übergabevorrichtung, die die Bauteile (**12**) durch Einblasen von Luft aus einem Bauteilstapel vereinzelt, aufnimmt .

11. Greifvorrichtung nach einem der Ansprüche 1 bis 10, dadurch gekennzeichnet, dass der Greifer (**11**) die Bauteile (**12**) auf einem Transportband oder in einer Bearbeitungsstation absetzt.

Es folgen 2 Blatt Zeichnungen

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Anhängende Zeichnungen

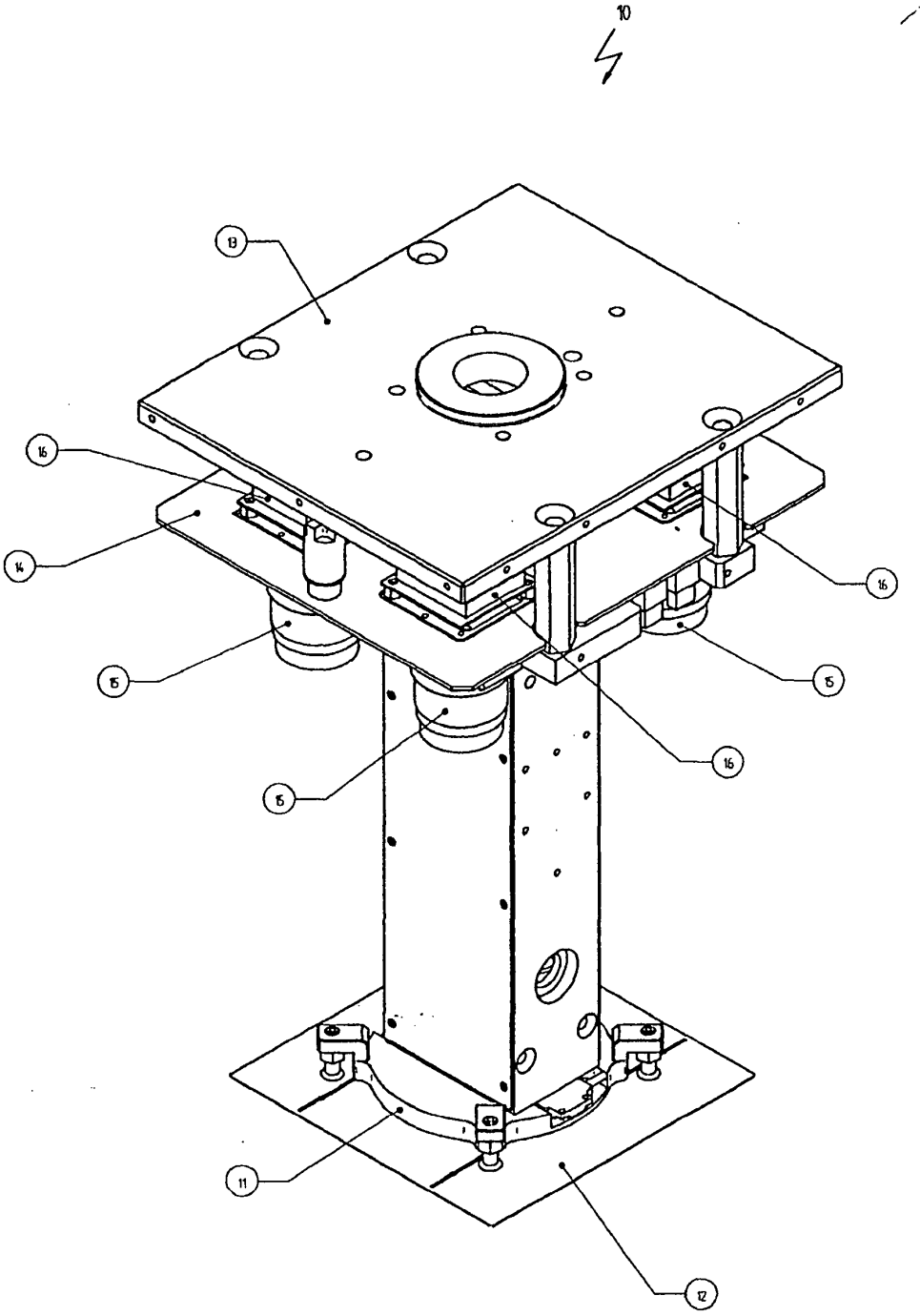


Fig. 1

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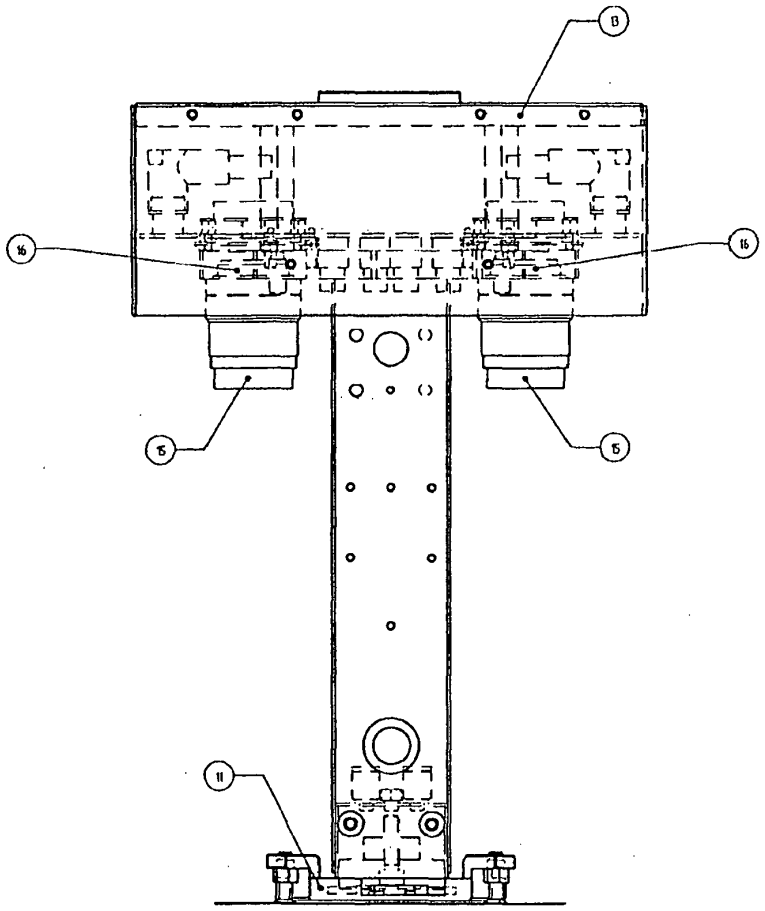


Fig. 2

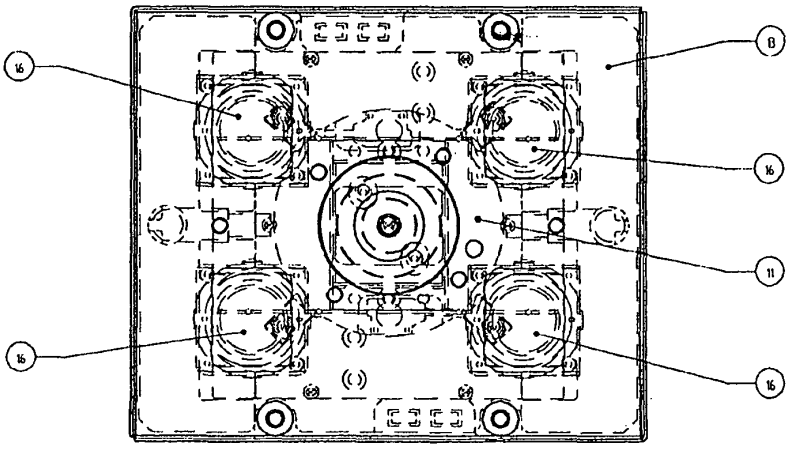


Fig3

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Title: **JP2000024973A2: BIN PICKING POSITION DATA CALIBRATION METHOD, MEDIUM STORING SOFTWARE FOR REALIZING METHOD, AND DEVICE FOR EXECUTING METHOD**

Derwent Title: Bin-picking position data calibration method for Robot system involves setting up standard model of background object using which the permanent position of band conveyor and workbench are calibrated [Derwent Record]



View Image

1 page

Country: **JP** Japan
Kind: **A2** Document Laid open to Public inspection

Inventor: **FUJIWARA NOBUYUKI**;
ONDA TOSHIKAZU;

Assignee: **MEIDENSHA CORP**
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Published / Filed: **2000-01-25** / 1998-07-13

Application Number: **JP1998000196965**

IPC Code: IPC-7: **B25J 13/08**; G01B 11/00; G06T 7/00;

Priority Number: 1998-07-13 **JP1998000196965**

Abstract: PROBLEM TO BE SOLVED: To realize the calibration of the bin picking position data with a simple system without preparing a special device by setting the reference object model on the basis of an unmovable background object such as a belt conveyor and a work bench existing in the field of a camera.

SOLUTION: A new vision system of an image measuring device is set by a vision setting part 1, the calibration coordinate conversion data calculated by a caliburation cordinate converting data calculating part 3 is caliburated on the basis of the matching result by the background object model matching part 2, and the device positional relationship data is caliburated on the basis of the device positional relationship by that time by a device positional relationship data composing part 4. Further it comprises a component model data caliburating part 5 for caliburating the caliburation coordinate conversion data and the component model data by that time, and the position data necessary for a bin picking system is caliburated. Whereby the system can be normally operated even when the positional attitude of a camera is shifted to some degree.

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Family: None

Other Abstract Info: DERABS G2000-175774 DERABS G2000-175774

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OrderPatent

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(71) Applicant: MEIDENSHA CORP
(72) Inventor: FUJIWARA NOBUYUKI
ONDA TOSHIKAZU

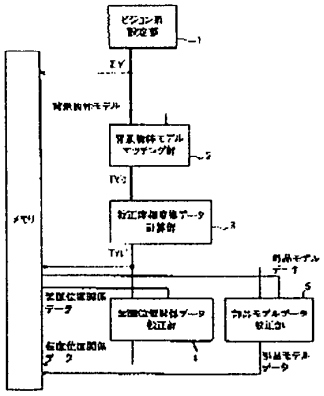
(54) BIN PICKING POSITION DATA CALIBRATION METHOD, MEDIUM STORING SOFTWARE FOR REALIZING METHOD, AND DEVICE FOR EXECUTING METHOD

(57) Abstract:

PROBLEM TO BE SOLVED: To realize the calibration of the bin picking position data with a simple system without preparing a special device by setting the reference object model on the basis of an unmovable background object such as a belt conveyor and a work bench existing in the field of a camera.

SOLUTION: A new vision system of an image measuring device is set by a vision setting part 1, the calibration coordinate conversion data calculated by a caliburation cordinate converting data calculating part 3 is caliburated on the basis of the matching result by the background object model matching part 2, and the device positional relationship data is caliburated on the basis of the device positional relationship by that time by a device positional relationship data composing part 4. Further it comprises a component model data caliburating part 5 for caliburating the caliburation coordinate conversion data and the component model data by that time, and the position data necessary for a bin picking system is caliburated. Whereby the system can be normally operated even when the positional attitude of a camera is shifted to some degree.

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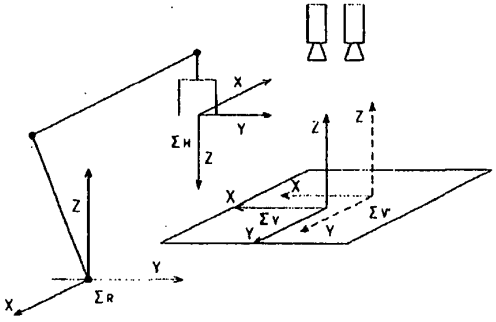
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最終頁に続く

(54)【発明の名称】　ビンピッキング位置データ較正方法及びその方法を実現するソフトウェアを記録した媒体並びにこの方法を実施する装置

(57)【要約】
【課題】　ビンピッキングシステムに必要な各装置の位置関係及び部品検出に必要な位置データを較正することである。
【解決手段】　画像計測装置の新ビジョン系の設定を行うビジョン系設定部１と、背景物体モデルによりモデルマッチングを行う背景物体モデルマッチング部２と、マッチング結果より較正座標変換データを計算する較正座標変換データ計算部３と、較正座標変換データと今までの装置位置関係データを用いて装置位置関係データを較正する装置位置関係データ構成部４と、較正座標変換データと今までの部品モデルデータを用いて部品モデルデータを較正する部品モデルデータ較正部５とを備え、ビンピッキングシステムに必要な位置データを較正する。



位置データ較正に用いる座標系の例

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【特許請求の範囲】
【請求項1】 カメラの視野内に存在するベルトコンベア或いは作業台等の位置が変化しない背景物体を基に基準物体モデルを設定することを特徴とするビンピッキング位置データ較正方法及びその方法を実現するソフトウェアを記録した媒体並びにこの方法を実施する装置。
【請求項2】 カメラ視野内に固定した識別の容易なマーク物体を基に基準物体モデルを設定することを特徴とするビンピッキング位置データ較正方法及びその方法を実現するソフトウェアを記録した媒体並びにこの方法を実施する装置。
【請求項3】 位置データ較正作業時に、用意しておいたジグによってマーク物体をカメラ視野内に位置精度良く取り付けることを特徴とするビンピッキング位置データ較正方法及びその方法を実現するソフトウェアを記録した媒体並びにこの方法を実施する装置。
【請求項4】 ロボットアームにマーク物体を取り付けることを特徴とするビンピッキング位置データ較正方法及びその方法を実現するソフトウェアを記録した媒体並びにこの方法を実施する装置。
【請求項5】 基準物体モデルを設定するための基準部品を作業者側で適切に用意することを特徴とするビンピッキング位置データ較正方法及びその方法を実現するソフトウェアを記録した媒体並びにこの方法を実施する装置。
【発明の詳細な説明】
【0001】
【発明の属する技術分野】本発明は、いわゆるロボットシステムにおけるビンピッキング位置データ較正方法及びその方法を実現するソフトウェアを記録した媒体並びにこの方法を実施する装置に関する。特に、ビンピッキングシステムに必要な各装置の位置関係及び部品検出に必要な位置データを較正する手段を提供するものである。
【0002】
【背景技術】ビンピッキングシステムは対象部品の位置姿勢を画像計測装置で検出し、その情報を元にロボットアームで対象部品をハンドリングするシステムである。また、画像計測装置としては、入力画像から得られる対象物体の輪郭、凹凸、模様等の特徴を直線、円弧等で近似したデータであるとともにステレオ計測等で得た三次元位置データを有する特徴データと、対象物体のモデルの三次元位置データを有する特徴データとのマッチングをとることで対象物体の三次元位置姿勢を得るものがある。
【0003】対象部品の位置検出方法としてモデルベーストマッチング法があり、部品のモデル作製方法としても種々の提案がある。ハンドリングの際必要な、ロボットアーム装置と画像計測装置との相対関係を求める方法として従来より様々な提案がある。
【0004】
【発明が解決しようとする課題】ビンピッキングシステムを正しく動作させるためには、対象部品の位置検出やハンドリングデータを計算するために必要な各装置の位置関係が既知であり、またその位置関係が正しく保たれていなければならない。
【0005】しかしながら、カメラの故障や寿命、事故によるカメラの破損等でカメラを交換する場合は、カメラの位置やそれに伴う画像計測装置の座標系が変わるため、今までのデータを全て新しく作り直す必要がある。またカメラ取付部の経年変化によりカメラの位置姿勢にズレが生じた場合、対象部品の検出位置姿勢が実体の位置姿勢と異なるため、システムの動作に不具合が生じる。
【0006】
【課題を解決するための手段】本発明の請求項1に係るビンピッキング位置データ較正方法及びその方法を実現するソフトウェアを記録したフロッピーディスク、CD-ROM等の媒体並びにこの方法を実施するビンピッキング位置データ較正装置は、カメラの視野内に存在するベルトコンベアや作業台といった位置が変化しない背景物体を基に基準物体モデルを設定することを特徴とする。そのため、基準物体モデルを設定するための特別な装置を用意する必要がなく、簡素なシステムを構成でき、装置のコストを小さくすることができるメリットがある。
【0007】本発明の請求項2に係るビンピッキング位置データ較正方法及びその方法を実現するソフトウェアを記録したフロッピーディスク、CD-ROM等の媒体並びにこの方法を実施するビンピッキング位置データ較正装置は、カメラ視野内に固定した識別の容易なマーク物体を基に基準物体モデルを設定することを特徴とする。そのため、高精度な較正座標変換データを得ることができ、システムの信頼性を向上できる。またマークがカメラ視野内に固定されているため、頻繁な定期位置データ較正を容易に行うことができるメリットがある。
【0008】本発明の請求項3に係るビンピッキング位置データ較正方法及びその方法を実現するソフトウェアを記録したフロッピーディスク、CD-ROM等の媒体並びにこの方法を実施するビンピッキング位置データ較正装置は、カメラ視野内にマーク物体を固定できない場合でも、位置データ較正作業時に、用意しておいたジグによってマーク物体をカメラ視野内に位置精度良く取り付けることを特徴とする。そのため、高精度な較正座標変換データを得ることができ、システムの信頼性を向上できるメリットがある。
【0009】本発明の請求項4に係るビンピッキング位置データ較正方法及びその方法を実現するソフトウェアを記録したフロッピーディスク、CD-ROM等の媒体並びにこの方法を実施するビンピッキング位置データ較

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正装置は、カメラ視野内にマーク物体を固定できない場合でも、また、作業場にマーク物体を取り付けるためのジグが用意できない場合でも、位置精度良く動作するロボットアームにマーク物体を取り付けることを特徴とする。そのため、カメラ視野内にマーク物体を位置精度良く設置して、高精度な較正座標変換データを得ることができ、システムの信頼性を向上できるメリットがある。

【0010】本発明の請求項5に係るビンピッキング位置データ較正方法及びその方法を実現するソフトウェアを記録したフロッピーディスク、CD-ROM等の媒体並びにこの方法を実施するビンピッキング位置データ較正装置は、基準物体モデルを設定するための基準部品を作業者側で適切に用意することを特徴とする。そのため、基準物体モデルを設定するための特別な装置を用意する必要がなく、システムのコストを小さくすることができる。また、基準部品にマーク物体と同様に識別の容易な部品を選び、位置精度良く動作するロボットアームによって基準部品を位置精度良く設置することで、高精度な較正座標変換データを得ることができ、システムの信頼性を向上できるメリットがある。

【0011】

【発明の実施の形態】(1)基本的な考え方

本発明の目的はピンピッキングシステムに必要な各装置の位置関係及び部品検出に必要な位置データを較正することである。カメラの位置姿勢が変化した場合、それに伴い画像計測装置の新しい座標系を設定する必要がある。

【0012】この時画像計測装置の今までの座標系と新しく設定した座標系の位置関係が検出できれば、その位置関係データを用いて各装置の位置関係データや部品検出に必要な部品データを新しく設定した画像計測装置の座標系を基にしたデータへ変換することができる。そこで、本発明では部品モデル作製位置に設置した物体について、今までの座標系で作った部品モデルを使用して新しい座標系においてモデルマッチングを行うことで、画像計測装置の今までの座標系と新しく設定した座標系の位置関係を求める。

【0013】(2)各装置の座標系と相対関係

図1の様に各座標系を設定する。

ここで各座標系は次のものである。

Σ_V：旧ビジョン系(画像計測装置の今までの座標系)

$\Sigma_{V'}$：新ビジョン系(画像計測装置の新しく設定した座標系)

Σ_R：ロボット系(ロボットアーム装置の座標系)

Σ_H：ハンド系(ハンドの対象物体ハンドリング時の座標系)

【0014】各装置間の位置関係はその装置の座標系から別の装置の座標系への座標変換データとして求められる。

T_{RV}：ロボット系Σ_Rから旧ビジョン系Σ_Vへの座標変換

T_{VH}：旧ビジョン系Σ_Vからハンド系Σ_Hへの座標変換

$T_{RV'}$：ロボット系Σ_Rから新ビジョン系$\Sigma_{V'}$への座標変換

$T_{V'H}$：新ビジョン系$\Sigma_{V'}$からハンド系Σ_Hへの座標変換

$T_{VV'}$：旧ビジョン系Σ_Vから新ビジョン系$\Sigma_{V'}$への座標変換

【0015】(3)較正座標変換データの計算

データ較正に必要な、変換データは旧ビジョン系Σ_Vから新ビジョン系$\Sigma_{V'}$への座標変換データ$T_{VV'}$である。これをモデルマッチングによって求める。旧ビジョン系Σ_Vにおいて基準物体の部品モデルを作っておき、基準物体をモデル作製位置に設置して、新ビジョン系$\Sigma_{V'}$において同一のモデルを用いてモデルマッチングを行うと、新ビジョン系$\Sigma_{V'}$を基にする基準物体の位置姿勢$T_{V',0}$を検出できる。

【0016】この時基準物体は旧ビジョン系Σ_Vにおいて全く動かない位置姿勢にあるため、先ほど新ビジョン系$\Sigma_{V'}$において検出した基準物体の位置姿勢$T_{V',0}$は、新ビジョン系$\Sigma_{V'}$から旧ビジョン系Σ_Vへの座標変換$T_{V',V}$を示す。よって、データ較正に必要な座標変換データは旧ビジョン系Σ_Vから新ビジョン系$\Sigma_{V'}$への座標変換データ$T_{VV'}$として次のように求められる。

$$T_{VV'}=T_{V',0}^{-1} \quad \cdots(1)$$

【0017】(4)装置位置関係の較正

ロボット系Σ_Rと新ビジョン系$\Sigma_{V'}$の位置関係は較正座標変換データと今までの位置関係より次のように計算できる。

$$T_{RV'}=T_{RV}T_{VV'} \quad \cdots(2)$$

新ビジョン系$\Sigma_{V'}$とハンド系Σ_Hの位置関係は較正座標変換データと今までの位置関係より次のように計算できる。

$$T_{V'H}=T_{VV'}^{-1}T_{VH} \quad \cdots(3)$$

【0018】(5)部品モデルデータの較正

部品の三次元形状モデルは三次元的な直線特徴や曲線特徴で構成され、それらの三次元データはビジョン系を基にした特徴上の点の三次元位置データである。そこで部品の三次元形状モデルの較正は、モデルを構成する点位置データの旧ビジョン系Σ_Vから新ビジョン系$\Sigma_{V'}$への座標変換で行うことができる。旧ビジョン系Σ_Vを基準にした点p_Vは新ビジョン系$\Sigma_{V'}$を基準にした点$p_{V'}$へ次のように変換される。

【0019】$$p_{V'}=T_{VV'}^{-1}p_V \quad \cdots(4)$$

こうして変換した三次元形状モデルの点を再構成することで、部品の三次元形状モデルの較正を行うことができる。新ビジョン系$\Sigma_{V'}$を基にした三次元形状モデルが計算されれば、カメラの新しい位置姿勢においての見え方モデルであるイメージ上の二次元形状モデルは、三次元形状モデルのカメラのイメージ平面への透視変換によって較正することができる。

【0020】(6)基準物体モデルの設定

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（6．1）背景物体による基準物体モデルの設定
カメラの視野内にベルトコンベアや作業台といった位置が変化しない物体が存在する場合は図2のように背景物体を基準物体とし、基準物体モデルを設定することができる。
【0021】（6．2）固定マーク物体による基準物体モデルの設定
カメラ視野内に位置が変化しない固定マーク物体を設置できる場合は、図3のように固定マーク物体を基準物体とし、基準物体モデルを設定することができる。
【0022】（6．3）取付マーク物体による基準物体モデルの設定
装置に常時取り付けてはいないが、較正作業の際何らかのジグによって取付マークを設置できる場合は、図4のように取付マーク物体を基準物体とし、基準物体モデルを設定することができる。
【0023】（6．4）ロボットアームに取り付けたマーク物体による基準物体モデルの設定
ロボットアームにマーク物体を取り付けることができる場合は、図5のようにそのマーク物体を基準物体とし、基準物体モデルを設定することができる。
【0024】（6．5）基準部品による基準物体モデルの設定
較正作業用に基準部品として選んだ部品を、ロボットアーム等を用いて同一の位置に設置できる場合は、図6のようにその基準部品を基準物体とし、基準物体モデルを設定することができる。
【0025】（7）位置データ較正方法
（7．1）背景物体による位置データ較正方法
カメラの位置姿勢が変化した場合、図7に示すフローチャートに従い、次の手順でビンピッキングシステムの位置データを較正する。
①画像計測装置の新ビジョン系の設定を行う。
②背景物体モデルによりモデルマッチングを行う。
③マッチング結果より較正座標変換データ$T_{VV'}$を計算する。
④較正座標変換データと今までの装置位置関係データを用いて装置位置関係データを較正する。
⑤較正座標変換データと今までの部品モデルデータを用いて部品モデルデータを較正する。
【0026】（7．2）固定マーク物体による位置データ較正方法
カメラの位置姿勢が変化した場合、図8に示すフローチャートに従い、次の手順でビンピッキングシステムの位置データを較正する。
①画像計測装置の新ビジョン系の設定を行う。
②固定マーク物体モデルによりモデルマッチングを行う。
③マッチング結果より較正座標変換データ$T_{VV'}$を計算する。
④較正座標変換データと今までの装置位置関係データを用いて装置位置関係データを較正する。
⑤較正座標変換データと今までの部品モデルデータを用いて部品モデルデータを較正する。
【0027】（7．3）取付マーク物体による位置データ較正方法
カメラの位置姿勢が変化した場合、図9に示すフローチャートに従い、次の手順でビンピッキングシステムの位置データを較正する。
①画像計測装置の新ビジョン系の設定を行う。
②取付マーク物体モデルによりモデルマッチングを行う。
③マッチング結果より較正座標変換データ$T_{VV'}$を計算する。
④較正座標変換データと今までの装置位置関係データを用いて装置位置関係データを較正する。
⑤較正座標変換データと今までの部品モデルデータを用いて部品モデルデータを較正する。
【0028】（7．4）ロボットアームに取り付けたマーク物体による位置データ較正方法
カメラの位置姿勢が変化した場合、図10に示すフローチャートに従い、次の手順でビンピッキングシステムの位置データを較正する。
①画像計測装置の新ビジョン系の設定を行う。
②ロボットアームに取り付けたマーク物体モデルによりモデルマッチングを行う。
③マッチング結果より較正座標変換データ$T_{VV'}$を計算する。
④較正座標変換データと今までの装置位置関係データを用いて装置位置関係データを較正する。
⑤較正座標変換データと今までの部品モデルデータを用いて部品モデルデータを較正する。
【0029】（7．5）基準部品による位置データ較正方法
カメラの位置姿勢が変化した場合、図11に示すフローチャートに従い、次の手順でビンピッキングシステムの位置データを較正する。
①画像計測装置の新ビジョン系の設定を行う。
②基準部品モデルによりモデルマッチングを行う。
③マッチング結果より較正座標変換データ$T_{VV'}$を計算する。
④較正座標変換データと今までの装置位置関係データを用いて装置位置関係データを較正する。
⑤較正座標変換データと今までの部品モデルデータを用いて部品モデルデータを較正する。
【0030】
【実施例】〔実施例1〕本発明の第1の実施例に係る背景物体による位置データ較正装置を図12に示す。本実施例は、請求項1に係るものである。この装置は、画像計測装置の新ビジョン系の設定を行うビジョン系設定部

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1と、背景物体モデルによりモデルマッチングを行う背景物体モデルマッチング部2と、マッチング結果より較正座標変換データを計算する較正座標変換データ計算部3と、較正座標変換データと今までの装置位置関係データを用いて装置位置関係データを較正する装置位置関係データ構成部4と、較正座標変換データと今までの部品モデルデータを用いて部品モデルデータを較正する部品モデルデータ較正部5とを備え、ビンピッキングシステムに必要な位置データを較正する。

【0031】〔実施例2〕本発明の第2の実施例に係る固定マーク物体による位置データ較正装置を図13に示す。本実施例は、請求項2に係るものである。この装置は、実施例1の背景物体モデルマッチング部2に代えて、固定マーク物体モデルによりモデルマッチングを行う固定マークモデルマッチング部6を設け、ビンピッキングシステムに必要な位置データを較正する。

【0032】〔実施例3〕本発明の第3の実施例に係る取付マーク物体による位置データ較正装置を図14に示す。本実施例は、請求項3に係るものである。この装置は、実施例1の背景物体モデルマッチング部2に代えて、取付マーク物体モデルによりモデルマッチングを行う取付マークモデルマッチング部7を設け、ビンピッキングシステムに必要な位置データを較正する。

【0033】〔実施例4〕本発明の第4の実施例に係るロボットアームに取り付けたマーク物体による位置データ較正装置を図15に示す。本実施例は、請求項4に係るものである。この装置は、実施例1の背景物体モデルマッチング部2に代えて、ロボットアームに取り付けたマーク物体モデルによりモデルマッチングを行うロボット取付マーク物体モデルマッチング部8を設け、ビンピッキングシステムに必要な位置データを較正する。

【0034】〔実施例5〕本発明の第5の実施例に係る基準部品による位置データ較正装置を図16に示す。本実施例は、請求項5に係るものである。この装置は、実施例1の背景物体モデルマッチング部2に代えて、基準部品モデルによりモデルマッチングを行う基準部品モデルマッチング部9を設けて、ビンピッキングシステムに必要な位置データを較正する。

【0035】

【発明の効果】以上、実施例に基づいて具体的に説明したように、本発明によれば、カメラの故障や寿命、事故によるカメラの破損等でカメラを交換する場合でも、ビンピッキングシステムに必要な位置データを較正できるため、以下の効果を奏する。

(1) 今までのデータを全て新しく作り直す必要がない。

(2) カメラ交換に伴う作業による作業時間を大幅に短縮できる。

(3) 大量の部品モデルデータを扱い易く、多品種を扱う工程に容易に対応できる。

(4) 過去に作った大量の部品モデルデータのデータベースを効率よく扱うことができる。

(5) カメラ交換に伴う作業コストを小さくすることができる。

(6) カメラ交換に伴う作業者の負担を軽減できる。

(7) カメラ交換作業を容易に行うことができる。

(8) 定期的に位置データ較正を行うことにより、カメラ取付部の経年変化によってカメラの位置姿勢に多少のズレが生じた場合でも、システムを正常に動作させ続けることができる。

(9) 定期的に位置データ較正を行うことによって、システムの信頼性が向上する。

【図面の簡単な説明】

【図1】位置データ較正に用いる座標系を示す説明図である。

【図2】背景物体による基準物体モデルを示す説明図である。

【図3】固定マーク物体による基準物体モデルを示す説明図である。

【図4】取付マーク物体による基準物体モデルを示す説明図である。

【図5】ロボットアームに取り付けたマーク物体による基準物体モデルを示す説明図である。

【図6】基準部品による基準物体モデルを示す説明図である。

【図7】背景物体による位置データ較正方法を示すフローチャートである。

【図8】固定マーク物体による位置データ較正方法を示すフローチャートである。

【図9】取付マーク物体による位置データ較正方法を示すフローチャートである。

【図10】ロボットアームに取り付けたマーク物体による位置データ較正方法を示すフローチャートである。

【図11】基準部品による位置データ較正方法を示すフローチャートである。

【図12】背景物体による位置データ較正装置を示す構成図である。

【図13】固定マーク物体による位置データ較正装置を示す構成図である。

【図14】取付マーク物体による位置データ較正方法装置を示す構成図である。

【図15】ロボットアームに取り付けたマーク物体による位置データ較正装置を示す構成図である。

【図16】基準部品による位置データ較正装置を示す構成図である。

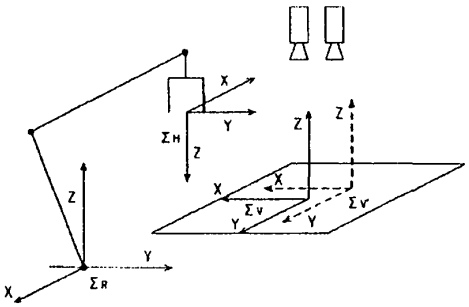
【符号の説明】

1 ビジョン系設定部
2 背景物体モデルマッチング部
3 較正座標変換データ計算部
4 装置位置関係データ構成部

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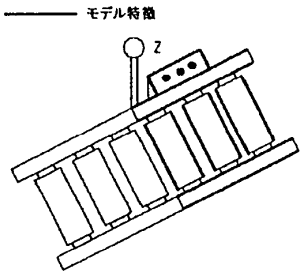
5　部品モデルデータ較正部
6　固定マークモデルマッチング部
7　取付マークモデルマッチング部
8　ロボット取付マーク物体モデルマッチング部
9　基準部品モデルマッチング部

【図1】



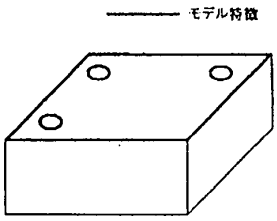
位置データ較正に用いる座標系の例

【図2】



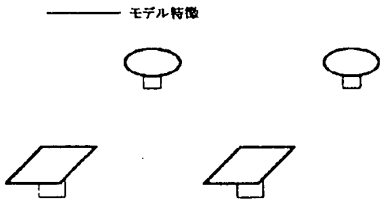
背景物体による基準物体モデルの設定例

【図6】



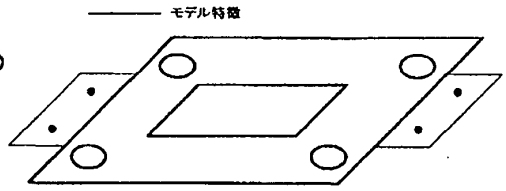
基準部品による基準物体モデルの設定例

【図3】



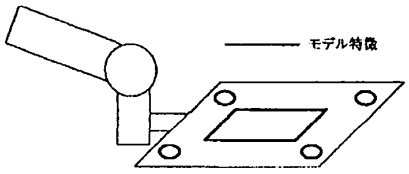
固定マーク物体による基準物体モデルの設定例

【図4】



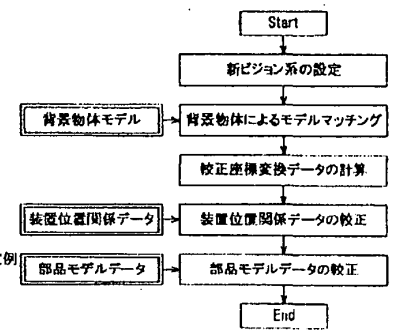
取付マーク物体による基準物体モデルの設定例

【図5】



ロボットアームに取り付けたマーク物体による基準物体モデルの設定例

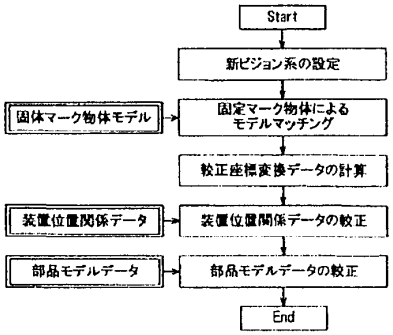
【図7】



背景物体による位置データ較正方法のフローチャートの例

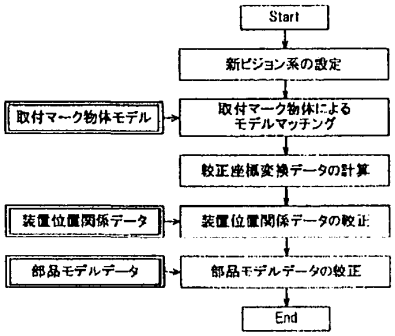
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【図8】



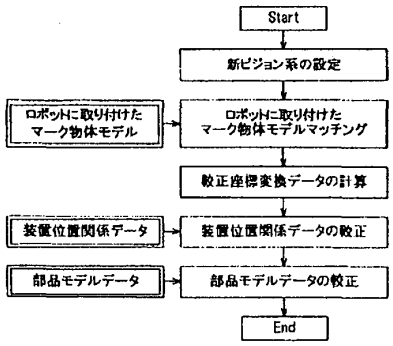
固定マーク物体による位置データ較正方法のフローチャートの例

【図9】



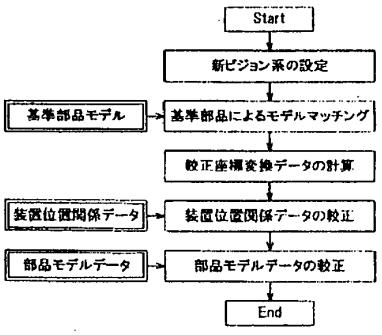
取付マーク物体による位置データ較正方法のフローチャートの例

【図10】



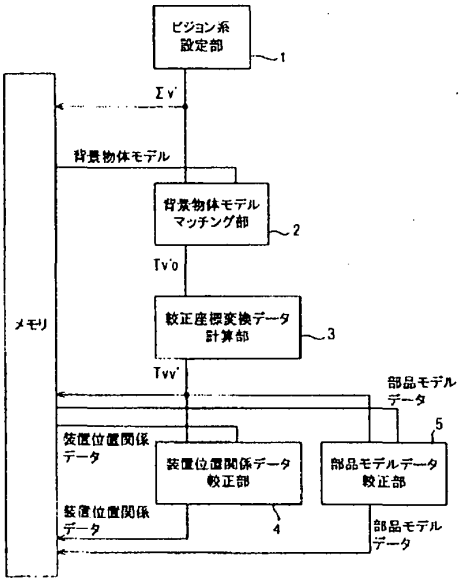
ロボットアームに取り付けたマーク物体による
位置データ較正方法のフローチャートの例

【図11】



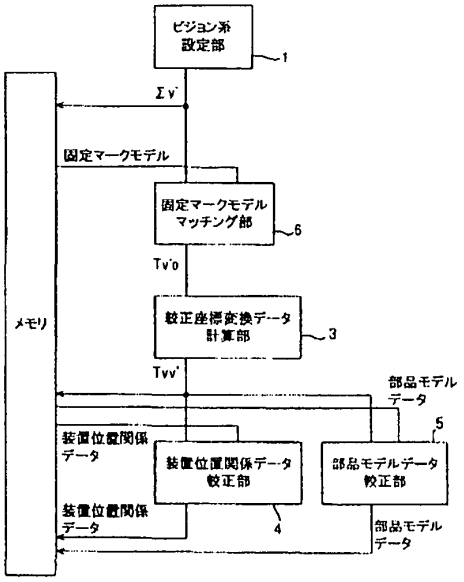
基準部品による位置データ較正方法のフローチャートの例

【図12】



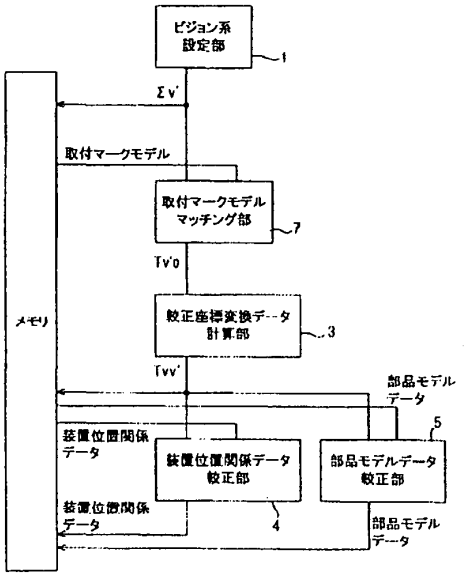
背景物体による位置データ較正装置の例

【図13】



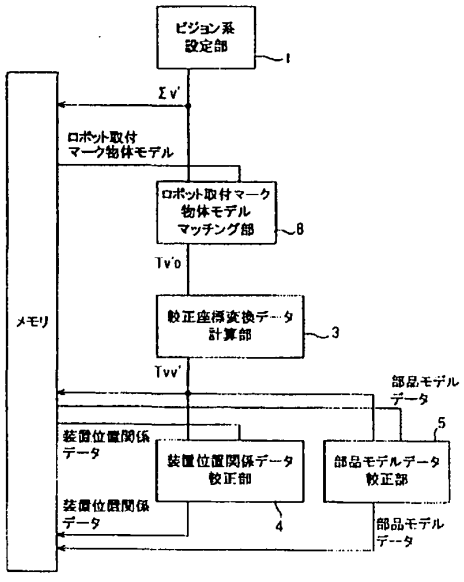
固定マーク物体による位置データ較正装置の例

【図14】



取付マーク物体による位置データ較正装置の例

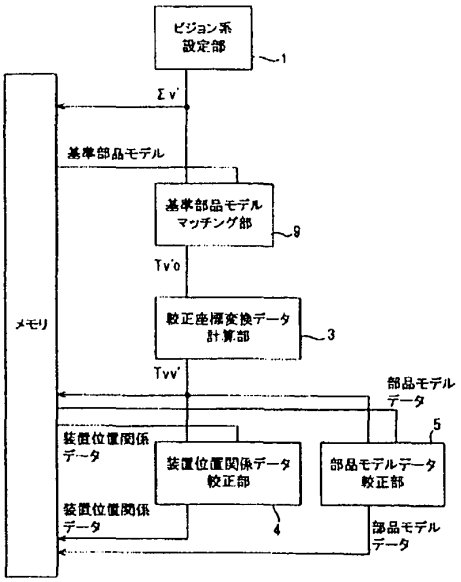
【図15】



ロボットアームに取り付けたマーク物体による
位置データ較正装置の例

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【図16】



基準部品による位置データ較正装置の例

フロントページの続き

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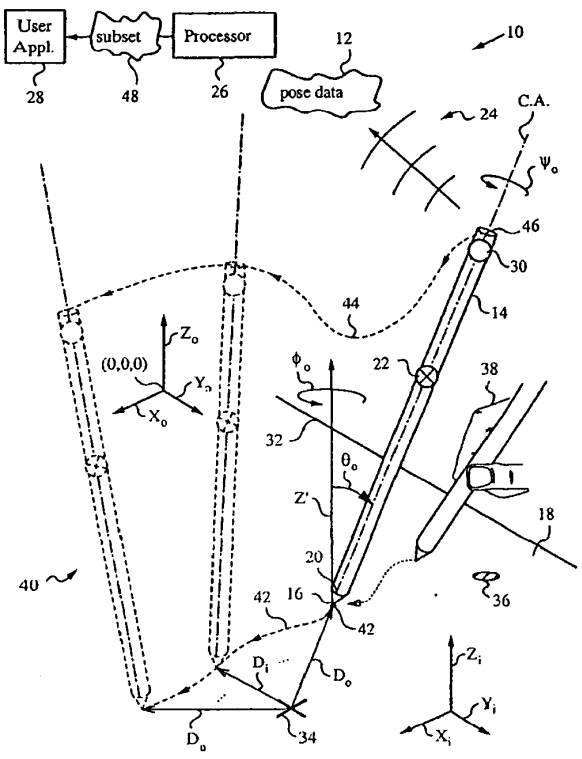
(74) Agents: **ALBOSZTA, Marek** et al.; Lumen IPS, 2345 Yale Street, 2nd Floor, Palo Alto, CA 94306 (US).

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[Continued on next page]

(54) Title: PROCESSING POSE DATA DERIVED FROM THE POSE OF AN ELONGATE OBJECT



(57) Abstract: An apparatus and method for processing pose data derived from a pose of an elongate object such as, for example, a jotting implement, a pointer, a robotic arm or a cane. The elongate object has a tip contacting a plane surface with one or more invariant features. The pose of the elongate object is measured optically from on-board by an optical measuring system with the aid of the invariant feature. The pose is used for preparing a corresponding pose data and a subset of the pose data is identified and transmitted to an application such as a user application, where the subset can serve as command data or input data. Since the elongate object moves while its tip is contacting the surface the pose is measured periodically at sufficiently frequent measurement times t_i to describe the motion at a desired temporal resolution. The subset can include all or a portion of the orientation data that describe the orientation of the elongate object in space and/or position data of the tip on the surface. The position can be a relative position of the tip with respect to any feature or its previous position, or an absolute position in world coordinates. The subset can also contain a mix of orientation and position data.

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(19) United States

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(54) PROCESSING POSE DATA DERIVED FROM THE POSE OF AN ELONGATE OBJECT

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(52) U.S. Cl. 345/156

(57) ABSTRACT

An apparatus and method for processing pose data derived from a pose of an elongate object such as, for example, a jotting implement, a pointer, a robotic arm or a cane. The elongate object has a tip contacting a plane surface with one or more invariant features. The pose of the elongate object is measured optically from on-board by an optical measuring system with the aid of the invariant feature. The pose is used for preparing a corresponding pose data and a subset of the pose data is identified and transmitted to an application such as a user application, where the subset can serve as command data or input data. Since the elongate object moves while its tip is contacting the surface the pose is measured periodically at sufficiently frequent measurement times t_i to describe the motion at a desired temporal resolution. The subset can include all or a portion of the orientation data that describe the orientation of the elongate object in space and/or position data of the tip on the surface. The position can be a relative position of the tip with respect to any feature or its previous position, or an absolute position in world coordinates. The subset can also contain a mix of orientation and position data.

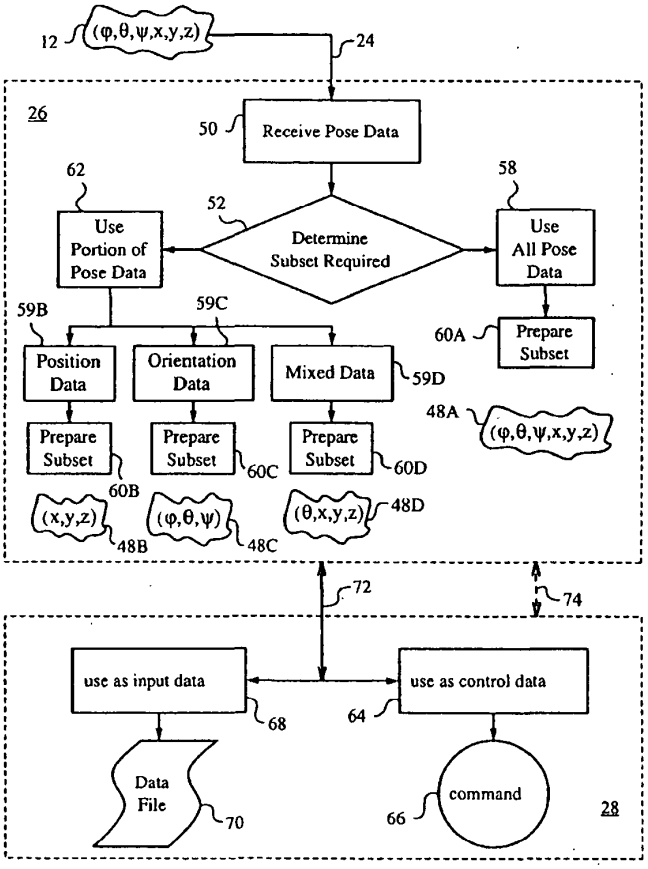


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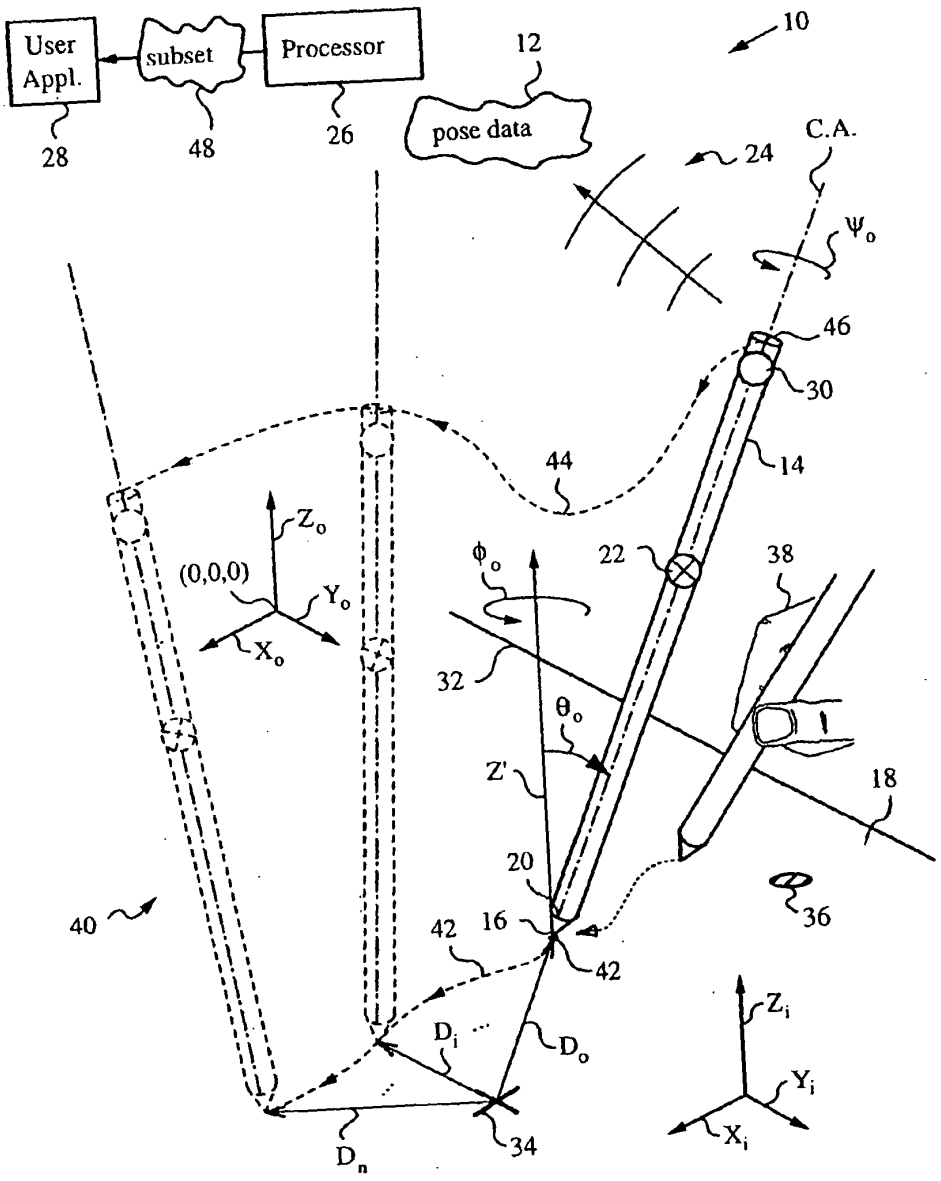

User Appl.
subset
Processor
12
10
28
48
26
pose data
24
C.A.
ψ_o
46
30
14
44
Z_o
(0,0,0)
Y_o
X_o
ϕ_o
22
38
32
θ_o
Z'
18
20
40
42
16
36
42
Z_i
D_i
D_o
Y_i
X_i
34
D_n

FIG. 1

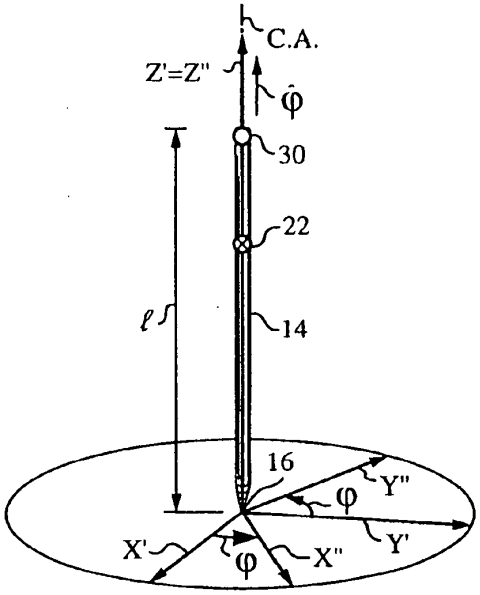


FIG. 2A

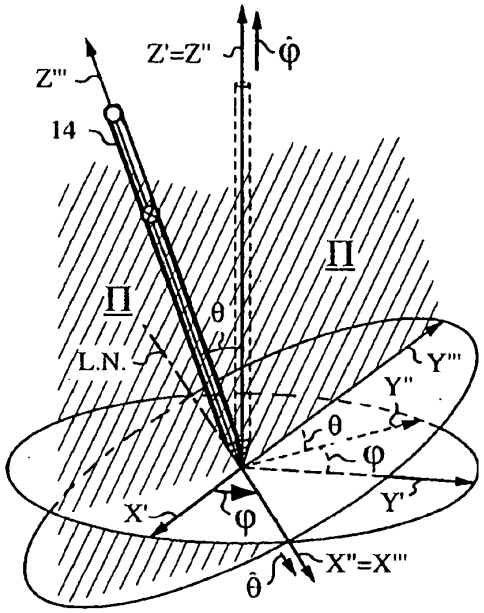


FIG. 2B

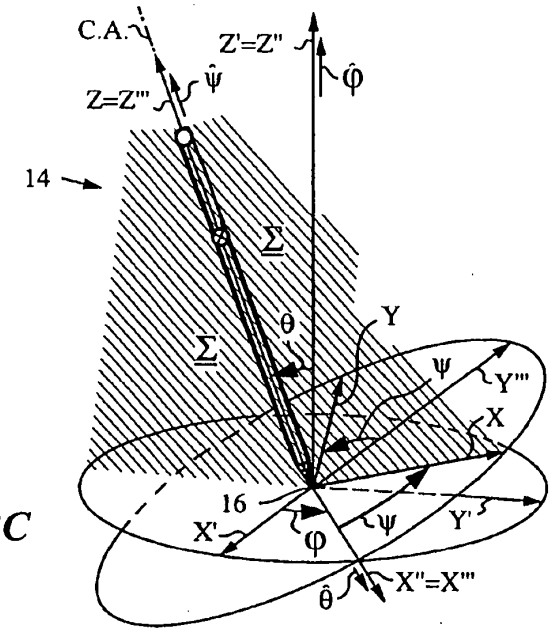


FIG. 2C

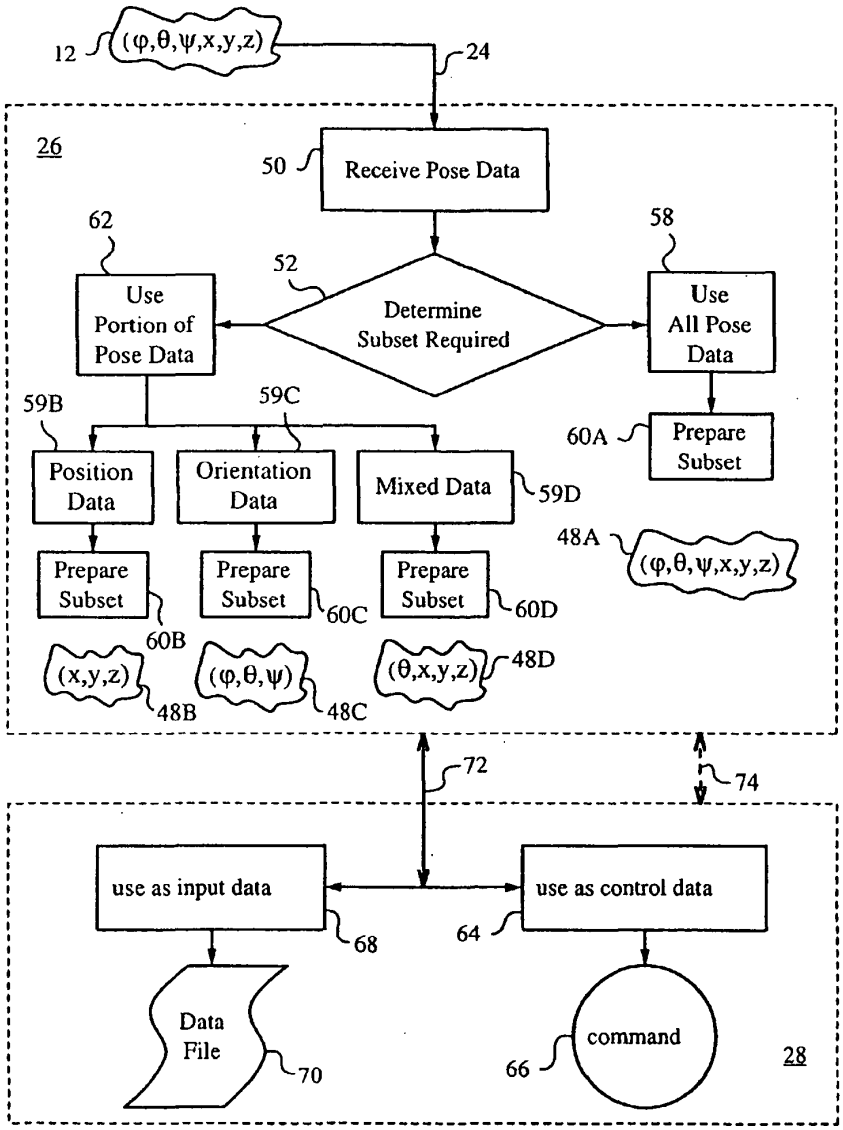

12
(φ,θ,ψ,x,y,z)
24
26
50
Receive Pose Data
62
52
58
Use Portion of Pose Data
Determine Subset Required
Use All Pose Data
59B
59C
60A
Prepare Subset
Position Data
Orientation Data
Mixed Data
59D
48A
(φ,θ,ψ,x,y,z)
Prepare Subset
Prepare Subset
Prepare Subset
60B
60C
60D
(x,y,z)
(φ,θ,ψ)
(θ,x,y,z)
48D
48B
48C
72
74
use as input data
use as control data
68
64
Data File
command
66
70
28

FIG. 3

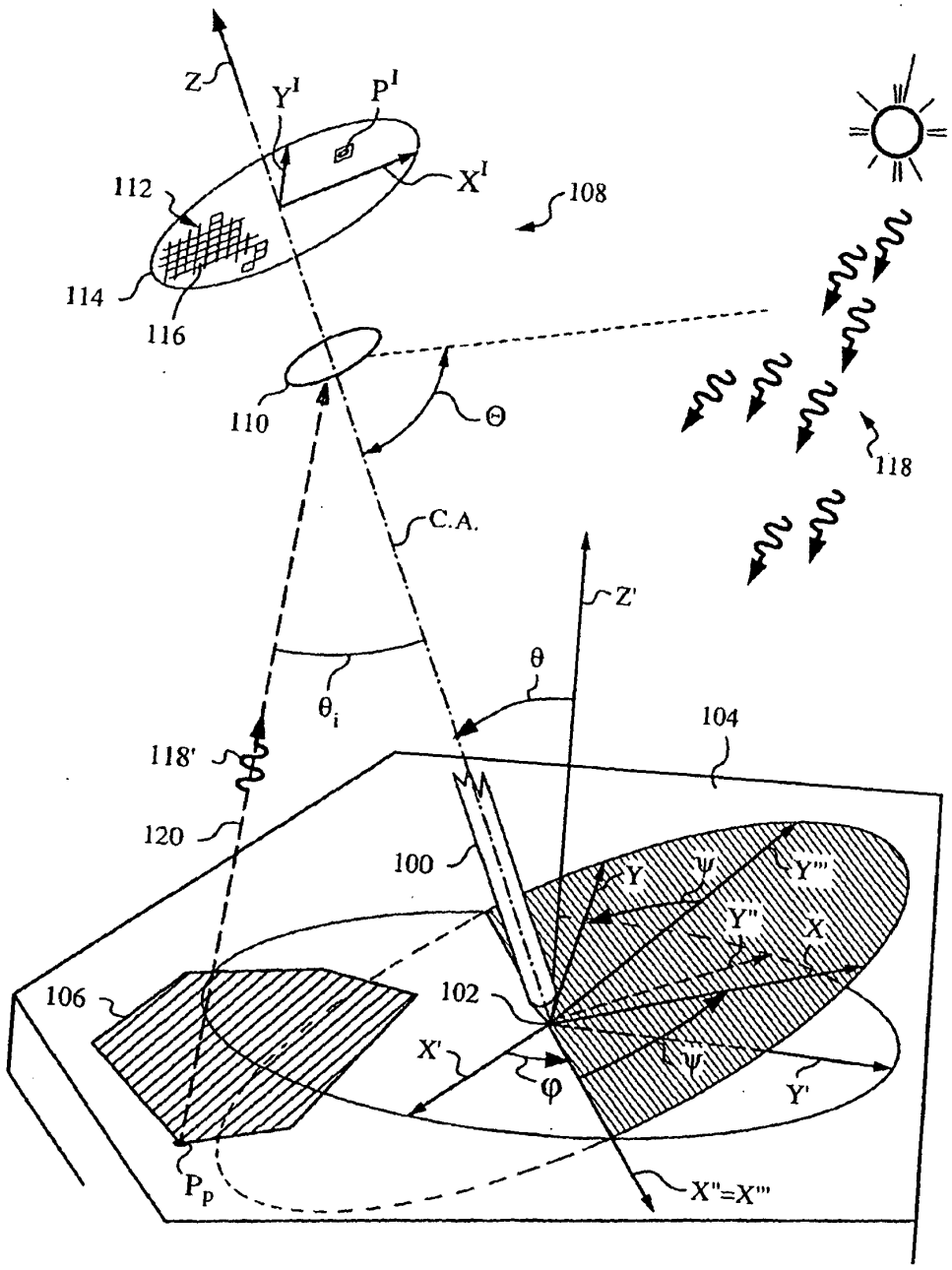

Z
Y^I
P^I
X^I
112
108
114
116
110
Θ
118
C.A.
Z'
θ
θ_i
104
118'
120
100
Y
ψ
Y'''
Y''
X
106
102
X'
φ
ψ'
Y'
P_p
X''=X'''

FIG. 4

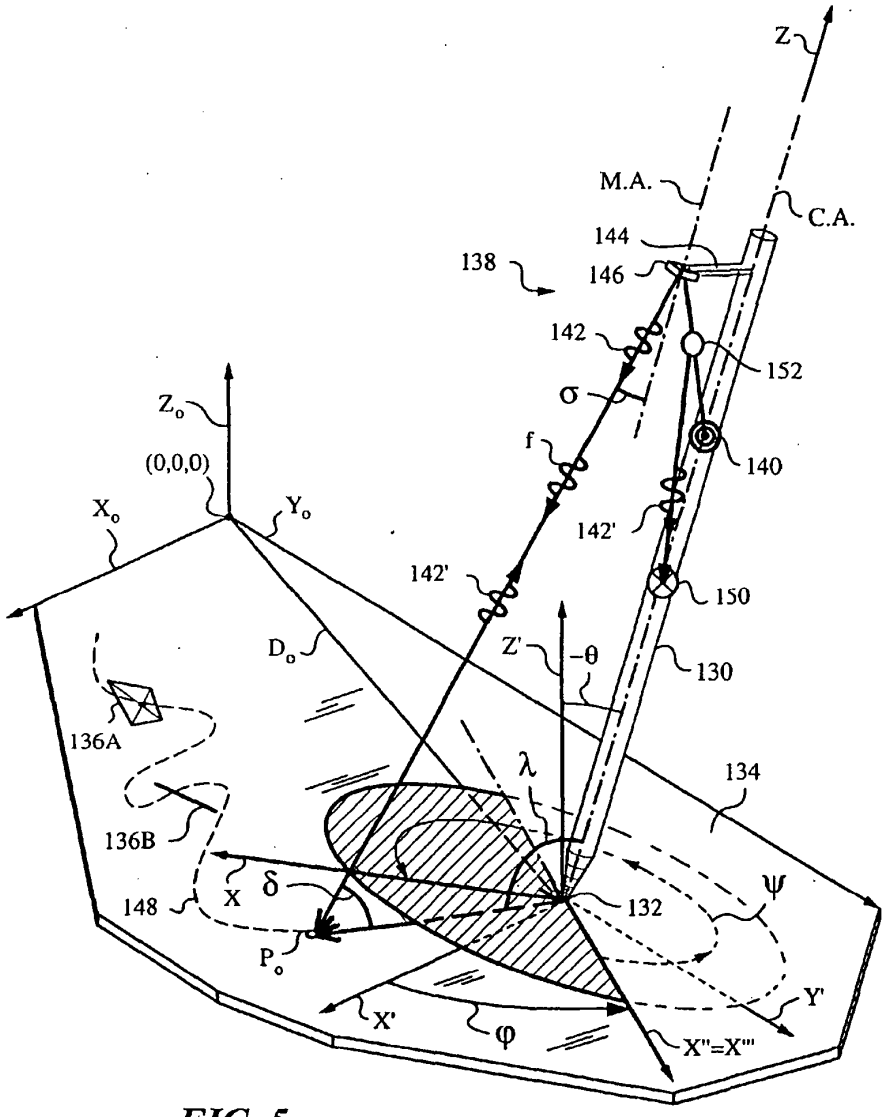

Z
M.A.
C.A.
144
138
146
142
152
σ
Z_o
f
140
(0,0,0)
X_o
Y_o
142'
142'
150
D_o
Z'
−θ
130
136A
λ
134
136B
δ
X
148
132
ψ
P_o
Y'
X'
φ
X"=X'"

FIG. 5

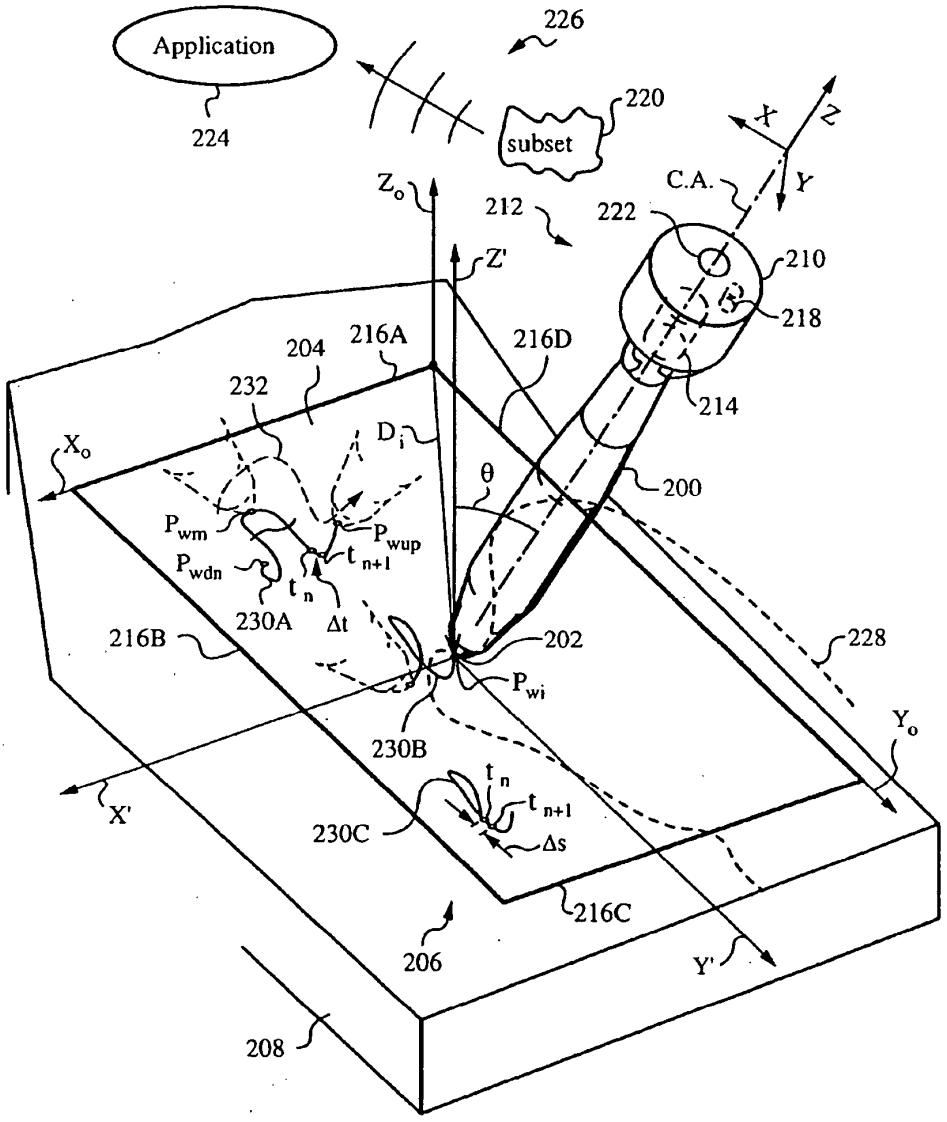

Application
224
226
220
subset
X
Z
Y
C.A.
Z_o
212
222
210
218
Z'
204
216A
216D
232
214
X_o
D_i
θ
200
P_{wm}
P_{wup}
P_{wdn}
t_{n+1}
t_n
230A
Δt
216B
202
228
P_{wi}
Y_o
230B
t_n
t_{n+1}
X'
230C
Δs
216C
206
Y'
208

FIG. 6

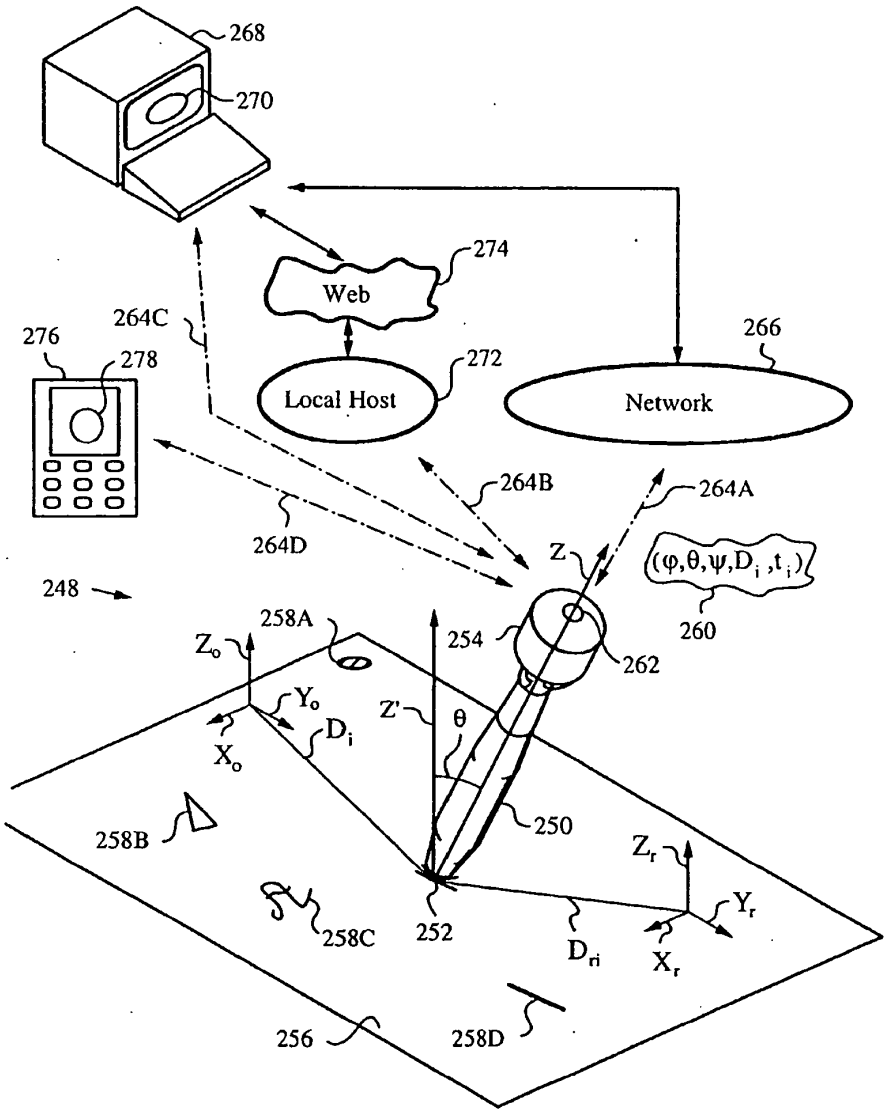

268
270
274
Web
264C
276
278
272
Local Host
266
Network
264B
264A
264D
Z
$(\varphi,\theta,\psi,D_i,t_i)$
260
248
258A
254
262
Z_o
Y_o
D_i
Z'
θ
X_o
250
258B
Z_r
Y_r
258C
252
D_{ri}
X_r
256
258D

FIG. 7

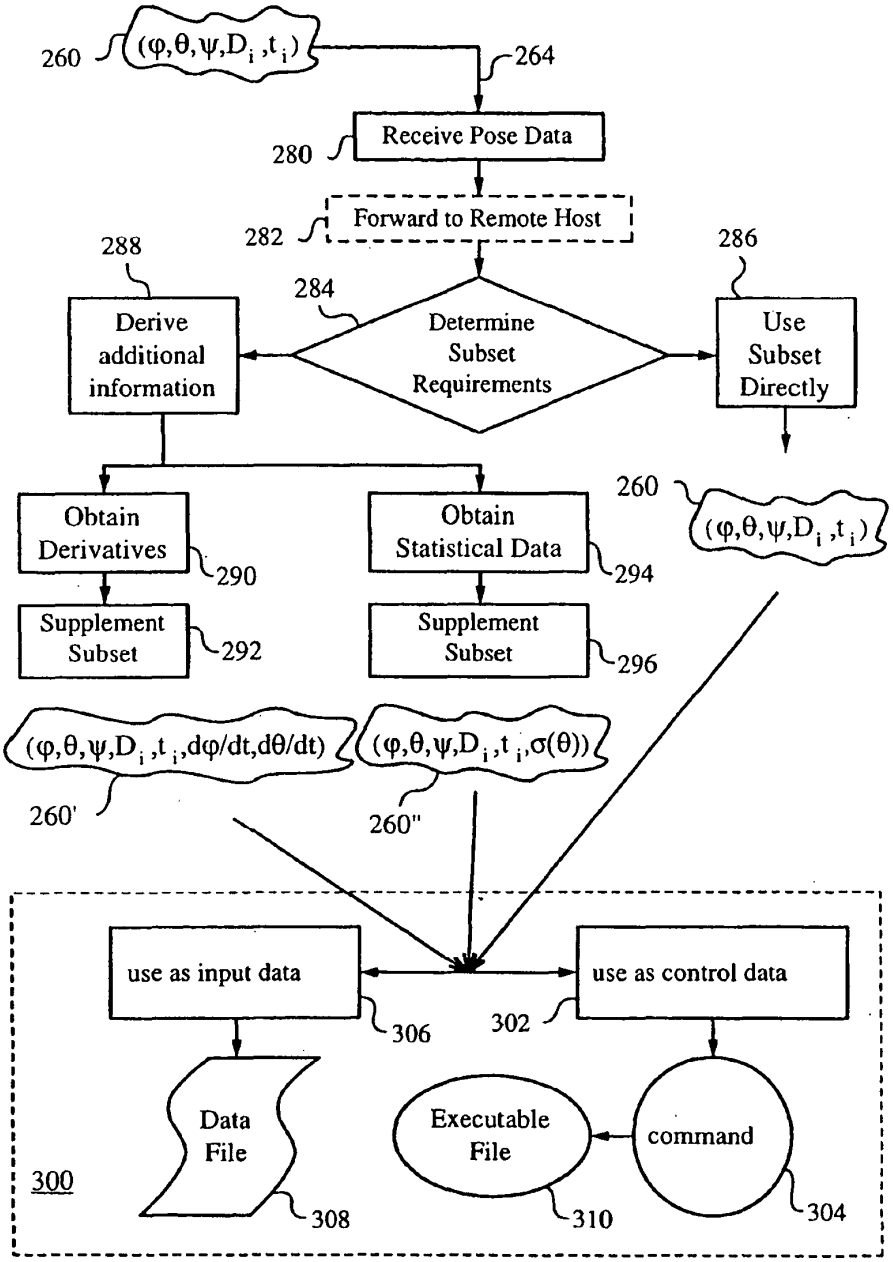

260
$(\varphi,\theta,\psi,D_i,t_i)$
264
280
Receive Pose Data
282
Forward to Remote Host
288
284
286
Derive additional information
Determine Subset Requirements
Use Subset Directly
Obtain Derivatives
290
Obtain Statistical Data
294
260
$(\varphi,\theta,\psi,D_i,t_i)$
Supplement Subset
292
Supplement Subset
296
$(\varphi,\theta,\psi,D_i,t_i,d\varphi/dt,d\theta/dt)$
$(\varphi,\theta,\psi,D_i,t_i,\sigma(\theta))$
260'
260"
use as input data
306
use as control data
302
Data File
308
Executable File
310
command
304
300

FIG. 8

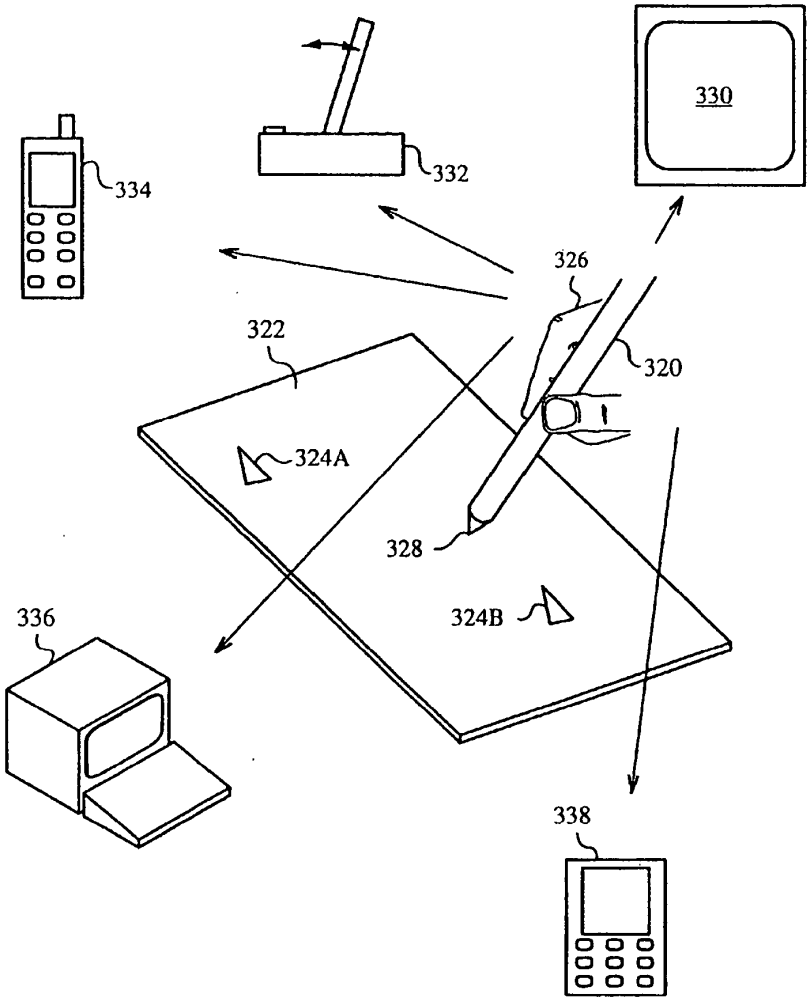


FIG. 9

PROCESSING POSE DATA DERIVED FROM THE POSE OF AN ELONGATE OBJECT

FIELD OF THE INVENTION

[0001] The present invention relates generally to an apparatus and method for processing data derived from a pose of an elongate object having a tip in contact with a plane surface.

BACKGROUND OF THE INVENTION

[0002] When an object moves with respect to stationary references such as a ground plane, fixed points, lines or reference surfaces, knowledge of the object's inclination with respect to these references can be used to derive a variety of its parameters of motion as well as its pose. Over time, many useful coordinate systems and methods have been developed to track the pose of objects and to parameterize their equations motion. For a theoretical background the reader is referred to textbooks on classical mechanics such as Goldstein et al., Classical Mechanics, 3rd Edition, Addison Wesley 2002.

[0003] In one specific field it is important to know the pose of an object to derive the position of its tip while it contacts a plane surface. Various types of elongate objects can benefit from knowledge of their pose and position of their tip, and more precisely the absolute position (in world coordinates) of their tip while it is in contact with a plane surface. These objects include walking canes when in touch with the ground, pointers when in touch with a display or projection surface, writing devices when in touch with a writing surface, and styluses when in touch with an input screen.

[0004] The need to determine the absolute position of the tip or nib is deeply felt in the field of input devices such as pens and styluses. Here, the absolute position of the tip has to be known in order to analyze the information written or traced by the user on the writing surface. Numerous teachings of pens and related input devices providing relative tip position and absolute tip position are discussed in the prior art. Some of these teachings rely on inertial navigation devices including gyroscopes and accelerometers as described in U.S. Pat. Nos. 6,492,981; 6,212,296; 6,181,329; 5,981,884; 5,902,968. Other techniques combine inertial navigation with force sensing as described in U.S. Pat. Nos. 6,081,261; 5,434,371. The prior art also teaches capturing and analyzing forces applied to the pen point in U.S. Pat. No. 5,548,092. Still other techniques rely on triangulation using signal receivers and auxiliary devices on or adjacent to the writing surface as found in U.S. Pat. Nos. 6,177,927; 6,124,847; 6,104,387; 6,100,877; 5,977,958; 5,484,966. It should be noted that various forms of radiation including short radio-frequency (RF) pulses, infra-red (IR) pulses, and ultrasound pulses have been taught for triangulation and related techniques. A few examples of yet another set of solutions employing digitizers or tablets are discussed in U.S. Pat. Nos. 6,050,490; 5,750,939; 4,471,162.

[0005] The prior art also addresses the use of optical systems to provide relative, and in some cases, absolute position of the tip of a pen or stylus on a surface. For example, U.S. Pat. No. 6,153,836 teaches emitting two light beams from the stylus to two receivers that determine angles with respect to a two-dimensional coordinate system defined within the surface. The tip position of the stylus is found with the aid of these angles and knowledge of the location of the receivers. U.S. Pat. No. 6,044,165 teaches integration of force sensing at the tip of the pen with an optical imaging system having a camera positioned in the world coordinates and looking at the pen and paper. Still other teachings use optical systems observing the tip of the pen and its vicinity. These teachings include, among others, U.S. Pat. Nos. 6,031,936; 5,960,124; 5,850,058. According to another approach, the disclosure in U.S. Pat. No. 5,103,486 proposes using an optical ballpoint in the pen. More recently, optical systems using a light source directing light at paper have been taught, e.g., as described in U.S. Pat. Nos. 6,650,320; 6,592,039 as well as WO 00217222 and U.S. Pat. Appl. Nos. 2003-0106985; 2002-0048404.

[0006] In some prior art approaches the writing surface is provided with special markings that the optical system can recognize. Some early examples of pens using special markings on the writing surface include U.S. Pat. Nos. 5,661,506; 5,652,412. More recently, such approach has been taught in U.S. Pat. Appl. 2003-0107558 related literature. For still further references, the reader is referred to U.S. patent application Ser. Nos. 10/640,942 and 10/745,371 and the references cited therein.

[0007] Most of the prior art approaches listed above are limited in that they yield relative position of the tip on the writing surface. Tablets and digitizers obtain absolute position but they are bulky and inconvenient. Of the approaches that provide absolute position of the tip without tablets by using optical systems, most rely on observing the relationship of markings provided on the writing surface to the tip of the pen. This approach is limiting it that it requires a specially-marked writing surface, which acts as a quasi-tablet.

[0008] In addition to being cumbersome, state-of-the-art pens and styluses employing optical systems usually generate a limited data set. In fact, most only provide data corresponding to the trace traversed on the writing surface. Meanwhile, there are many applications that could benefit from a rich stream of data from the pen or stylus. In fact, the prior art indicates many situations in which interactions between a user employing a pen or stylus and a machine, e.g., a computer, are limited. For a few examples of applications and systems that could benefit from a richer stream of data from the pen or stylus the reader is referred to U.S. Pat. Nos. 6,565,611; 6,502,114; 6,493,736; 6,474,888; 6,454,482; 6,415,256; 6,396,481 and U.S. Pat. Appl. Nos. 2003-0195820; 2003-0163525; 2003-0107558; 2003-0038790; 2003-0029919; 2003-0025713; 2003-0006975; 2002-0148655; 2002-0145587 and U.S. Pat. No. 6,661,920.

OBJECTS AND ADVANTAGES

[0009] In view of the shortcomings of the prior art, it is the object of the invention to provide an apparatus and method for processing pose data derived from a pose of an elongate object such as a jotting implement, cane, pointer or a robotic arm. Specifically, it is an object of the invention to provide for processing or pose data derived in this manner and identification of a subset of the pose data for use as control data or input data in applications.

[0010] These and numerous other advantages will become apparent upon reading the detailed description in conjunction with the drawing figures.

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SUMMARY OF THE INVENTION

[0011] The present invention provides a method for processing pose data derived from a pose of an elongate object whose tip is contacting a plane surface with one or more invariant features. In accordance with the method, the tip is placed on the surface and the physical pose of the elongate object is measured optically from on-board the elongate object with the aid of the invariant feature. The pose data corresponding to the pose is prepared and a subset of the pose data is identified. The subset is transmitted to an application such as a user application, where the subset can serve as command data or input data. The elongate object can undergo a motion while its tip is contacting a surface. Thus, in a preferred embodiment the method calls for periodically measuring the pose data at measurement times t_i such that the pose data at successive measurement times t_i can be used to describe the motion at a desired temporal resolution.

[0012] The subset can include all or a portion of orientation data that describe the orientation of the elongate object in space. The orientation data can include an inclination angle θ or any angle or set of angles describing orientation in suitable coordinates, e.g., polar coordinates. Alternatively, the subset can include all or a portion of position data of the tip on the surface. The position can be a relative position of the tip relative to any feature including one or more of the invariant features or an absolute position of the tip on the surface in world coordinates. The subset can also contain a mix of orientation and position data.

[0013] In one embodiment, the orientation of the elongate object is described by Euler angles and the subset of the pose data includes at least one Euler angle. In fact, in this embodiment the inclination angle θ can be simply the second Euler angle. In addition, the subset can contain a roll angle ψ (third Euler angle) and a rotation angle ϕ (first Euler angle). The orientation data contained can be used as any type of input. For example, the orientation data can represent control data that is used for executing commands in the application or input data that is entered into the application or simply stored in an appropriate format. Of course, the position data can also be used as any type of input, including control data and input data. It should be noted, that the subset can also contain all of the pose data, e.g., when the application is a motion-capture application.

[0014] The invariant features can be permanent or temporary, and spatial or temporal. The plane surface can be a jotting surface, such as a paper surface, a screen, a tablet, a pad or any other type of surface on which a user can perform a jotting operation. In this embodiment the elongate object is preferably a jotting implement such as a pen, pencil or stylus. In general, the elongate object can also be a pointer, a robotic arm or a cane. In fact, the elongate object is any object that whose pose can be used to derive input data.

[0015] The invention further provides an apparatus for processing pose data describing the motion of the elongate object whose tip is contacting the surface. The apparatus has a measuring arrangement for optically measuring the pose from on-board the elongate object. The measurement can be periodic at measurement times t_i and the periodicity of this measurement is chosen depending on the application and resolution, e.g., temporal resolution, of pose and pose data required. The apparatus has a processor for preparing the pose data corresponding to the pose and identifying a subset of the pose data. A communication link is provided for transmitting the subset to an application.

[0016] The processor is preferably mounted on the elongate object. In applications where considerable data processing is performed by the processor, the processor can be remote. The communication link is preferably a wireless communication link.

[0017] The subset separated from the pose data by the processor can be sent to the application for further processing the subset, e.g., using it as input data, by using the same or a different communication link, depending on the location of the host running the user application for which the subset is used as input data. For example, the host is a computer and the application is a data file. In this case the subset can contain input data into the data file. Alternatively, the host is a digital device and the user application is an executable file for executing a command and the subset contains control data. The application can also be a motion-capture application for capturing the motion of the elongate object, or a trace-capture application for capturing the trace described by the tip of the elongate object on the surface during the motion.

[0018] The details of the invention will now be described in detail with reference to the drawing figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] **FIG. 1** is a three-dimensional view of an apparatus of the invention illustrating the motion of an elongate object whose tip is contacting a surface.

[0020] **FIG. 2A-C** are diagrams illustrating the Euler rotation convention as used herein.

[0021] **FIG. 3** is a block diagram illustrating the formatting or preparation of the pose data into subsets.

[0022] **FIG. 4** is a three-dimensional view of an elongate object with an imaging system for measuring the pose.

[0023] **FIG. 5** is a three-dimensional view of an elongate object with a scanning system for measuring the pose.

[0024] **FIG. 6** is a three-dimensional view of a preferred application in which the elongate object is a jotting implement for jotting on a plane surface.

[0025] **FIG. 7** is a diagram illustrating the jotting implement communicating pose data to remote devices via communication links.

[0026] **FIG. 8** is a block diagram illustrating the uses of command and input data derived from the pose data of the jotting implement of **FIG. 7**.

[0027] **FIG. 9** is a diagram illustrating still another embodiment of the apparatus of invention.

DETAILED DESCRIPTION

[0028] The present invention will be best understood by first referring to **FIG. 1** illustrating an exemplary apparatus **10** for processing pose data **12** derived from a pose of an elongate object **14**. Elongate object **14** moves while its tip **16** is in contact with a plane surface **18**. Apparatus **10** processes pose data **12** that describe the pose of elongate object **14** at a number of measurement times. Thus, pose data **12**

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describes the motion that elongate object **14** executes or is made to execute by a user while tip **16** is in contact with surface **18**. A sensor **20**, e.g., a piezoelectric element or any other suitable sensor can be used to ascertain when tip **16** is contacting surface **18**.

[0029] Elongate object **14** is any type of generally elongated object whose pose when object **14** is stationary or in motion yields useful pose data **12**. For example, elongate object **14** is a cane used for walking support and surface **18** is a walking surface, or elongate object **14** is a robotic arm and surface **18** is a work surface. In still other cases, elongate object **14** is a jotting implement, such as a pen, pencil or stylus and surface **18** is a jotting surface. In the present embodiment elongate object **14** is a pointer and surface **18** is a screen or a tracing surface.

[0030] Elongate object **14** has an on-board measuring arrangement **22** for optically measuring its pose with the aid of one or more invariant features **32, 34, 36** on surface **18**. In the present case all features **32, 34, 36** are all on surface **18**. In general, however, it is also possible to use features that are not in the plane of surface **18** if there is a sufficient number of features on surface **18**.

[0031] In the present embodiment, invariant features are an edge **32**, a reference point **34** and a surface structure **36**. These invariant features are merely exemplary of the types of features that can be temporarily or permanently associated with surface **18** and be used for measuring the pose of object **14**. Invariant features **32, 34, 36** are used in deriving a relative or absolute position of tip **16** on surface **18** and for measuring the remaining portion of the pose, i.e., the orientation of pointer **14**. Preferably, the positions of invariant features **32, 34** and **36** are defined in world coordinates (X_o,Y_o,Z_o). Furthermore, if possible, the location of invariant features **32, 34** and **36** is preferably such that at least a subset of them is visible to arrangement **22** for all poses that object **14** is expected to assume.

[0032] A number of optical measurement methods using on-board arrangement **22** to recover pose of object **14** can be employed. In any of these methods arrangement **22** uses on-board elements to obtain pose data **12** in accordance with any well-known pose recovery technique including geometric invariance, triangulation, ranging, path integration and motion analysis.

[0033] In the preferred embodiment arrangement **22** is an optical measurement arrangement such as an imaging system or a scanning system mounted on pointer **14** for on-board determination of the pose with reference to one or more of invariant features **32, 34, 36** on surface **18**.

[0034] Apparatus **10** has a processor **26** for preparing pose data **12** corresponding to the pose of pointer **14** and for identifying a subset **48** of pose data **12** required by an application **28**. Specifically, application **28** uses subset **48** which may contain all or less than all of pose data **12**. Note that processor **26** can be located on pointer **14** or be remote, as is the case in this embodiment.

[0035] A communication link **24** is provided for sending pose data **12** to application **28**. Preferably, communication link **24** is a wireless communication link established with the aid of a wireless transmitter **30** mounted on pointer **14**. In embodiments where processor **26** and application **28** are mounted on pointer **14**, communication link **24** can be an electrical connection. In still other embodiments, communication link **24** can be a wired remote link.

[0036] During operation a user **38** holds pointer **14** in hand. User **38** places tip **16** of pointer **14** on surface **18** with invariant features **32, 34, 36** and executes a movement such that pointer **14** executes a motion **40**. For better visualization, motion **40** is indicated in dashed lines **42, 44** that mark the positions assumed by tip **16** and end **46** of pointer **14** during motion **40**.

[0037] For the purposes of this invention, line **42** is referred to as the trace of tip **16**. Also, for the purposes of the present invention, motion **40** is defined to end at the time when tip **16** stops contacting surface **18**.

[0038] Motion **40** may produce no movement of end **46** or tip **16**, i.e., no trace **42**. In fact, motion **40** is not limited by any parameter other than that tip **16** must remain in contact with surface **18**. Thus, changes in orientation of pointer **14** are also considered to be motion **40**, just as changes in position (i.e., change in x and y coordinates) of tip **16** on surface **18**. In the present case, orientation of pointer **14** is described by inclination angle θ, rotation angle ϕ and roll angle ψ referenced with respect to a center axis C.A. of pointer **14**. A change in at least one of these angles constitutes motion **40**.

[0039] In the present case, tip **16** touches down on surface **18** at point **48**. At the time of touch down center axis C.A. of pointer **14** is inclined to a surface normal Z' at inclination angle θ equal to θ_o. Furthermore, rotation and roll angles ϕ, ψ are equal to ϕ_o, ψ_o respectively. For convenience, in the present embodiment angles θ, ϕ, ψ are Euler angles. Of course, other angles can be used to describe the orientation of pointer **14**. In fact, a person skilled in the art will appreciate that any convention for describing the rotations of pointer **16** can be adapted for this description. For example, the four Caylyle-Klein angles or quaternions can be employed.

[0040] FIGS. **2A-C** illustrate a convention for describing the orientation of pointer **14** using the Euler angles. Pointer **14** has a length l measured from tip **16** at the origin of non-rotated object coordinates (X',Y',Z') as shown in **FIG. 2A**.

[0041] Center axis C.A. is collinear with the Z' axis and it passes through tip **16** and the origin of non-rotated object coordinates (X',Y',Z'). In the passive rotation convention used herein objects coordinates will be attached to pointer **14** while pointer **14** is rotated from initial upright position.

[0042] Now, **FIG. 2A** illustrates a first counterclockwise rotation by first Euler angle ϕ of object coordinates (X',Y',Z') about the Z' axis. This rotation of the object coordinates does not affect the Z' axis so once rotated Z" axis is collinear with non-rotated Z' axis (Z"=Z'). On the other hand, axes X' and Y' are rotated by first Euler angle ϕ to yield once rotated axes X" and Y".

[0043] **FIG. 2B** illustrates a second counterclockwise rotation by second Euler angle θ applied to once rotated object coordinates (X",Y",Z"). This second rotation is performed about the once rotated X" axis and therefore it does not affect the X" axis (X'"=X"). On the other hand, axes Y" and Z" are rotated by second Euler angle θ to yield twice rotated axes Y'" and Z'". This second rotation is performed

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in a plane Π containing once rotated axes Y", Z" and twice rotated axes Y'", Z'". Note that axis C.A. of pointer **14** is rotated counterclockwise by second Euler angle θ in plane Π and remains collinear with twice rotated axis Z'".

[0044] A third counterclockwise rotation by third Euler angle ψ is applied to twice rotated object coordinates (X'", Y'", Z'") as shown in **FIG. 1C**. Rotation by ψ is performed about twice rotated axis Z'" that is already collinear with object axis Z rotated by all three Euler angles. Meanwhile, twice rotated axes X'", Y'" are rotated by ψ to yield object axes X,Y rotated by all three Euler angles. Object axes X,Y,Z rotated by all three Euler angles φ, θ and ψ define Euler rotated object coordinates (X,Y,Z). Note that tip **16** of pointer **14** remains at the origin of all object coordinates during the Euler rotations.

[0045] Now, referring back to **FIG. 1**, the pose of pointer **14** includes its orientation, i.e., Euler angles (φ, θ, ψ), and position of tip **16**, i.e., the coordinates (x,y,z) of the point at which tip **16** contacts surface **18**. For convenience, the orientation of pointer **14** and position of tip **16** are expressed in world coordinates (X_o,Y_o,Z_o). World coordinates (X_o,Y_o,Z_o) have a world origin (0,0,0) that can be used to describe an absolute position of tip **16** on surface **18**. In fact, world coordinates (X_o,Y_o,Z_o) can be used for an absolute measure of any parameter(s) of the pose of pointer **14**. Alternatively, any parameter(s) of the pose of pointer **14** can be described in a relative manner, e.g., with reference to non-stationary or relative coordinates (X_i,Y_i,Z_i) or simply with respect to the previous pose.

[0046] To describe the absolute pose of pointer **14** it is convenient to relate Euler rotated object coordinates describing the orientation of pointer **14** to world coordinates (X_o,Y_o,Z_o). To do this, one notes that the orientation of object axis Z' in world coordinates (X_o,Y_o,Z_o) prior to the three Euler rotations is normal to plane (X_o,Y_o). Second Euler angle θ defines the only counterclockwise rotation of object coordinates that is not about an object Z axis (this second rotation is about the X"=X'" axis rather than axis Z', Z" or Z'"). Thus, Euler angle θ is an inclination angle θ between the completely Euler rotated object axis Z or axis C.A. and original object axis Z', which is normal to plane (X_o,Y_o) at the point of contact of tip **16**.

[0047] Optical measuring arrangement **22** measures the pose of pointer **14** during motion **40** at measurement times t_i and processor **26** prepares corresponding pose data **12**. Pose data **12** consists of measured values of parameters (φ,θ,ψ,x,y,z) at measurement times t_i. Invariant features **32**, **34**, **36** whose positions are defined in world coordinates (X_o,Y_o,Z_o) are employed by optical measuring arrangement **22** to express pose data **12** in world coordinates (X_o,Y_o,Z_o) . The frequency of the periodic measurements depends on the use of pose data **12** and desired performance, e.g., temporal resolution. It should be noted that periodic measurement is not limited to any predetermined time or frequency schedule. In other words, the times between any two successive measurements of the pose can be arbitrary. Preferably, however, arrangement **22** measures the pose at a frequency that is high enough to obtain pose data **12** that describe motion **40** at the temporal resolution required by application **28**.

[0048] Wireless transmitter **30** of communication link **24** sends pose data **12** or parameters (φ,θ,ψ,x,y,z) collected at measurement times t_i to processor **26**. Pose data **12** can be transmitted continuously, in bursts, in parts, at arbitrary or preset times or as otherwise desired. Processor **26** prepares a subset **48** of pose data **12**, for example the absolute position (x,y) of tip **16** and sends it to application **28**. Application **28** uses absolute position (x,y) of tip **16** at measurement times t_i to chart trace **42** of tip **16** on surface **18** as pointer **14** executes motion **40**. In other words, unit **28** recovers trace **42** corresponding to the movement of tip **16**. Note that the resolution of trace **42** recovered by unit **28** can be improved by increasing the number of pose measurements or increasing the frequency of measurement times t_i. It should be noted that pose data **12** should be formatted for appropriate communications between transmitter **30**, processor **26** and application **28**. Any suitable communication and formatting standards, e.g., IEEE interface standards, can be adapted for these purposes. For specific examples of formatting standards the reader is referred to Rick Poyner, LGC/Telegraphics, "Wintab™ Interface Specification: 16-bit and 32-bit API Reference", revision of May 9, 1996; Universal Serial Bus (USB), "Device Class Definition for Human Interface Devices (HID)", Firmware Specification, USB Implementers' Forum, Jun. 27, 2001 and six-degree of freedom interface by Ulrica Larsson and Johanna Pettersson, "Development and evaluation of a 6DOF interface to be used in a medical application", Thesis, Linkopings University, Department of Science and Technology, Sweden, Jun. 5, 2002.

[0049] The remaining pose data **12**, i.e., (φ,θ,ψ,z) can also be used in the present embodiment. Specifically, processor **26** can prepare additional subsets or send all of the remaining pose data as a single subset to application **28** or to a different application or device serving a different function. Any mix of orientation and position data derived from pose data **12** can be used in subset **48**. In fact, in some embodiments processor **26** keeps all pose data **12** in subset **48** such that all pose data **12** is used by application **28**. This is done when application **28** has to reconstruct the entire motion **40** and not just trace **42** of tip **16** on surface **18**. For example, this is done when application **28** includes a motion-capture application. Once again, the temporal resolution of motion **40** can be improved by increasing the frequency of measurement times t_i. Note that in this case parameters of pose data **12** that vary slowly are oversampled.

[0050] It should also be noted that surface **18** is plane and hence the value of parameter z does not change. Thus, z can be set at a constant value, e.g., z=0, and left out of pose data **12** to reduce the amount of data that needs to be transmitted by transmitter **30**.

[0051] In **FIG. 3** a block diagram illustrates the processing of pose data **12** by processor **26** and its use by application **28** in more detail. In a first step **50**, pose data **12** is received by processor **26** via communication link **24**. In a second step **52**, processor **26** determines which portion or subset **48** of pose data **12** is required. This selection can be made based on application **28**. For example, when application **28** is a trace-capture application that charts trace **42**, then only position data of tip **16**, i.e., (x,y) need to be contained in subset **48**. On the other hand, when application **28** is a motion-capture application, then all pose data **12** need to be contained in subset **48**.

[0052] In step **58** all pose data **12** is selected and passed to a subset formatting or preparing step **60A**. In step **60A** pose

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data **12** is prepared in the form of subset **48A** as required by application **28**. For example, pose data **12** is arranged in a particular order and provided with appropriate footer, header and redundancy bits (not shown), or as otherwise indicated by data porting standards such as those of Rick Poyner, LGC/Telegraphics (op. cit.).

[0053] In step **62**, only a portion of pose data **12** is selected. Three exemplary cases of partial selection are shown. In the first case, only position data is required by application **28**.

[0054] Hence, in a step **59B** only position data (x,y,z) is selected and the remaining pose data **12** is discarded. In a subsequent step **60B**, position data (x,y,z) is prepared in the form of subset **48B** as required by application **28** and/or as dictated by the porting standards. In the second case, in a step **59C**, only orientation data (ϕ,θ,ψ) is selected and the rest of pose data **12** is discarded. Then, in a step **60C**, orientation data (φ,θ,ψ) is prepared in the form of a subset **48C** for use by application **28**. In the third case, in a step **59D**, a mix of pose data **12**, including some position data and some orientation data are selected and processed correspondingly in a step **60D** to prepare a subset **48D**.

[0055] A person skilled in the art will appreciate that the functions described can be shared between processor **26** and application **28**, e.g., as required by the system architecture and data porting standards. For example, some preparation of subset **48** can be performed by application **28** upon receipt. It should also be noted that in some embodiments pose data **12** can be pre-processed by transmitter **30** or post-processed at any point before or after preparation of the corresponding subset **48** in accordance with any suitable algorithm. For example, a statistical algorithm, such as a least squares fit can be applied to pose data **12** derived at different measurement times t_i or to successive subsets **48**. Furthermore, quantities such as time derivatives of any or all parameters of pose data **12**, i.e.,

$$\left(\frac{dx}{dt}, \frac{dy}{dt}, \frac{dz}{dt}, \frac{d\phi}{dt}, \frac{d\theta}{dt}, \frac{d\psi}{dt}\right)$$

[0056] can be computed. Also, various sampling techniques, e.g., oversampling can be used.

[0057] Subset **48** is transmitted to application **28** via a communication channel **72**. Application **28** receives subset **48** as an input that is treated or routed according to its use. For example, in a step **64**, subset **48** is used as control data. Thus, subset **48** is interpreted as an executable command **66** or as a part of an executable command. On the other hand, in a step **68**, subset **48** is used as input data and saved to a data file **70**.

[0058] In one embodiment, application **28** passes information to processor **26** to change the selection criteria for subset **48**. Such information can be passed via communication channel **72** or over an alternative link, e.g., a feedback link **74**. For example, application **28** requests subset **48A** to be transmitted and uses subset **48A** as input data for data file **70**. At other times, application **28** requests subset **48C** to be transmitted and uses subset **48C** as command data for executable command **66**. Alternatively, processor **26** can indicate a priori whether any subset **48** should be treated as input data or control data. In still another alternative, user **38** can indicate with the aid of a separate apparatus, e.g., a switch mounted on pointer **14** (not shown), whether subset **48** is intended as control data or input data. A person skilled in the art will recognize that there exist a large number of active and passive methods for determining the interpretation and handling of data being transmitted in subset **48** by both processor **26** and application **28**.

[0059] In general, the optical measuring performed by on-board optical measuring arrangement can be implemented in a number of ways. For example, **FIG. 4** illustrates an elongate object **100** with a tip **102** contacting a plane surface **104** endowed with an invariant feature **106**. Invariant feature **106** is a polygon of known orientation, size and position on surface **104**. Note that only a portion of object **100** is indicated for better visualization. Object **100** is aligned along the Z axis, which is collinear with a center axis C.A. that is used for reference to world coordinates (not shown).

[0060] An optical measuring system **108** is mounted on object **100** for performing on-board optical measurements of pose. In fact, system **108** is an imaging system or image capturing system for optically measuring the pose of object **100** using invariant feature **106**. Imaging system **108** has a lens **110** and an image capturing device **112** in the form of an electronic optical sensor or pixel array positioned in an image plane **114** defined by lens **110**. Preferably, lens **110** has a wide field of view Θ and a substantially single viewpoint for preserving 3-D perspective information of nearby surroundings. Lens **110** can include various optics including refractive, reflective and/or catadioptric optics accompanied by optical relays, mirrors, apertures, field flatteners, image guides and other elements, as will be appreciated by one skilled in the art. In fact, lens **110** should be selected as appropriate for imaging surface **104**.

[0061] Array **112** has imaging pixels **116** positioned in image plane **114** described by orthogonal axes X', Y'. These axes are parallel to axes X and Y of rotated object coordinates. The Euler angles from non-rotated to rotated object coordinates are as indicated.

[0062] During operation, radiation **118** such as sunlight or artificial illumination is incident on surface **104**. A scattered portion **118'** of radiation **118** travels to elongate object **110** at an angle of incidence θ_i to central axis C.A. More precisely, scattered portion **118'** such as that propagating along path **120** scattered from a point P_p of a corner of invariant feature **106** arrives within solid angle Θ and is imaged by imaging system **108** on image plane **114** at image point P'. Scattered portion **118'** from point P_p and from the remainder of feature **106** and plane **104** or their portions carries with it image information. This spatial intensity variation or image information is used to determine the pose of object **100** in accordance with any technique for recovering position from an image of surface **104** and feature **106** produced on imaging pixels **116** of array **112**. A person skilled in the art will recognize that perspective imaging is particularly well-suited for this purpose. For more information on appropriate imaging optics and methods the reader is referred to U.S. patent application Ser. No. 10/640,942.

[0063] Another alternative for implementing an on-board optical measuring arrangement is shown in **FIG. 5**. Here, an elongate object **130** with a tip **132** contacting a plane surface

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134 endowed with invariant features 136 uses a scanning system 138 as its on-board optical measuring arrangement. The Euler angles from non-rotated to rotated object coordinates are indicated. Invariant features 136 include a quadrilateral 136A and a line 136B, both of known size, orientation and position in world coordinates (X_o,Y_o,Z_o).

[0064] Scanning system 138 has a source 140 of probe radiation 142, an arm 144, and a scan mirror 146 for directing probe radiation 142 at surface 134. Scanning system 138 uses a driver for driving scan mirror 146 to scan surface 134 and invariant features 136. For example, scan mirror 146 is a biaxial scan mirror driven by a biaxial driver. Mirror 146 directs radiation 142 at a scan angle α with respect to a mirror axis M.A., which in the present embodiment is parallel to a center axis C.A. of object 130. The driver varies scan angle σ in accordance with a scan pattern 148 to effectuate the scan of surface 134 and features 136. At a particular scan angle σ, radiation 142 is incident on surface 134 at a particular point P_o and at an angle of incidence or inclination angle δ with respect to surface 134. Point PO moves over surface 134 and features 136 in accordance with scan pattern 148 as dictated by the driver and pose of object 130.

[0065] Probe radiation 142 scatters at point P_o based on incident directions of probe radiation 142 to surface 134, frequency f of probe radiation 142, as well as physical characteristics of surface 134 and of invariant features 136. The response of a back-scattered portion 142' of probe radiation 142 to surface 134 and features 136 can thus be described by temporal changes in the intensity of back-scattered portion 142' as scanning occurs. In general, the response of back-scattered portion 142' to surface 134 and to features 136 can include not only a change in intensity but also a polarization-based response. This response of back-scattered portion 142' of probe radiation 142 to surface 134 and to invariant features 136 can be used to measure the pose of object 130. It should be noted that any invariant feature yielding a detectable reaction to probe radiation 142 and whose position in world coordinates is fixed can be used.

[0066] The pose of object 130 in 3-D space includes the position of tip 132 on surface 134 as well as the orientation of elongate object 130 in three dimensional space. In this embodiment, the position of tip 132 in world coordinates (X_o,Y_o,Z_o) is expressed by a vector Do and the orientation by Euler angles (ϕ,θ,ψ). This is particularly convenient, since the inclination of elongate object 130 to plane surface 134 described by an inclination angle θ between an axis of object 130, in this case axis C.A. and a normal to surface 134, i.e., axis Z', and second Euler angle θ are equivalent.

[0067] Surface 134 and invariant features 136A and 136B cause a temporal intensity variation in back-scattered portion 142' corresponding to scan point P_o of probe radiation 142 traversing them. The temporal intensity variation of back-scattered portion 142' is measured by a detector 150. In the present embodiment, detector 150 and an optic 152, e.g., a beam-splitter, are provided on object 130 to direct back-scattered portion 142' of probe radiation 142 to detector 150 for detecting the intensity variation. The pose of object 130 is obtained from the knowledge of scan pattern 148, surface 134 and invariant features 136 in accordance with any suitable spatio-temporal scanning technique. Additional knowledge such as inclination angle θ or second Euler angle and third Euler angle θ can be employed in deriving absolute position of tip 132. Angles θ and ψ can be obtained from an inclinometer (not shown) or any other apparatus and/or method. For some specific examples of scanning techniques that can be used in measuring the pose of object 130 reader is referred to U.S. patent application Ser. No. 10/745,371.

[0068] In still other embodiments the on-board optical measuring arrangement can combine elements of imaging and scanning in a hybrid system. For example, pixel arrays with passive imaging pixels and active illumination pixels can be used to form hybrid imaging and scanning elements. In addition, systems with distinct points of view can be used to take advantage of stereo imaging and scanning techniques. In still other embodiments, one can use an optical system having a pixel array that operates in a projection rather than imaging mode, i.e., the optics associated with this system do not perform only imaging but also project radiation from the pixel array. A person skilled in the art will recognize that there exist a large number of alternatives for constructing the optical measuring arrangement.

[0069] FIG. 6 is a three-dimensional view of a preferred embodiment as a pen, pencil or stylus. In particular, jotting implement 200 is a pen whose tip 202 is a writing nib in contact with a plane surface 204 of a sheet of paper 206 on a tabletop 208. Pen 200 has a center axis C.A. aligned with the Z axis in Euler rotated pen coordinates (X,Y,Z). An inclination angle θ corresponding to second Euler angle is shown with respect to Z' axis which also represents a surface normal.

[0070] A housing 210 is mounted at a top end 212 of pen 200. Housing 210 has an optical measuring arrangement 214 for optically measuring the pose of pen 200 from on-board pen 200. Optical measuring arrangement 214 is an imaging system, a scanning system or a hybrid system. Surface 204 of paper 206 has invariant features 216A, 216B, 216C, and 216D in the form of paper edges. Features 216 are used by optical measuring arrangement 214 to measure the pose of pen 200.

[0071] Housing 210 holds a processor 218 for preparing pose data corresponding to the pose measured by optical measuring arrangement 214 and identifying a subset 220 of the pose data. A transmitter 222 is provided in housing 210 for transmitting subset 220 to an application 224 via a wireless communication link 226. Since the elements in housing 210 and their operation have been described above they will not be addressed in detail in this embodiment.

[0072] A user holds pen 200 in hand 228 and moves it while contacting surface 204 to produce marks representing handwriting, for example. Hand 228 is indicated in a dashed outline for better visualization. A pressure sensor or other device (not shown) ascertains contact between nib 202 and surface 204. While the user is jotting, optical measuring apparatus periodically measures the pose of pen 200. In particular, while pen 200 is in motion corresponding to jotting, optical measuring arrangement 214 measures the pose periodically at measurement times t_i such that the pose data describes the motion of pen 200 in sufficient detail to be useful in application 224.

[0073] For example, when application 224 is a general motion-capture application the frequency of measurement times t_i is on the order of 75 Hz. In some motion-capture

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applications such as biometric applications requiring precise knowledge of the motion pen **200**, e.g., to derive a biometric of hand **228**, more frequent measurement times t_i, e.g., in excess of 100 Hz can be used. In particular, such precise knowledge can be required when the biometric application is a user verification application. In another embodiment, application **224** is a trace-capture application for capturing traces **230**A, **230**B and **230**C marked by pen **200** on paper **206**. More precisely, application **224** is an on-line or off-line handwriting recognition application requiring that measurement times t_i be on the order of 100 Hz ($\Delta t=1/100$ s) to properly recognize handwriting. Another application **224** may require that a distance Δs that nib **202** moves on paper surface **204** between successive measurements be on the order of 1/200 of an inch or about 0.12 mm. In still another embodiment, the trace-capture application can be a signature verification application that can require higher precision than handwriting recognition. It should be noted that the biometric application can also perform user identification and/or signature verification. In the present embodiment, application **224** is an on-line handwriting recognition application and measurement times t_i are repeated at a frequency on the order of 100 Hz.

[0074] During operation the user moves hand **228** translating to a motion of pen **200** resulting in ink traces **230** on surface **204** of paper **206**. Traces **230** are produced when nib **202** contacts surface **204** at a writing point during the motion. Optical measuring arrangement **214** measures the pose of pen **200** periodically at measurement times t_i with the aid of invariant features **216** while traces **230** are being produced.

[0075] A first writing point P_{wdn}, sometimes referred to as pen-down, and a last writing point P_{wup}, sometimes referred to as pen-up, are indicated on trace **230**A which nib **202** produced during a motion **232** of pen **200**. Also indicated is an intermediate writing point P_{wm} at a location at which nib **202** was located during a specific measurement time t_m. Two writing points at successive measurement times t_n and t_{n+1} are also shown and, for illustrative purposes, a time duration Δt between them. Trace **230**B is shown in the process of being written by the user. Trace **230**C has already been written, and two writing points at successive measurement times t_n and t_{+1} are shown separated by a distance Δs.

[0076] Application **224** is an on-line handwriting recognition application and so the frequency of measurement times t_i between pen-down and pen-up points for each trace **230**A, **230**B and **230**C is on the order of 100 Hz such that time duration Δt is about 1/100 s. Therefore, pose of pen **200** is measured by arrangement **214** with a temporal resolution of about 1/100 s.

[0077] Processor **218** prepares pose data corresponding to the succession of poses assumed by pen **200** in motions executed between pen-down and pen-up points. Processor **218** also identifies the pose data this is required in subset **220** to run application **224**. In some handwriting recognition applications, subset **220** need only contain the absolute positions of nib **202** at measurement times t_i corresponding to writing points P_{wi}. In other words, subset **220** only contains position data of nib **202** on surface **204** rather than orientation data of pen **200**. Furthermore, the locations of writing points P_{wi} are expressed by corresponding vectors Di in global coordinates (X_o,Y_o,Z_o) having an origin at the top right corner of paper **206**.

[0078] In an alternative embodiment, handwriting recognition application **224** requires orientation data in subset **220**. For example, an on-line handwriting recognition application **224** requires inclination angle θ to be contained in subset **220**. Note that inclination angle θ is also the second Euler angle. Still other handwriting recognition application **224** requires subset **220** to contain more or even all orientation data, i.e., all three Euler angles. In fact, processor **218** can be informed by application **224** of its particular requirements at any given time with respect to subset **220**, e.g., via communication link **226**. In cases where subset **220** is to contain additional information, such as first or higher-order derivatives of any combination of or all position and orientation data, e.g., second order derivatives

$$\left(\frac{d^2x}{dt^2}, \frac{d^2y}{dt^2}, \frac{d^2z}{dt^2}, \frac{d^2\phi}{dt^2}, \frac{d^2\theta}{dt^2}, \frac{d^2\psi}{dt^2}\right),$$

[0079] these can either be computed by processor **218** and included in subset **220**, or they can be computed by application **224**, as convenient.

[0080] In an alternative embodiment, pen **200** is a stylus that leaves no traces **230**. In other words, nib **202** is a point that makes no markings. In this embodiment surface **204** does not have to be a paper surface; it can be replaced by any plane surface on which jotting can be performed. Otherwise the method is the same as described above.

[0081] **FIG. 7** illustrates another embodiment of an apparatus **248** for processing pose data derived from a pose of an elongate object **250** having a tip **252**. Object **250** is a stylus whose tip **252** does not produce traces. Object **250** has a housing **254** containing an optical measuring arrangement and a processor (not shown). A wireless transmitter **262** is provided for communication.

[0082] Tip **252** is placed on a plane surface **256** with invariant features **258**A, **258**B, **258**C, and **258**D. The measurement arrangement relies on features **258** for periodically measuring the pose of stylus **250** at measurement times t_i when tip **252** contacts surface **256**. The processor prepares pose data corresponding to the pose and identifies a subset **260** to be transmitted. In the present case, subset **260** contains all pose data and is transmitted after each measurement time t_i with a time stamp, also referenced by t_i. Position data is expressed in the form of a vector D_i in world coordinates (X_o,Y_o,Z_o) selected by the optical measurement arrangement. Orientation data is expressed in Euler angles.

[0083] Transmitter **262** transmits subset **260** via communication links **264**A, **264**B, **264**C and **264**D to various devices having resident applications requiring subset **260**. Specifically, link **264**A connects to a network **266** that in turn connects to a computer **268**, e.g., a personal computer that runs an application **270** requiring subset **260**. Network **266** can be any type of network, including the internet, a local area network (LAN), a telephone network or any network capable of transmitting subset **260**. Link **264**B connects to a local host **272**, e.g., a host computer, which is in communication with computer **268** via web **274**. It should be noted that application **270** can be shared between computer **268** and local host **272**, or each can use set **260** for its own separate application. Alternatively, local host **272** can

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serve as a relay computer only. Link **264C** connects directly to computer **268** and may be a short-distance link, e.g., a link which is only active when stylus **250** is operating in proximity to computer **268**. Link **264D** connects to a device **276** running another application **278**. For example, device **276** is a personal digital assistant (PDA) or a cellular telephone. In fact, link **264D** can be an infrared link or an ultrasound link, in which case a corresponding transmitter is used to replace wireless transmitter **262**. It should be noted that stylus **250** can communicate via any combination of links **264** with any device it needs to be in communication with at any given time. The devices may use links **264** to communicate their availability and subset preferences to stylus **250** at any time.

[0084] During operation, stylus **250** can include in subset **260** absolute position data or vector D_i expressed in world coordinates. Alternatively, stylus **250** can include in subset **260** relative position data or vector D_{ri} in relative coordinates (X_r,Y_r,Z_r). In still another alternative, subset **260** includes relative position data with respect to the previous position, i.e., vector $\Delta D=D_{ri}-D_{ri-1}$. That is because some applications require only knowledge of the relative position of tip **252**. It should also be noted that the processing of pose data and identification of subset **260** is a task that can be shared between pen **250** and any other devices. In fact, the processor required for processing the pose to derive the pose data and identify subset **260** can reside entirely on another device, e.g., on computer **268**.

[0085] **FIG. 7** is a block diagram illustrating a few exemplary uses of command and input data from subset **260** of jotting implement **250**. In a first step **280**, subset **260** is received by either a local host or a network via communication link **264**. If subset **260** is intended for a remote host, then it is forwarded to the remote host in a step **282**.

[0086] In a second step **284**, a processor in the intended host (local host or remote host, as the case may be) determines the requirements for subset **260**. This selection can be made based on an intended application **300**. For example, when application **300** only requires the parameters already contained in subset **260**, then subset **260** is forwarded to step **286** for preparation and direct use. Alternatively, when application **300** requires additional parameters, subset **260** is forwarded to step **288** for derivation of these additional parameters.

[0087] For example, the additional parameters are derivatives of one or more of the parameters in subset **260**. Thus, subset **260** is sent to a differentiation module **290** and then to a preparation module **292** for supplementing subset **260** with the derivatives. In the example shown, time derivatives of Euler angles ϕ and θ are required and thus, supplemented and prepared subset **260'** contains these time derivatives.

[0088] Alternatively, statistical information about one or more of the parameters in subset **260** are required. Thus, subset **260** is sent to a statistics module **294** and then to a preparation module **296** for supplementing subset **260** with the statistical information. In the present example, the statistical information is a standard deviation of second Euler angle θ. Thus, supplemented and prepared subset **260"** contains the

[0089] A person skilled in the art will appreciate that the functions described can be shared between local and remote hosts as well as application **300**, e.g., as required by the system architecture and data porting standards. For example, some preparation and supplementing of subset **260** can be performed by application **300** upon receipt.

[0090] Subset **260** is transmitted to application **300** for use as an input that is treated or routed according to its use. For example, in a step **302**, subset **260'** is used as control data. Thus, subset **260'** is interpreted as an executable command **304** or as a part of an executable command and used in an executable file **310**. On the other hand, in a step **306**, subset **260"** is used as input data and saved to a data file **308**.

[0091] In one specific application, application **300** is a trace-capture application and subset **260'** is used as control data in accordance with standard Boolean logic. Specifically, application includes a Boolean logic symbol reformatting function to translate the control data into a Boolean logic command, e.g., OR, AND or XOR.

[0092] **FIG. 9** is a diagram illustrating still another embodiment of the apparatus of invention. In this embodiment an elongate object **320** is a jotting implement employed on a jotting surface **322** with invariant features **324A** and **324B**. Jotting surface **322** can be a screen, a pad, a paper surface or any other convenient surface from which jotting implement **320** can determine pose with the aid of an on-board optical measuring arrangement in accordance with the above teaching. Jotting implement **320** is a pen, pencil or a stylus.

[0093] A user **326** employs jotting implement **320** by placing its tip **328** on surface **322** and executing motions to generate pose data. Pose data is processed into subsets and transmitted to a variety of user devices that include, but are not limited to, a mainframe computer **330**, a joystick **332**, a cellular telephone **334**, a personal computer **336** and a personal digital assistant **338**. Each of these devices uses the appropriate portion of the subset. For example, joystick **332** strips all parameters other than Euler angles ϕ, θ and uses these as control data. Alternatively, joystick **332** retains Euler angle ψ and uses it as control data to emulate an activation button function. On the other hand, cellular telephone **334** uses Euler angles to select dial numbers and position data as control data to execute a dial command.

[0094] It should be noted that the elongate object can be any type of elongate device whose physical pose can yield useful data. Thus, although the above examples indicate that the elongate object is a jotting implement, pointer, cane, or robotic arm other elongate objects can be used. Also, the subset identified form the pose data can be supplemented with various additional data that may be derived from other devices that are or are not on-board the elongate object.

[0095] Furthermore, the pose data and/or data in the subset can be encrypted for user protection or other reasons, as necessary.

[0096] It will be evident to a person skilled in the art that the present invention admits of various other embodiments. Therefore, its scope should be judged by the claims and their legal equivalents.

1. A method for processing pose data derived from a pose of an elongate object having a tip, said method comprising:

a) placing said tip on a plane surface with an invariant feature;

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b) measuring said pose optically from on-board said elongate object using said invariant feature;

c) preparing pose data corresponding to said pose;

d) identifying a subset of said pose data; and

e) transmitting said subset to an application.

2. The method of claim 1, wherein said elongate object is undergoing a motion and said measuring is performed periodically at measurement times t_i, such that said pose data describes said motion.

3. The method of claim 1, wherein said subset comprises orientation data.

4. The method of claim 3, wherein said subset comprises an inclination angle θ.

5. The method of claim 3, wherein said subset comprises at least one Euler angle.

6. The method of claim 3, wherein said orientation data is used as input selected from the group consisting of control data and input data.

7. The method of claim 2, wherein said subset comprises position data of said tip on said surface.

8. The method of claim 7, wherein said position data comprises a position of said tip relative to said invariant feature.

9. The method of claim 7, wherein said position data comprises an absolute position of said tip on said surface.

10. The method of claim 7, wherein said position data comprises a position of said tip relative to a previous absolute position of said tip on said surface.

11. The method of claim 7, wherein said position data is used as an input selected from the group consisting of control data and input data.

12. The method of claim 1, wherein said plane surface comprises a jotting surface and said elongate object is a jotting implement.

13. The method of claim 12, wherein said jotting surface is selected from the group consisting of a screen, a tablet, a pad and a paper surface.

14. The method of claim 1, wherein said elongate object is selected from the group consisting of jotting implements, pointers, robotic arms and canes.

15. The method of claim 14, wherein said jotting implements are selected from the group consisting of pens, pencils and styluses.

16. An apparatus for processing pose data derived from a pose of an elongate object having a tip, said apparatus comprising:

a) a plane surface for placing said tip thereon, said plane surface having an invariant feature;

b) an optical measuring means for optically measuring said pose from on-board said elongate object using said invariant feature;

c) a processor for preparing pose data corresponding to said pose and identifying a subset of said pose data; and

d) a communication link for transmitting said subset to an application.

17. The apparatus of claim 16, wherein said optical measuring means comprises a periodic measurements means for periodically measuring said pose at measurement times t_i.

18. The apparatus of claim 16, wherein said processor is mounted on said elongate object.

19. The apparatus of claim 16, wherein said communication link is a wireless communication link.

20. The apparatus of claim 16, wherein said elongate object is selected from the group consisting of jotting implements, pointers, robotic arms and canes.

21. The apparatus of claim 20, wherein said jotting implements are selected from the group consisting of pens, pencils and styluses.

22. The apparatus of claim 16, wherein said application comprises a data file and said subset comprises input data to said data file.

23. The apparatus of claim 16, wherein said application comprises an executable file and said subset comprises control data to said executable file.

24. The apparatus of claim 16, wherein said application comprises a motion-capture application.

25. The apparatus of claim 24, wherein said motion-capture application comprises a biometric application.

26. The apparatus of claim 25, wherein said biometric application comprises a user verification application.

27. The apparatus of claim 16, wherein said application comprises a trace-capture application.

28. The apparatus of claim 27, wherein said trace-capture application comprises a handwriting recognition application.

29. The apparatus of claim 27, wherein said trace-capture application comprises a signature verification application.

30. The apparatus of claim 27, wherein said trace-capture application comprises a Boolean logic symbol reformatting function.

* * * * *

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Publication Title:

ASSEMBLING ROBOT

Abstract:

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(A1) A 3-dimensional form of a sample product constituted by a plurality of parts having known forms is measured by imaging the sample product from a plurality of directions. Arrangement data representing the 3-dimensional positions and orientations of the parts constituting the sample product are obtained by construction detecting module (12) on the basis of the measured 3-dimensional form of the sample product. Task planning module (13) sets a task for moving a part to be used for constructing a product and task sequence of the task by using arrangement data acquired by construction detecting module (12). Upon generation of motion command data for controlling a robot for constructing the product in accordance with the task set by task planning module (13), the generated motion command is output to motion control module (14).; The construction robot is controlled by the motion control module (14), and the same product as the sample product is constructed.

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⑲日本国特許庁（JP）　⑪特許出願公開

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㊹発明の名称　組立てロボット

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明　細　書

1．発明の名称

組立てロボット

2．特許請求の範囲

既知形状を有した複数の部品を組合わせてなる見本製品を複数方向から撮像して得られた複数の2次元形状から前記見本製品の3次元形状を得る3次元計測器と、この3次元計測器から得られた3次元形状および前記既知の各部品の形状から前記見本製品を構成する各部品の配置情報を得る構造検出手段と、前記各部品の3次元位置を移動させるロボット本体と、前記構造検出手段にて得られた各部品の配置情報から、各部品を前記配置情報の示す位置へ移動させるための各単位作業を算出する単位作業算出手段と、前記各部品を用いて前記見本製品と同一製品を組立てる場合における前記各単位作業の作業順序を算出する作業計画手段と、この作業計画手段にて得られた作業順序に従って、前記各単位作業を前記ロボット本体を駆動する動作指令データへ順次変換する動作計画手段と、この動作計画手段にて変換された各動作指令データで前記ロボット本体を駆動する駆動制御手段とを備えたことを特徴とする組立てロボット。

3．発明の詳細な説明

［発明の目的］

（産業上の利用分野）

本発明は複数の部品からなる見本製品の構造を検出して、この見本製品と同一製品を自動的に組立てる組立てロボットに関する。

（従来の技術）

従来、例えばコンベア等にて順次搬入される複数種類の部品を組合わせて一つの最終製品に組立てる組立てロボットにおいては、まず、人間が最終製品の構造を調べて、最終製品を構成する各部品の3次元位置と姿勢各とを算出する。そして、それらの3次元位置と姿勢各からなる配置情報からその部品を所定位置から配置情報の示す位置へ移動させるため単位作業を算出する。さらに、各部品を順次組立てて一つの最終製品にするまでの作業順序（組立て順序）を求める。そして、各

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単位作業および作業順序をロボット本体が理解できるプログラムに編集して、ロボット本体を駆動させる。

また、組立てロボットに視覚、触覚等のセンサを取付け、予め人間が組込んだプログラムに従って、組立て時の各部品の位置を自動補正したり、動作を自動変更するものも開発されている。

また、ホストコンピュータから、このコンピュータに組込まれたＣＡＤ（コンピュータによる自動設計）データから得られる前記各部品に対する単位作業や作業順序を受領して、前記最終製品を自動的に組立る組立てロボットも提案されている。

しかしながら、一般に組立てロボットを駆動制御するプログラムの作成作業は非常に煩雑であり、しかも多数のアームやハンドを動作させる必要があるので、実際にロボットを駆動させてプログラムチェックを実施する場合にプログラムミスに起因する誤動作による危険発生が懸念される。

また、前述したセンサを用いて各部品の位置を自動補正するプログラムはさらに複雑になる。

また、ＣＡＤデータを利用したプログラム自動化については、上述した問題は発生しないが、ホストコンピュータで最終製品に対する自動設計を実行する場合に、自動設計には直接関係のない組立て順序（作業順序）までＣＡＤ化する必要がある。その結果、自動設計のためのプログラム作成が非常に煩雑になる。

このように、従来の組立てロボットにおいては、プログラム作成が非常に煩雑になる問題がある。さらに、最終製品の形状が少しでも変更になると、最初からプログラムを作成し直す必要があり、さらに煩雑になる。特に、ＣＡＤデータを使用する場合は、ホストコンピュータのＣＡＤデータの作成まで遡ってプログラム訂正を実施する必要がある。したがって、組立てロボットの稼動率を考慮すると上記ＣＡＤデータを使用する方法は実用的でない。

（発明が解決しようとする問題点）

上述したように、従来の組立てロボットにおいては、ロボット本体を駆動制御するプログラムの作成が煩雑であり、プログラム作成の専任者が必要であった。また、稼動させるまでの準備作業に多大の時間を必要とした。

本発明は、このような事情に基づいてなされたものであり、見本製品の３次元構造を自動的に検出してそれに基づいて各部品の単位作業および作業順序を得ることによって、たとえ最終製品（見本製品）の構造が変化したとしてもプログラム変更の必要がなく、簡単に製造製品の変更ができる組立てロボットを提供することを目的とする。

［発明の構成］

（問題点を解決するための手段）

本発明の組立てロボットは、既知形状を有した複数の部品を組合わせてなる見本製品を複数方向から撮像して得られた複数の２次元形状から見本製品の３次元形状を得る３次元計測器と、この３次元計測器から得られた３次元形状および既知の各部品の形状から見本製品を構成する各部品の配置情報を得る構造検出手段と、各部品の３次元位置を移動させるロボット本体と、構造検出手段にて得られた各部品の配置情報から、各部品を配置情報の示す位置へ移動させるための各単位作業を算出する単位作業算出手段と、各部品を用いて見本製品と同一製品を組立てる場合における各単位作業の作業順序を算出する作業計画手段と、この作業計画手段にて得られた作業順序に従って、各単位作業を前記ロボット本体を駆動する動作指令データへ順次変換する動作計画手段と、この動作計画手段にて変換された各動作指令データで前記ロボット本体を駆動する駆動制御手段とを備えたものである。

（作用）

このように構成された組立てロボットであれば、既知形状を有した複数の部品を組合わせてなる最終製品と同一構成の見本製品全体の３次元形状は複数方向から撮像された２次元形状から求められる。さらに、見本製品を構成する各部品の形状は既知であるので、３次元形状から各部品の位置と姿勢とからなる配置情報を判断できる。すなわち見本製品の構造が検出できる。

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そして、得られた各部品の配置情報から、各製品を用いて見本製品と同一の最終製品を組立てる場合における各製品の移動を示す単位作業および作業順序が求められる。各単位作業はロボット本体を駆動させるための動作指令データへ変換され、前記作業順序に従って、順次ロボット本体へ送出される。しかして、見本製品と同一構成の最終製品が組立てられる。

したがって、見本製品と同一製品が自動的に組立てられるので、プログラム変更を行なうことなく見本製品を変更することによって最終製品を変更できる。

（実施例）

以下本発明の一実施例を図面を用いて説明する。

第１図は実施例の組立てロボットの概略構成を示す模式図である。最終製品を構成する各部品１を搬入するコンベア２に隣接してロボット本体３が設置されている。このロボット本体３は、左右に配設された２本のアーム４，５と、各アーム４，５の先端に取付けられた各ハンド６，７と、各ハンド６，７で各部品１を掴む場合の握力を検出する各力覚センサ８，９等が組込まれている。また、ロボット本体３には最終製品と同一構成の見本製品１０の２次元形状を得るための一対のＣＣＤカメラ１１ａ，１１ｂが取付けられている。

各ＣＣＤカメラ１１ａ，１ｂで得られた見本製品１０の異なる方向から見た各２次元形状データは構造検出モジュール１２へ入力される。この構造検出モジュール１２にて得られた見本製品１０の構造データは作業計画立案モジュール１３へ入力される。この作業計画立案モジュール１３は、作業計画部１３ａと動作計画部１３ｂとで構成されている。作業計画立案モジュール１３から出力された各動作指令データは駆動制御モジュール１４へ入力される。この駆動制御モジュール１４は入力された動作指令データに従ってロボット本体３を駆動制御する。

このロボット本体３は、一種の［センサ付知能ロボット］であり、駆動制御モジュール１４から例えば一つの部品１を指定位置へ移動させるための各アーム４，５および各ハンド６，７に対する動作指令データが入力すると、前記一対のＣＣＤカメラ１１ａ，１１ｂおよび力覚センサ８，９のフィードバック信号でもって動作を修正しながら各部品１に対する移動作業を実行する。

なお、前記見本製品１０は既知形状を有した複数の部品１を組合わせて構成されている。そして、ロボット本体３はコンベア２にて順次搬入される各部品１をハンド６，７で掴んで見本製品１０と同一の最終製品を組立てる。なお、図中１５は最終製品の組立て途中を示す半完成品である。

前記構造検出モジュール１２は、一種のマイクロプロセッサで構成されており、第２図のブロック図で示すことが可能である。すなわち、一対のＣＣＤカメラ１１ａ，１１ｂは、自己の位置を対象物である見本製品１０に対して種々移動させながら、又は見本製品１０を回転させながら、この見本製品１０を複数方向から撮像する。見本製品１０を種々の方向から観測するのは、一方向から物体を観測しただけでは見えない部分の、測定を行なうためである。

３次元測定器１６は、各ＣＣＤカメラ１１ａ，１１ｂで撮像された複数方向の２次元形状データから見本製品１０の各頂点，稜線の３次元座標を求める。次の階層別分類器１７は、３次元計測器１６で求めた見本製品１０の各頂点、各稜線の３次元座標を、高さ方向の各階層に分類し、階層毎の断面外形情報を得る。

断面解析器１８は、上記階層別分類器１７で得られた階層別の断面外形情報、及び部品形状メモリ１９から得られた各部品毎の形状データを比較して、その断面に含まれる部品を同定し、各階層毎に含まれる部品の情報を得る。なお、前記部品形状メモリ１９内には、この見本製品１０を構成する各部品１毎に３次元形状を決定するための断面形状データを含む各データが予め記憶されている。

次の構造認識器６は、断面解析器１８によって抽出された各階層毎の部品情報を階層間で結合し、

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前記部品メモリ１９から送出される各部品１の形状データを参照して、見本製品１０を構成する各部品の３次元位置及び姿勢からなる配置情報を出力する。構造認識器２０から出力された各部品１の配置情報は構造データメモリ２１へ書込まれる。

しかして、前記種別分類器１７，画面解釈器１８および構造認識器２０は見本製品１０に対する構造検出手段を構成する。

前記構造データメモリ２１内には、第３図に示すように、見本製品１０を構成する各部品１毎に、部品番号（パーツNo），部品の型式番号（タイプNo），例えば部品１の中心位置における見本製品１０に組込んだ状態における３次元座標（Ｘ，Ｙ，Ｚ）で示される位置データ，およびその位置における立体方位角（α，β，γ）で示される姿勢データが記憶される。

次に，例えば，マイクロプロセッサ等のプログラム制御手順で示される作業計画立案モジュール１３の説明を行なう。

この作業計画立案モジュール１３内には、第４図に示すように、コンベア２にて順次搬入されてくる最終製品を構成する各部品１を前記構造データメモリ２１内に設定された位置および姿勢からなる配置情報の指定する位置へ移動させるための移動データ等からなる各単位作業を格納する単位作業メモリ２２が形成されている。また、この単位作業メモリ２２には各単位作業毎にその単位作業を実行する順序Ａを格納する順序領域２２ａが形成されている。

また、標準作業関数メモリ２３が形成されている。すなわち、ロボット本体３が実行する各単位作業は例えばコンベア２にて搬入される部品１を構造データメモリ２１の配置情報の指定する位置へ移動させる作業である。したがって，部品１を掴む位置の情報、移動先の配置情報（Ｘ，Ｙ，Ｚ，α，β，γ）、若干の部品形状データ等を、パラメータとすると、実際にロボット本体３へ印加する各アーム４，５および各ハンド６，７へ送出する動作指令データＰ１，Ｐ２，…，Ｐｎは前記各パラメータの関数として定義できる。なお、各部品１を掴む位置はＣＣＤカメラ１１ａ，１１ｂにてその位置が自動的に把握されるので、上記関数に含まれない場合が多い。そして、標準作業関数メモリ２３は、上記各関数を記憶する。

そして、作業計画部１３ａは第５図の流れ図を実行する。すなわち、構造データメモリ２１から各部品１の位置座標（Ｘ，Ｙ，Ｚ）と姿勢角（α，β，γ）とからなる配置情報を読出して，該当部品を最終位置へ移動させるための各単位作業を作成する。そして、単位作業メモリ２２の各領域へ順次格納する。

構造データメモリ２１に記憶された全部の部品１に対する単位作業が単位作業メモリ２２へ格納されると、Ｐ１以降において，各単位作業の順序付処理を行なう。すなわち，最終製品を組立てる場合は、下方に位置する部品１を先に位置させ，その後、上方に位置する部品１を下方位置の部品１上に載置する必要がある。具体的には、構造データメモリ２１内の各部品１の配置情報の各座標（Ｘ軸）座標位置を比較して、各部品１の上下関係を決定し、下位置の部品１に対する単位作業の作業順序を上位置の部品１に対する単位作業の作業順序より先に設定する。流れ図上の処理としては，単位作業メモリ２２の各番地の単位作業を比較して最優先の単位作業を順序１と決定して、該当単位作業の順序領域に順序１を設定する。次に順序１の単位作業を除いた残りの各単位作業を比較して最優先の単位作業を順序２と決定して，該当単位作業の順序領域に順序２を設定する。このように単位作業メモリ２２の全部の単位作業に対する順序Ａを設定する。

作業計画部１３ａにおいて，単位作業メモリ２２に対する各単位作業及び作業順序Ａの設定処理が終了すると、プログラム制御が動作計画部１３ｂへ移動し，第６図の流れ図で示す動作計画処理が実行される。流れ図が開始されると，先ず単位作業メモリ２２の読出しポインタを兼用する作業順序Ａを１に設定する。そして、Ｐ２にて単位作業メモリ２２の作業順序Ａの領域の単位作業を読出す。そして，Ｐ３にて作業標準関数メモリ

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２３に記憶されている各関数で表示された各動作指令データＰ１～Ｐｎを読出す。そして、先に読出された単位作業に含まれる座標（Ｘ，Ｙ，Ｚ）や姿勢角（α，β，γ）やその他のこの単位作業を実行するための各種データ値を用いて、各動作指令データＰ１～Ｐｎの実際の値を算出して、次の駆動制御モジュール１４へ送出する。

以上で一つの単位作業に対するロボット本体３のアーム４，５やハンド６，７を駆動制御するための動作指令データＰ１～Ｐｎへの展開処理が終了したので、作業順序Ａを１だけ増加する。Ｐ４にて増加後の作業順序Ａが単位作業メモリ２２に格納されている単位作業数Ｎを越えていないことを確認すると、Ｐ２へ戻り、次の作業順序Ａの単位作業に対する動作指令データへの展開処理を開始する。

Ｐ４にて単位作業メモリ２２に記憶された全部の単位作業に対する動作指令データへの展開処理が終了すると，プログラムの制御を駆動制御モジュール１４へ移動させる。

しかして、駆動制御モジュール１４は、作業計画立案モジュール１３から各動作指令データを受領すると、第７図の流れ図に従って、ロボット本体３に対する駆動制御処理を実行する。まず、作業計画立案モジュール１３から作業順序で単位作業毎にその単位作業に対応する動作指令データＰ１～Ｐｎおよび作業順序Ａが入力すると，入力された各動作指令データＰ１～Ｐｎおよび作業順序Ａを一旦動作指令データメモリへ格納する。Ｐ５にて全部の単位作業に対応する動作指令データの動作指令データメモリへの格納処理が終了すると、読出順序を指定する作業順序Ａを初期値１に設定する。そして，Ｐ６にて、作業順序Ａに対応する動作指令データＰ１～Ｐｎを動作指令データメモリから読出して、ロボット本体３へ送出する。

ロボット本体３は入力した動作指令データＰ１～Ｐｎに従って、コンベア２にて搬入された該当部品１を指定位置へ移動させる。

Ｐ７にてロボット本体３による一つの単位作業の完了を検出すると、作業順序Ａを１だけ増加する。Ｐ８にて増加後の作業順序Ａが単位作業数Ｎを越えていないことを確認すると、Ｐ６へ戻り、次の作業順序Ａの単位作業に対する動作指令データを読出してロボット本体３へ送出する。

Ｐ８にて作業順序Ａが最終順序Ｎを越えると、ロボット本体３による一つの最終製品の組立て作業は終了する。

このように構成された組立てロボットであれば、最終製品を構成する各部品１の形状データを予め部品形状メモリ１９内に設定しておき、最終製品と同一構成の見本製品１０を製作し、ロボット本体３に取付けられたＣＣＤカメラ１１ａ，１１ｂの視野内に配設された回転台に載置して１回転させる。そして、ＣＣＤカメラ１ａ，１１ｂにて複数方向から２次元画像を撮像させる。すると、構造抽出モジュール１２内で見本製品１０の構造が検出される。そして，作業計画立案モジュール１３で最終製品を組立てる場合の各単位作業および作業順序が決定される。そして、ロボット本体３の各アーム４，５や各ハンド６，７を実際に駆動させる動作指令データとて駆動制御モジュール１４を介してロボット本体３へ印加される。

したがって、各部品の形状データを予めキー入力するのみで、見本製品１０と同一構成の最終製品がこの組立てロボットによって自動的に組立てられることになる。このことは、一旦、３次元構造を解析したり作業順序を解析するプログラムを設定すれば、見本製品１０の組立て構造を変更するのみで、最終製品の組立て構造を任意に変更できる。

したがって，最終製品の組立て構造が変更する度にロボット本体３を駆動制御するためのプログラムを変更したり作り直す必要がないので、製造製品を簡単に変更できる。その結果，組立てロボットにおける製造製品の段替え作業が簡素化され、専任のプログラマーを必要とせず、不慣れな作業員でも間違えることなく簡単に段替え作業ができ、組立てロボット全体の稼動率を向上できる。また，段替えの度にプログラムチェックを行なう必要が

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ないので、安全性を大幅に向上できる。

なお、本発明は上述した実施例に限定されるものではない。例えば、実際に部品を移動させて最終製品を組立てるロボット本体３および駆動制御モジュール１４と、見本製品１０の構造を解析して各単位作業の計画立案を行なう構造検出モジュール１２および作業計画立案モジュール１３とを分離して、両者を個別に稼動させることにより、複数台の組立てロボットを設置する場合に、構造検出モジュール１２と作業計画立案モジュール１３の設置台数をロボット本体３と駆動制御モジュール１４の設置台数より少なくすることが可能である。すなわち、上記構造検出モジュール１２と作業計画立案モジュール１３は製品に変更が生じたときのみ必要となる。

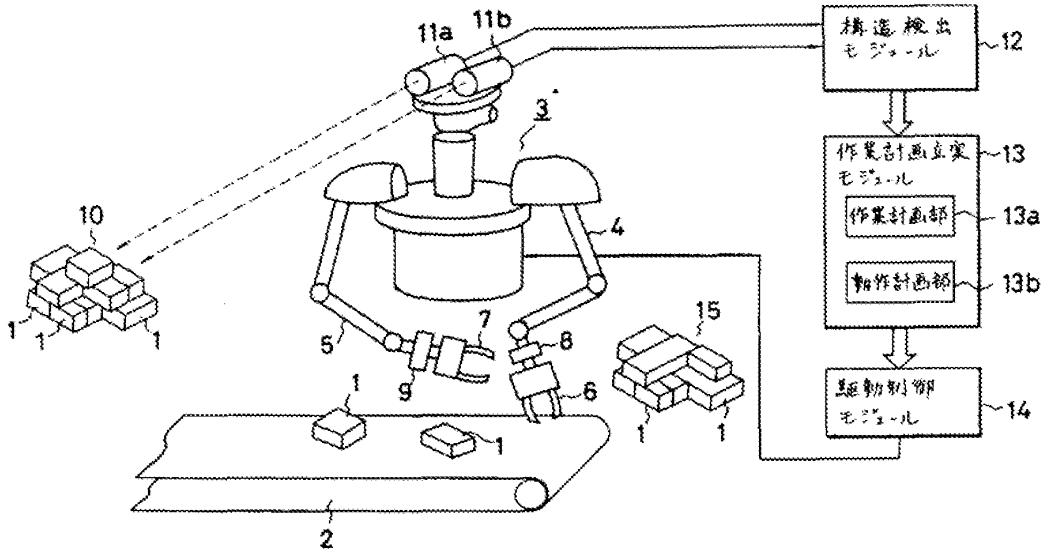
〔発明の効果〕

以上説明したように本発明によれば、見本製品の３次元構造を自動的に検出してそれに基づいて各部品の単位作業および作業順序を得るようにしている。したがって、たとえ最終製品（見本製品）の構造が変化したとしてもプログラム変更の必要がなく、簡単な操作でもって、かつ安全に製造製品の変更ができる。

４．図面の簡単な説明

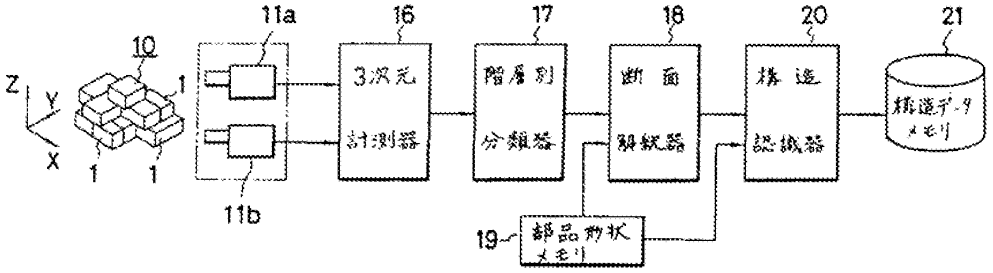
図は本発明の一実施例に係わる組立てロボットを示すものであり、第１図は全体の構成を示す模式図、第２図は構造検出モジュールを示すブロック図、第３図は構造データメモリの記憶内容を示す図、第４図は作業計画立案モジュールの記憶内容を示す図、第５図乃至第７図は動作を示す説明図である。

１…部品、２…コンベア、３…ロボット本体、４，５…アーム、６，７…ハンド、１０…見本製品、１１ａ，１１ｂ…ＣＣＤカメラ、１２…構造検出モジュール、１３…作業計画立案モジュール、１３ａ…作業計画部、１３ｂ…動作計画部、１４…駆動制御モジュール、１６…３次元計測部、１９…部品形状メモリ、２０…構造認識器、２１…構造データメモリ、２２…単位作業メモリ、２３…標準作業関数メモリ。

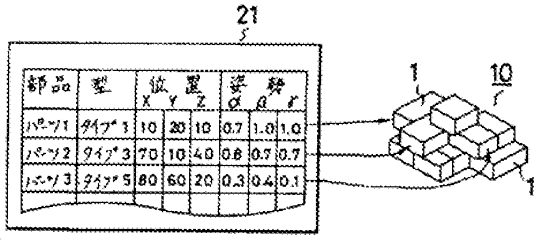


第１図

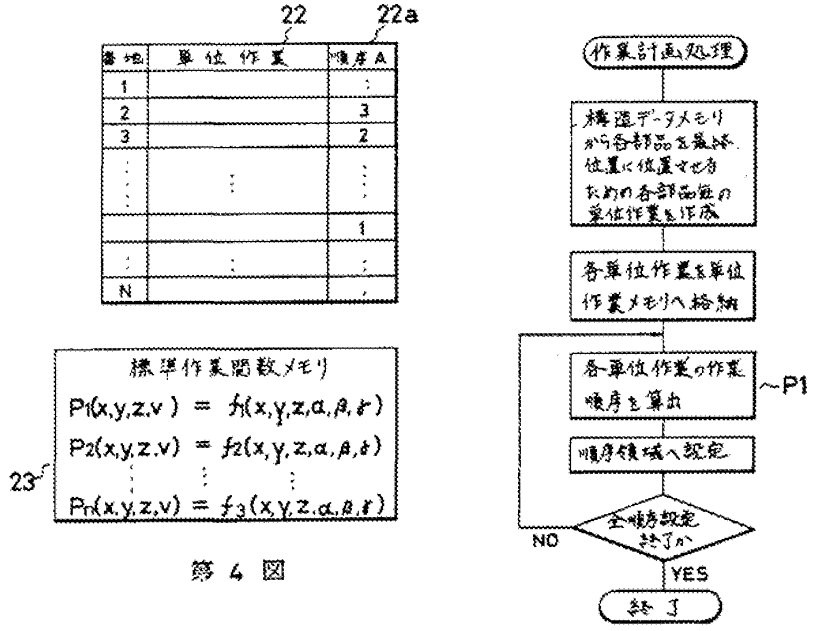
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第 2 図



第 3 図



第 4 図　　第 5 図

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第 6 図

第 7 図

特開昭63-288683 (8)

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	Babak Habibi et al.
Application No.	:	10/634,874
Filed	:	August 6, 2003
For	:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS

Examiner	:	McDieunel Marc
Art Unit	:	3664
Docket No.	:	170154.401C1
Date	:	November 25, 2009

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

INFORMATION DISCLOSURE STATEMENT TRANSMITTAL

Commissioner for Patents:

In accordance with 37 CFR 1.56 and 1.97 through 1.98, applicants wish to make known to the U.S. Patent and Trademark Office the references set forth on the attached Information Disclosure Statement. Copies of cited U.S. patents and published patent applications are not required and accordingly have not been provided. Copies of any other cited references are enclosed. As to any reference cited, applicants do not admit that it is "prior art" under 35 U.S.C. §§ 102 or 103, and specifically reserve the right to traverse or antedate any such reference, as by a showing under 37 CFR 1.131 or other method. Although the aforesaid references are made known to the Patent and Trademark Office in compliance with applicants' duty to disclose all information they are aware of which is believed relevant to the examination of the above-identified application, applicants believe that their invention is patentable.

Please acknowledge receipt of this Information Disclosure Statement and kindly make the cited references of record in the above-identified application.

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A fee of $180 is submitted in accordance with 37 CFR 1.97(c). The Director is authorized to charge any other fees which may be required, or credit any overpayment to Deposit Account No. 19-1090.

Respectfully submitted,

SEED Intellectual Property Law Group PLLC

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PATENT

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FEE DEFICIENCY AUTHORIZATION FORM

Commissioner for Patents:

Applicants hereby authorize the Director to charge any deficiencies in fees due by way of the enclosed papers only under 37 CFR 1.16 and 1.17 to Deposit Account No. 19-1090.

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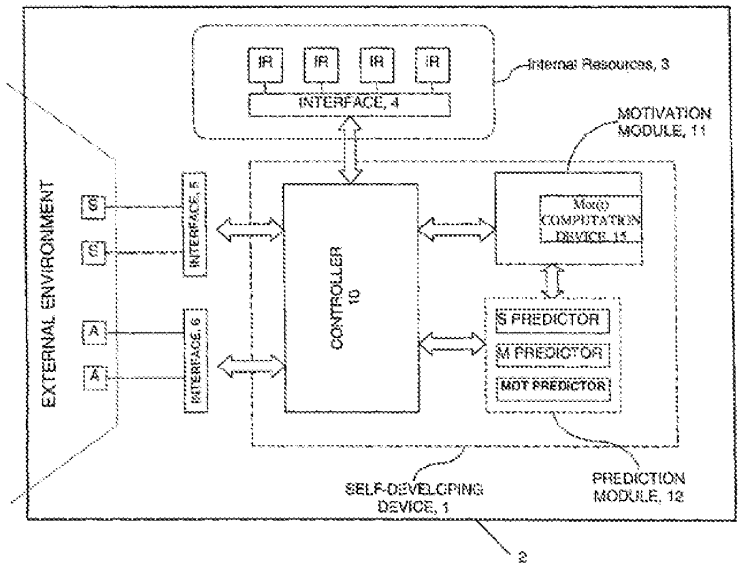
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(54) An architecture for self-developing devices

(57) A self-developing device (1) capable of open-ended development makes use of a special motivational system for selecting which action should be taken on the environment by an associated sensory-motor apparatus (2). For a given candidate action, a motivational module (11) calculates a reward associated with the corresponding values that would be taken by one or more motivational variables that are independent of the nature of the associated sensory-motor apparatus. Preferred motivational variables are dependent on the developmental history of the device (1), and include variables quantifying the predictability, familiarity and stability of sensory-motor variables serving as the inputs to the device (1). The sensory-motor variables represent the status of the external environment and/or the internal resources (3) of the sensory-motor apparatus (2) whose behaviour is controlled by the self-developing device (1). Open-ended development is enabled by attributing a reward which is proportional to the rate of change of the history-dependent motivational variables.

FIG.2



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Description

[0001] The present invention relates to an architecture for self-developing devices. More particularly, the invention relates to self-developing devices adapted so as to be capable of continuously developing new know-how (this is sometimes referred to as the capacity to engage in "lifelong learning").

[0002] The present invention typically finds application in sensory-motor devices such as robotic devices.

[0003] It is to be understood that, in the present document, when the expression "sensory-motor" is used the word "motor" does not necessarily entail physical motion. The word "motor" is used, in opposition to the word "sensory", so as to designate the effect a device or agent has on its environment rather than the perception that agent has of its environment. For a robotic device the term "motor" may indeed designate physical actions performed by the device, e.g. changing the attitude of its head, changing the angle of a joint, etc.. However, for an autonomous agent implemented in software, the term "motor" can designate signals which the agent causes to be output so as to affect its environment.

[0004] The aim of developmental robotics is to build devices capable of lifelong learning. One of the challenges for research in this area is to find design principles for robots so that they are capable of extending their sensory-motor competences. These robots usually start with crude capabilities for perception and action, and try to bootstrap new know-how based on their "experience". Several researchers have investigated how some particular competence can emerge using a bottom-up mechanism - see, for example, "Learning and communication in imitation: an autonomous robot perspective" by P. Andry et al, IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans, 31(5):431-444, Sept. 2001; "Better vision through manipulation" by G. Metta and P. Fitzpatrick, from "Proceedings of the second international workshop on epigenetics robotics: modeling cognitive development in robotic systems", p.97-104, ed. C. Prince et al, 2002 ; "A developmental approach accelerates learning of joint attention" by Y. Nagai et al, Proceedings of the second international conference of development and learning, 2002; and "Articulations of sensory-motor experiences by forwarding forward model" by J. Tani in "From animals to animats 7", pub. MIT Press, Cambridge Ma., USA, 2002.

[0005] Different types of systems can be envisaged for motivating the boost-strapping of know-how. Conventionally, motivational systems are task-dependent. One possible approach consists in defining a reward function adapted to the behavior that the robot has to develop. When the agent performs the desired task it receives feedback (a reward), typically from the environment or from an external user. Several state-of-the art techniques in machine learning show how a robot can learn to behave in order to maximize such a reward function - see, for example, "Reinforcement learning: A survey" by L. P. Kaelbling et al, Journal of Artificial Intelligence Research, 4, 1996.

[0006] Fig. 1(a) illustrates in schematic form the architecture of a conventional behaviour-based agent adapted to behave so as to maximize a reward function. As shown in Fig. 1(a), the architecture of the conventional agent can be represented in terms of the interaction of three processes: a "situation awareness" process, a "motivation" process, and a "actuation" process.

[0007] The "situation awareness" process corresponds to the components and functions within the agent which serve to determine or characterize what is currently happening, and serve to "understand" it or put it into context. This process determines what is happening by looking at what is the status of the external environment (perceived via the agent's sensors), what is the status of the internal environment (that is, the agent's internal systems and/or resources), and what is the current behaviour being exhibited by the agent (for example, what are the positions of the agent's limbs, the attitude of its head, etc.).

[0008] The "situation awareness" process will generally have a knowledge base or model against which it can compare the current situation. This enables the agent to "understand" the current situation and/or to put it into context. For example, the agent may be able to decide whether the current situation has happened before and, if so, with what frequency, or to attribute a label to the current situation (e.g. "I am under a tree"). This process may be able to anticipate, based on past experience, what will happen in the near future, both at the sensory and motor level. In a general manner, the "situation awareness" process is aware of the sensory-motor trajectory that the agent is experiencing. According to some proposals, the agent's knowledge base or model can be dynamically updated depending upon the agent's experience.

[0009] The "actuation process" corresponds to the components and functions within the agent which decide which action the agent should perform next, and then implement that action. In general, the "actuation" process will decide, based on data from the "situation awareness" process and the "motivation" process, which action should be performed in order to obtain the greatest reward.

[0010] The "motivation" process evaluates the desirability of a given sensory-motor situation. A situation is desirable if it results in significant rewards. Conventionally, the "motivation" process evaluates the desirability of a situation that may be created as a result of action performed by the agent. Thus, the output from the "motivation" process plays a role in the selection of action to be performed by the agent.

[0011] In some known systems, several internal "motivational variables" are defined and are associated with reward functions. The agent adopts a behaviour which maximizes the "reward" as evaluated according to the reward functions.

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Typically, motivational variables are calculated from the values of internal and external variables which represent, respectively, the status of the agent's internal systems and the status of the agent's sensor inputs.

[0012] Conventionally, both the motivational variables and the associated reward functions are specific to the task the robot has to learn. It means that for each new behavior to be developed, the designer has to define new motivational variables and reward functions. For example, if it important for an agent to maintain a particular level of hydration then it would have a sensor detecting the current level of hydration (the output of which constitutes a sensory-motor variable "level of hydration") and an associated motivational variable representing a motivation such as "thirst". When the "level of hydration" variable reaches a value at or near the low end of the permitted range then the associated motivational variable "thirst" will take a large value. This motivational variable is specific to the task of maintaining correct hydration and cannot readily be reused for any other purpose.

[0013] Moreover, the aim of reward functions is usually to ensure that the agent adopts behaviour which will keep input sensory-motor variables within a predefined range. For example, the sensory-motor variable "level of hydration" may need to be kept within a specified range to ensure correct operation of the agent. Accordingly the reward function will be designed such that there will be a large reward associated with action which minimizes the value of the motivational variable "thirst".

[0014] The preferred embodiments of the present invention provide a new kind of system, which can be termed "a self-developing device", that can develop new competences from scratch, driven only by internal motivations. The motivational principles used by the device are independent of any particular task. As a consequence, they can constitute the basis for a general approach to development of sensory-motor competences.

[0015] The preferred embodiments of the invention make use of a motivational system in which internal motivational variables are history-dependent, that is, the value of the motivational variable depends upon the developmental history of the self-developing device (either upon the values taken by associated sensory-motor variables at different times, or upon the evolution of the internal parameters of a device or devices cooperating in the computation of the motivational variable).

[0016] The preferred embodiments of the invention also provide a new kind of device in which behaviour can be selected based on rewards which are proportional to the rate of change (i.e. the derivative) of the value of an internal motivational variable, not just minimizing or maximizing the motivational variable's value.

[0017] The present invention provides a self-developing device comprising:

input means for determining the value of a set of one or more sensory-motor variables representative of the status of the environment;

control means for outputting a set of one or more control signals adapted to control action of a sensory-motor apparatus with which the self-developing device is associated in use;

a motivation module for calculating a reward associated with a candidate value that can be taken by said set of control signals; and

selection means for deciding, based on reward values calculated for candidate control-signal values by the motivation module, which value should be taken by said set of control signals, the selection means controlling the control means to output the selected value;

wherein the motivation module is adapted to evaluate rewards by calculating a function of at least one motivational variable whose value is derived from said set of sensory-motor variables;

characterized in that the motivation module uses a computation device adapted to perform a history-dependent calculation to calculate the value of said at least one motivational variable, said history-dependent calculation being dependent upon at least one of:

a) one or more time-varying internal parameters of the computation device or of a device cooperating with the computation device in the computation of the at least one motivational variable, and,

b) values taken at different times by said at least one sensory-motor variable of said set.

[0018] Because the self-developing device of the present invention changes its behavior autonomously driven by motivational principles that are independent of a particular task, the same "engine" can be applied to a variety of sensory-motor development problems and the same device can engage in a process of life-long learning.

[0019] Moreover, the motivational variables applied by the motivation module are history-dependent variables, that is, the value of the motivational variable depends upon the evolution over time of an underlying sensory-motor variable or the evolution over time of the internal parameters of the device(s) involved in computing the motivational variable.

[0020] By making use of history-dependent motivational variables, the reward available to the self-developing device when selecting a particular behaviour changes over time as a result of the history of the device. Thus, the behaviour that is necessary in order to obtain a reward evolves dependent upon the development, or experience, of the self-

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developing device.

[0021] Preferably, the motivation module calculates a reward of increased value when there is a large change in a history-dependent motivational variable. This drives the self-developing device towards open-ended development, enabling it to extend its "awareness" of its environment as it develops new sensory-motor competences. The self-developing device discovers its environment (and any actuators associated with itself) through sensory-motor exploration. It is by causing action on its environment that the self-developing device recognizes situations. As this sensory-motor exploration continues in an open-ended manner, the "awareness" of the device keeps increasing.

[0022] The way in which the self-developing device develops depends on (a) the physical constraints of the sensory-motor apparatus with which it is associated and (b) the environment in which the device is placed. Two independent devices of this type will engage in developmental pathways that tend to be similar because of (a) but different because of (b). As each self-developing device follows a unique developmental path, it can be considered to be unique. In several applications, this uniqueness resulting from the history of the device is what makes it valuable.

[0023] Examples of preferred types of history-dependent motivational variable that can be used in the present invention are variables indicative of the predictability, familiarity and stability of sensory-motor variables that are input to the self-developing device.

[0024] According to the present invention, the motivation module will typically determine the reward associated with a candidate set of motor control signals based on a single reward function associated with a single type of history-dependent motivational variable (for example, a reward function which takes a high value when the predictability of the system increases). However, it is possible to take into account two or more reward functions, using a weighted sum to evaluate an overall reward associated with a candidate set of motor control signals.

[0025] In certain preferred embodiments of the invention, the self-developing device includes a prediction module which is capable of recurrently predicting a series of future values of the sensory-motor variables and motivational variables. The control means generates a group of different candidate sets of control signals, and the motivation module calculates an expected reward for each candidate set in the group, based on the series of rewards expected to be obtained when the motivational variables take the series of respective future values predicted by the prediction module for that candidate set. The candidate set which produces the greatest expected reward will be selected for output.

[0026] The self-developing device of the present invention is, in effect, a behaviour engine that decides which action should be taken by an autonomous agent with which the self-developing device is associated. In use, this behaviour engine will typically form part of the control portion of a device (such as a robotic device) which includes sensors for determining properties of the external environment and/or the status of the device's internal resources, and includes actuators and/or signal generators to implement the selected action.

[0027] According to this aspect of the invention, a robot (or other autonomous agent) can be obtained which is capable of open-ended learning.

[0028] The above and further objects, features and advantages of the present invention will become apparent from the following description of preferred embodiments thereof, given by way of example, and illustrated by the accompanying drawings, in which:

Fig.1 shows, in schematic form, how the architecture of a device can be represented in terms of the interaction of three processes, in which:

Fig.1A represents the architecture of a conventional behaviour-based agent, and

Fig. 1 B represents the architecture of a self-developing device according to the present invention;

Fig.2 is a block diagram showing in schematic form the main components of a sensory-motor apparatus equipped with a self-developing device according to a preferred embodiment of the present invention;

Fig.3 is a graph showing the evolution of the average of a motivational variable "Predictability", $\boldsymbol{P(t)}$, during a first experiment, by simulation, in which a reward function generates a reward for increases in the "Predictability" motivational variable, with regard to a first embodiment of the invention implementing a simple vision system;

Fig.4 is a graph showing the evolution of a "head pan position" variable, $\boldsymbol{h_{pan}}$, during the experiment of Fig.3;

Fig.5 is a graph showing the evolution of the average of a motivational variable "Familiarity", $\boldsymbol{F(t)}$, during a second experiment, by simulation, in which a reward function generates a reward for increases in the "Familiarity" motivational variable, with regard to the first embodiment of the invention;

Fig.6 is a graph showing the evolution of the "head pan position" variable, $\boldsymbol{h_{pan}}$, during the experiment of Fig.5;

Fig.7 is a graph showing the evolution of the average of a motivational variable "Stability of head pan position", $\boldsymbol{\sigma_{pan}(t)}$, and the evolution of the average of a motivational variable "Stability of head tilt position", $\boldsymbol{\sigma_{tilt}(t)}$, during a third experiment, performed by simulation, in which a reward function generates a reward for maximization of the stability of the head position, with regard to the first embodiment of the invention;

Fig.8 is a graph showing the evolution of the "head pan position" variable, $\boldsymbol{h_{pan}}$, during the experiment of Fig.7;

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Fig.9 is a graph showing the evolution of the average of a motivational variable "Stability of the light's relative position in the pan direction", $\sigma_{idpan}(t)$, and the evolution of the average of a motivational variable "Stability of the light's relative position in the tilt direction", $\sigma_{idtilt}(t)$, during a fourth experiment, performed by simulation, in which a reward function generates a reward for maximization of the stability of the light's relative position, with regard to the first embodiment of the invention;

Fig.10 is a graph showing the evolution of the "head pan position" variable, h_{pan}, during the experiment of Fig.9;

Fig.11 is a photograph of a robotic device whose behaviour can be controlled by making use of the motivational variables employed in the simulations of Figs. 3 to 10;

Fig.12 is a graph showing the evolution of six motivational variables within the device of Fig.11 during a further experiment;

Fig.13 is a graph showing the evolution of the head pan position of the device of Fig.11, and the position of a perceived light, in the experiment of Fig.12;

Fig.14 shows, at magnified scale, a detail of Fig.13;

Fig.15 shows the head pan-tilt trajectory of the device of Fig.11 during the experiment of Fig.12;

Fig.16 is a sequence of 6 images which illustrates the evolution of the behaviour of a retina according to a second embodiment of the present invention, during an experiment;

Fig.17 is a graph showing how a motivational variable "average predictability" evolves during the experiment of Fig.16;

Fig.18 is a combined graph/image illustrating the trajectory of the centre of the retina at the beginning of the experiment of Fig.16;

Fig.19 is a combined graph/image illustrating the trajectory of the centre of the retina at the end of the experiment of Fig.16;

Fig.20 is a graph showing the percentage of time steps during which the centre of the retina was located in the face region of an image, during the experiment of Fig.16;

Fig.21 is a diagram illustrating schematically a first-order coupling achieved as a self-developing device according to the invention gains knowledge of the environment;

Fig.22 is a diagram illustrating schematically a second-order coupling achieved as two self-developing devices according to the invention gain knowledge of the environment and of each other;

Fig.23 is a diagram illustrating schematically a third-order coupling achieved as two self-developing devices according to the invention acquire the ability to enter into complex interactions with each other; and

Fig.24 is a diagram schematically illustrating the way in which a self-developing device according to the present invention can progressively develop so as to establish first, second- and third-order couplings.

[0029] The general architecture of a self-developing device according to the present invention will now be described, and will be followed by detailed descriptions of certain examples illustrating how this architecture can be used for bootstrapping new sensory-motor know-how.

[0030] In the following detailed description it will be assumed that the self-developing device is embodied in a robotic apparatus of some kind, which acts in relation to the external environment via one or more actuators. However, it is to be understood that the self-developing device of the invention can also be embodied in software agents and the like which act on the environment in ways which do not involve physical motion.

[0031] Fig.2 illustrates the main components of a self-developing device 1 according to a preferred embodiment of the invention, which serves as a behaviour engine for a robotic apparatus 2. In other words, the behaviour of the robotic apparatus 2 is controlled by the self-developing device 1.

[0032] The self-developing device (SDD) 1 is a sensory-motor device which derives information about the environment internal to the robotic apparatus 2 (that is, data regarding the status of the robotic apparatus's internal resources 3), via an interface 4, and obtains information about the external environment from sensors, S, via an interface 5. The SDD 1 is also aware of the status of the current behaviour of the robotic apparatus 2 in the external environment, that is, it is aware of what is the status of various actuators A of the robotic apparatus 2. The SDD controls the actuators A and receives data from them via an interface 6.

[0033] The SDD 1 has three main components: a controller (or actuation centre) 10, a motivation module 11 and a prediction module 12. The motivation module 11 comprises a computation device 15 which computes the values of motivational variables. The computation module 15 may cooperate with other components, for example the prediction module 12, in order to calculate the value of one or more motivational variable. The prediction module preferably includes three prediction devices (Π_m, Π_s and Π_{mot}) which take the current sensory-motor situation as an input and try to predict respectively the future motor situation, the future sensory situation and the future state of the motivation vector.

[0034] The architecture and functioning of the SDD 1 will now be described in greater detail.

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Inputs and Outputs

[0035] At any given time t the SDD's perception of the environment (external and internal) can be summarized by a vector ***S(t)*** and its action on the environment can be summarized by a vector ***M(t)***. In a general manner, the components of the vector **S(t)** comprise the values of the signals derived from the internal and external sensors, the components of the vector ***M(t)*** are the values of variables describing the status of the actuators. In general ***M(t)*** will correspond to the control signals sent to the actuators at the time ***t***. The effect of the signal ***M(t)*** on the actuator may be delayed, depending upon how the actuator works. The sensory-motor vector ***SM(t)*** summarizes both kinds of information.

[0036] Incidentally, it is not mandatory for **S(t)** and ***M(t)*** to include data relating to every single one of the sensors and actuators which may be present in the sensory-motor device 2 with which the SDD 1 is associated.

[0037] The behavior of the SDD consists in determining what should be its current behaviour ***M(t)*** based on the current perceived (sensory) situation **S(t)** and on previous sensory-motor situations ***SM(t-1), SM(t-2),....*** Given the constraints provided by the environment, the SDD 1 develops in an unsupervised manner.

[0038] Once again, as explained above, the self-developing device may act upon the environment in a manner which does not require physical motion, for example, when the SDD is a software agent which acts on the environment by outputting signals of various kinds.

Overview of the architecture

[0039] In a similar way to a conventional behaviour-based agent, the architecture of a self-developing device according to the present invention can be schematized by the interaction of three processes, as illustrated schematically in Figure 1B. The three processes can be characterized as: a "motivation" process, a "prediction" process and an "actuation" process.

[0040] Once again, the "motivation" process is responsible for the evaluation of the desirability of a given sensory-motor situation. A set of one or more *motivational variables* ***Mot(t)*** is defined and associated with a set of *reward functions* ***R***. An important feature of the self-developing devices according to the present invention is the use of motivation variables which are independent of the nature of the sensory-motor apparatus whose behaviour is being controlled. These variables typically result from internal computations based on the behavior of the two other processes (Prediction and Actuation) - see below. The "motivation" process is conducted by the motivation module 11 represented in Fig.2.

[0041] The computation device 15 computes values for the motivational variables ***Mot(t)*** based on ***SM(t)***. Advantageously, computational device 15 is capable of making computations of three kinds:

a) computations in which the value of ***Mot(t)*** depends only on ***SM(t)***,
that is: ***Mot(t) = f(SM(t))***.
These will be traditional kinds of motivational variables.

b) computations that are "historic" in the sense that the value of Mot(t) depends upon ***SM(t), SM(t-1)***, etc.
that is: ***Mot(t) = f(SM(t),SM(t-1),SM(t-2),...)***
In other words the values of the motivational variables depend upon sensory-motor vector values at more than one time.

c) computations that are "historic" or "development-dependent" because the manner of computing ***Mot(t)*** based on ***SM(t)*** depends upon the history of the computation device and/or the history of one or more other deivces which cooperate with the computation device in the calculation of the motivational variables,
that is: ***Mot(t) = g(SM(t))***, where ***g*** changes over time as the computation device (and/or cooperating device) evolves.

In this case, it is necessary to have knowledge of parameters internal to the computation device 15 and cooperating devices in order to determine what is the appropriate function ***g*** to apply at a given time. The nature of these internal parameters depends upon the nature of the computation device and cooperating devices. If one of the devices cooperating in the computation comprise a neural network, then "type (c)" computations of ***Mot(t)*** may require knowledge of the current values of the weights of the neural network. If one of the devices cooperating in the computation is prototype-based, then "type (c)" computations of ***Mot(t)*** may require knowledge of the current set of prototypes, etc. The computation device 15 and devices, such as the prediction module 12, with which it may cooperate in the calculation of motivational variables are adaptive devices which means that the values of their internal parameters will change based on experience. Thus, the appropriate function ***g*** of ***(SM(t))*** will change over time.

[0042] The "prediction" process tries to predict the evolution of the sensory-motor trajectories, in other words what ***SM(t)*** will be given ***SM(t-1), SM(t-2)***, etc. The "prediction" process is implemented by the prediction module 12 of Fig. 2, which advantageously makes use of three prediction devices dedicated respectively to the prediction of ***M(t), S(t)***

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and ***Mot(t)***. All the "understanding" the device has of its environment, its "awareness", is embodied in the rules applied by these prediction devices.

[0043] Finally, the "actuation" process decides, based on the status of the two other processes, which action should be performed in order to obtain rewards. As illustrated in Fig.2, the "actuation" process is implemented by a controller 10, which can also be designated "actuation centre". According to the preferred embodiments of the present invention, this controller 10 implements four functions :

(a) generation of candidate motor commands,
(b) anticipation of the corresponding sensory-motor trajectories (using the Prediction process, i.e. prediction module 12), that is prediction of ***SM(t+1), SM(t+2),*** etc. from ***SM(t), SM(t-1), SM(t-2),*** etc., based on the expected consequences of implementing the candidate motor commands,
(c) evaluation of each simulated trajectory in terms of the corresponding expected rewards (using the "motivation" process) and, eventually,
(d) selection of the best (i.e. most rewarding) motor commands from amongst the candidates.

[0044] The motivation, prediction and actuation processes evolve based on the experiences of the SDD 1, as indicated by the arrows shown in the circles representing these processes in Fig. 1B. What the SDD is aware of, what it is motivated for and the way it acts on its environment change over time as the result of its developmental trajectory (this evolution is indicated by the arrows surrounding the three processes in Fig. 1B). The above three processes will now be considered in more detail.

Motivation

[0045] As indicated above, the motivation process is based on a set of one or more motivational variables mot_i. The present invention makes use of motivational variables that are independent of the particular sensory-motor device with which the SDD is being used. Being rather abstract, these motivational variables can be used to drive the behaviour and development of substantially any sensory-motor device. Moreover, these motivational variables are independent of the particular task being performed by the apparatus associated with the SDD.

[0046] In order to create the condition for an open-ended sensory-motor exploration, motivational variables have been chosen whose value depends on the developmental history of the device. This means that the way of receiving rewards for such motivations is constantly changing as the device develops. These motivational variables are calculated using the computation device 15 according to computations of types b) and c) described above. It can be advantageous for the computation device 15 to cooperate with other components of the SDD 1 in order to calculate the motivational variables.

Examples of the Preferred Motivational Variables According to the Invention

[0047] Below there are details of three kinds of motivational variables that have been used in embodiments of SDD 1 according to the present invention with good results: these are "Predictability", "Familiarity" and "Stability". However, it is to be understood that this list is not exhaustive - it is expected that other kinds of motivational variables could be used whose value depends on the developmental history of the SDD (either evolution of ***SM(t)*** or evolution of the internal parameters of the device(s) involved in the computation of the motivational variables).

[0048] Predictability: The "predictability" motivational variable seeks to quantify to what extent the SDD can predict the current sensory context **S(t)** based on the previous sensory-motor context **SM(t-1)**. As mentioned above, the SDD 1 is equipped with a prediction module 12 that tries to learn sensory-motor trajectories. If ***e(SM(t-1),S(t))*** is the current error for predicting ***S(t)*** by the S Predictor based on ***SM(t-1)***, one possible definition of the predictability ***P(t)*** is given by:

$$P(t) = 1 - e(SM(t-1),S(t)),$$

It will be seen that calculation of the motivational variable ***P(t)*** involves data from the prediction module 12 as well as computation by the computation device 15. The value of this motivational variable at a given time will thus depend upon the evolution of the internal parameters of both these components.

[0049] Familiarity: The "familiarity" motivational variable seeks to quantify to what extent the sensory-motor transition that leads to ***S(t)*** from ***SM(t-1)*** is a common pathway. The computation device 15 of the SDD 1 is equipped with a subsystem evaluating the frequency of this transition (that is, the number of times the sensory-motor transition ***SM(t-1)*** → ***S(t)*** has occurred during a recent time period ***(t-T)*** to ***t)***. If $f_{\tau}(SM(t-1),S(t))$ is the current frequency of the transition that leads to ***S(t)***, the familiarity motivational variable ***F(t)*** can be defined as :

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$$F(t) = f_T(SM(t-1),S(t))$$

[0050] Stability: The "stability" motivational variable seeks to quantify whether or not the current sensory variable s_i of $S(t)$ is far from its average value. The computation device 15 of the SDD 1 tracks the average value $\langle s_i \rangle_T$ for the recent period $[(t-T)$ to $t]$. So, for each sensory variable s_i one possible definition for the stability σ_i (t) is given by:

$$\sigma_i(t) = 1 - \sqrt{\{(s_i - \langle s_i \rangle_T)^2\}}$$

[0051] It will be understood that the "Predictability" motivational variable is calculated using computations of type (c) and the "Stability" motivational variable is computed using computations of type (b) described above. The "Familiarity" motivational variable can be calculated using computations that can be considered to be type (b) or type (c) depending upon whether the frequency of occurrence of a given transition is evaluated over the whole "lifetime" of operation of the device or over a shorter period, and on whether or not the length of this period is adaptive.

Reward functions

[0052] Each motivational variable **v** is associated with a *reward function* $r(v,t)$. It takes the general form:

$$r(v,t) = f_t(v(t), v(t-1), v(t-2), \ldots)$$

In other words, the value of the reward can depend upon one, two or a series of successive values of the motivational variable **v**.

[0053] In the preferred embodiments of the present invention four kinds of reward functions can be used, $r_{max}(v,t)$, $r_{min}(v,t)$, $r_{inc}(v,t)$ and $r_{dec}(v,t)$.

[0054] $r_{max}(v,t)$ (or $r_{min}(v,t)$): When using this reward function, the device is rewarded when it *maximizes* (or *minimizes*) the value **v** of the associated motivational variable. This is similar to the way in which motivational variables are generally treated (e.g homeostatic models in "Designing sociable robots" by C. Breazeal, Bradford book - M.I.T. Press, 2002).

$$r_{max}(v,t) = v(t).$$

From this definition of $r_{max}(v,t)$ it follows that the reward is maximized when the value of the motivational variable is maximized. (In the case where it is desired to minimize the value **v** of the motivational variable, one could use the definition $r_{max}(V,t) = 1-v(t)$.)

[0055] $r_{inc}(v,t)$ (or $r_{dec}(v,t)$): when using this reward function, the device tries to maximize *increases* (or, for $r_{dec}(v,t)$, to maximize decreases) in the value of the motivational variable instead of maximizing (or minimizing) the variable itself. In this case it can be considered that:

- when the SDD seeks to maximize increases in the "predictability" motivational variable it is seeking "learning" experiences, that is, experiences which increase its understanding of the environment,
- when the SDD seeks to maximize increases in the "familiarity" motivational variable it is seeking "discoveries", and
- when the SDD seeks to maximize increases in the "stability" motivational variable it is seeking strategies that lead to a better control of its environment.

As shall be seen, this reward function $r_{inc}(v,t)$ is important with regard to the dynamics of the system.

[0056] The reward function $r_{inc}(v,t)$ can be defined, as follows:

$$r_{inc}(v,t) = \begin{cases} (v(t) - v(t-1)) : & v(t) > v(t-1) \\ 0 \quad : & v(t-1) \geq v(t) \end{cases}$$

[0057] It follows from the above definition of the reward function $r_{inc}(v,t)$ that the greater the increase in the value of

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the motivational variable, the higher the reward generated by this reward function.

[0058] When the self-developing device explores a new behaviour based on $r_{inc}(v,t)$, initially there will be relatively large increases in history-dependent motivational variables, such as predictability $P(t)$, familiarity $F(t)$, and stability $\sigma(t)$. Thus, initially, the reward function $r_{inc}(v,t)$ will produce a large reward associated with the new behaviour. However, as the self-developing device becomes better acquainted with the "new" behaviour (which equates to gaining knowledge of its environment) the values of these motivational variables will change by smaller and smaller amounts. Thus, the reward function $r_{inc}(v,t)$ yields a smaller and smaller reward for adopting this behaviour. By using the reward function $r_{inc}(v,t)$ in association with history-dependent motivational variables, the self-developing device is driven to explore new behaviours and then, when they have been mastered, to move on to others.

[0059] The effects of $r_{inc}(v,t)$ and $r_{dec}(v,t)$ are not symmetrical. To some extent $r_{dec}(v,t)$ achieves a similar result to a reward function which seeks to minimize an associated motivational variable, whereas $r_{inc}(v,t)$ has a function which is very dissimilar from a reward function seeking to maximize an associated motivational variable. When associated with the preferred motivational variables $P(t)$, $F(t)$ and $\sigma(t)$, $r_{dec}(v,t)$ drives the system to behave in a manner which will lead to an increase in prediction error, into situations which are less and less familiar, and situations which are more and more unstable. When the self-developing device 1 is in a "safe" environment, use of $r_{dec}(v,t)$ with $P(t)$, $F(t)$ and $\sigma(t)$ can provide good learning strategies.

[0060] The properties of the four reward functions can be summarized, as follows:

$r_{max}(v,t)$ provides conservative strategies, causing the sensory-motor device to do what it already does best.
$r_{inc}(v,t)$ drives the system to explore unknown situations using known ones, in order to progress.
$r_{min}(v,t)$ and $r_{dec}(v,t)$ cause novelty-driven exploration directing the system to progress towards what it does not yet master ($r_{min}(v,t)$) or towards what seems to be the most difficult to master ($r_{dec}(v,t)$). These strategies do not involve undue risk if the sensory-motor device is in a safe environment.

Calculating an "Overall Reward"

[0061] As will be seen from the specific embodiments discussed below, in many applications it is sufficient for the self-developing device to evaluate the reward associated with a given behaviour (that is, associated with taking a candidate action *mi*) by using a single reward function based on a single motivational variable.

[0062] However, it is also possible to make use of two or more reward functions, for example based on respective different motivational variables (although it is also possible to use different reward functions based on a common motivational variable - e.g. the motivational system could seek to optimize $r_{max}(P(t))$ and $r_{inc}(P(t))$ thus arriving at a compromise between exploration and conservative strategies).

[0063] In a case where the motivational system uses two or more reward functions, when assessing the desirability of a given candidate behaviour, the controller 10 of the SDD 1 must consider the overall reward $RM(t)$ that would be obtained as a result of this behaviour, taking into account the reward functions associated with all the applicable motivational variables, $Mot(t)$. Preferably, a parameter α_i is assigned to each motivational variable mot_i. This parameter α_i enables a relative weight to be assigned to each motivational variable when determining the overall reward of vector $Mot(t)$.

$$R(M(t)) = \sum_{moti} \alpha_i \, . \, r\,(mot_i,t)$$

[0064] The weights α_i can be preset by the designer of the SDD 1. Alternatively, for greater autonomy/task-independence, the weights can be determined automatically by a weight-setting device (not shown) which is used in conjunction with the SDD 1. The automatic weight-setting device will typically implement known machine-learning techniques and select weights in order to maximize an independent "fitness function". The automatic weight-setting device could be implemented using a further SDD.

Prediction

[0065] The awareness of the device comes from its ability to predict sensory-motor trajectories. Recognizing a situation is recognizing a sensory-motor pathway. This standpoint follows the lines of current research that consider that perception emerges from motor actions. In this context see, for example, "La construction du reel chez l'enfant" by J. Piaget, pub. Delachaux & Niestle, Neuchatel & Paris, 1937; "The tree of knowledge: the biological roots of human understanding" by H. Maturana & F. Varela, pub. Shambhala, USA, 1992; "A sensory-motor account of vision and visual consciousness" by J. O'Regan and A. Noe, in Behavioural and Brain Sciences, 24(5),2001; and "Le sens du

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mouvement" by A. Berthoz, pub. Editions Odile Jacob, Paris, Frace, 1997.

[0066] This view, also known as active perception, is now shared by a growing number of robotic engineers (see, for example, "Active vision and feature selection in evolutionary behavioral systems" by D. Marocco and D. Floreano, in "From Animals to Animats 7" op. cit., and "Better vision through manipulation" by G. Metta and P.Fitzpatrick, op. cit.).

[0067] At a given time t, the self-developing device of the present invention experiences a particular sensory-motor context that can be summarized in a vector ***SM(t)***. As mentioned above, the preferred embodiments of the present invention use three prediction devices: Π_m, Π_s, Π_{mot}. The three devices take the current situation ***SM(t)*** as an input and try to predict, respectively, the future motor situation ***M(t+1)***, the future sensory situation ***S(t+1)*** and the future state of the motivation vector ***Mot(t+1)***.

[0068] At each time step, the three devices learn the correct prediction by comparing the current situation with the previous one.

$$\Pi_m\ (SM(t\text{-}1)) \rightarrow M(t)$$

$$\Pi_s\ (SM(t\text{-}1)) \rightarrow S(t)$$

$$\Pi_{mot}\ (SM(t\text{-}1)) \rightarrow Mot(t)$$

where $\rightarrow$ indicates a comparison, Π_m (SM(t-1)) is the prediction of M(t) made by prediction device Π_m based on (SM (t-1)), Π_s (SM(t-1)) is the prediction of S(t) made by prediction device Π_s based on (SM(t-1)), and Π_{mot} (SM(t-1)) is the prediction of Mot(t) made by prediction device Π_{mot} based on (SM(t-1)).

[0069] The landscape of the motivation that Π_{mot} must learn is dependent on the performance of the two other prediction devices. The motivational variable *P(t)* is determined by the error rate of Π_s, and the other motivational variables change according to the action selection process which in turn results from the prediction of Π_m and Π_s (see below). As a consequence, Π_{mot} must adapt continuously during the bootstrapping process.

[0070] The prediction devices can be implemented in different manners, for instance:

- using a recurrent Elman neural network with a hidden layer / context layer (see "Finding structure in time" by J.L. Elman from Cognitive Science, 14:179-211,1990). Because this network is recurrent it predicts its output based on the value of the sensory-motor vectors several time steps before ***t***.
- using a prototype-based prediction system that learns prototypic transitions and extrapolates the result for unknown regions. It takes the form of a set of vectors associating a static sensory-motor context ***SM(t-1)*** with the predicted vector ***(M(t),S(t)*** or ***Mot(t))***. New prototypes are regularly learned in order to cover most of the sensory-motor space. The prediction is made by combining the results of the ***k*** closest prototypes. This prediction system is faster and more adaptive than the Elman network, but may prove to be less efficient for complex sensory-motor trajectories.

The general architecture according to the preferred embodiments of the present invention can be used regardless of the kind of devices that are employed in the prediction module 12. Thus the prediction devices II can be implemented using a variety of state-of-the-art techniques other than those specifically mentioned above. However, it is desirable that the selected prediction devices have high performance in order to ensure efficient learning for the system as a whole.

Actuation

[0071] The actuation process performed by the controller 10 anticipates the possible evolutions of the sensory-motor trajectories and tries to choose the motor commands that should lead to the maximum reward. Several techniques taken from reinforcement learning literature can be used to solve these kind of problems - see, for example, "Reinforcement learning: A survey" by L. P. Kaelbling et al, op. cit. In the system according to the preferred embodiment of the present invention, the process can be separated into four phases:

Generation : The system constructs a set of candidate motor commands {*mi*}. For some applications this phase can be trivial, but more elaborate calculations will be required when dealing with complex actuators. As an example of a simple case: if the current value of an actuator control signal, m_0, is 0.7 then the controller 10 may randomly shift the current value so as to produce candidate values such as 0.55, 0.67, 0.8, 0.75, for m_0.

Anticipation : By using the prediction devices in a recurrent manner the self-developing device 1 simulates the

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sensory-motor evolutionary path $\{SM_{mi}\}$ that can be expected to arise for a given candidate set of motor commands, over T time steps. The system combines the result of both Π_m and Π_s to predict future sensory-motor situations and uses Π_{moi} to predict the evolution of the motivation vector ***Mot(t)***.

Evaluation : For each evolutionary path $\{SM_{mi}\}$ an expected reward R_{mi} is computed as the sum of all the future rewards expected to arise during the T time steps.

$$R_{mi}(t) = \sum_{j=t}^{t+T} R(Mot(j))$$

Prediction accuracy decreases if the value of T is too great. Typical acceptable values for T are in the range of 2 to 10.

Selection : The motor command $\{mi\}$ corresponding to the highest R_{mi} is chosen for output by the controller 10. in other words, the behaviour of the sensory-motor device 2 associated with the SDD 1 will be controlled according to the candidate command signals ***mi*** giving the greatest reward.

[0072] In order to evaluate to what extent the self-developing device of the present invention is capable of open-ended learning, the general architecture described above was implemented in two embodiments which are described below.

Embodiment 1 : A simple tracking system

[0073] This first embodiment was directed to a mechanism for bootstrapping competence in a simple visual tracking system. The system was intended to learn to track a moving light.

[0074] In the first months of their life, babies develop, almost from scratch, sensory-motor competences enabling them to localize lights sources, pay attention to movement and track moving objects (see "Understanding children's development" by P. Smith et al, pub. Blackwell, 1998). The embodiment presented here does not attempt to model precisely this developmental pathway but to illustrate how general motivational principles can drive the bootstrapping of corresponding competences.

[0075] The AIBO ERS-210, a four-legged robot produced by Sony Corporation, is equipped with a CCD camera and can turn its head in the pan and tilt directions (a third degree of liberty exists but is not exploited in this experiment) - see, "Development of an autonomous quadruped robot for robot entertainment" by M. Fujita et H. Kitano, in "Autonomous Robots",5:7-20,1998. In the present embodiment, the vision system of the AIBO ERS-210 was simplified to an extreme point and a self-developing device according to the invention was implemented in software in order to process sensory data provided by this vision system and to direct motor control of the pointing of the vision system.

[0076] The robot extracts from each image it analyses the point of maximum intensity. The visual system perceives only the coordinates of this maximum (i_{dpan}, i_{dtilt}) expressed relative to the image center. The robot also perceives the position of its head in a pan-tilt coordinate system (h_{pan}, h_{tilt}). At each time step its perception can be summarized by a vector ***S(t)*** having four dimensions.

$$S(t) = \begin{vmatrix} idpan(t) \\ idtilt(t) \\ hpan(t) \\ htilt(t) \end{vmatrix}$$

[0077] The robot moves its head according to motor commands (m_{dpan}, m_{dtilt}).

$$\text{i.e. } M(t) = \begin{vmatrix} mdpan(t) \\ mdtilit(t) \end{vmatrix}$$

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[0078] So, the sensory-motor vector ***SM(t)*** at each time step has 6 dimensions.

$$SM(t) = \begin{vmatrix} mdpan(t) \\ mdtilt(t) \\ idpan(t) \\ idtilt(t) \\ hpan(t) \\ htilt(t) \end{vmatrix}$$

[0079] Initially the SDD does not know anything about the sensory-motor device (here, a robot) with which it is associated. Can the robot equipped with the SDD develop a simple attention behavior in which it intentionally fixes its gaze on a certain number of things in its environment? To do this, it must discover the structure of several couplings in its sensory-motor device. It must discover, notably:

- How a relative command (m_{dpan}, m_{dtilt}) affects the next position (h_{pan}, h_{tilt}) of the head. (This sensory-motor coupling is constrained by the head limit positions resulting from the structure of the robot's body.)
- How a relative command (m_{dpan}, m_{dtilt}) affects the movement of the visual field, in particular the position of (i_{dpan}, i_{dtilt}). (This sensory-motor coupling is again constrained by the robot's body and also by the structure of what happens in the environment.)

[0080] In short, the robot must learn to perceive its environment by moving its head in the right manner.

[0081] A number of different motivational variables and associated reward functions could be defined, in accordance with the present invention, in an attempt to provide the robot with the ability to learn the desired tracking behaviour. For example, it could be contemplated to make use of reward functions based on any or all of the following motivational variables: the predictability variable ***P(t)***, the familiarity ***F(t)*** and four stability variables (one for each sensory-motor variable). This yields a possible motivational vector ***Mot(t)*** having 6 dimensions:

$$Mot(t) = \begin{vmatrix} P(t) \\ F(t) \\ \sigma idpan(t) \\ \sigma idtilt(t) \\ \sigma hpan(t) \\ \sigma htilt(t) \end{vmatrix}$$

Simulated environment

[0082] In order better to understand the role of each internal motivation in determining the development of the robot's behaviour a series of experiments was conducted in a simple simulated environment. The presence of a light performing a sinusoidal movement in the environment was simulated, according to the following relationships:

$$light_{pan}(t) = K * \sin(\rho(t))$$

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$$light_{tilt}(t) = L * \sin(p(t) + \beta)$$

$$p(t+1) = p(t) + \delta$$

where δ = a small increment, L = the magnitude of the oscillations in the tilt domain, K = the magnitude of the oscillations in the pan domain, and β = the phase difference between the oscillations in the pan and tilt domains. The oscillations in the tilt domain have a smaller amplitude than in the pan domain (i.e. ***L < K***).

[0083] The robot perceives the relative position of the light compared to its own position.

$$i_{dpan}(t) = light_{pan}(t) - h_{pan}(t)$$

$$i_{dtilt}(t) = light_{tilt}(t) - h_{tilt}(t)$$

[0084] At each time step, the SDD associated with the robot decides the most appropriate action $\{m_{dpan}, m_{dtilt}\}$ to perform. The effect of this action is simulated using the following simple rules :

$$g_{pan}(t+1) = m_{dpan}(t) + h_{pan}(t)$$

$$g_{tilt}(t+1) = m_{dtilt}(t) + h_{tilt}(t)$$

[0085] The constraints on the robot's body are simulated by imposing limits on the possible positions for the head: max_{pan}, min_{pan}, max_{tilt}, min_{tilt}.

$$h_{pan}(t+1) = \begin{cases} max_{pan} & : \quad g_{pan}(t+1) > max_{pan} \\ min_{pan} & : \quad g_{pan}(t+1) < min_{pan} \\ g_{pan}(t+1) & : \quad \text{otherwise} \end{cases}$$

[0086] A similar equation is defined for $h_{tilt}(t+1)$.

Increase in predictability

[0087] In a first experiment, the robot was driven using a reward function based only on its "predictability" motivational variable. More particularly, the self-developing device driving the robot's behaviour made use of a reward function which rewards increases in the predictability level ***P(t)***, the magnitude of the reward being proportional to the size of the increase in ***P(t)***. In effect, this means that the robot seeks for "learning" situations. As it learns, sensory-motor trajectories that used to give rewards tend to be less interesting. These dynamics push the robot towards an open-ended dynamic of exploration.

[0088] Figure 3 shows the evolution of the average predictability level ***P(t)*** during this experiment. It quickly reaches a high value. This shows that the robot (or, more precisely its SDD) has learned the overall effect of movement on the light's position and on the position of its own head. As the robot tries to experience *increases* in predictability and not simply to maximize it, small oscillations can be seen near the maximum value. They correspond to new sensory-motor trajectories that the robot explores.

[0089] Figure 4 shows the evolution of h_{pan}, the pan position of the head, during 1000 time steps of the above-described experiment (the corresponding evolution of $light_{pan}$ is also indicated by the sinusoidal curve in Fig.4). A very similar curve can be plotted for the tilt dimension. The movement is rather complex as the robot gets away from predictable sensory-motor trajectories and tries to explore new ones. It is interesting to observe that the movement is not completely decorrelated from the movement of the light as the robot explores different perceptual effects of its motor commands. The evolution of the average h_{pan} position shows that the system progressively explores the amplitude of

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the possible pan positions by oscillating around the zero position.

Increase in familiarity

[0090] In a second experiment, the robot was driven using a reward function based only on its "familiarity" motivational variable. More particularly, the self-developing device driving the robot's behaviour made use of a reward function which rewards increases in the familiarity level $F(t)$, the magnitude of the reward being proportional to the size of the increase in familiarity. In a similar way as for predictability, unfamiliar situations tended to become familiar after a while and, as a consequence, less rewarding. These dynamics drive the robot into a continuous exploration behavior.

[0091] Figure 5 shows the evolution of the average familiarity level $F(t)$ during this experiment. The robot manages progressively to reach a very high level of familiarity. Similarly to the evolution seen during the previous experiment, we see oscillations due to the pressure of experiencing *increases* in familiarity. Each reduction of the familiarity level corresponds to the exploration of new parts of the sensory-motor space.

[0092] Figure 6 shows the evolution of the pan position of the head during 1000 time steps of the present experiment. The movement looks a bit like the one obtained in the first experiment, but some differences can be noticed. The average position curve shows the robot has first tended to explore positions corresponding to high pan values then progressively switched to low pan values. This switch, that seems to occur independently of the oscillation of the light, did not appear as clearly for the experiment on predictability. The familiarity motivation pushes the robot to explore trajectories in the sensory-motor space independently of how well it masters them. Employing reward functions using the familiarity and predictability motivations can be seen as two complementary ways for the SDD to get the sensory-motor device to explore different sensory-motor trajectories.

Maximization of sensory stability

[0093] A third set of experiments were conducted using reward functions based on the four motivational variables concerning the stability of each component of the sensory vector $S(t)$. They were all associated with the *maximize* reward function r_{max}.

Head stability

[0094] First of all the case was considered where the stability concerns the head position. This corresponds to the variables $\sigma_{hpan}(t)$ and $\sigma_{htilt}(t)$. The self-developing device driving the robot's behaviour employs a reward function which ensures that the robot seeks sensory-motor trajectories in which its head position, in pan and tilt, remains stable in time. Figure 7 shows the evolution of average stability during an experiment in which the robot uses this reward system. In this context the task is rather easy, the robot has simply to discover that it has to stop moving its head in order to obtain significant rewards. Stability is reached rapidly for both the pan and tilt direction.

[0095] The evolution of head pan position, h_{pan}, during this experiment is graphed in Fig.8. The evolution observed in Figure 8 shows that the head position stabilizes around its initial position after a short period of oscillation. (The evolution of $light_{pan}$ is also indicated via the sinusoidal wave shown in Fig.8).

Light stability

[0096] Next the case was considered where rewards were associated with maximizing the stability $(\sigma_{idpan}, \sigma_{idtilt})$ of the relative position of the perceived light. In this case the task is a bit more complex as the light is not directly controlled by the robot. The robot has to discover that it can act upon the relative position of the light by moving its head in the appropriate directions.

[0097] Figure 9 illustrates the evolution of the average stability of σ_{idpan} and σ_{idtilt} during an experiment using this reward system. The robot manages to control the stability of the light in the tilt domain faster than in the pan domain, probably because the movement has a smaller amplitude in the tilt domain $(L<K)$.

[0098] Figure 10 illustrates the evolution of the head pan position, h_{pan}, during the same experiment. After a short time for tuning, the robot develops a tracking behavior and follows the light quite precisely. As the robot seeks sensory stability, each movement of the light can be seen as a perturbation that it learns to compensate. The development of this visual know-how results directly from the effect of the environment on the sensory-motor device. (The evolution of $light_{pan}$ is also indicated via the sinusoidal wave shown in Fig.10).

[0099] With this series of experiments, we have a clearer idea of the effect of each reward system on the bootstrapping process. The two first motivations, increase in predictability and familiarity, push the robot to explore its sensory-motor device. The last four, maximization of sensory stability, lead the robot, on the one hand, to stop moving its head, and, on the other hand, to develop a tracking behavior.

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Experiment on the robot

[0100] A further experiment was conducted on an AIBO ERS-210 (shown in figure 11). The software components for this experiment were written in C++ using the publicly available OPEN-R SDK. The software ran on board the AIBO ERS-210, and the data generated during the experiment were directly written on a MemoryStick for later analysis.

[0101] At each time step the robot computes the point of maximum light intensity in its visual field. The relative position of this point provides the two inputs $i_{dpan}(t)$ and $i_{dtilt}(t)$. The robot measures its own head position $h_{pan}(t)$ and $h_{tilt}(t)$. Unlike the case during the simulation experiments discussed above, this measurement is not completely accurate. In the same way, due to different mechanical constraints, the relative movement resulting from the action $m_{dpan}(t)$ and $m_{dtilt}(t)$ can be rather noisy.

[0102] The reward system used could potentially have included all six of the motivational variables previously studied. As mentioned earlier, in a case where multiple reward functions are used, the relative weight of each variable in the computation of the overall reward is preferably determined by the set of parameters α_i.

[0103] For the present experiment, these weights α_i were set so that the robot developed the know-how for paying attention to the different light patches present in its environment. This means it should develop a tracking behavior but also an exploratory skill for not being stuck in front a given light.

[0104] As head stability is to some extent counterproductive for such a goal, it was decided that $\sigma_{hpan}(t)$ and $a_{htilt}(t)$ should not be used as motivational variables in this experiment. As a consequence, all the reward functions were associated with the same weight $\alpha_i = k$, except the two controlling the head stability (which received the value $\alpha_i = 0$).

[0105] The experiment lasted 10 minutes. The robot was placed in front of an uncontrolled office setting. Figure 12 shows the evolution of the six motivational variables during this experiment. As expected, the four motivational variables associated with the weight k, obtained high values. The relative position of the light rapidly reached a plateau, but predictability and familiarity kept increasing. The motivational variables for head stability oscillated at a lower level.

[0106] Figure 13 shows the evolution of head pan position during the experiment, as well as the position of the perceived light. The robot seems to track the light but, since the robot is motivated for exploration, its position oscillated around a local light maximum permitting the robot to find another local light maximum.

[0107] This behavior can be seen more clearly on Figure 14 which magnifies a detail from Figure 13. The head pan position increases so as to approach a local maximum, then oscillates around it for a while. At some point a larger oscillation makes the robot discover a higher local maximum. The robot switches back and forth several times between the two maxima and finally continues its exploration towards higher pan values. This kind of behavior is a typical result of the search to increase predictability and familiarity. The robot uses familiar and predictable contexts as bases for progressively continuing its exploration.

[0108] Figure 15 illustrates the overall pan-tilt trajectory for the duration of the present experiment. It appears that the robot has concentrated its exploration on the righthand part of the scene. It seemed to have highly explored one particular area and progressively searched for other maxima in its immediate neighborhood. This exploration yields a kind of "map" of the position of the local light maxima, as shown on Figure 15. This map can be used to characterize the place where the robot stands. This representation does not exist as such for the robot but is the result of the know-how it developed with its sensory-motor device. The robot is not capable of perceiving all these light positions at the same time, but it is confident (based on its acquired sensory-motor visual know-how) that they are there.

Embodiment 2: An self-developing active gaze system

[0109] This experiment shows how the same general architecture can be used to develop an active vision system, that is, a vision system which concentrates on the active parts of a scene (which, in general, will be more important). This system develops the capability of recognizing visual situations, through sensory-motor exploration. This embodiment is inspired by research in developmental psychology about attention and eye movements - see "Eye movements and vision" by A.L. Yarbus, pub. Plenum Press, New York, 1967; "Animate vision" by D. Ballard, from Artificial Intelligence, 48:57-86, 1991; and "Control of selective perception using Bayes nets and decision theory" by R.D. Rimey and C.M. Brown, from International Journal of Computer Vision, 12(2):173-207,1994.

[0110] The vision system described here shares some similarity with an active vision system described by Marocco and Floreano (see "An evolutionary active-vision system" by T. Kato and D. Floreano, Proc. Of the congress on evolutionary computation (CEC01), IEEE Press, 2001; and "Active vision and feature selection in evolutionary behavioral systems" by D. Marocco and D. Floreano, op. cit.). However, the latter uses an evolutionary robotics paradigm in order to evolve the desired behaviour: populations of robots are evolved and the best individuals are selected according to a predefined fitness function - see "Evolutionary Robotics: biology, intelligence and technology of self-organizing machines" by S. Nolfi and D. Floreano, pub. MIT Press, Cambridge, Ma., USA, 2000. By way of contrast, the system according to the present embodiment uses a developmental perspective to arrive at the desired behaviour.

[0111] In the present embodiment, a self-developing device was used to drive the behaviour of a system equipped

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with a square-shaped retina using an ***R x R*** matrix of perceptual cells. This retina is used to view an image. The position of the retina relative to the image can be changed, and the retina can zoom in and out. Based on the zooming factor, the retina averages the color of the image in order to produce a single value for each cell of the retina. With such a system, it is possible to rapidly scan the pattern present in the overall image and zoom in to perceive some details more accurately.

[0112] In the present embodiment, in order to become an active vision system the system has to learn how to "act" on the image by moving and zooming the retina in order to get a higher reward as defined by its reward system.

[0113] More precisely, for a given image snapshot *I(t)*, the sensory vector *S(t)* contains the renormalized grayscale value of the ***R x R*** pixels of the retina.

$$S(t) = \begin{vmatrix} Pix_{1,1}(t) \\ Pix_{2,1}(t) \\ \dots \\ Pix_{R,R}(t) \\ X(t) \\ Y(t) \\ Z(t) \end{vmatrix}$$

[0114] The motor vector ***M(t)*** contains the values for the three possible actions the retina can performed : changing the x and y values and the zooming factor.

$$M(t) = |Dx(t)\ Dy(t)\ Dz(t)|$$

[0115] As for the previous embodiment, the self-developing device does not have any prior knowledge about the sensory-motor device with which it is associated. It must discover the structure of several couplings in this sensory-motor device, notably it must learn to:

- understand the effects of ***Dx(t), Dy(t), Dz(t)*** on ***X(t+1), Y(t+1)*** and ***Z(t+1),*** This is a context-independent sensory-motor mastery, yet the constraints linking the 6 variables are rather complex, in particular due to the boundaries of the visual fields.
- understand the relationship between ***Dx(t), Dy(t), Dz(t)*** and the values of the pixels on the retina. This depends on the particular images the system is exploring, but the system must be capable of discovering sensory-motor trajectories that should be applicable in different contexts.

[0116] In this embodiment a reward function was used based only on the predictability motivational variable, ***P(t).*** It can be considered that there was a motivational vector of dimension 1 (corresponding only to the predictabily variable ***P(t))***

$$Mot(t) = |P(t)|$$

Experimental results : minimizing Predictability

[0117] In this experiment, the self-developing device used a reward function $r_{min}(v,t)$ which assigned a higher reward when the predictability variable ***P(t)*** decreased - in other words the device seeks to minimize the value of the predictability variable. This means that the device tries to explore sensory-motor pathways that it masters the least. As it explores these pathways ***P(t)*** increases, which leads the system to change again its behavior. A similar result could have been obtained using the reward function $r_{dec}(v,t)$.

[0118] This experiment made use of a sequence of 200 image frames of a person talking, recorded using a video

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camera. During this sequence of images, the person's head, mouth, eyes and hands moved. This sequence of 200 frames was used as a cyclic image input ***I(t)*** for the system. Figure 16 illustrates the behavior of the retina for a sequence of six images at given times in its development. The sequence of images in Fig.16 runs from top-left to bottom-right. Values of the retina cells are shown in Fig.16 using semitransparent greyscale levels.

[0119] As can be seen from Fig.16, the retina starts with a low zooming factor and progressively focuses on the upper part of head of the person. The square seen at the left upper part of the image reflects the value of ***P(t)*** (black low predictability, white high predictability).

[0120] The system was allowed to develop during 2000 time steps (10 cycles of the input video sequence). Figure 17 shows the evolution of the average predictability $< P(t) >$ during this period.

[0121] Despite the fact that the self-developing device seeks unpredictable situations (which explains why the curve regularly drops), the average predictability is increasing in the long run. This means that the system manages to be better at predicting the effects of the retina movements on the sequence of images.

[0122] Figures 18 and 19 illustrate two trajectories of the center of the retina, taken at the beginning of the development phase and the end of the experiment, repsectively. Both trajectories correspond to the same number of time steps but the first one is much more widely spread than the other. At the beginning of the experiment, the retina was scanning the whole image in a rather uniform manner. At the end of the experiment it seemed to concentrate on the moving parts (hands and heads) because they proved to be the most difficult to predict. The retina was not preprogrammed to pay attention to movements, but this functionality emerged driven by the system dynamics.

[0123] More precisely, Figure 20 shows the time the retina spent in the "face area" during this experiment. The "face area" was manually defined for each image of the person talking, and a note was made of the number of time steps in which the retina was in that zone. Figure 20 clearly shows that, after a first phase of exploration, the system focuses its attention on the face.

[0124] This second embodiment shows how a self-developing retina can autonomously develop the capability of focusing its attention on "interesting" aspects of its environment. The device is motivated by a general kind of "curiosity". Although in this experiment the system was illustrated using video images of a person talking, the system is not specialized for this kind of stimuli.

[0125] It will be seen from the above-described embodiments and experiments that the self-developing device architecture according to the present invention does indeed enable open-ended learning in different applications.

First order, second order and third order couplings

[0126] Using the architecture according to the present invention, a self-developing device can extend its "awareness" as it masters new sensory-motor know-how. This process can be viewed as the establishment of couplings of different kinds. Three kinds of couplings can be identified - first order coupling, second-order coupling and third-order coupling - although they all rely on similar bootstrapping mechanisms.

[0127] First order coupling concerns direct interaction with the stable aspects of the environment (see Fig. 21, in which the circular symbol represents an SDD and the spiral symbol represents the environment). By conducting sensory-motor experiments the device can develop attention mechanisms, a primitive idea of object, and contextual knowledge about its direct environment. Initially the device is immersed in a continuous flow of perceptual information and does not know how to act upon it in order to turn it into a structured world. The above-described experiments show how it can develop such a sensory-motor know-how.

[0128] Second-order couplings are couplings between self-developing devices and concern the development of coordinated interactions like joint attention or simple communicative behavior (see Fig.22). If two self-developing devices share the same environment their behavior will have an effect on one another : they will engage in coupled developmental pathways.

[0129] Third-order couplings concern the coordination of second-order couplings to form a higher form of interaction (see Fig.23). Examples of such couplings are complex dances, turn taking or linguistic behaviors. If two self-developing devices have developed a sufficiently good interactional know-how they can use this shared mastery to engage in more complex interaction which presupposes an initial repertoire of common interaction patterns.

[0130] The kind of self-developing devices described above can potentially establish all of these three kinds of couplings. Devices can be envisioned which will go through developmental pathways that would include the development of such complex competences, each new mastery building up on the previous ones. The progressive development of competences is illustrated schematically in Figure 24.

[0131] Self-developing devices according to the present invention provide a general solution to a large number of bootstrapping problems. The motivation system that drives the development of such devices is independent of the nature of the sensory-motor apparatus to be controlled. For this reason, the same developmental engine can be used to explore the behavior of substantially any sensory-motor device. These devices may find application not only in entertainment robotics but also in many other kind of devices, for example: computer games, new musical instruments,

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wearable computers/intelligent clothes, interactive houses, internet software agents.

[0132] The skilled person will readily appreciate, based on his common general knowledge and the contents of the references cited above, what physical components and software routines to use to implement the various devices and functions described above. Accordingly, further details are not given here. Moreover, it will be understood that the partitioning of functions between distinct devices as described above with reference to Fig. 1B and Fig.2 was made to simplify the discussion. Functions described as being performed by one specific device, for example, the controller 10, may in practice be performed by a different module, depending upon the implementation. Furthermore, the self-developing device can be implemented using modules which combine functions which are ascribed above to separate components. Finally, various of the functions may be partially or entirely implemented in software.

[0133] Although the present invention has been described above with reference to certain preferred embodiments thereof, it is to be understood that the invention is not limited by reference to the specific features of those preferred embodiments.

[0134] In particular, values for the "predictability", "familiarity" and "stability" variables can be calculated using different equations from those specified.

[0135] Furthermore, although the preferred embodiments make use only of motivational variables of the preferred kinds (which are independent of any particular sensory-motor apparatus, and historically-dependent), it is to be understood that the SDD of the invention could make use of a mix of motivational variables, some being motivational variables of the above preferred kind and others being more conventional, task-dependent motivational variables.

[0136] In a similar way, although the above-described preferred embodiments of the invention make use of four preferred types of reward function, it is to be understood that other kinds of reward functions can be used in addition.

Claims

1. A self-developing device comprising:

   input means for determining the value of a set of one or more sensory-motor variables ***(S(t))*** representative of the status of the environment;
   control means (10) for outputting a set of one or more control signals *(M(t))* adapted to control action of a sensory-motor apparatus with which the self-developing device is associated in use;
   a motivation module (11) for calculating a reward ***(R(v,t))*** associated with a candidate value that can be taken by said set of control signals ***(M(t));*** and
   selection means (10) for deciding, based on reward values calculated by the motivation module (11), which value should be taken by said set of control signals ***(M(t)),*** the selection means controlling the control means to output the selected value;

   wherein the motivation module (11) is adapted to evaluate rewards by calculating a function ***(R(v,t))*** of at least one motivational variable (v) whose value is derived from at least one of the sensory-motor variables of said set ***(SM(t));***
   characterized in that the motivation module (11) uses a computation device (15) adapted to perform a history-dependent calculation to calculate the value of said at least one motivational variable (v), said history-dependent calculation being dependent upon at least one of:

   a) one or more time-varying internal parameters of the computation device (15) or of a device cooperating with the computation device in the computation of the at least one motivational variable (v), and,
   b) values ***(SM(t),SM(t-1))*** taken at different times by said at least one sensory-motor variable of said set.

2. The self-developing device of claim 1, and comprising prediction means (12) for predicting the value of at least one sensory-motor variable **(S(t))** in said set at a first time ***(t)*** based on a value of said set of sensory-motor variables ***(SM(t-1))*** at an earlier time ***(t-1);***
   wherein the motivation module (11) is adapted to evaluate rewards by calculating a function ***R(v,t)*** of a predictability motivational variable ***(P(t))*** indicative of the accuracy of the prediction performed by the prediction means (12).

3. A self-developing device according to claim 2, wherein the value of the predictability motivational variable ***(P(t))*** at said first time ***(t)*** is calculated according to the following equation:

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$$P(t) = 1 - e(SM(t-1),S(t)),$$

where e(SM(t-1),S(t)) is the prediction error of the prediction means (12) when predicting the value of said at least one sensory-motor variable ***(S(t))*** in said set at said first time ***(t)*** based on a value of said set of sensory-motor variables ***(SM(t-1))*** at an earlier time ***(t-1)***.

4. A self-developing device according to claim 2 or 3, wherein the prediction means (12) comprises at least one device selected in the group comprising: a recurrent Elman neural network with a hidden layer, and a prototype-based prediction system.

5. The self-developing device of claim 1, and comprising frequency-checking means for determining the frequency of a transition from a first value of the set of sensory-motor variables ***(SM(t-1))*** to a second value of the set of sensory-motor variables ***(S(t))***;

wherein the motivation module (11) is adapted to evaluate rewards by calculating a function ***R(v,t)*** of a familiarity motivational variable ***(F(t))*** at said first time ***(t)***, the familiarity motivational variable ***(F(t))*** being indicative of the frequency, as determined by the frequency-checking means, of the transition to the value ***(S(t))*** of the set of sensory-motor variables at said first time ***(t)*** from the preceding value ***(SM(t-1))*** of the set of sensory-motor variables at said earlier time ***(t-1)***.

6. The self-developing device of claim 5, wherein the value of the familiarity motivational variable ***(F(t))*** at said first time ***(t)*** is calculated according to the following equation:

$$F(t) = f_T(SM(t-1),S(t)),$$

where $f_T(SM(t-1),S(t))$, is the number of times, during a time period of first length ***(T)*** preceding said first time ***(t)***, that the transition has occurred to the value ***(S(t))*** of the set of sensory-motor variables at said first time ***(t)*** from the preceding value ***(SM(t-1))*** of the set of sensory-motor variables.

7. The self-developing device of claim 1, and comprising averaging means for determining the average $(\langle s_i \rangle_T)$ of one of said sensory-motor variables (s_i) over an interval of said first length ***(T)***;

wherein the motivation module (11) is adapted to evaluate rewards by calculating a function ***R(v,t)*** of a stability motivational variable $(\sigma_i(t))$ indicative of how close is the value of said sensory-motor variable (s_i) at said first time (t) to the average $(\langle s_i \rangle_T)$ over a preceding interval of said first length ***(T)***.

8. The self-developing device of claim 7, wherein the value of the stability motivational variable $(\sigma_i(t))$ at said first time ***(t)*** is calculated according to the following equation:

$$\sigma_i(t) = 1 - \sqrt{\{(s_i(t) - \langle S_i \rangle_T)^2\}},$$

where $s_i(t)$ is the value of said sensory-motor variable at said first time ***(t)***.

9. The self-developing device of any one of claims 1 to 8, wherein the motivation module (11) is adapted to apply a reward function $(r_{max}(v,t))$ which generates a reward which maximizes the value of said at least one motivational variable ***(v)***.

10. The self-developing device of any one of claims 1 to 8, wherein the motivation module (11) is adapted to apply a reward function $(r_{min}(v,t))$ which generates a reward which minimizes the value of said at least one motivational variable ***(v)***.

11. The self-developing device of any one of claims 1 to 8, wherein the motivation module (11) is adapted to apply a reward function $(r_{inc}(v,t))$ which generates a reward which maximizes the increase in said at least one motivational variable ***(v)***.

12. The self-developing device of any one of claims 1 to 8, wherein the motivation module (11) is adapted to apply a reward function $(r_{dec}(v,t))$ which generates a reward which maximizes the decrease in said at least one motivational

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variable ***(v)***.

13. The self-developing device of any previous claim, wherein the motivation module (11) is adapted to apply two or more reward functions ***(r(mot$_i$)*** based on respective different motivational variables ***(mot$_i$)*** and to calculate, based on a weighted sum of said two or more reward functions, an overall reward ***(R(M(t))*** associated with a candidate value ***(mi)*** of said set of control signals ***(M(t))***.

14. The self-developing device of any previous claim, and comprising a prediction module (12) for predicting future values of the sensory-motor and motivational variables ***(SM(t), mot$_i$)***;

wherein, for each of a plurality of candidate values ***(mi)*** of said control signals ***(M(t))***, the prediction module (12) is adapted to predict, by recurrence, values of the sensory-motor and motivational variables ***(SM(t), mot$_i$)*** at a series of future instants; and

the motivation module (11) is adapted to calculate, for each of the plurality of candidate values ***(mi)***, a reward value ***(R_{mi}(t))*** which is the sum of a series of expected rewards corresponding to said predicted values of the motivational variables at said series of future instants.

15. A sensory-motor apparatus being an autonomous software or hardware agent (2) and comprising:

the self-developing device (1) of any previous claim, and

a set of one or more sensors ***(S, IR)*** adapted to sense the properties of the environment comprising the environment internal and external to the agent (2); and

means (A) for acting on the environment in accordance with the control signals ***(M(t))*** output by the control means (10) of the self-developing device (1);

wherein the set of one or more sensory-motor variables (***SM(t)***) includes variables corresponding to the output from said set of sensors (***S, IR***).

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FIG.1A

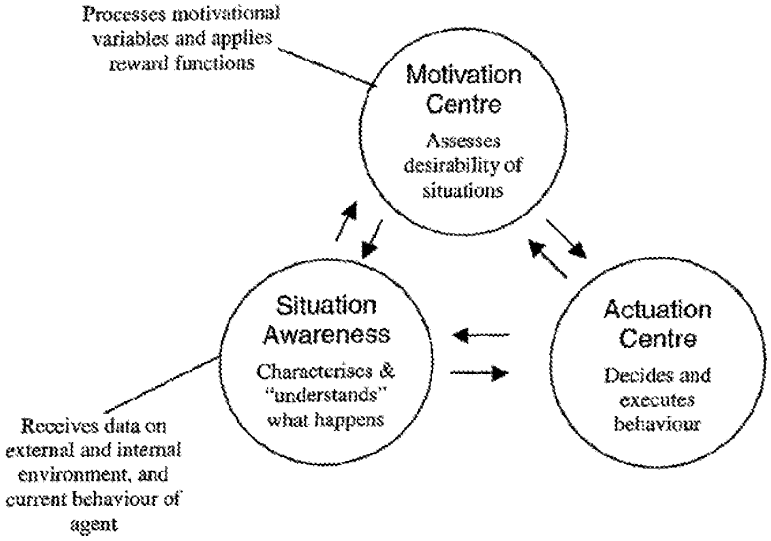


FIG.1B

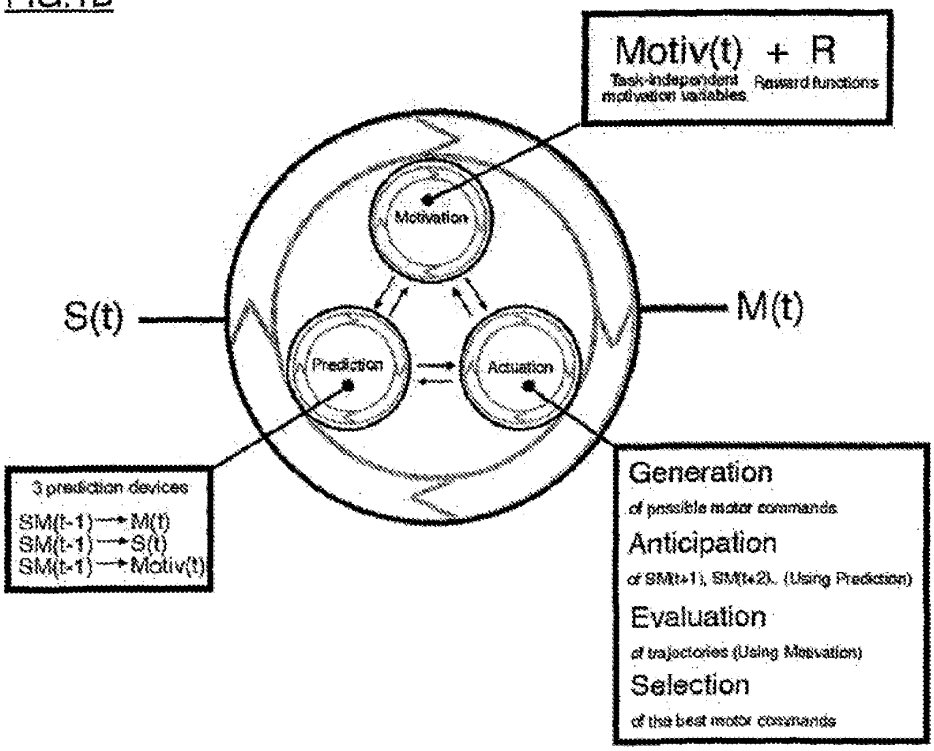


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FIG.2

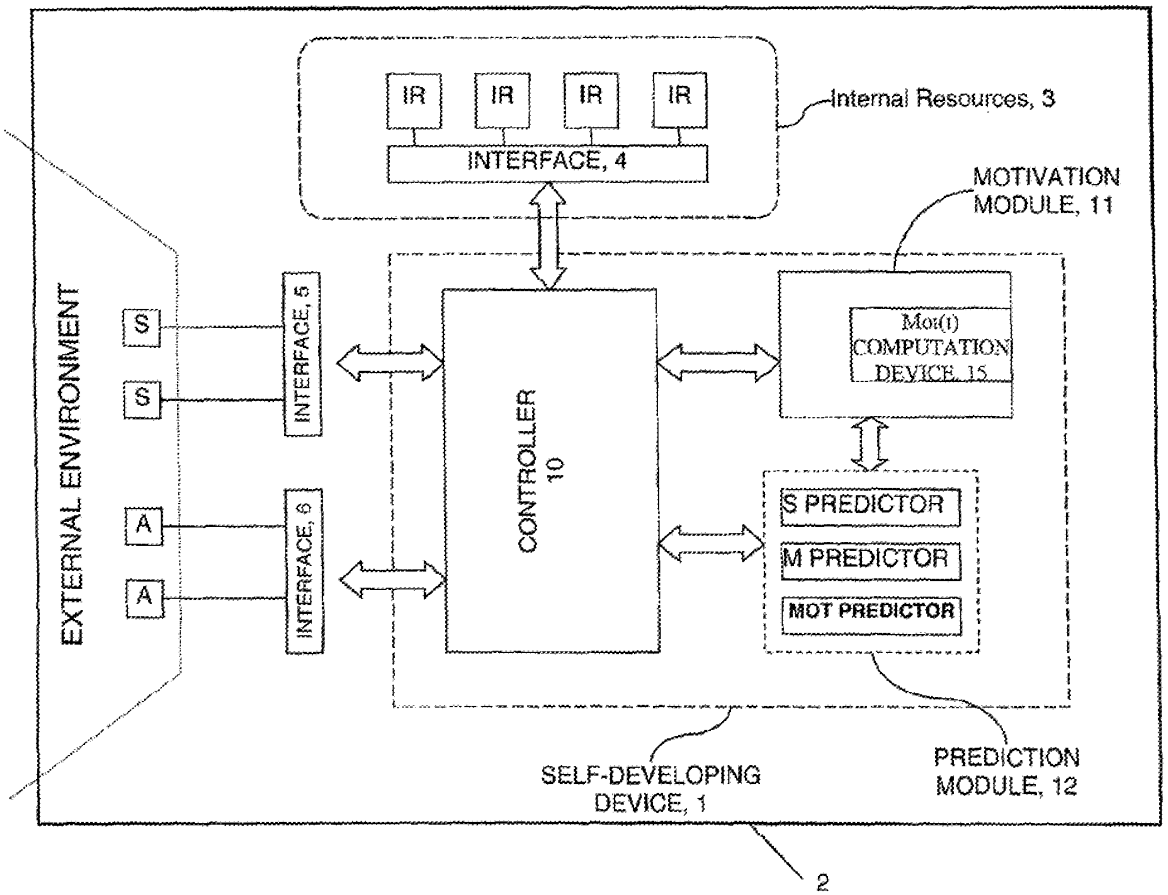


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FIG.3

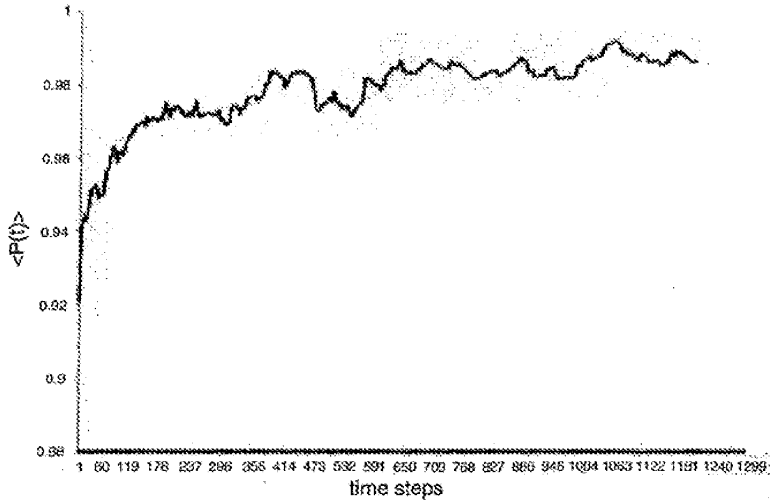


FIG.4

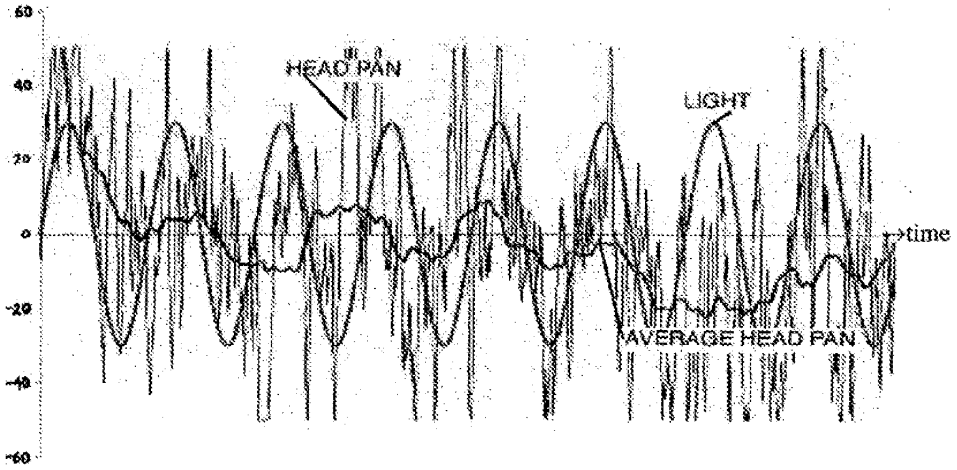


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FIG.5

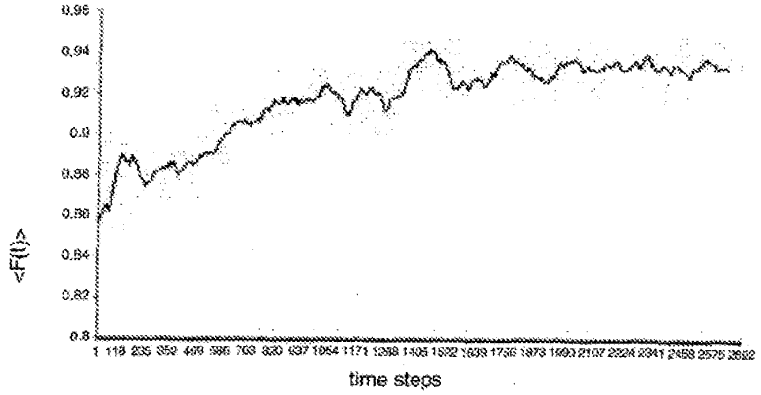


FIG.6

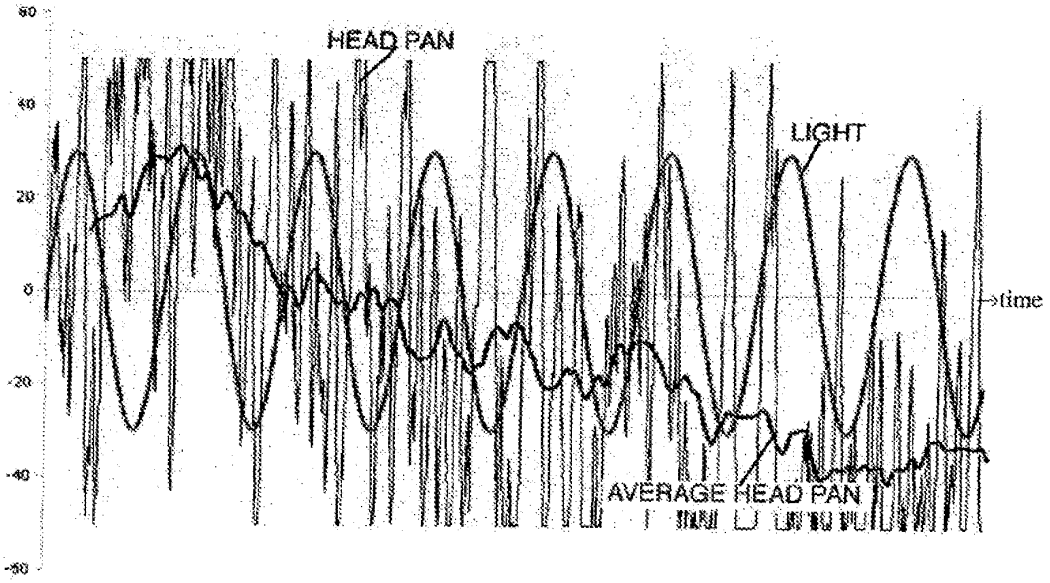


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FIG.7

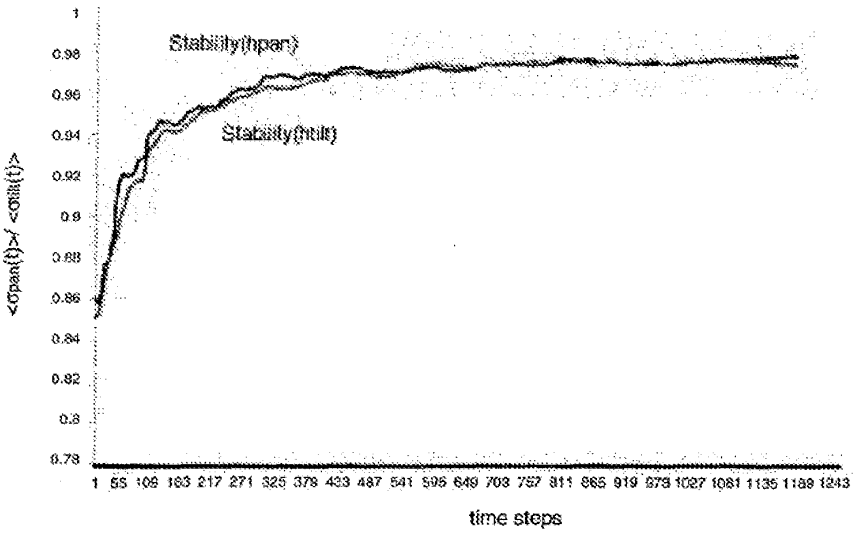


FIG.8

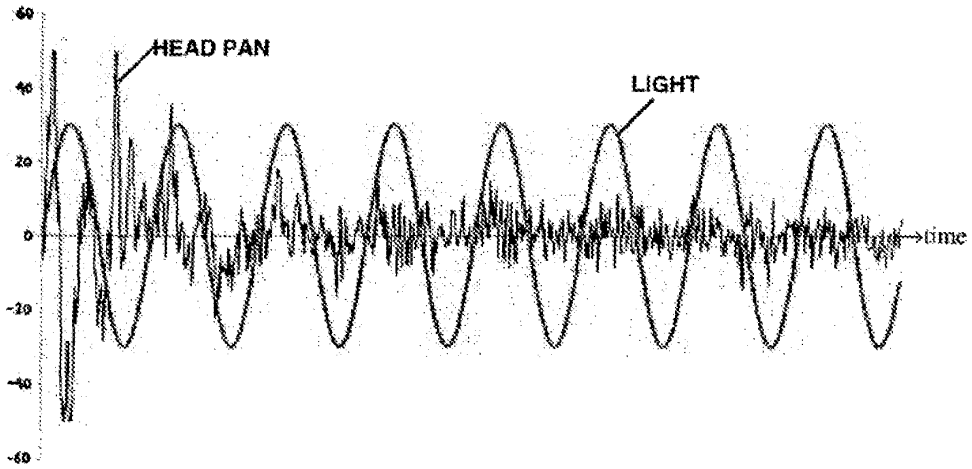


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FIG.9

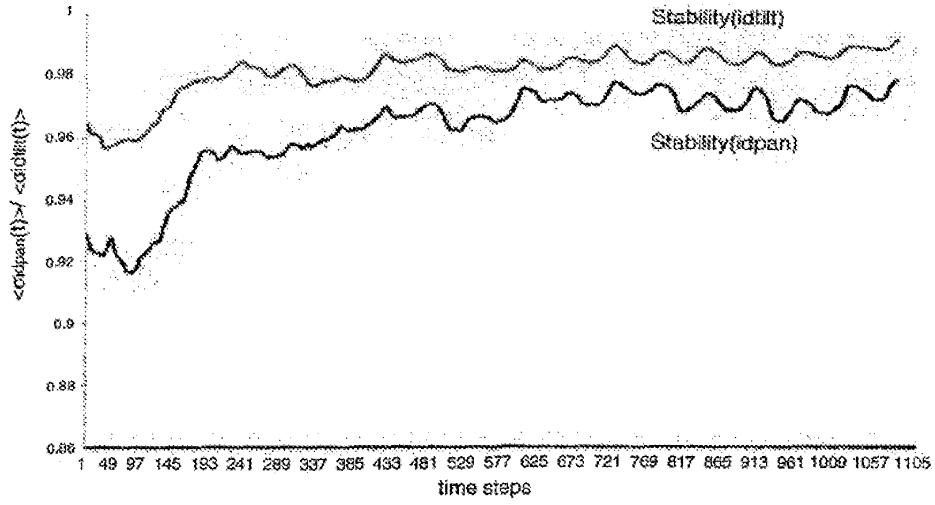


FIG.10

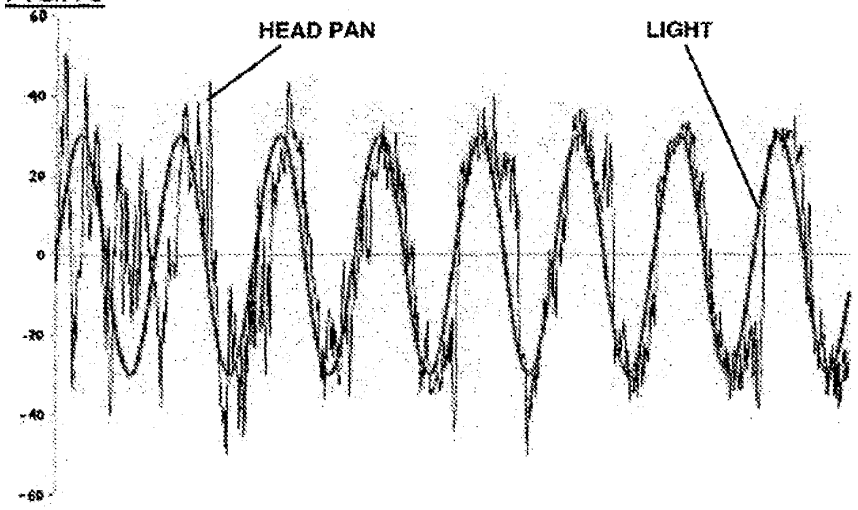


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FIG.11

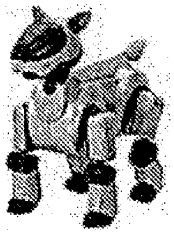


FIG.12

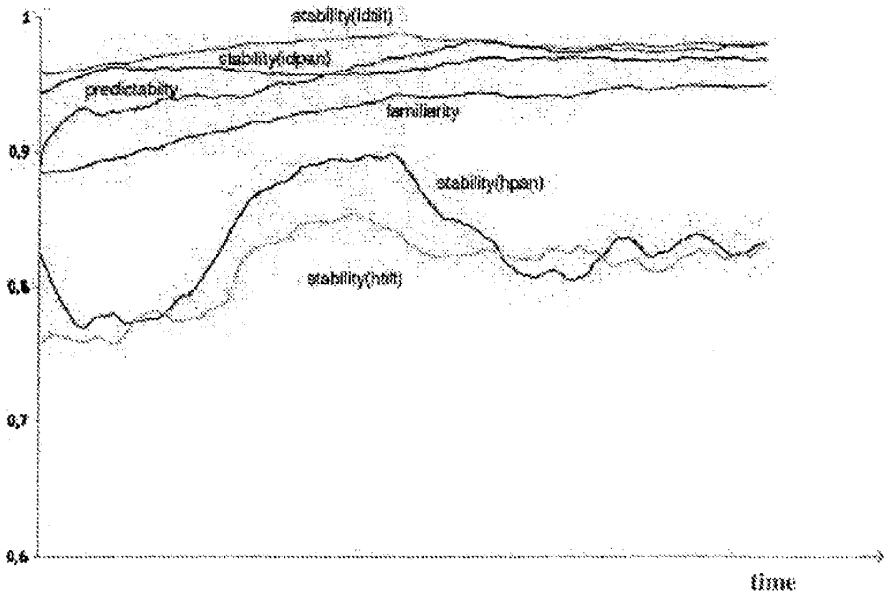


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FIG.13

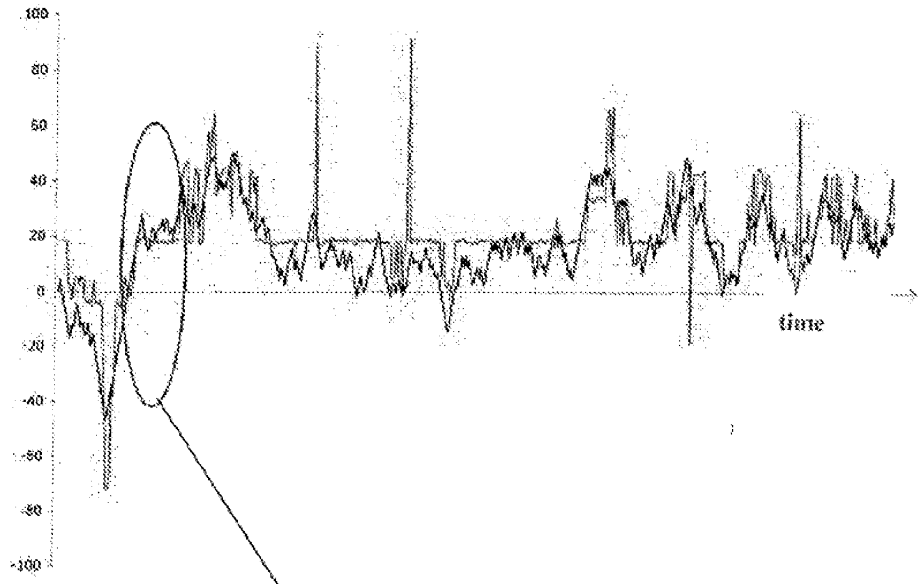


FIG.14

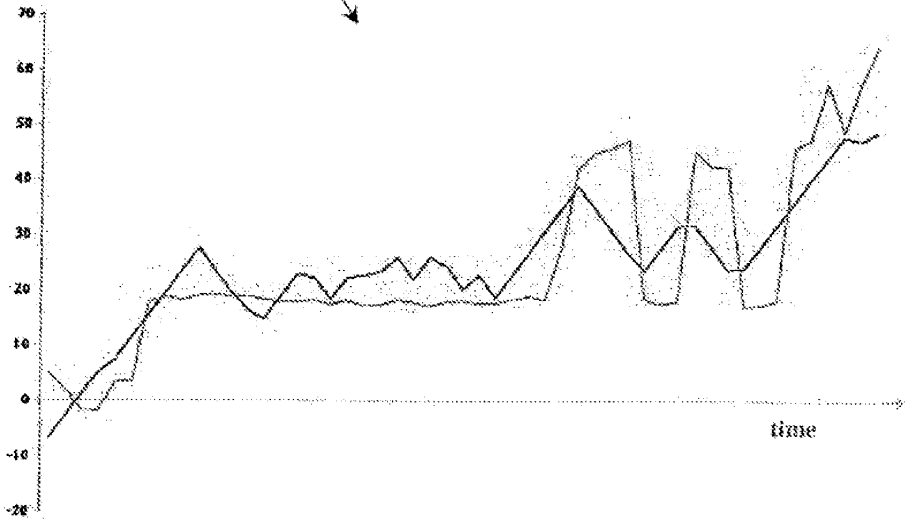


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FIG.15

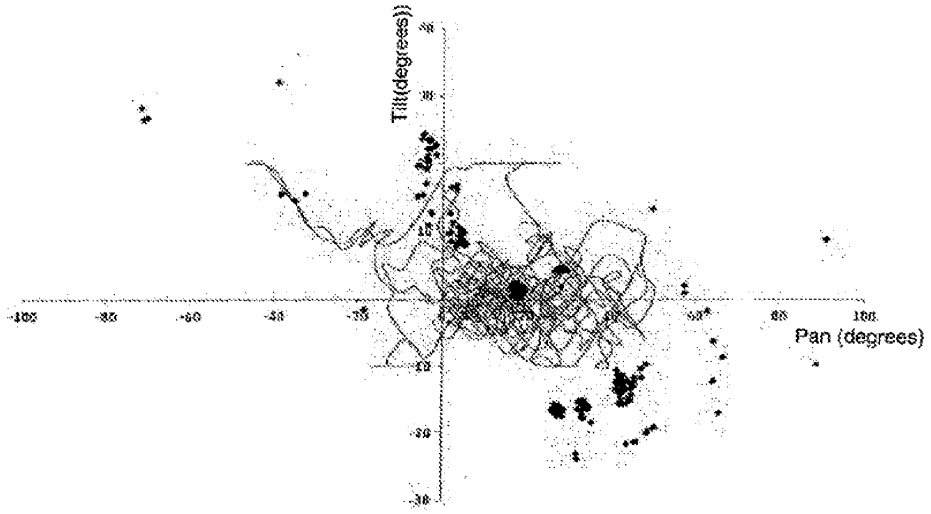


FIG.17

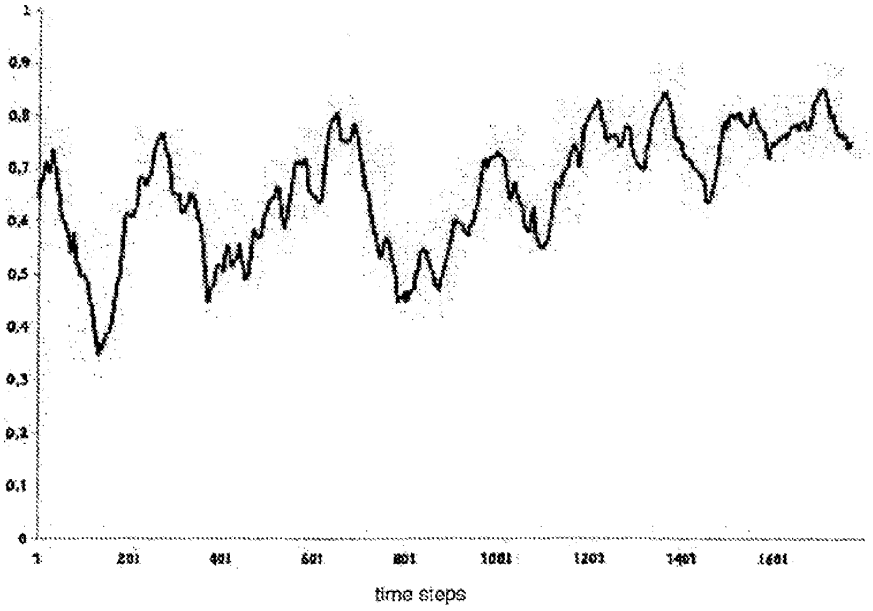


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FIG.16



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FIG.18

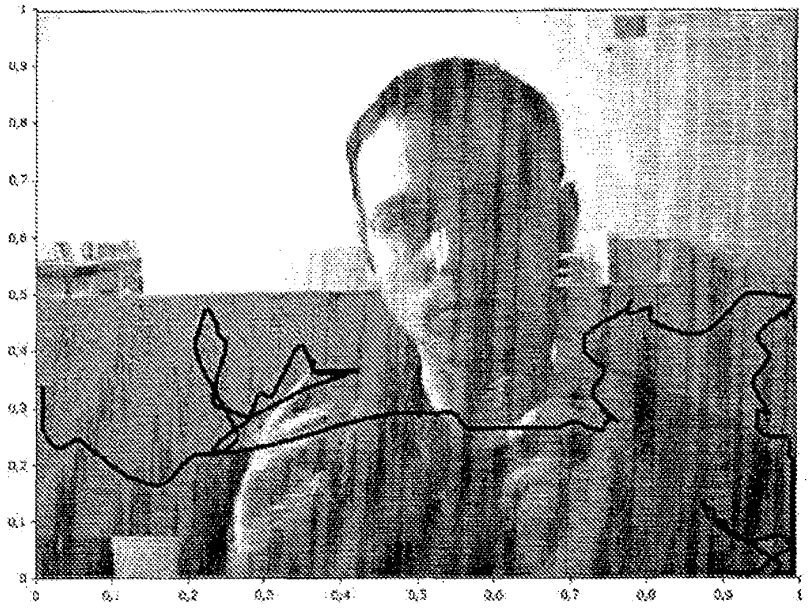


FIG.19

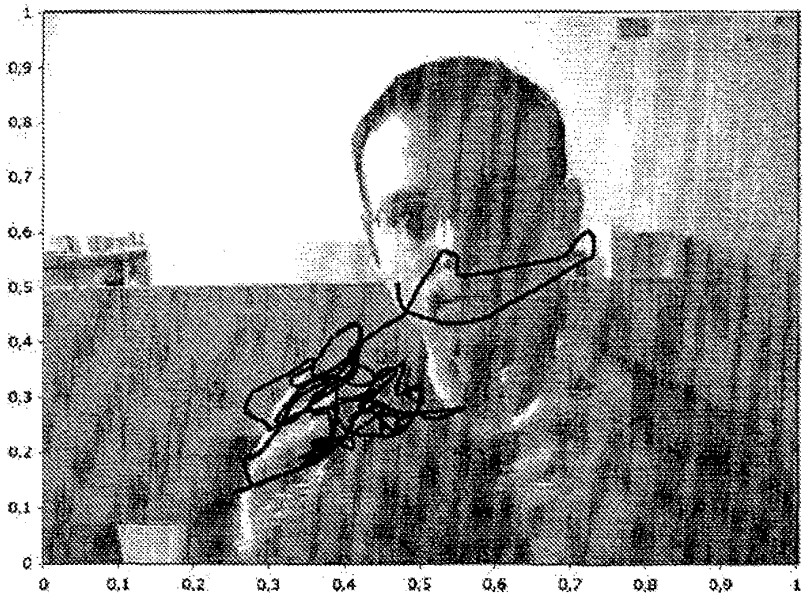


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FIG.20

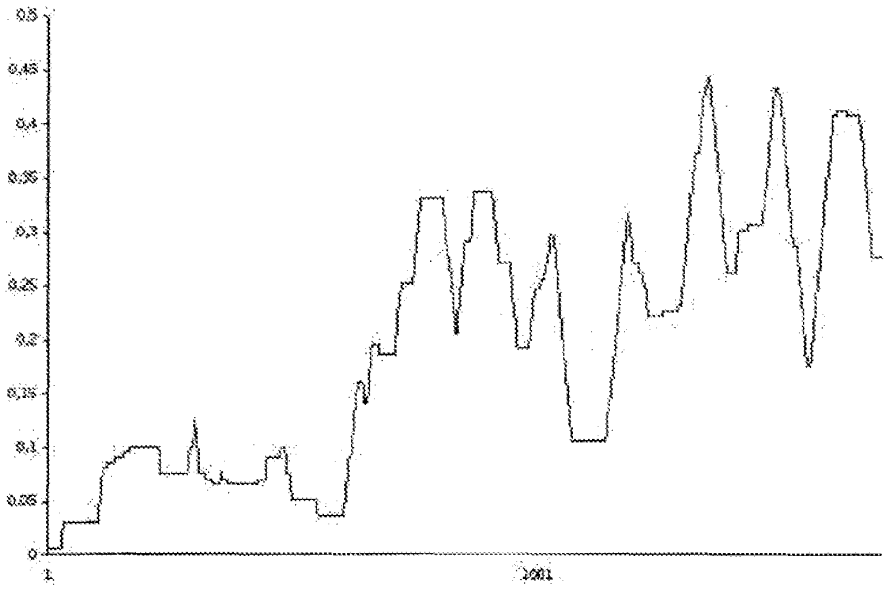


FIG.21

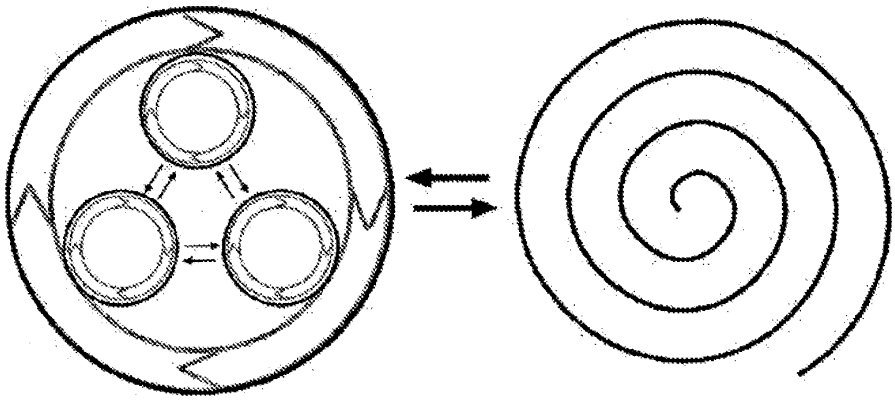


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FIG.22

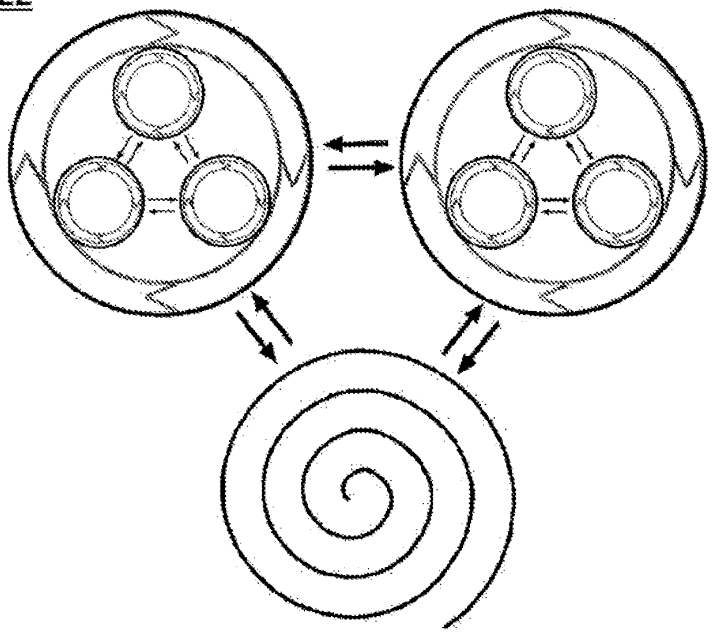


FIG.23

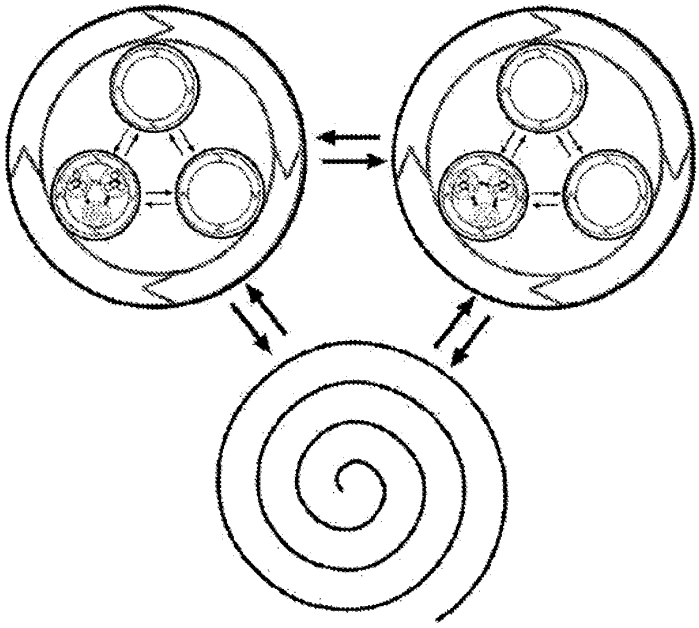


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FIG.24

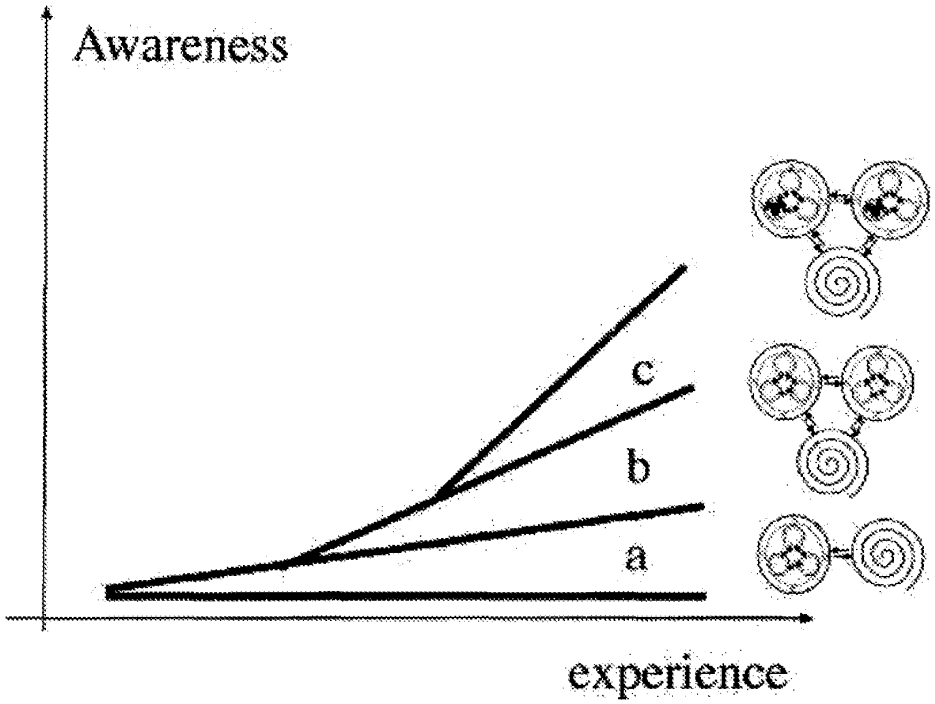


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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 29 1359

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	HUANG X, WENG J: "Novelty and Reinforcement Learning in the Value System of Developmental Robots" PROCEEDINGS SECOND INTERNATIONAL WORKSHOP ON EPIGENETIC ROBOTICS: MODELING COGNITIVE DEVELOPMENT IN ROBOTIC SYSTEMS 94, 10 - 11 August 2002, XP002280505 Lund, Sweden * page 1, left-hand column, line 1 - page 8, right-hand column, line 22 *	1-15	G06N3/00
X	KULAKOV A, STOJANOV G: "Structures, inner values, hierarchies and stages: essentials for developmental robot architectures" PROCEEDINGS SECOND INTERNATIONAL WORKSHOP ON EPIGENETIC ROBOTICS: MODELING COGNITIVE DEVELOPMENT IN ROBOTIC SYSTEMS, 10 - 11 August 2002, XP002280506 Lund, Sweden * page 1, left-hand column, line 1 - page 6, right-hand column, line 11 *	1-15	
A	WENG J, ZHANG Y: "Developmental Robots - A New Paradigm" PROCEEDINGS SECOND INTERNATIONAL WORKSHOP ON EPIGENETIC ROBOTICS: MODELING COGNITIVE DEVELOPMENT IN ROBOTIC SYSTEMS, 10 - 11 August 2002, XP002280507 Lund, Sweden * page 1, left-hand column, line 1 - page 11, right-hand column, line 37 *	1-15	TECHNICAL FIELDS SEARCHED (Int.Cl.7) G06N G06F

-/--

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 May 2004	Itoafa, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
O : non-written disclosure
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EPO FORM 1503 03.82 (P04C01)

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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 29 1359

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	SCHMIDHUBER J: "Curious model-building control systems" PROCEEDINGS OF THE INTERNATIONAL JOINT CONFERENCE ON NEURAL NETWORKS. SINGAPORE, NOV. 18 - 21, 1991, NEW YORK, IEEE, US, vol. 2, 18 November 1991 (1991-11-18), pages 1458-1463, XP010054430 ISBN: 0-7803-0227-3 * page 1458, line 1 - page 1462, line 32 *	1,2	
D,A	KATO T ET AL: "An. evolutionary active-vision system" PROCEEDINGS OF THE CONGRESS ON EVOLUTIONARY COMPUTATION (CEC01), vol. 1, 27 May 2001 (2001-05-27), pages 107-114, XP010551785 * page 1, left-hand column, line 1 - page 3, left-hand column, line 28 *	1,2,4	
D,A	ANDRY P, GAUSSIER P, MOGA S, BANQUET J, NADEL J: "Learning and communication via imitation: an autonomous robot perspective" IEEE TRANSACTION ON SYSTEMS, MAN AND CYBERNETICS, PART A: SYSTEMS AND HUMANS, vol. 31, no. 5, September 2001 (2001-09), pages 431-444, XP002280508 USA * page 1, left-hand column, line 1 - page 10, right-hand column, line 51 *	1-15	TECHNICAL FIELDS SEARCHED (Int.Cl.7)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 May 2004	Itoafa, A

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Electronic Patent Application Fee Transmittal	
Application Number:	10634874
Filing Date:	06-Aug-2003
Title of Invention:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS
First Named Inventor/Applicant Name:	Babak Habibi
Filer:	Frank Abramonte/Sandy Clayton
Attorney Docket Number:	170154.401C1
Filed as Small Entity	

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	1806	1	180	180
		Total in USD ($)		**180**

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/634,874	08/06/2003	Babak Habibi	170154.401C1	7619

500 7590 03/02/2010

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

EXAMINER	
MARC, MCDIEUNEL	
ART UNIT	PAPER NUMBER
3664	

MAIL DATE	DELIVERY MODE
03/02/2010	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/634,874	HABIBI ET AL.	
	Examiner	Art Unit	
	MCDIEUNEL MARC	3664	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *25 November 2009*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *33-47 and 49-61* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *33-38,40-47 and 49-61* is/are rejected.

7)☒ Claim(s) *39* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *05 June 2009* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *11/25/2009*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

ABB Inc. Exhibit 1002, Page 786 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

DETAILED ACTION

1. Claims 33-47 and 49-61 are pending.

2. Applicant's arguments, see regarding a single camera performing the calibration, filed 11/25/2009, with respect to the rejection(s) of claim(s) 33-47 and 49-61 under under 35 U.S.C. 102(b) as being anticipated by Wei et al. (*Multisensory Visual servoing by a Neural Network*, 1999) have been fully considered and are persuasive. Therefore, the rejection has been withdrawn. However, upon further consideration, a new ground(s) of rejection is made in view

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later

invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

5. Claims 33-38, 40-47 and 49-61 are rejected under 35 U.S.C. 103(a) as being unpatentable over McGee et al. (US 4942539 A) in view of Wei et al. (*Multisensory Visual servoing by a Neural Network*, 1999).

As per claim 33, McGee et al. teaches a single camera for automatically determining the position and orientation of an object by utilizing as few as a single digital image generated by as few as a single camera without the use of a structured light. The digital image contains at least three non-colinear geometric features of the object that equates to the single camera of this application (see abs. and fig. 1, particularly the single camera and "a programmed computer together with reference data and camera calibration data to provide at least three non-parallel 3-D lines. The 3-D lines are utilized by an iterative algorithm to obtain data relating to the position and orientation of the object in 3-D space."). McGee et al. does not specifically teach the following limitations as taught by the secondary reference Wei et al.

Wei et al., in the other hand teaches a multisensory visual servoing by a neural network, including a capturing a number of images of a calibration object (see fig. 4) by the camera (see page 279, col. 2, lines 1-7, and fig. 4, wherein evidence has shown about two camera instead of one); determining a set of (*intrinsic parameters*)[1] (see page 276, col. 2, section II., and col. 1,

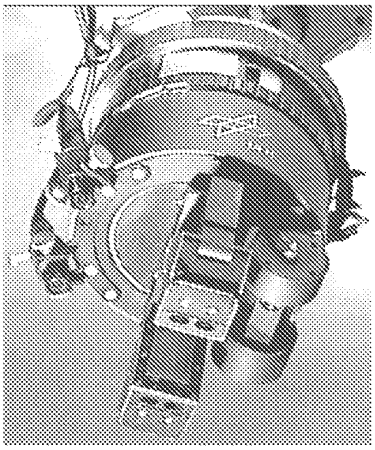
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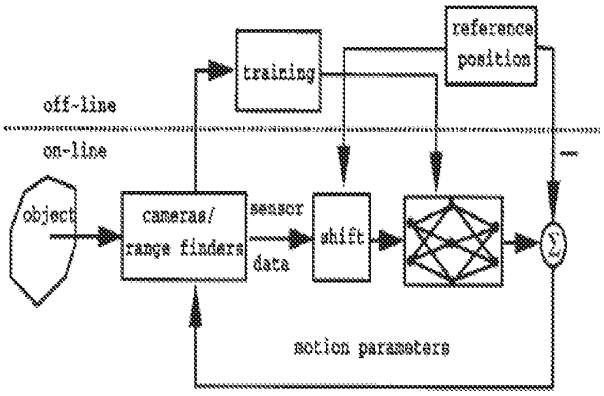
[1] **Intrinsic parameters** = The intrinsic matrix containing 5 intrinsic parameters. These parameters encompass focal length, image format, and principal point. The parameters $\alpha_x = f \cdot m_x$ and $\alpha_y = f \cdot my$ represent focal length in terms of pixels, where m_x and m_y are the scale factors relating pixels to distance. Nonlinear intrinsic parameters such as lens distortion are also important

second paragraph, wherein both intrinsic and extrinsic parameters have been covered by "sensor/camera calibration", and fig. 2 for motion parameters) of the camera (see figs. 2-3) from at least one of the number of images of the calibration object (see page 276, col. 1, third paragraph, lines and 1-8, and page 279, col. 2, lines 12-13) captured by the camera (as seen in fig. 3 below); and determining a set of extrinsic parameters (see page 1, col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered) of the camera (see figs. 2-3) from at least one of the number of images of the calibration object captured by the camera (see fig. 4, wherein the clearer picture has been considered as calibrated), the set of extrinsic parameters (see page 1, col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered as noted above) comprising a camera (see figs. 2-3, wherein any one of the cameras performs the required function, and having more than one falls under design choice) space-to-training space transformation defining a transformation between a space reference frame and a training space reference frame (see page 2, particularly "space-to-training space transformation" has been interpreted as from object to the camera/range finders, to the training and to the geometric transformation, "a space reference frame" has been interpreted as from the reference position to the algorithm module to the camera/range finders, to the shift and finally to the geometric transformation and col. 1, wherein reference frame has been considered as position frame).

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although they cannot be included in the linear camera model described by the intrinsic parameter matrix. Many modern camera calibration algorithms estimate these intrinsic parameters as well.





As per claim 34, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a positioning the camera (see figs. 2-3) with respect to the calibration object (see page 276, second paragraph lines 1-5 and col. 2, section II., particularly "Here uniqueness means that the sensory data should be able to uniquely determine the end-effector's relative position with respect to the object, while redundancy requires that one use more than the minimum number of sensory data to achieve robustness in the pose determination.").

As per claim 35, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method wherein positioning the camera (see figs. 2-3) with respect to the calibration object (see abs. and fig. 4) comprises positioning the camera orthogonally (see fig. 3, wherein the camera has been considered mounted orthogonally) with respect to a ruled template with a number of features (see page 5, table II, which has been considered as template), where a known or determinable physical relationship exists between at least some of the features (see page 277, cols. 1-2, particularly table I, wherein roll, pitch and yaw have been considered as physical features).

As per claim 36, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method wherein positioning the camera (see figs. 2-3) with respect to the calibration object (see abs. and fig. 4) comprises positioning the camera (see figs. 2-3, wherein the camera being position to see/track an object on a conveyor) with respect to a sample of a type of object the robot will manipulate (see fig. 2, particularly the object and page 276, section I. lines 1-5), the sample having a number of features, where a known or determinable physical relationship exists between at least some of the features (see page 277, cols. 1-2, particularly table I, wherein roll, pitch and yaw have been considered as physical features).

As per claim 37, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method wherein capturing a number of images of a calibration object (see abs. and fig. 4) by the camera comprises capturing at least one image at each of a plurality of positions spaced perpendicularly from the calibration object (see page 276 col. 1, third paragraph, particularly "used an eye-on-hand configuration to track an object on a conveyor." being on the conveyor brings a plurality of positions even perpendicular position).

As per claim 38, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method wherein capturing a number of images of a calibration object by the camera (see figs. 2-3) comprises capturing at least one image at each of a plurality of different orientations with respect to the calibration object (see page 276 col. 1, third paragraph, particularly "used an eye-on-hand configuration to track an object on a conveyor." being on the conveyor brings a plurality of positions even different orientations).

As per claim 40, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method wherein determining a set of extrinsic parameters (see page 276, col. 2, section II., and col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered by "sensor/camera calibration", and fig. 2 for motion parameters) of the camera (see figs. 2-3 as noted above) from at least one of the number of images of the calibration object (see fig. 4) captured by the camera, the set of extrinsic parameters (see page 276, col. I1, section II., and col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered by "sensor/camera calibration", and fig. 2 for motion parameters) comprising a camera (see figs. 2-3) space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame (see page 2, particularly "space-to-training space transformation" has been interpreted as from object to the camera/range finders, to the training and to the geometric transformation, "a space reference frame" has been interpreted as from the reference position to the algorithm module to the camera/range finders, to the shift and finally to the geometric transformation and col. 1, wherein reference frame has been considered as position frame) comprises determining a respective translation component along three orthogonal axes, and a respective rotation component about the three orthogonal axes (see fig. 2, wherein the axes the box between the shift and ⊗, has been considered as orthogonal axes).

As per claim 41, **Wei et al.**, teaches a multisensory visual servoing by a neural network including a method that further comprising determining a camera space-to-tool space transformation based (see page 276, col. 1, particularly "tracking an object on a conveyor" has automatically determine camera space-to-tool and page 277, section *B. Dealing with the*

Inexactness of the Mapping has dealt with the transformation) at least in part on at least two of the number of images captured by the camera of the calibration object (see fig. 4, has been broadly interpreted as the two images of the calibration).

As per claim 42, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method that further comprising: determining a camera space-to-tool space transformation based (see page 276, col. 1, particularly "tracking an object on a conveyor" has automatically determine camera space-to-tool and page 277, section *B. Dealing with the Inexactness of the Mapping* has dealt with the transformation) on single one of the number of images captured by the camera of the calibration object (see fig. 3 as noted above) and on a number of physical coordinates of at least one feature of the calibration object (see page 277, cols. 1-2, particularly table I, wherein roll, pitch and yaw have been considered as physical features).

As per claim 43, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method that further comprising: capturing an image of a teaching object (see fig. 2, wherein the object has been considered as a teaching one) of a type of object that will be manipulated by the robot (see abs. and fig. 3); selecting a number of features from the captured image of the teaching object (see abs., and fig. 4); determining a set of object space coordinates for each of the selected features from the captured image of the teaching object (see fig. 4).

As per claim 44, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method wherein selecting a number of features (see page 2, col. 1) from the captured image of the teaching object (see fig. 4, and the object on the conveyor as noted above being teaching object to be captured) comprises selecting six features from the captured image of the

teaching object (see page 280, particularly table II, has been considered having a plurality of selectable image position).

As per claim 45, **Wei et al.**, teaches a multisensory visual servoing by a neural network including a method that further comprising determining an object space-to-camera space transformation defining a transformation between an object space reference frame and the camera space reference frame (see page 2, particularly "space-to-training space transformation" has been interpreted as from object to the camera/range finders, to the training and to the geometric transformation, "a space reference frame" has been interpreted as from the reference position to the algorithm module to the camera/range finders, to the shift and finally to the geometric transformation and col. 1, wherein reference frame has been considered as position frame).

As per claim 46, **Wei et al.**, teaches a multisensory visual servoing by a neural network including a method that comprising determining a position and an orientation of an object frame in the tool frame reference frame (see page 276, col. 1, wherein reference frame has been considered as position frame and table II. for position and orientation) based at least in part on the object frame-to-camera space and camera space-to-tool space transformations (see abstract, pages 1-2 and fig. 2).

As per claim 47, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method that further comprising: providing the position and orientation of the object (see fig. 4) frame to the robot; and training an intended operation path inside the object frame (see page 276 col. 1, third paragraph, particularly "used an eye-on-hand configuration to track an

object on a conveyor." being on the conveyor brings a plurality of positions even different orientations).

As per claim 49, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method that further comprising: adjusting a position of the movable portion of the robot if the number of features located in the captured image of the target object is determined to be an insufficient number of features (see page 276, col. 1, particularly the abs. for calibration); and capturing another two-dimensional image of the volume containing the target object (see fig. 2-4, wherein image taken by the camera being considered has having the capacity to do two- or three-dimensional images) before determining the object space-to-camera space transformation for the target object (see figs. 2 and 3 as noted above).

As per claim 50, McGee et al. teaches a single camera for automatically determining the position and orientation of an object by utilizing as few as a single digital image generated by as few as a single camera without the use of a structured light. The digital image contains at least three non-colinear geometric features of the object that equates to the single camera of this application (see abs. and fig. 1 as see below, particularly the single camera and "a programmed computer together with reference data and camera calibration data to provide at least three non-parallel 3-D lines. The 3-D lines are utilized by an iterative algorithm to obtain data relating to the position and orientation of the object in 3-D space."). McGee et al. does not specifically teach the following limitations as taught by the secondary reference Wei et al.

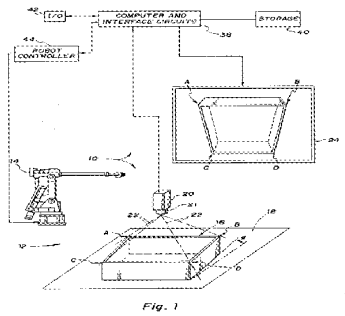


Fig. 1

Wei et al., in the other hand teaches a multisensory visual servoing by a neural network, including capturing a two-dimensional image of a volume containing a target object (see fig. 4, wherein the camera being considered for 2D or 3D images); locating a number of features in the captured image of the target object (see page 276 and col. 1, as noted above); and determining an object space-to-camera space transformation for the target object (see fig. 4, wherein automatically the camera determines the target) based at least in part on a position of at least some of the located features using only the captured image and an algorithm (see page 276, col. 1 and page 279, col. 2, first paragraph, wherein the user of neural network avoids computations) that employs a known or determinable physical relationship between at least some of the located features (see page 277, cols. 1-2, particularly table I, wherein roll, pitch and yaw have been considered as physical features).

As per claim 51, **Wei et al.**, teaches a multisensory visual servoing by a neural network including a method that further comprising determining a camera space-to-tool space transformation based (see page 276, col. 1, particularly "tracking an object on a conveyor" has automatically determine camera space-to-tool and page 277, section *B. Dealing with the Inexactness of the Mapping* has dealt with the transformation) at least in part on at least two of

the number of images captured by the camera of the calibration object (see fig. 4, has been broadly interpreted as the two images of the calibration).

As per claim 52, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a method that comprising: determining a position of the object (see fig. 4 and table II) frame in the tool space reference frame (see page 2, col. 1, wherein reference frame has been considered as position frame); and providing an object frame to the robot (see fig. 3-4).

As per claim 53, McGee et al. teaches a single camera for automatically determining the position and orientation of an object by utilizing as few as a single digital image generated by as few as a single camera without the use of a structured light. The digital image contains at least three non-colinear geometric features of the object that equates to the single camera of this application (see abs. and fig. 1, particularly the single camera and "a programmed computer together with reference data and camera calibration data to provide at least three non-parallel 3-D lines. The 3-D lines are utilized by an iterative algorithm to obtain data relating to the position and orientation of the object in 3-D space."). McGee et al. does not specifically teach the following limitations as taught by the secondary reference Wei et al.

Wei et al., in the other hand teaches a multisensory visual servoing by a neural network including a system that useful in robotics the apparatus comprising capture at a number of images of a calibration object (see abs. and fig. 4) means for calibrating the camera, by: determining a set of intrinsic parameters (page 276, col. 2, section II., and col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered by "sensor/camera calibration", and fig. 2 for motion parameters) of the camera from at least one of the number of images of the calibration object captured by the camera (see abs. and figs. 2-3 as noted above);

and determining a set of extrinsic parameters (see page 276, col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered) of the camera from at least one of the number of images of the calibration object (see page 276 as noted above) captured by the camera, the set of extrinsic parameters (see page 276, col. 2, section II., and col. 1, second paragraph, wherein both intrinsic and extrinsic parameters have been covered by "sensor/camera calibration", and fig. 2 for motion parameters) comprising a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame (see page 2, particularly "space-to-training space transformation" has been interpreted as from object to the camera/range finders, to the training and to the geometric transformation, "a space reference frame" has been interpreted as from the reference position to the algorithm module to the camera/range finders, to the shift and finally to the geometric transformation and col. 1, wherein reference frame has been considered as position frame); and means for estimating a pose of a target object (see page 276, section 2., wherein pose determination has been considered for estimation of the pose), by capturing a two-dimensional image of a volume containing a target object (see fig. 2-4, wherein image taken by the camera being considered has having the capacity to do two- or three-dimensional images); and locating at least six features in the captured image of the target object (see page 280, particularly table II, has been considered having a plurality of selectable image position); and determining an object space-to-camera space transformation based on at least in part on a position of at least some of the located features in solely the captured image using an algorithm that employs a known or determinable physical relationship between at least some of the located features (see page 277,

cols. 1-2, particularly table I, wherein roll, pitch and yaw have been considered as physical features and second *B. Dealing with the Inexactness of the Mapping*).

As per claim 54, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a system that comprising: means for training, comprising:
capturing an image of a teaching object (see fig. 4) of a type of object (see fig. 4) that will be manipulated by the robot; selecting a number of features (see page 2, col. 1) from the captured image of the teaching object (see fig. 4); determining a set of object (see fig. 4) space coordinates for each of the selected features (see page 2, col. 1) from the captured image of the teaching object (see fig. 4); an determining an object (see fig. 4) space-to-camera (see figs. 2-3) space transformation defining a transformation between an object (see fig. 4) space reference frame (see page 2, col. 1, wherein reference frame has been considered as position frame) and the camera (see figs. 2-3) space reference frame (see page 2, col. 1, wherein reference frame has been considered as position frame).

As per claim 55, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a system wherein the means for calibrating, the means for estimating a pose, and the means for training comprises at least one programmed computer (see abstract, page 1, col. 1 and page 4, col. 2, second paragraph).

As per claim 56, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a system wherein the means for calibrating, the means for estimating a pose, and the means for training comprises at least one computer-readable medium (see abstract, page 1, col. 1 and page 4, col. 2, second paragraph) storing instructions operating at least one computer (see abstract, page 1, col. 1 and page 4, col. 2, second paragraph).

As per claim 57, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a system wherein the pose estimating means estimates the pose of the target object (see fig. 4) further by: adjusting a position of the movable portion of the robot (see fig. 3) if the number of features (see page 2, col. 1) located in the captured image of the target object (see fig. 4) is determined to be an insufficient number of features (see page 2, col. 1).

As per claim 58, McGee et al. teaches a single camera for automatically determining the position and orientation of an object by utilizing as few as a single digital image generated by as few as a single camera without the use of a structured light. The digital image contains at least three non-colinear geometric features of the object that equates to the single camera of this application (see abs. and fig. 1, particularly the single camera and "a programmed computer together with reference data and camera calibration data to provide at least three non-parallel 3-D lines. The 3-D lines are utilized by an iterative algorithm to obtain data relating to the position and orientation of the object in 3-D space."). McGee et al. does not specifically teach the following limitations as taught by the secondary reference Wei et al.

Wei et al., in the other hand teaches a multisensory visual servoing by a neural network, including a system that useful in robotics, the apparatus that capture a number of images of a calibration object means for calibrating the camera, by: determining a set of intrinsic parameters (see page 276 and footnote as noted above) of the camera from at least one of the number of images of the calibration object captured by the camera (see figs. 2-4 as noted above); and determining a set of extrinsic parameters (see page 276 as noted above) of the camera from at least one of the number of images of the calibration object captured by the camera (see abstract and fig. 4 as noted above), the set of extrinsic parameters (see page 276 as noted above)

comprising a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame (see page 2, particularly "space-to-training space transformation" has been interpreted as from object to the camera/range finders, to the training and to the geometric transformation, "a space reference frame" has been interpreted as from the reference position to the algorithm module to the camera/range finders, to the shift and finally to the geometric transformation and col. 1, wherein reference frame has been considered as position frame); and means for estimating a pose of a target object (seepage 276, col. 2, section II., wherein pose determination has been taken as estimation of a pose), by capturing a two-dimensional image of a volume containing a target object (see fig. 4); locating at least five features in the captured image of the target object (see table II as noted above); and determining an object space-to-camera space transformation based at least in part on a position of at least some of the located features using the captured image without any additional captured images and an algorithm (see page 276, col. 1 and page 279, col. 2, first paragraph, wherein the user of neural network avoids computations) that employs a known or determinable physical relationship between at least some of the located features (see page 277, cols. 1-2, particularly table I, wherein roll, pitch and yaw have been considered as physical features and second *B. Dealing with the Inexactness of the Mapping*).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the robot type of McGee et al., with the robot type of Wei et al., because this modification would have a single camera for performing the calibration into Wei's et al., thereby improving the efficiency and the reliability of the single camera of the single image 3D vision guided robotics.

As per claim 59, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a system wherein the means for calibrating and the means for estimating a pose comprises at least one programmed computer (see abstract, page 276, col. 2, section II., wherein pose determination has been taken as estimation of a pose and page 279, col. 2, second paragraph, particularly "If we use analytic computer vision methods to solve the same problem, a lot of calibrations have to be involved").

As per claim 60, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a system wherein the means for calibrating and the means for estimating a pose comprises at least one computer-readable medium (see abstract, page 276, col. 1 and page 279, col. 2, second paragraph) storing instructions operating at least one computer (see abstract, page 276, col. 1, wherein "traditional computer" inherently works with computer-readable medium, and page 4, col. 2, second paragraph).

As per claim 53, **Wei et al.**, teaches a multisensory visual servoing by a neural network, including a system wherein the pose estimating means estimates the pose of the target object (see fig. 4) further by: adjusting a position of the movable portion of the robot (see fig. 3) if the number of features (see page 2, col. 1) located in the captured image of the target object (see fig. 4) is determined to be an insufficient number of features (see page 2, col. 1).

Allowable Subject Matter

6. Claim 39 and is objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

7. The following is a statement of reasons for the indication of allowable subject matter:

The prior art of record fail to teach determining at least one of a focal length, a first order radial lens distortion coefficient, a set of coordinates of a center of a radial lens distortion, or a scale factor indicative of a framegrabber scanline resampling uncertainty.

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to MCDIEUNEL MARC whose telephone number is (571)272-6964. The examiner can normally be reached on 6:30-5:00 Mon-Thu.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Khoi Tran can be reached on (571) 272-6919. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

/McDieunel Marc/
Examiner, Art Unit 3664
/KHOI TRAN/
Supervisory Patent Examiner, Art Unit 3664

Notice of References Cited	Application/Control No. 10/634,874	Applicant(s)/Patent Under Reexamination HABIBI ET AL.	
	Examiner MCDIEUNEL MARC	Art Unit 3664	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-4,942,539	07-1990	McGee et al.	700/253
*	B	US-6,081,370	06-2000	Spink, Roger	359/369
*	C	US-5,300,869	04-1994	Skaar et al.	318/587
*	D	US-4,871,252	10-1989	Beni et al.	356/457
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
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	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Xu et al., Determining Camera Intrinsic and Extrinsic Parameters from Multiple Images of Multiple Balls, 2002, Internet, pg. 1-5
	V	
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	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

ABB Inc. Exhibit 1002, Page 805 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 170154.401C1	APPLICATION NO. 10/634,874
INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	APPLICANTS Babak Habibi et al.	
	FILING DATE August 6, 2003	GROUP ART UNIT 3664

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	AA	4,011,437	03/08/77	Hohn	235	151.11	
	AB	4,187,454	02/05/80	Ito et al.	318	568	
	AC	4,294,544	10/13/81	Altschuler et al.	356	376	
	AD	4,523,809	06/18/85	Taboada et al.	350	163	
	AE	4,687,325	08/18/87	Corby, Jr.	356	1	
	AF	4,791,482	12/13/88	Barry et al.	358	107	
	AG	4,879,664	11/07/89	Suyama et al.	364	518	
	AH	4,985,846	01/15/91	Fallon	364	513	
	AI	5,160,977	11/03/92	Utsumi	356	376	
	AJ	5,208,763	05/04/93	Hong et al.	364	551.02	
	AK	5,325,468	06/28/94	Terasaki et al.	395	97	
	AL	5,446,835	08/29/95	Iida et al.	395	133	
	AM	5,461,478	10/24/95	Sakakibara et al.	356	375	
	AN	5,499,306	03/12/96	Sasaki et al.	382	291	
	AO	5,521,830	05/28/96	Saito	364	474.34	
	AP	5,568,593	10/22/96	Demarest et al.	395	82	
	AQ	5,608,818	03/04/97	Chini et al.	382	153	
	AR	5,715,166	02/03/98	Besl et al.	364	474.24	
	AS	5,745,523	04/28/98	Dent et al.	375	216	
	AT	5,784,282	07/21/98	Abitbol et al.	364	474.28	
	AU	5,802,201	09/01/98	Nayar et al.	382	153	
	AV	5,809,006	09/15/98	Davis et al.	369	275.4	
	AW	5,870,527	02/09/99	Fujikawa et al.	395	80	

EXAMINER	DATE CONSIDERED

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant

1509406

Date: November 25, 2009

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.M./

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U.S. PATENT DOCUMENTS

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	AA	5,974,169	10/26/99	Bachelder	382	151	
	AB	6,004,016	12/21/99	Spector	364	167.02	
	AC	6,064,759	05/16/00	Buckley et al.	382	154	
	AD	6,278,906	08/21/01	Piepmeier et al.	700	250	
	AE	6,392,744	05/21/02	Holec	356	4.03	
	AF	6,463,358	10/08/02	Watanabe et al.	700	253	
	AG	6,490,369	12/03/02	Beiman	382	153	
	AH	6,516,092	02/04/03	Bachelder et al.	382	181	
	AI	6,529,627	03/04/03	Callari et al.	382	154	
	AJ	6,546,127	04/08/03	Seong et al.	382	152	
	AK	6,549,288	04/15/03	Migdal et al.	356	603	
	AL	6,580,971	06/17/03	Bunn et al.	700	259	
	AM	6,721,444	04/13/04	Gu et al.	382	154	
	AN	6,724,930	04/20/04	Kosaka et al.	382	154	
	AO	6,741,363	05/25/04	Kaupert	356	602	
	AP	6,748,104	06/08/04	Bachelder et al.	382	151	
	AQ	6,836,702	12/28/04	Brogårdh et al.	700	245	
	AR	6,970,802	11/29/05	Ban et al.	702	153	
	AS	7,006,236	02/28/06	Tomasi et al.	356	614	
	AT	7,009,717	03/07/06	Van Coppenolle et al.	356	603	
	AU	7,084,900	08/01/06	Watanabe et al.	348	94	
	AV	7,177,459	02/13/07	Watanabe et al.	382	151	

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U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
	AA	2002/0019198	02/14/02	Kamono	451	41	
	AB	2002/0156541	10/24/02	Yutkowitz	700	28	
	AC	2003/0182013	09/25/03	Moreas et al.	700	145	
	AD	2004/0037689	02/26/04	Watanabe et al.	414	730	
	AE	2004/0041808	03/04/04	Ban et al.	345	419	
	AF	2004/0073336	04/15/04	Huang et al.	700	245	
	AG	2004/0081352	04/29/04	Ban et al.	382	154	
	AH	2004/0193321	09/30/04	Anfindsen et al.	700	257	
	AI	2005/0002555	01/06/05	Kumiya et al.	382	153	
	AJ	2005/0097021	05/05/05	Behr et al.	705	36	
	AK	2005/0126833	06/16/05	Takenaka et al.	180	8.1	
	AL	2005/0233816	10/20/05	Nishino et al.	473	131	
	AM	2005/0246053	11/03/05	Endou et al.	700	188	
	AN	2006/0025874	02/02/06	Huffington et al.	700	44	
	AO	2006/0088203	04/27/06	Boca et al.	382	153	
	AP	2006/0119835	06/08/06	Rastegar et al.	356	28	
	AQ	2006/0210112	09/21/06	Cohen et al.	382	103	
	AR	2007/0073439	03/29/07	Habibi et al.	700	213	
	AS	11/754,218		Habibi et al.			05/25/07
	AT	11/779,812		Habibi			07/18/07
	AU	11/833,187		Boca et al.			08/02/07
	AV	11/857,680		Boca et al.			09/19/07
	AW	60/719,765		Habibi et al.			09/23/05

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	AA	60/808,903		Habibi et al.			05/26/06
	AB	60/832,356		Habibi			07/20/06
	AC	60/845,932		Boca et al.			09/19/06
	AD	60/875,073		Beis et al.			12/16/06

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	TRANSLATION	
					YES	NO
	AE	1 043 126	10/11/00	EP		
	AF	1 043 642	10/11/00	EP		
	AG	1 043 689	10/11/00	EP		
	AH	1 484 716	12/08/04	EP		
	AI	102 36 040	02/19/04	DE (+ abstract in English)		
	AJ	2000024973	01/25/00	JP (+ abstract in English)		
	AK	2005/074653	08/18/05	WO		
	AL	63288683	11/25/88	JP (+ abstract in English)		
	AM					
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	APPLICANTS Babak Habibi et al.	
	FILING DATE August 6, 2003	GROUP ART UNIT 3664

OTHER PRIOR ART *(Including Author, Title, Date, Pertinent Pages, Etc.)*

	AA		Aloimonos, J., et al., "Active Vision," *IEEE*, pp. 35-54, 1987.
	AB		Anonymous, "Precise Length Measurement at VSM (Vereinigte Schmirgel-Und Maschinen-Fabriken AG)," *News of the Astech GMBH 2001*(4), December 31, 2001.
	AC		Bajcsy, R., "Active Perception," *Proc. IEEE 76*(8):996-1005, 1988
	AD		Bakhtari, A., et al., "Active-Vision Based Multi-Sensor Surveillance – An Implementation," *IEEE Transactions on Systems, Man and Cybernetics, Part C: Applications and Reviews, 36*(5):668-680, September 2006.
	AE		Borotschnig, H., et al., "Active Object Recognition in Parametric Eigenspace," *Proc. 9th British Machine Vision Conference*, pp. 629-638, 1998.
	AF		Bouthemy, P., "A Maximum Likelihood Framework for Determining Moving Edges," *IEEE Trans. Pattern Analysis and Machine Intelligence 11*(5):499-511, 1989.
	AG		Brown, M., et al., "3D Model Acquisition by Tracking 2D Wireframes," *Proc. 11th British Machine Vision Conference*, pp. 656-665, 2000.
	AH		Callari, F., et al., "Active Recognition: Using Uncertainty to Reduce Ambiguity," *Proc. 13th International Conference on Pattern Recognition*, pp. 925-929, 1996.
	AI		Chaumette, F., "Potential Problems of Stability and Convergence in Image-Based and Position-Based Visual Servoing," in D. Kriegman, G. Hager and S. Morse, editors, *The Confluence of Vision and Control, Vol. 237* of Lecture Notes in Control and Information Sciences, pp. 66-78, Springer-Verlag, 1998.
	AJ		Chaumette, F., et al., "Structure from Controlled Motion," *IEEE Trans. Pattern Analysis and Machine Intelligence 18*(5):492-504, May 1996.
	AK		Constantinescu, D., et al., "Smooth and Time-Optimal Trajectory Planning for Industrial Manipulators along Specified Paths," *Journal of Robotic Systems 17*(5):233-249, 2000.
	AL		Corke, P.I., et al., "A New Partitioned Approach to Image-Based Visual Servo Control," *IEEE Trans. On Robotics and Automation 17*(4):507-515, August 2001.
	AM		Deguchi, K., "Optimal Motion Control for Image-Based Visual Servoing by Decoupling Translation and Rotation," in *Proc. Int. Conf. Intelligent Robots and Systems*, pp.705-711, October 1998.
	AN		Drummond, T., et al., "Real-time Tracking of Complex Structures with On-line Camera Calibration," *Proceedings of British Machine Vision Conference*, pp. 574-583, 1999.

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INFORMATION DISCLOSURE STATEMENT (Use several sheets if necessary)	FILING DATE August 6, 2003	GROUP ART UNIT 3664

OTHER PRIOR ART *(Including Author, Title, Date, Pertinent Pages, Etc.)*

	AA		Eriksen, R.D., et al., "Classification and pose estimation of unconstrained 3D objects," *34th International Symposium on Robotics*, June 2-5, 2003, 7 pages.
	AB		Hartley et al., *Multiple View Geometry in Computer Vision,* Cambridge University Press, Cambridge, 2000
	AC		Holliday et al., "Demonstration of Automated Robotic Workcell for Hazardous Waste Characterization," *Proceedings of the International Conference on Robotics and Automation 3*(10):788-794, May 2, 1993.
	AD		Hutchinson, S.A., et al., "Planning Sensing Strategies in a Robot Work Cell with Multi-Sensor Capabilities," *IEEE Trans. Robotics and Automation 5*(6):765-783, 1989
	AE		Hutchison et al., "A Tutorial on Visual Servo Control," *IEEE Transactions on Robotics and Automation 12*(5), October 1996
	AF		Lowe, D.G., "Robust Model-based Motion Tracking Through the Integration of Search and Estimation," *International Journal of Computer Vision 8*(2):113-122, 1992.
	AG		Macfarlane, S., et al., "Jerk-Bounded Manipulator Trajectory Planning: Design for Real-Time Applications," *IEEE Trans. Robotics and Automation 19*(1):42-52, 2003.
	AH		Marjanovic et al., "Self-Taught Visually-Guided Pointing for a Humanoid Robot," XP-002220054, pp. 35-44, 1996.
	AI		Miura, J., et al., "Task-Oriented Generation of Visual Sensing Strategies in Assembly Tasks," CMU School of Computer Science Tech Report CMU-CS-95-116, 42 pages, 1995.
	AJ		Motai, Y., et al., "Concatenate Feature Extraction for Robust 3D Elliptic Object Localization," *Proc. Of the 19th ACM Symposium on Applied Computing*, pp. 21-28, 2004.
	AK		Murase, H., et al., "Visual Learning and Recognition of 3-D Objects from Appearance," *International Journal of Computer Vision 14*(1):5-24, 1995.
	AL		Naish, M.D., et al., "Coordinated dispatching of proximity sensors for the surveillance of manoeuvring targets," *Journal of Robotics and Computer Integrated Manufacturing 19*(3):283-299, 2003.
	AM		Nomura et al., "Integrated Visual Servoing System to Grasp Industrial Parts Moving on Conveyer by Controlling 6D0F Arm," *Systems, Man, and Cybernetics, 2000 IEEE International Conference 3*:1768-1775, October 2000.
	AN		Papanikolopoulos et al., "Six Degree-of-Freedom Hand/Eye Visual Tracking with Uncertain Parameters," *IEEE Transactions on Robotics and Automation 11*(5):725-732, October 1995.

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	APPLICANTS Babak Habibi et al.	
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OTHER PRIOR ART *(Including Author, Title, Date, Pertinent Pages, Etc.)*

	AA		Sang, T., et al., "Vision Assisted Robotic Tele-training," *IEEE International Conference on Mechatronics and Automation*, pp. 1288-1293, July 2005.
	AB		Tarabanis, K.A., et al., "A Survey of Sensor Planning in Computer Vision," *IEEE Transactions on Robotics and Automation 11*(1):86-104, February 1995.
	AC		Tarabanis, K.A., et al., "The MVP Sensor Planning System for Robotic Vision Tasks," *IEEE Transactions on Robotics and Automation 11*(1):72-85, February 1995.
	AD		Vincze, M., "Robust tracking of ellipses at frame rate," *The Journal of Pattern Recognition 34*(2):487-498, 2001.
	AE		Whaite, P., et al., "From Uncertainty to Visual Exploration," *IEEE Transactions on Pattern Analysis and Machine Intelligence 13*(10):1038-1049, 1991.
	AF		Wilson et al., "Relative End-Effector Control Using Cartesian Position Based Visual Servoing," *IEEE Transactions 12*(5):684-696, 1996.
	AG		Zhou, F., et al., "Complete calibration of a structured light stripe vision sensor through planar target of unknown orientations," *Image and Vision Computing 23*:59-67, 2005.
	AH		Office Action for U.S. Application No. 11/183,228, 12 pages, Mail Date 12/06/2006.
	AI		Amendment filed in U.S. Application No. 11/183,228, 24 pages, Mail Date 04/05/2007.
	AJ		Office Action for U.S. Application No. 11/183,228, 14 pages, Mail Date 06/08/2007.
	AK		Amendment filed in U.S. Application No. 11/183,228, 8 pages, Mail Date 09/04/2007.
	AL		
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EXAMINER	DATE CONSIDERED
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WEST Search History

Hide Items | Restore | Clear | Close

DATE: Saturday, February 13, 2010

Hide?	Set Name	Query	Hit Count
Prior Art			
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DB=PGPB,USPT,EPAB,JPAB,DWPI,TDBD; PLUR=YES; OP=ADJ			
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☐	L17	L1 and (camera or video) and (calibrated or claibrates or calibrating or calibration) and (object or part or material or workpiece) and algorithm	2
☐	L16	L1 and (camera or video) and (calibrated or claibrates or calibrating or calibration) same (object or part or material or workpiece) and algorithm	2
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☐	L14	extrinsic and parameters and L13	1
☐	L13	irobot	398
☐	L12	calibrat$6 and L11	164
☐	L11	reference frame and L10	334
☐	L10	(700/245 |700/246 |700/253 |700/257 |700/258 |700/259 |700/279 or 29/218 |29/702 |29/714 |29/720 |29/407.1 |29/407.04 or 318/568.13 | 318/568.15 |318/568.16 |318/640 or 348/42 |348/94 |348/154 |348/190 | 348/291 |348/287552 or 901/6 |901/14 |901/17 |901/46 |901/47 or 414/730 |414/737 or 382/154).ccls.	13533
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☐	L8	wafer and computer and L7	3002
☐	L7	camera and L6	9659
☐	L6	(robot$6 or articulat$3 or automat$6 or autonomous$2 or CNC or machine $2 or mechanical device or mechan$6 or servomechan$4) and L5	38436
☐	L5	calibrat$$ and semiconductor and (correct$3 or fix$3)	44891

ABB Inc. Exhibit 1002, Page 813 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

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END OF SEARCH HISTORY

ABB Inc. Exhibit 1002, Page 814 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10634874	HABIBI ET AL.
	Examiner	Art Unit
	Marc, McDieunel	3664

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/22/2007	02/09/2008	02/10/2009	08/12/2009	02/13/2010				
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4	35	✓	=	=	✓	✓				
5	36	✓	=	=	✓	✓				

ABB Inc. Exhibit 1002, Page 815 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10634874	HABIBI ET AL.
	Examiner	**Art Unit**
	Marc, McDieunel	3664

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/22/2007	02/09/2008	02/10/2009	08/12/2009	02/13/2010				
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8	39	✓	=	=	✓	O				
9	40	✓	=	=	✓	✓				
10	41	✓	=	=	✓	✓				
11	42	✓	=	=	✓	✓				
12	43	✓	=	=	✓	✓				
13	44	✓	=	=	✓	✓				
14	45	✓	=	=	✓	✓				
15	46	✓	=	=	✓	✓				
16	47	✓	=	=	✓	✓				
16	48	✓	-	-	-	-				
17	49	✓	=	=	✓	✓				
1	50	✓	=	=	✓	✓				
18	51	✓	=	=	✓	✓				
19	52	✓	=	=	✓	✓				
20	53	✓	=	=	✓	✓				
21	54	✓	=	=	✓	✓				
22	55	✓	=	=	✓	✓				
23	56	✓	=	=	✓	✓				
24	57	✓	=	=	✓	✓				
25	58	✓	=	=	✓	✓				
26	59	✓	=	=	✓	✓				
27	60	✓	=	=	✓	✓				
28	61	✓	=	=	✓	✓				

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	Babak Habibi et al.
Application No.	:	10/634,874
Filed	:	August 6, 2003
For	:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS

Examiner	:	McDieunel Marc
Art Unit	:	3664
Docket No.	:	170154.401C1
Date	:	September 2, 2010

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

RESPONSE

Commissioner for Patents:

In response to the Office Action dated March 2, 2010, please extend the period of time for response 3 months, to expire on September 2, 2010. Enclosed are a Petition for an Extension of Time and the requisite fee.

This is a Response to the Office Action mailed March 2, 2010, in which a three (3) month Shortened Statutory Period for Response was set, due to expire June 2, 2010. Thirty-two (32) claims, including four (4) independent claims, were paid for in the application. The Director is authorized to charge any additional fees due by way of this Response, or credit any overpayment, to our Deposit Account No. 19-1090. Claims 33-47 and 49-61 are pending.

Applicants thank the Examiner for withdrawing the anticipation rejection based on Wei et al. (*Multisensory Visual Servoing by a Neural Network*, 1990) and for identifying claim 39 as allowable if rewritten in independent form.

Information Disclosure Statement

Applicants filed a Supplemental IDS on June 5, 2009. It is respectfully requested that an initialed copy of the IDS be provided to Applicants to confirm consideration thereof.

Rejections Under 35 U.S.C. § 103

Claims 33-38, 40-47 and 49-61 were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 4,942,539 issued to McGee et al. (hereinafter "McGee") in view of "*Multisensory Visual Servoing by a Neural Network*" by Wei et al. (hereinafter "Wei").

Claim 50 is independent so will be discussed before the claims that depend therefrom. Claim 50 recites:

> A method useful in three-dimensional pose estimation for use with a single camera mounted to a movable portion of a robot, the method comprising: capturing a two-dimensional image of a volume containing a target object; locating a number of features in the captured image of the target object; and determining an object space-to-camera space transformation for the target object based at least in part on a position of at least some of the located features using only the single captured image and an algorithm that employs a known or determinable physical relationship between at least some of the located features.

McGee teaches a single camera for automatically determining the position and orientation of an object by utilizing as few as a single digital image generated by as few as a single camera with the use of structured light.

The Office states that:

[t]he digital image contains at least three non-colinear features of the object that equates to the single camera of this application (see abs. and fig. 1 as see below, particularly the single camera and "a programmed computer together with reference data and camera calibration data to provide at least three non-parallel 3-D lines. The 3-D lines are utilized by an iterative

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algorithm to obtain data relating to the position and orientation of the object in 3-D space.") See Office Action page 10.

Respectfully, Applicants do not understand what this statement means or how three non-collinear features in an image can *equate* to a single camera. Applicants respectfully request clarification of such statement.

The Office goes on to state that McGee does not teach certain limitations which are purportedly taught by the secondary reference Wei. Office Action, page 10, final sentence. In particular, the Office appears to rely on Wei for teaching capturing images of a volume containing a target object, determining an object space-to-camera space transformation for the target object based at least in part on a position of at least some of the located features using only the captured image and an algorithm that employs a known or determinable physical relationship between at least some of the located features. Office Action, page 11. To support such the Office equates the variables roll, pitch and yaw set out in table I of Wei as the known or physical relationship between features, and purportedly page 277 cols 1-2. Id. However, the variable roll, pitch and yaw are *Cartesian motion* parameters for movement of the *end-effecter*, *not features* of the *object*, let alone a known or determinable physical relationship between located features of the object. Such is clearly described at page 276, col. 2, under heading II. A. In particular, Wei teaches that rigid motion is fully described via a rotation matrix and translation vector, and row, pitch, yaw or Euler angles are convenient representations for the rotation matrix. Id. Notably, the discussion at page 277, col. 1-2 heading B relied on by the Office does not appear to address the roll, pitch or yaw parameters.

Additionally, McGee and Wei take fundamentally different approaches to machine vision. Wei expressly teaches away[1] from calibration, distinguishing itself from

[1] MPEP 2143, A, Example 1 (The Court stated that "[d]espite the fact that each of the elements of the Adams battery was well known in the prior art, to combine them as did Adams required that a person reasonably skilled in the prior art must ignore" the teaching away of the prior art that such batteries were impractical and that water-activated batteries were successful only when combined with electrolytes detrimental to the use of magnesium electrodes. *Id.* at 42-43, 50-52, 148 USPQ at 480, 483. "When the prior art teaches away from combining certain known elements, discovery of successful means of combining them is more likely to be nonobvious."*KSR*, 550 U.S. at ___, 82 USPQ2d at 1395).

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traditional computer vision methods which require both the sensors and their mounting parameters to be calibrated in advance. See Wei, page 276, col. 1, abstract and section I, first full paragraph. As explained in Applicants' last response, Wei requires multiple cameras and teaches the use of stereo vision to produce multiple images. See Wei, page 276, col. 2 second full paragraph. Wei also relies on a neural network to process information. Wei also appears to focus on motion of the end-effecter, rather than determining position and orientation of the object relative to the end-effecter. See Wei, page 276, abstract and col. 2, second full paragraph ("end-effecter's Cartesian motion"), and page 277, cols. 1-2. In contrast, McGee teaches an approach which can use a single camera and a single image, and appears to employ conventional digital computers to perform image processing. Also in contrast to Wei, McGee requires camera calibration. See McGee, col. 5, lines 53-66. Further, McGee appears to focus on determining the position and orientation of the object, rather than relying iteratively assessing the motion of the end-effecter.

In sum, there is no teaching, motivation or suggestion to combine the teachings of McGee and Wei, nor does the Office offer any. See MPEP 2141[2] In any case, the fundamental principal of operation of these references, as well as their specific teachings, appear to be completely inconsistent with one another. To combine the teachings, one would not only have to *ignore* the specific teachings of at least one of these references, but would also have to *modify the principal of operation* of at least one of these references. See MPEP 2141 and 2143.

Claim 33 depends from claim 50 and further recites, *inter alia* "determining a set of extrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera, the set of extrinsic parameters comprising a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame."

---

[2] ("The key to supporting any rejection under 35 U.S.C. 103 is the clear articulation of the reason(s) why the claimed invention would have been obvious. The Supreme Court in *KSR* noted that the analysis supporting a rejection under 35 U.S.C. 103 should be made explicit. The Court quoting *In re Kahn,* 441 F.3d 977, 988, 78 USPQ2d 1329, 1336 (Fed. Cir. 2006), stated that "'[R]ejections on obviousness cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.'" *KSR*, 550 U.S. at ___, 82 USPQ2d at 1396.").

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As explained above, claim 50 is allowable over McGee and Wei. The Office relies on Wei for purportedly teaching capturing a number of images of a calibration object and determining intrinsic and extrinsic parameters of the camera. Office Action, pages 3-4. However, Wei *expressly teaches away* from any calibration. See Wei, page 276, col. 1, abstract and section I, first full paragraph. Further, the Office relies on the two images captured by the stereo cameras of Wei. Office Action page 3. However, as explained in Applicants' last response, the claims are directed to a method employing a single camera. Thus, reliance on the stereo camera of Wei is misplaced.

Claim 34 depends from claims 33 and 50 and further recites "positioning the camera with respect to the calibration object." As explained above, claims 50 and 33 are allowable over McGee and Wei. The Office asserts that Wei teaches positioning the camera with respect to a calibration object, relying on Figures 2 and 3 and page 276, second paragraph lines 1-5 and col. 2, section II. Office Action page 5.

Wei *expressly teaches away* from calibration. Thus, it appears impossible to contend that Wei teaches positioning a camera relative to a *calibration* object. There is no basis for contending such, and such contention requires *ignoring* the clear teachings of Wei.

Claim 35 depends from claims 33, 34 and 50 and further recites "positioning the camera orthogonally with respect to a ruled template with a number of features, where a known or determinable physical relationship exists between at least some of the features."

As explained above, claims 50 and 33 are allowable over McGee and Wei. The Office asserts that Wei teaches positioning the camera orthogonally with respect to a calibration object, relying on Figures 2-4 and page 276, second paragraph lines 1-5 and col. 2, section II. Office Action page 5. In particular, the Office alleges that Figure 3 shows the camera mounted orthogonally with respect to a ruled template. Id.

Applicants note that Wei actually teaches *two* cameras, not *one*. Figure 3 of Wei is an isometric or perspective view, and does not show the relative position or orientation of the cameras with respect to any object or frame of reference. Hence, it is impossible to conclude that the cameras in Wei are orthogonal to a ruled template. The Office does not identify any object in Wei as representing a ruled template, nor even allege that Wei teaches use of a ruled

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template. Further, since Wei *expressly teaches away* from calibration, it appears impossible to contend that Wei teaches positioning a camera relative to a *calibration* object. There is no basis for contending such, and such contention requires *ignoring* the clear teachings of Wei. The Office further relies on the roll, pitch and yaw variables as constituting the physical features. As explained above in reference to claim 50, such are parameters indicative of the *movement of the end-effecter* rather than features of the object or relationship between features of the object.

Claim 36 depends from claims 33, 34 and 50 and further recites "wherein positioning the camera with respect to the calibration object comprises positioning the camera with respect to a sample of a type of object the robot will manipulate, the sample having a number of features, where a known or determinable physical relationship exists between at least some of the features."

As explained above, claims 50 and 33 are allowable over McGee and Wei. The Office asserts that Wei teaches positioning the camera orthogonally with respect to a calibration object, relying on Figures 2-4 and page 276, second paragraph lines 1-5 and col. 2, section II. Office Action page 6.

As explained in reference to claim 35, Wei not only doesn't teach positioning a camera with respect to a calibration object but actively teaches away from calibration. Also as explained in reference to claim 35, the roll, pitch and yaw variables do not identify physical parameters of the object, but rather are parameters of the *movement of the end-effecter*.

Claim 37 depends from claims 33, 34 and 50 and further recites "wherein capturing a number of images of a calibration object by the camera comprises capturing at least one image at each of a plurality of positions spaced perpendicularly from the calibration object."

As explained above, claims 50 and 33 are allowable over McGee and Wei. The Office relies on the passage of Wei at page 276, col. 1, third paragraph (*i.e.*, "used an eye-on-hand configuration to track an object on a conveyor"). Again, the Office's reliance on Wei with respect to calibration is completely misplaced as Wei *clearly teaches against calibration*.

Claim 38 depends from claims 33, 34 and 50 and further recites "wherein capturing a number of images of a calibration object by the camera comprises capturing at least one image at each of a plurality of different orientations with respect to the calibration object."

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As explained above, claims 50 and 33 are allowable over McGee and Wei. Again, the Office's reliance on Wei with respect to calibration is misplaced as Wei clearly *teaches against calibration*. Additionally, the Office fails to appreciate the difference between the "positions" along the conveyor line, and the recited "orientations" of claim 38.

Claim 40 depends from claims 33 and 50 and further recites "wherein determining a set of extrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera, the set of extrinsic parameters comprising a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame comprises determining a respective translation component along three orthogonal axes, and a respective rotation component about the three orthogonal axes."

As explained above, claims 50 and 33 are allowable over McGee and Wei. The Office relies on Wei for purportedly teaching determining both intrinsic and extrinsic parameter of the camera from images of the calibration object. Office Action, page 7.

Wei teaches the use of two cameras and laser finders to calculate an *object's* extrinsic parameters. Wei does *not* use *camera* calibration information to determine an object's extrinsic parameters, and again, Wei clearly *teaches away from calibration of the cameras*. See Wei, page 276, col. 1, abstract and section I, first full paragraph.

Claim 41 depends from claims 33 and 50 and further recites "determining a camera space-to-tool space transformation based at least in part on at least two of the number of images captured by the camera of the calibration object."

As explained above, claims 50 and 33 are allowable over McGee and Wei. As explained above in reference to claim 40, Wei not only fails to teach use of camera calibration information to determine a transformation, but actively *teaches away from calibration of cameras.* See Wei, page 276, col. 1, abstract and section I, first full paragraph.

Claim 42 depends from claims 33 and 50 and further recites "determining a camera space-to-tool space transformation based on single one of the number of images captured by the camera of the calibration object and on a number of physical coordinates of at least one feature of the calibration object."

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As explained above, claims 50 and 33 are allowable over McGee and Wei. Wei appears to even mention using one image and one feature to calculate a camera space-to-tool transformation, and given the stereo camera and range finder set up would not appear to be amendable to such an approach. Also, as explained above in reference to claim 40, Wei not only fails to teach use of *camera calibration information* to determine a transformation, but actively *teaches away from calibration of cameras*. See Wei, page 276, col. 1, abstract and section I, first full paragraph.

Claim 43 depends from claim 50 and further recites, *inter alia,* "selecting a number of features from the captured image of the teaching object; and determining a set of object space coordinates for each of the selected features from the captured image of the teaching object."

As explained above, claim 50 is allowable over McGee and Wei. The Office contends that Wei teaches the additional limitations of claim 43, specifically relying on the abstract and Figure 4. Office Action, page 8. Figure 4 shows a stereo view of an object with two black blobs artificially marked thereon, but does not describe selecting such features nor determining a set of object space coordinates for each feature. Wei, page 279, col. 2, first full paragraph. The abstract generally describes using two kinds of sensor day, namely camera images and laser range data, as input to a multilayer feedforward neural network to associate the *direct transformation from the sensory data to the required motions*. Wei, page 276, abstract and col. 2 first full paragraph. Such not only fails to teach the above quoted limitations, but strongly suggests that no intermediate transformations are calculated. If the Office persists in this rejection, Applicants' respectfully request that the Office point out particularly where the above quoted limitations may be found in Wei or at least explain how the Office is inferring such.

Claim 44 depends from claims 43 and 50 and further recites "wherein selecting a number of features from the captured image of the teaching object comprises selecting six features from the captured image of the teaching object."

As explained above, claims 50 and 43 are allowable over McGee and Wei. The Office contends that Wei teaches the additional limitations of claim 43, specifically relying on Figure 4 and discussion of imaging while an object moves along a conveyor. Office Action,

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pages 8-9. However, the cameras in Wei stay fixed, hence while separate images may be captured of an object at each of a plurality of positions as the object translates relative to the cameras. Such appears to simple capture the same features from multiple different orientations. Notable, claim 44 recites selecting six features from *the captured image*, singular, *not* plural, thus Wei does not teach or suggest the limitation of claim 44.

Claim 45 depends from claims 43 and 50 and further recites "determining an object space-to-camera space transformation defining a transformation between an object space reference frame and the camera space reference frame."

As explained above, claims 50 and 43 are allowable over McGee and Wei. The Office relies on Wei for teaching this additional limitation. Office Action, page 9. In particular, the Office interprets "space-to-training space transformation . . . as from object to the camera/range finders, to the training and to the geometric transformation" and has interpreted "a space reference frame . . . as from the reference position to the algorithm module to the camera/range finders, to the shift and finally to the geometric transformation." Id.

Respectfully, Applicants' do not understand what such means. Reference frames are commonly understood as a coordinate system in which one works or takes measurements. Transformations are essentially mathematical based definitions that allow mapping between various reference frames. The Office's interpretation of reference frame does not appear to make sense under any conventional understanding of the term. Clarification is respectfully requested.

In any case, Wei requires two cameras and two laser range finders, which are not co-located. (In fact, stereo placement is required.) Hence, there appears to be no object space-to-camera space transformation. Further, as described in reference to claim 43, Wei teaches *direct transformation from the sensory data to the required motions*. Wei, page 276, abstract and col. 2 first full paragraph. Such not only fails to teach the above quoted limitation, but strongly suggests that no intermediate transformations are calculated.

Claim 46 depends from claims 45, 43 and 50 and further recites "determining a position and an orientation of an object frame in the tool frame reference frame based at least in part on the object frame-to-camera space and camera space-to-tool space transformations."

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As explained above, claims 50, 43 and 45 are allowable over McGee and Wei. The Office relies on Wei for teaching the additional limitation of claim 46. Office Action, page 9. In particular, the Office states that "the reference frame has been considered as position frame and table II for position and orientation." Id. Again, the interpretation appears highly questionable. It is unclear how a table of data is interpreted to be part of a reference frame.

In any case, Wei teaches *direct transformation from the sensory data to the required motions*. Wei, page 276, abstract and col. 2 first full paragraph. Such not only fails to teach the above quoted limitation, but strongly suggests that no intermediate transformations are calculated.

Claim 47 depends from claims 46, 45, 43 and 50 and further recites "providing the position and orientation of the object frame to the robot; and training an intended operation path inside the object frame."

As explained above, claims 50, 43, 45 and 46 are allowable over McGee and Wei. The Office relies on Wei for teaching the additional limitation of claim 47. Office Action, page 9-10. While Wei appears to drive the robot, Wei appears to simply provide required motions directly to the robot. Wei, page 276, abstract and col. 2 first full paragraph. Thus, there would be no reason for Wei to provide position and orientation of the object frame to the robot as recited in claim 47. Nor would such have to take place in the object frame, as opposed to the robot or tool reference frame.

Claim 49 depends from claim 50 and further recites, *inter alia*, "adjusting a position of the movable portion of the robot if the number of features located in the captured image of the target object is determined to be an insufficient number of features."

As explained above, claim 50 is allowable over McGee and Wei. The Office relies on Wei for teaching the additional limitation of claim 49. Office Action, page 10. In particular, the Office appears to be relying on the two images captured by the stereoscopic cameras. Id. However, the stereoscopic cameras capture two images without regard to the number of features located. Wei does not appear to address what would happen if an insufficient number of features were located. In fact, Applicants' representative is unable to find any mention in Wei of a minimum number of features.

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Claim 51 depends from claim 50 and further recites "determining at least one movement of the robot that orients the camera orthogonally with respect to the target object based at least on part on the object space-to-camera space transformation."

As explained above, claim 50 is allowable over McGee and Wei. The Office relies on Wei for teaching the additional limitation of claim 51. Office Action, pages 11-12.

As explained above with reference to claim 35, Applicants note that Wei actually teaches *two* cameras, not *one*. Figure 3 of Wei is an isometric or perspective view, and does not show the relative position or orientation of the cameras with respect to any object or frame of reference. Hence, it is impossible to conclude that the cameras in Wei are positioned orthogonally, and one can only wonder how both cameras can be positioned orthogonally when the cameras must be in a stereoscopic arrangement.

Claim 52 depends from claims 51 and 50 and further recites "determining a position of the object frame in the tool space reference frame; and providing an object frame to the robot."

As explained above, claims 50 and 51 are allowable over McGee and Wei. The Office relies on Wei for teaching the additional limitation of claim 52. Office Action, page 12.

Wei appears to simply provide required motions directly to the robot. Wei, page 276, abstract and col. 2 first full paragraph. Thus, there would be no reason for Wei to provide a position of the object frame in the tool space reference frame nor to provide an object frame to the robot as recited in claim 52.

Claim 53 is independent and recites, *inter alia,* "means for calibrating the camera, by: determining a set of intrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera; and determining a set of extrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera, the set of extrinsic parameters comprising a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame."

The Office relies on Wei for purportedly teaching the above quoted limitations. Office Action, page 12. As discussed above in reference to claim 50, as well as other claims,

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Wei not only fails to teach such, but actively *teaches away* from *camera calibration*. See Wei, page 276, abstract, col. 1, section I first full paragraph.

Claim 53 also recites "locating at least six features in the captured image of the target object." Again the Office relies on Wei for the above quoted limitation. Office Action page 13. As explained above in reference to claim 44, the cameras in Wei stay fixed, hence while separate images may be captured of an object at each of a plurality of positions as the object translates relative to the cameras. Such appears to simple capture the same features from multiple different orientations. Wei does not appear to teach or suggest selecting six features from *the captured image*, singular, *not* plural, thus Wei does not teach or suggest the limitation of claim 53.

Claim 53 further recites, *inter alia,* "determining an object space-to-camera space transformation based at least in part on a position of at least some of the located features in solely the captured image using an algorithm that employs a known or determinable physical relationship between at least some of the located features." Again the Office relies on Wei for the above quoted limitation. Office Action pages 13-14. As previously explained, Wei appears to simply provide required motions directly to the robot. Wei, page 276, abstract and col. 2 first full paragraph. Thus, there would be no reason for Wei to determine an object space to a camera space transformation. In fact, Wei employs two cameras, and the Office fails to consider how such a transformation could possibly make sense

Claim 54 depends from claim 53 and further recites, *inter alia*, "selecting a number of features from the captured image of the teaching object; determining a set of object space coordinates for each of the selected features from the captured image of the teaching object; and determining an object space-to-camera space transformation defining a transformation between an object space reference frame and the camera space reference frame."

Again the Office relies on Wei. Office Action, page 14. Claim 54 however is patentable over the cited references for similar reasons as those explained above in reference to claim 43.

Claim 57 depends from claims 50 and 53 and further recites "adjusting a position of the movable portion of the robot if the number of features located in the captured image of the

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target object is determined to be an insufficient number of features." Claim 57 is patentable over the references for similar reasons as those explained above with reference to claim 49.

Claim 58 is independent and recites, *inter alia*, "means for calibrating the camera, by: determining a set of intrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera; and determining a set of extrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera, the set of extrinsic parameters comprising a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame."

The Office relies on Wei for purportedly teaching the above quoted limitations. Office Action, page 15. As discussed above in reference to claim 50, as well as other claims, Wei not only fails to teach such, but actively *teaches away* from *camera calibration*. See Wei, page 276, abstract, col. 1, section I first full paragraph.

Claim 58 further recites, *inter alai*, "means for estimating a pose of a target object, by: locating at least five features in the captured image of the target object; and determining an object space-to-camera space transformation based at least in part on a position of at least some of the located features using the captured image without any additional captured images and an algorithm that employs a known or determinable physical relationship between at least some of the located features."

The Office relies on Wei for purportedly teaching the above quoted limitations. Office Action, page 16. As discussed above, for example in reference to claim 53, while Wei may teach acquiring separate of an object at each of a plurality of positions as the object translates along a conveyor relative to the cameras, such appears to simple capture the same features from multiple different orientations. Wei does not appear to teach or suggest locating at least five features from *the captured image*, singular, *not* plural. Thus, Wei does not teach or suggest the above quoted limitation of claim 58.

Also as discussed above, for example in reference to claim 53, Wei appears to simply provide required motions directly to the robot. Wei, page 276, abstract and col. 2 first full paragraph. Thus, there would be no reason for Wei to determine an object space to a camera

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space transformation. In fact, Wei employs two cameras, each of which would have their own reference frames. The Office fails to consider how such a transformation could possibly make sense.

Claim 59 depends from claim 58 and further recites "wherein the means for calibrating and the means for estimating a pose comprises at least one programmed computer." The Office relies on Wei for teaching such. Office Action, page 59. However, Wei clearly *teaches away* from calibration of the cameras. See Wei, page 276, abstract, col. 1, section I first full paragraph.

Claim 61 depends from claim 58 and further recites "adjusting a position of the movable portion of the robot if the number of features located in the captured image of the target object is determined to be an insufficient number of features."

The Office Action does not appear to provide any specific explanation of the rejection of claim 61. However, claim 61 is patentable over the references for similar reasons as those explained in reference to claims 49 and 57.

Conclusion

Applicants respectfully submit that the pending claims are in condition for allowance. Any remarks in support of patentability of one claim should not be imputed to any other claim, even if similar terminology is used. Any remarks referring to only a portion of a claim should not be understood to base patentability on that portion; rather, patentability must rest on each claim taken as a whole. Applicants do not acquiesce to each of the Examiner's rejections and to each of the Examiner's assertions regarding what the cited references show or teach, even if not expressly discussed herein.

If the undersigned attorney has overlooked a relevant teaching in any of the references, the Examiner is requested to point out specifically where such teaching may be found. In light of the above remarks, Applicants respectfully submit that all pending claims are allowable. Applicants, therefore, respectfully request that the Examiner reconsider this application and timely allow all pending claims. The Examiner is encouraged to contact the undersigned by telephone to discuss the above and any other distinctions between the claims and

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the applied references, if desired. If the Examiner notes any informalities in the claims, the Examiner is encouraged to contact the undersigned by telephone to expediently correct such informalities.

Respectfully submitted,

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PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a) FY 2009 (Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).)	Docket Number 170154.401C1
Application Number 10/634,874	Filed August 6, 2003
For METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS	
Art Unit 3664	Examiner McDieunel Marc

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

	Fee	Small Entity Fee	
☐ One month (37 CFR 1.17(a)(1))	$130	$65	$_____
☐ Two months (37 CFR 1.17(a)(2))	$490	$245	$_____
☒ Three months (37 CFR 1.17(a)(3))	$1110	$555	$555
☐ Four months (37 CFR 1.17(a)(4))	$1730	$865	$_____
☐ Five months (37 CFR 1.17(a)(5))	$2350	$1175	$_____

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☒ The Director is hereby authorized to charge the above fees, or credit any overpayment, to Deposit Account Number 19-1090.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the ☐ applicant/inventor.

☐ assignee of record of the entire interest. See 37 CFR 3.71
Statement under 37 CFR 3.73(b) is enclosed (Form PTO/SB/96).

☒ attorney or agent of record. Registration No. 38,066

☐ attorney or agent under 37 CFR 1.34.
Registration number if acting under 37 CFR 1.34. _____ .

/Frank Abramonte/	September 2, 2010
Signature	Date
Frank Abramonte	206-622-4900
Typed or printed name	Telephone Number

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required.

SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450. 1699473_1.DOC

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	Babak Habibi et al.
Application No.	:	10/634,874
Filed	:	August 6, 2003
For	:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS

Examiner	:	McDieunel Marc
Art Unit	:	3664
Docket No.	:	170154.401C1
Date	:	September 2, 2010

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

FEE DEFICIENCY AUTHORIZATION FORM

Commissioner for Patents:

Applicants hereby authorize the Director to charge any deficiencies in fees due by way of the enclosed papers only under 37 CFR 1.16 and 1.17 to Deposit Account No. 19-1090.

Respectfully submitted,

SEED Intellectual Property Law Group PLLC

/Frank Abramonte/
Frank Abramonte
Registration No. 38,066

701 Fifth Avenue, Suite 5400
Seattle, Washington 98104
Phone: (206) 622-4900
Fax: (206) 682-6031

1699471_1.DOC

ABB Inc. Exhibit 1002, Page 833 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

REVOCATION OF POWER OF ATTORNEY WITH NEW POWER OF ATTORNEY AND CHANGE OF CORRESPONDENCE ADDRESS		
	Application Number	10/634,874
	Filing Date	August 6, 2003
	First Named Inventor	Babak Habibi
	Art Unit	3664
	Examiner Name	McDieunel Marc
	Attorney Docket Number	170154.401C1

I hereby revoke all previous powers of attorney given in the above-identified application.

☐ A Power of Attorney is submitted herewith.

OR

☒ I hereby appoint the practitioners at Seed IP Law Group PLLC, Customer Number: **00500**

☒ Please change the correspondence address for the above-identified application to:

☒ The address associated with Customer Number **00500**

OR

☐ Firm *or* Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the:

☐ Applicant/Inventor.

☒ Assignee of record of the entire interest. See 37 CFR 3.71. Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96)

☒ As assignee of record of the entire interest I/we hereby elect, under 37 CFR 3.71, to prosecute the application to the exclusion of the inventor(s).

SIGNATURE of Applicant or Assignee of Record

Signature	Rick Wei	Date	September
Name	Rick Weidinger		
Title and Company (Assignee)	Manager		
	RoboticVisionTech LLC		

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below*.

☐ *Total of _____ forms are submitted.

SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

1699606_1.DOC

STATEMENT UNDER 37 CFR 3.73(b)

Applicant/Patent Owner: **Babak Habibi et al.**

Application No./Patent No.: **10/634,874** Filed/Issue Date: **August 6, 2003**

Entitled: **METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS**

RoboticVISIONTech LLC (Name of Assignee) a **Limited liability company** (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that it is:

1. [X] the assignee of the entire right, title, and interest; or
2. [ ] an assignee of less than the entire right, title and interest. (The extent (by percentage) of its ownership interest is _____%)

in the patent application/patent identified above by virtue of either:

A. [ ] An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

OR

B. [X] A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: **Babak Habibi, Simona Pescaru, Mohammad Sameti, and Remus Florinel Boca** To: **Braintech Canada, Inc.**

   The document was recorded in the United States Patent and Trademark Office at Reel **017740**, Frame **0616**, or for which a copy thereof is attached.

2. From: **Braintech Canada, Inc.** To: **Braintech, Inc.**

   The document was recorded in the United States Patent and Trademark Office at Reel **022668**, Frame **0472**, or for which a copy thereof is attached.

3. From: **Braintech, Inc.** To: **RoboticVISIONTech LLC**

   The document was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

[ ] Additional documents in the chain of title are listed on a supplemental sheet.

[X] As required by 37 CFR 3.73(b)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[**NOTE**: A separate copy (*i.e.*, a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

Rick We

Signature _____ Date _____

Rick Weidinger Typed or printed name

Manager Title

SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Docket No. 170154.401C1 1699609_1.DOC

ASSIGNMENT OF RIGHTS AND BILL OF SALE

FOR VALUE RECEIVED, and in consideration for the payment of $2,500,701.37 (the "Purchase Price") by RoboticVISIONTech LLC, a Nevada limited liability company (the "Purchaser"), the undersigned Braintech, Inc., a Nevada corporation, Braintech Industrial, Inc., a Delaware corporate, and Braintech Government & Defense, Inc., a Delaware corporation (collectively, the "Seller") hereby sells, assigns, sets over, and transfers to the Purchaser all right, title and interest of each of the Seller in and to the assets set forth on Exhibit "A" attached hereto and incorporated herein by this reference (the "Assets") "AS IS" and "WHERE IS" and without any representations or warranty, expressed or implied, as to quality, condition or fitness for any particular purpose of the Assets. The Seller does not make any covenants to and with Purchaser of any kind.

IN WITNESS WHEREOF, Seller has executed and delivered this Assignment of Rights and Bill of Sale effective as of this 24th day of May, 2010.

"Seller"

Braintech, Inc.,
a Nevada corporation

By: RoboticVISIONTech LLC,
a Nevada limited liability company
Its: Authorized Representative and Agent

By: Rick Weidinger
Its: Manager

Braintech Industrial, Inc.,
a Delaware corporation

By: RoboticVISIONTech LLC,
a Nevada limited liability company
Its: Authorized Representative and Agent

By: Rick Weidinger
Its: Manager

Braintech Government & Defense, Inc.,
a Delaware corporation

By: RoboticVISIONTech LLC,
a Nevada limited liability company
Its: Authorized Representative and Agent

By: Rick Weidinger
Its: Manager

"Purchaser"

RoboticVISIONTech LLC,
a Nevada limited liability company

By: Rick Weidinger
Its: Manager

OWNER NAME	CASE NO/SUBCASE COUNTRY	APPLICATION NO/DATE	PUBLICATION NO/DATE	PATENT N0/DATE	STATUS	INDIVIDUALS FILING PAPERS IN CONNECTION WITH THIS APPLICATION/PATENT
Braintech, Inc.	170154-401/ USA	10/153680 24-May-2002	20030144765 31-Jul-2003	6816755 09-Nov-2004	Granted (Only CON is listed below)	**[GET THIS FILE WRAPPER, WHICH IS NOT AVAILABLE ONLINE AND WILL TAKE AT LEAST 3 DAYS TO OBTAIN?]** **Assignees (from USPTO assignment records):** **BRAINTECH CANADA, INC.** **102 - 930 WEST 1ST STREET** **NORTH VANCOUVER, BRITISH COLUMBIA V7P 3** **BRAINTECH, INC.** **1750 TYSONS BOULEVARD** **SUITE 350** **MCLEAN, VIRGINIA 22102**
Braintech, Inc.	170154-401CI USA	10/634874 06-Aug-2003	20040172164 02-Sep-2004		Published (no con)	Original filing firm: Oyen Wiggs Green & Mutala Suite 480—The Station 601 West Cordova Street Vancouver, British Columbia Canada V6B 1G1 Oyen attorneys/agents of record: Gerald O.S. Oyen 27,280 Blake R. Wiggs 29,505 Bruce M. Green 30,524 David J. McGruder 32,375 Thomas W. Bailey 36,411 Gavin N. Manning 36,412 George F. Kondor 40,477 Craig A. Ash 48,228 Hilton W.C. Sue 51,325 (Bruce Green signed several filings)

ABB Inc. Exhibit 1002, Page 837 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

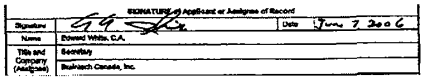
						Agent of record: SEED INTELLECTUAL PROPERTY LAW GROUP PLLC 701 FIFTH AVE SUITE 6300 SEATTLE WA 98104-7092 Including (for specific filings): Seed Intellectual Property Law Group PLLC  Frank Abramonte Registration No. 38,066 And SEED Intellectual Property Law Group PLLC /Eric M. Ringer, Ph.D./ Eric M. Ringer, Ph.D. Registration No. 47,028 Current Agent of Record: SEED INTELLECTUAL PROPERTY LAW GROUP PLLC 701 FIFTH AVE SUITE 5400 SEATTLE WA 98104 Named assignee: WHEREAS, Braintech Canada, Inc. (hereinafter referred to as ASSIGNEE), a Canadian corporation having a place of business at 102 - 930 West 1st Street, North Vancouver, British Columbia, Canada V7P 3N4, is desirous of acquiring the entire right, title and interest in Making a submission on behalf of Braintech:  SIGNATURE of Applicant or Assignee of Record Signature Date June 7 2006 Name Edward White, C.A. Title and Company (Assignee) Secretary Braintech Canada, Inc. Inventors:

ABB Inc. Exhibit 1002, Page 838 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

						Babak HABIBI _____ _____ 3308 Manning Crescent North Vancouver, B.C. V7H 2R6 Canada Dr. Simona PESCARU _____ _____ 113 - 980 West 1st Street North Vancouver, B.C. V7P 3N4 Canada

ABB Inc. Exhibit 1002, Page 839 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

						Remus Florinel BOCA _____ _____ 512 - 2012 Fullerton Avenue North Vancouver, B.C. V7P 3E3 Canada Mohammad SAMETI _____ _____ 2608 Sandstone Court Coquitlam, B.C. V3E 2T9 Canada
Braintech, Inc.	170154-401CA/ Canada	2369845 31-Jan-2003			Abandoned	Not U.S.
Braintech, Inc.	170154-401EP/ European Patent Convention	03734637.6 31-Jan-2003	1472052 03-Nov-2004		Abandoned	Not U.S.
Braintech, Inc.	170154-401JP/	2003-563782 31-Jan-2003	05-515910 02-Jun-2005		Abandoned	Not U.S.

ABB Inc. Exhibit 1002, Page 840 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

	Japan					
Braintech, Inc.	170154-401PC/ Patent Cooperation Treaty	CA2003/000139 31-Jan-2003	WO2003/064116 07-Aug-2003		Converted	Not U.S.
Braintech, Inc.	170154-402/ USA	11/183228 14-Jul-2005	20060088203 27-Apr 2006	7336814 26-Feb-2008	Granted (no further CON)	Named assignee: Braintech Canada, Inc. 102 – 930 West 1st Street North Vancouver BC Canada V7P 3N4 Inventors (if different address than already listed): BOCA, Remus 2009 - 2024 Fullerton Avenue North Vancouver, British Columbia V7P 3G4 Canada PESCARU, Simona 507 - 1263 Barclay Street Vancouver, British Columbia V6E 1H5 Canada
Braintech, Inc.	170154-402CA/Canada	2573728 14-Jul-2005			Abandoned	Not U.S.
Braintech, Inc.	170154-402EP/ European	05770174.0 14-Jul-2005	1776580 28-Mar-2007		Abandoned	Not U.S.

	Patent Convention					
Braintech Canada, Inc.	170154-402JP/ Japan	2007-521657 14-Jul-2005	2008-506953 06-Mar-2008		Published	Not U.S.
Braintech, Inc.	170154-402PI/ USA	60/587488 14-Jul-2004			NP-Filed (gives priority to PCT/US05/25083 and 11/183,228(included separately in this list))	No individuals who were not previously cited above.

ABB Inc. Exhibit 1002, Page 843 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

OWNER NAME	CASE NO/SUBCASE COUNTRY	APPLICATION NO/DATE	PUBLICATION NO/DATE	PATENT N0/DATE	STATUS	INDIVIDUALS FILING PAPERS IN CONNECTION WITH THIS APPLICATION/PATENT
Braintech, Inc.	170154-402PC/ Patent Cooperation Treaty	US2005/025083 14-Jul-2005	WO2006/019970 23-Feb-2006		Converted (no CON LISTED)	No individuals who were not previously cited above.
Braintech, Inc.	170154-404/ USA	11/534578 22-Sep-2006	20070073439 29-Mar-2007		Abandoned (no CON; priority provisional application listed separately)	Not considered because application was abandoned.
Brainech, Inc.	170154-404EP/ European Patent Convention	06815392.3/ 22-Sep-2006	1927038 04-Jun-2008		Abandoned	Not U.S.
Braintech, Inc.	170154-404JP/ Japan	2008-532487 22-Sep 2006	2009-509779 12-Mar-2009		Abandoned	Not U.S.
Braintech, Inc.	170154-404PI/ USA	60/719765 23-Sep-2005			NP-Filed (priority for 11/534,578 and PCT/US06/ 37346 (both separately listed))	The following individuals could be ignored because this application is not the basis of any pending or issued U.S. patents: Agent making a filing (with Seed Intellectual ….): DATE: September 23, 2005 Raymond W. Armentrout — REGISTRATION NO (if appropriate): 45,866 206-622-4900 — DOCKET NUMBER: 170154.404P1 Inventors (different addresses):

ABB Inc. Exhibit 1002, Page 844 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

						Babak Habibi North Vancouver BC Canada 1680 Orkney Place North Vancouver BC Canada V7P 3N4 Geoff Clark Vancouver BC Canada Vancouver BC Canada
Braintech, Inc.	170154-404PC/ Patent Cooperation Treaty	US2006/037346 22-Sep-2006	WO2007/035943 29-Mar-2007		Canceled (no CONs)	Ignored because not the basis of any pending or issued U.S. patents
Braintech, Inc.	170514-405 USA	11/957258 14-Dec-2007	2008/0181485 31-Jul-2008		Published (claims priority to 60/875,073; no CONs)	Inventors: WHEREAS, we, Jeffrey S. Beis and Babak Habibi (hereinafter referred to as ASSIGNORS), having mailing addresses of 5425 Indian River Drive, North Vancouver, British Columbia, Canada V7G 2T7 and 1680 Orkney Place, North Vancouver, British Columbia, Canada V7H 2Z1, respectively, are the joint inventors of an invention entitled "SYSTEM AND

ABB Inc. Exhibit 1002, Page 845 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Braintech, Inc.	170154-405PI/ USA	US2007/0887669 14-Dec-2007 (second 8 is error; there is no such application)	WO2008/076942 26 Jun-2008		Published	**TYPO** (actual application, US2007/087669, is separately listed below)
		60/875,073 (filed 12/15/06)			(is priority document for 11/957,258 and PCT/US07/ 87669 (both separately listed))	No new unique individuals.
Braintech, Inc.	170154-405PC/ Patent Cooperation Treaty	US2007/087669 14-Dec-2007	WO2008/076942 26-Jun-2008		Published (based on 60/875,073 (separately listed)	**Inventors:** BEIS, Jeffrey, S. 5425 Indian River Drive North Vancouver, British Columbia V7G 2T7 Canada HABIBI, Babak 1680 Orkney Place North Vancouver, British Columbia V7H 2Z1 Canada
Braintech, Inc.	170154-406/ USA	11/779812 18-Jul-2007	20080144884 19-Jun-2008		Published (based on 60/832,356 (separately listed); no CONs)	No new unique individuals
Braintech, Inc.	170154-406PI/ USA	60/832356 20-Jul-2006			NP-Filed 20-Jul-2007 (gives priority to 11/779,812 (separately	No new unique individuals

ABB Inc. Exhibit 1002, Page 846 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

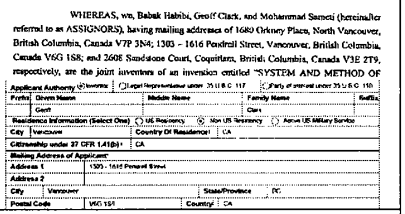
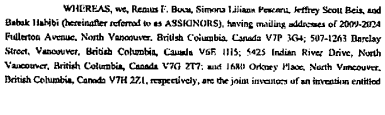
					listed))	
Braintech, Inc.	170154-407/ USA	11/754218 25-May-2007	20070276539 29-Nov-2007		Published (base don 60/808,903 (separately listed); no CONs)	Inventors:  WHEREAS, we, Babak Habibi, Geoff Clark, and Mohammad Saeedi (hereinafter referred to as ASSIGNORS), having mailing addresses of 1680 Orkney Place, North Vancouver, British Columbia, Canada V7P 3N4; 1303 - 1616 Pendrell Street, Vancouver, British Columbia, Canada V6G 1S8; and 2608 Sandstone Court, Coquitlam, British Columbia, Canada V3E 2T9, respectively, are the joint inventors of an invention entitled "SYSTEM AND METHOD OF
Braintech, Inc.	170154-407PI/ USA	60/808903 25-May-2006			NP-Filed (priority application for 11/754,218 and PCT/US07/ 12571 (both separately listed)	Inventor: Geoff Clark Vancouver BC Canada 1303 – 1616 Pendrell Street Vancouver BC Canada V6G 1S8
Braintech, Inc.	170154-407PC/ Patent Cooperation Treaty	US2007/012571 25-May-2007	WO2007/149183 27-Dec-2007		Abandoned (based on 60/808,903 (separately listed)	No new unique individuals.
Braintech, Inc.	170154-408/ USA	11/857680 19-Sep-2007	20080069435 20-Mar-2008		Published (base don 60/845,932 (separately listed); no CON)	Inventors:  WHEREAS, we, Renato F. Bosa, Simona Liliana Pescaru, Jeffrey Scott Beis, and Babak Habibi (hereinafter referred to as ASSIGNORS), having mailing addresses of 2009-2024 Fullerton Avenue, North Vancouver, British Columbia, Canada V7P 3G4; 507-1263 Barclay Street, Vancouver, British Columbia, Canada V6E 1H5; 5425 Indian River Drive, North Vancouver, British Columbia, Canada V7G 2T7; and 1680 Orkney Place, North Vancouver, British Columbia, Canada V7H 2Z1, respectively, are the joint inventors of an invention entitled

ABB Inc. Exhibit 1002, Page 847 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Braintech, Inc.	170154-408PI/ USA	60/845932 19-Sep-2006			NP-Filed (priority application for PCT/US07/ 20365 and 11/857,680 (both separately listed))	No new individuals.

ABB Inc. Exhibit 1002, Page 848 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

OWNER NAME	CASE NO/SUBCASE COUNTRY	APPLICATION NO/DATE	PUBLICATION NO/DATE	PATENT N0/DATE	STATUS	INDIVIDUALS FILING PAPERS IN CONNECTION WITH THIS APPLICATION/PATENT
Braintech, Inc.	170154-408PC/ Patent Cooperation Treaty	US2007/020365 19-Sep-2007	WO2008/036354 27-Mar-2008pp		Abandoned (based on 60/845,932 (separately listed); no CON)	No new individuals.
Braintech, Inc.	170154-409/ USA	11/833187 02-Aug-2007	20090033655 05-Feb-2009		Published (priority application for PCT/US08/ 71983 (separately listed))	No new individuals
Braintech Canada, Inc.	170154-409PC/ Patent Cooperation Treaty	US2008/071983 01-Aug-2008	WO2009/018538 05-Feb-2009		Published (based on 11/833,187 (separately listed))	No new individuals.
	170154-410/ USA				Never Filed	n/a
Braintech, Inc.	170154-410PI/ USA	60/971490 11-Sep-2007			Expired	**Unable to determine because this application is not publicly available because it is not the basis of a published application or issued patent**
	170154-410PC/ Patent				Never Filed	n/a

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ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

	Cooperation Treaty					
Inventor(s) is Owner/Applicant	170154-411/ USA	12/176190 18-Jul-2008	20100017033 (published 01-21-2010)		Pending (no CON or priority applications)	No new individuals. NOTE: there are no assignment documents recorded at the USPTO for this application.
	170154-412PI/ USA				Never Filed	n/a
	170154-413PI/ USA				Never Filed	n/a
	170154-414PI/ USA				Never Filed	n/a
Inventor(s) is Owner/Applicant	170154-415/ USA	12/249658 10-Oct-2008	US 20100092032, published 04-15-2010		Published (no CON or priority documents)	No new individuals. NOTE: there are no assignment documents recorded at the USPTO for this application.

ABB Inc. Exhibit 1002, Page 850 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Electronic Patent Application Fee Transmittal

Application Number:	10634874
Filing Date:	06-Aug-2003
Title of Invention:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS
First Named Inventor/Applicant Name:	Babak Habibi
Filer:	Frank Abramonte/Connie Charniak
Attorney Docket Number:	170154.401C1

Filed as Small Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 3 months with $0 paid	2253	1	555	555

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
		Total in USD ($)		**555**

Electronic Acknowledgement Receipt

EFS ID:	8350022
Application Number:	10634874
International Application Number:	
Confirmation Number:	7619
Title of Invention:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS
First Named Inventor/Applicant Name:	Babak Habibi
Customer Number:	00500
Filer:	Frank Abramonte/Connie Charniak
Filer Authorized By:	Frank Abramonte
Attorney Docket Number:	170154.401C1
Receipt Date:	02-SEP-2010
Filing Date:	06-AUG-2003
Time Stamp:	20:08:13
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$555
RAM confirmation Number	5406
Deposit Account	191090
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Amendment/Req. Reconsideration-After Non-Final Reject	170154_401C1_RESP.pdf	129072 07924c264e0d90c749a1c1c6dbf00c2a2b33bcfb	no	15
Warnings:					
Information:					
2	Extension of Time	170154_401C1_EOT.pdf	86997 1818537629 15f36534992f238658d1a800c84ce4	no	1
Warnings:					
Information:					
3	Miscellaneous Incoming Letter	170154_401C1_FDA.pdf	51237 2156a9da834db4fe9a9b5fef1f91eee8c6fdd2f4	no	1
Warnings:					
Information:					
4		170154_401C1_FORMALS.pdf	438878 ba4f865dc7a9317423dab7f47241cf891a51e133	yes	17

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Power of Attorney	1	1
	Assignee showing of ownership per 37 CFR 3.73(b).	2	17

Warnings:					
Information:					
5	Fee Worksheet (PTO-875)	fee-info.pdf	30449 f0a1b0d059e14077d02627b921f31e7cecfebecc	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	736633		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/634,874	08/06/2003	Babak Habibi	170154.401C1	7619

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EXAMINER	
MARC, MCDIEUNEL	

ART UNIT	PAPER NUMBER
3664	

MAIL DATE	DELIVERY MODE
12/15/2010	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/634,874	HABIBI ET AL.	
	Examiner	Art Unit	
	McDieunel Marc	3664	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *02 September 2010*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *33-47 and 49-61* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) *33-47, 50-56 and 58-60* is/are allowed.

6)☐ Claim(s) _____ is/are rejected.

7)☒ Claim(s) *49,57 and 61* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *5/6/09* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *6/5/09*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

ABB Inc. Exhibit 1002, Page 857 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

DETAILED ACTION

1. Claims 33-47 and 49-61 are pending.

2. The rejection to claims 33-38, 40-47 and 49-61 are rejected under 35 U.S.C. 103(a) as being unpatentable over McGee et al. (US 4942539 A) in view of Wei et al. (Multisensory Visual servoing by a Neural Network, 1999) is withdrawn.

3. The objection to claim 39 is withdrawn.

4. Applicant's arguments with respect to claims 33-47 and 49-61 have been considered but are moot in view of the new ground(s) of rejection. See rejection below.

Claim Rejections - 35 USC § 112

5. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

6. Claim 50 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. The phrase "using only the single captured image" does not have any support in the specification.

Specification

7. The amendment filed 06/05/2009 is objected to under 35 U.S.C. 132(a) because it introduces new matter into the disclosure. 35 U.S.C. 132(a) states that no amendment shall introduce new matter into the disclosure of the invention. The added material which is not supported by the original disclosure is as follows: See claim 50, wherein the phrase "using only the single captured image" does not have any support in the specification. Applicant is required to cancel the new matter in the reply to this Office Action.

8. The abstract of the disclosure is objected to because the web address should not be in the specification on page 6, line 11, "http://www.ai.mit.edu/people/bkph/papers/tsaiexplain.pdf". Correction is required. See MPEP § 608.01(b).

Claim Rejections - 35 USC § 103

9. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

10. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any

evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

11. Claims 33-35, 38, 41, 42 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al. (US 20020159628) in view of McGee et al. (4,942,539).

A per claim 33, Matusik et al. (US 20020159628) teaches capturing a number of images (see abs. particularly "A system digitizes a three-dimensional object as a three-dimension model by ") of a calibration object by the camera (see section [0022]);
determining a set of intrinsic parameters of the camera (see sections [0027-0028]) from at least one of the number of images (see abs. particularly "A system digitizes a three-dimensional object as a three-dimension model by ") of the calibration object captured by the camera (see section [0026]); and determining a set of extrinsic parameters of the camera from at least one of the number of images (see abs. particularly "A system digitizes a three-dimensional object as a three-dimension model by") of the calibration object captured by the camera (see section [0026]), the set of extrinsic parameters comprising (see sections [0027 and 0028]). Matusik et al. does not specifically teach a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame.

McGee et al. (4,942,539) teaches a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference

frame (see abs., wherein reference data has been reference frame; and "The offset is then transformed into the coordinate system or frame" has been taken defined transformation; and fig. 1, has shown evidence of a camera placed above the object which has been considered as space-to-training).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., with the teaching of McGee et al., because this modification would have introduced frame into frame into Matusik's et al. teaching, thereby "The camera is calibrated to determine internal camera geometric and optical characteristics (intrinsic parameters) and the 3-D position and orientation of the camera frame relative to the coordinate system at the station 12." (see McGee et al. col. 5, lines 54-58).

A per claim 34, Matusik et al. teaches a method positioning the camera with respect to the calibration object (see sections [0023 and 0026]).

A per claim 35, Matusik et al. teaches method wherein positioning the camera with respect to the calibration object (see sections [0023 and 0026]) comprises positioning the camera orthogonally with respect to a ruled template with a number of features (see fig. 1, wherein element 130 being placed orthogonally), where a known or determinable physical relationship exists between at least some of the features (see fig. 2, wherein physical relationship exists between element 130 and the object 150).

A per claim 38, Matusik et al. teaches a wherein capturing a number of images (see abs. particularly "A system digitizes a three-dimensional object as a three-dimension model by ") of a calibration object by the camera (see section [0022]) comprises capturing at least one image at each of a plurality of different orientations with respect to the calibration object (see section [0025]).

A per claim 41, Matusik et al. teaches a further comprising: based at least in part on at least two of the number of images (see abs. particularly "A system digitizes a three-dimensional object as a three-dimension model" and fig. 1, element 130, wherein each has been considered image taken means) captured by the camera of the calibration object (see section [0026]). Matusik et al. does not specifically teach determining a camera space-to-tool space transformation.

McGee et al. (4,942,539) teaches a camera space-to-tool space transformation (see abs., wherein reference data has been reference frame; and "The offset is then transformed into the coordinate system or frame" has been taken defined transformation; and fig. 1, has a camera which has been considered as space-to-tool).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., with the teaching of McGee et al., because this modification would have introduced frame into frame into Matusik's et al. teaching, thereby "The camera is calibrated to determine internal camera geometric and optical characteristics (intrinsic parameters) and the 3-D position and orientation of the camera frame relative to the coordinate system at the station 12." (see McGee's et al. col. 5, lines 54-58).

A per claim 42, Matusik et al. teaches a further comprising: determining a camera space-to-tool space transformation based on single one of the number of images (see abs. particularly "A system digitizes a three-dimensional object as a three-dimension model") captured by the camera of the calibration object (see section [0026]). Matusik et al. does not specifically teach a number of physical coordinates of at least one feature of the calibration object.

McGee et al. (4,942,539) teaches a number of physical coordinates of at least one feature of the calibration object (see abs., and fig. 1, has a object which has been as having physical coordinates).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., with the teaching of McGee et al., because this modification would have introduced coordinate into frame into Matusik's et al. teaching, thereby "The camera is calibrated to determine internal camera geometric and optical characteristics (intrinsic parameters) and the 3-D position and orientation of the camera frame relative to the coordinate system at the station 12." (see McGee's et al. col. 5, lines 54-58).

12. Claim 36, 37 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al. in view of McGee et al. as applied to claim 33 above, and further in view of Nayar et al. (US 5,802,201).

A per claim 36, Matusik et al. teaches a method wherein positioning the camera with respect to the calibration object (see sections [0023 and 0026]) comprises positioning the camera

with respect to a sample of a type of object (see fig. 1, elements 130 and 150, and element 150 has been taken for the object sample) where a known or determinable physical relationship exists between at least some of the features (see fig. 2, wherein physical relationship exists between element 130 and the object 150). Matusik et al. does not specifically teach a robot that that will manipulate, the sample having a number of features.

Nayar et al. (US 5,802,201) teaches a robot (see fig. 2, element 100) that will manipulate, the sample having a number of features (see col. 5, lines 23-35).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., with the teaching of Nayar et al., because this modification would have (introduced, provided, increased, added, enhanced) into Matusik's et al. teaching, thereby "" (see Nayar's et al.).

A per claim 37, Matusik et al. teaches a method wherein capturing a number of images (see abs. particularly "A system digitizes a three-dimensional object as a three-dimension model by ") of a calibration object by the camera (see section [0022]) comprises capturing at least one image at each of a plurality of positions (see section [0024]). Matusik et al. does not specifically teach capturing image spaced perpendicularly from the calibration object.

Nayar et al. teaches a robot capturing image spaced perpendicularly from the calibration object (see abs. and fig. 1, wherein the camera has been place on top of the object perpendicularly).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., with the teaching of Nayar et al.,

because this modification would have (introduced, provided, increased, added, enhanced) into Matusik's et al. teaching, thereby "" (see Nayar's et al.).

13. Claim 39 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al. in view of McGee et al. as applied to claim 33 above, and further in view of Armstrong et al. (US 20040233461) and Rhoads (US 20100040255)..

A per claim 39, Matusik et al. teaches in combination with McGee et al. a wherein determining a set of intrinsic parameters of the camera (see sections [0027-0028]) from the at least one of the number of images (see abs. particularly "A system digitizes a three-dimensional object as a three-dimension model by ") of the calibration object captured by the camera (see section [0026]). Matusik et al. does not specifically teach determining at least one of a focal length, a first order radial lens distortion coefficient, a set of coordinates of a center of a radial lens distortion, or a scale factor indicative of a frame grabber scanline resampling uncertainty.

Armstrong et al. (US 20040233461) teaches determining at least one of a focal length, a first order radial lens distortion coefficient (see sections [0054 and 0055], wherein the radial distortion has been considered as first order coefficient), a set of coordinates of a center of a radial lens distortion (see section [0056]), or a scale factor (see sections [0011, 0053 and 0083]) indicative of a framegrabber scanline resampling uncertainty (see sections [0374 and 0379], for scaling).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al. and McGee et al., with the teaching

of Armstrong et al. because this modification would have introduced translation and rotation into Matusik's et al. and McGee's et al. teaching, thereby "camera coordinate systems may be rotated in three-dimensional space with respect to the other" (see Armstrong's et al. section [0026]).

Although, Armstrong et al. in combination of Matusik et al. teach a scale, but not a scale factor, and framegrabber.

Rhoads (US 20100040255) teaches the well known features of scale factor (see section [0165]), and framegrabber (see section [0306]).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., McGee et al., and Armstrong et al. with the teaching of Rhoads, because this modification would have introduced scale factor into Matusik's et al. and McGee's et al. teaching, thereby "processing data representing video" (see Rhoads' abs.).

14. Claim 40 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al. in view of McGee et al. as applied to claim 33 above, and further in view of Armstrong et al. (US 20040233461)..

A per claim 40, Matusik et al. teaches a wherein determining a set of extrinsic parameters of the camera from at least one of the number of images (see abs. particularly "A system digitizes a three-dimensional object as a three-dimension model by ") of the calibration object captured by the camera (see section [0026]), the set of extrinsic parameters comprising (see

sections [0027 and 0028]). Matusik et al. does not specifically teach a camera space-to- training space transformation defining a transformation between a camera space reference frame and a training space reference frame.

McGee et al. (4,942,539) teaches a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame (see abs., wherein reference data has been reference frame; and "The offset is then transformed into the coordinate system or frame" has been taken defined transformation; and fig. 1, has shown evidence of a camera placed above the object which has been considered as space-to-training).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., with the teaching of McGee et al., because this modification would have introduced frame into frame into Matusik's et al. teaching, thereby "The camera is calibrated to determine internal camera geometric and optical characteristics (intrinsic parameters) and the 3-D position and orientation of the camera frame relative to the coordinate system at the station 12." (see McGee et al. col. 5, lines 54-58).

Matusik's et al. and McGee et al. comprises determining a respective translation component along three orthogonal axes, and a respective rotation component about the three orthogonal axes.

Armstrong et al. (US 20040233461) teaches determining a respective translation component along three orthogonal axes (see sections [0011, 0030 and 0031] for three orthogonal axes), and a respective rotation component about the three orthogonal axes (see abs., for rotation; and section [0011] for three orthogonal axes).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al. and McGee et al., with the teaching of Armstrong's et al. because this modification would have introduced translation and rotation into Matusik's et al. and McGee's et al. teaching, thereby "camera coordinate systems may be rotated in three-dimensional space with respect to the other" (see Armstrong's et al. section [0026]).

15. Claims 43 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al. in view of McGee et al. as applied to claim 33 above, and further in view of Horn (US 20010034481).

A per claim 43, Matusik et al. teaches a method that further comprising: capturing an image of a teaching object of a type of object that will be manipulated by the robot (see fig. 2, element 100); selecting a number of features from the captured image of the teaching object (see col. 3, lines 48-58, wherein retrieving has been taken as selecting). Matusik et al. does not specifically teach determining a set of object space coordinates for each of the selected features from the captured image of the teaching object.

Horn (US 20010034481) teaches photogrammetric sensor position estimation including determining a set of object space coordinates for each of the selected features from the captured image of the teaching object (see section [0017], wherein a set of object...for each camera met the set of ...).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., and McGee et al. with the teaching of Horn, because this modification would have introduced object space coordinates into Matusik's et al. and McGee et al. teaching, thereby "the camera position and field of view are also preferably selected so that the number of features, m, in each image are the same, and that the same m objects have been imaged in each image." (see Horn's section [0055]).

16. Claims 44 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al. in view of McGee et al. and Horn as applied to claim 33 above, and further in view of Nayar et al. (US 5,802,201).

A per claim 44, Matusik et al. teaches essential features of the invention substantially as claimed, but fails to teach a system wherein selecting a number of features from the captured image of the teaching object comprises selecting six features from the captured image of the teaching object.

Nayar et al. (US 5,802,201) teaches selecting a number of features from the captured image (see col. 3, lines 48-58, wherein retrieving has been taken as selecting) of the teaching object comprises selecting six features from the captured image of the teaching object (see col. 9, lines 19-21, wherein the six points have been considered as six features).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al. McGee et al., and Horn with the teaching of Nayar et al., because this modification would have introduced six points as six

features into Matusik's et al. McGee's et al. and Horn's teaching, thereby "three dimensional information is retrieved" (see Nayar's et al. col. 4, lines 32-33).

17. Claims 45-47 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al. in view of McGee et al. and Horn as applied to claim 33 above, and further in view of Maguire, Jr. (US 20100231706).

A per claim 45, Matusik et al. McGee et al. and Horn teach essential features of the invention substantially as claimed, but they fail to teach a determining an object space-to-camera space transformation defining a transformation between an object space reference frame and the camera space reference frame.

Maguire, Jr. (US 20100231706) teaches a camera including determining an object space-to-camera space transformation defining a transformation between an object space reference frame and the camera space reference frame (see abs.).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al. McGee et al. and Horn, with the teaching of Maguire, Jr., because this modification would have introduced reference frame of an object into Matusik's et al. McGee's et al. and Horn's teaching, thereby "successive images are computer generated images produced by a computer workstation from successive images taken from a camera navigated by a person within a three-axis reference frame of an object space" (see Mauire's Jr., claim 11).

A per claims 46 and 47, Matusik et al. McGee et al., Horn and Maguire, Jr. teach essential features of the invention substantially as claimed, but they fail to teach determining a position and an orientation of an object frame in the tool frame reference frame based at least in part on the object frame-to-camera space and camera space-to-tool space transformations; providing the position and orientation of the object frame to the robot; and training an intended operation path inside the object frame.

Maguire, Jr. teaches determining a position and an orientation of an object frame in the tool frame reference frame (see section [0008], wherein the virtual reality has been considered as reference frame for providing images in a display) based at least in part on the object frame-to-camera space and camera space-to-tool space transformations(see abs., and section [0161]); providing the position and orientation of the object frame to the robot (see sections [0016 and 0018]); and training an intended operation path inside the object frame (see abs.).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al. McGee et al. Horn and Maguire, Jr., with the teaching of Maguire, Jr., because this modification would have introduced reference frame of an object into Matusik's et al. McGee's et al. Horn's and Maguire's, Jr. teaching, thereby "successive images are computer generated images produced by a computer workstation from successive images taken from a camera navigated by a person within a three-axis reference frame of an object space" (see Mauire's Jr., claim 11).

18. Claim 50 is rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al., in view of Horn, Bancroft et al. and Ishiyama.

A per claim 50, Matusik et al. teaches substantially a method comprising: an algorithm that employs a known or determinable physical relationship between at least some of the located features (see fig. 2, wherein physical relationship exists between element 130 and the object 150). Matusik et al. teaches does not teach determining an object space-to-camera space transformation for the target object based at least in part on a position of at least some of the located features using only the captured image; a single camera mounted to a movable portion of a robot; capturing a two-dimensional image of a volume containing a target object; locating a number of features in the captured image of the target object; a single camera mounted to a movable portion of a robot; useful in three-dimensional pose estimation for use with, the method.

Horn (US 20010034481) teaches determining an object space-to-camera space transformation for the target object based at least in part on a position of at least some of the located features using only the captured image (see abs.).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., with the teaching of Horn, because this modification would have introduced object space coordinates into Matusik's et al. teaching, thereby "the camera position and field of view are also preferably selected so that the number of features, m, in each image are the same, and that the same m objects have been imaged in each image." (see Horn's section [0055]).

Matusik et al. and Horn teach essential features of the invention substantially as claimed, but they fail to teach a single camera mounted to a movable portion of a robot; a system that is useful in three-dimensional pose estimation.

Bancroft et al. (US 6,584,375) teaches a single camera mounted to a movable portion of a robot (see col. 22, lines 35-38, wherein the camera has been considered mounted on a movable part).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., and Horn with the teaching of Bancroft et al., because this modification would have introduced a camera mounted to the robot into Matusik's et al. and Horn's teaching, thereby " the robot equipped with audio and video equipment that can provide a record of what the robot observes while monitoring the retail environment" (see Bancroft's col. 35, lines 35-38).

Matusik et al. Horn and Bancroft et al. teach essential features of the invention substantially as claimed, but they fail to teach a system that is useful in three-dimensional pose estimation.

Ishiyama (US 20010033685) teaches a system that is useful in three-dimensional pose estimation (see abs., and section [0001]).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., Horn and Bancroft et al. with the teaching of Ishiyama, because this modification would have introduced frame into frame into Matusik's et al. Horn's and Bancroft's et al. teaching, thereby "2-D image of target object is obtained by use of a camera 55 as in input image." (see Ishiyama's section [0011]).

19. Claims 51 and 52 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al., in view of Horn, Bancroft et al. and Ishiyama as applied to claim 50 above, and further in view of Hudson (US 20010055069).

A per claims 51 and 52, Matusik et al., Horn and Bancroft et al. and Ishiyama teach essential features of the invention substantially as claimed, but they fail to teach determining at least one movement of the robot that orients the camera orthogonally with respect to the target object.

Hudson (US 20010055069) teaches a camera orthogonally-mounted including determining at least one movement of the robot that orients the camera orthogonally with respect to the target object (see abs. and section [0003]).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., Horn Bancroft et al. and Ishiyama with the teaching of Hudson, because this modification would have introduced frame into frame into Matusik's et al. Horn's Bancroft's et al. and Ishima's teaching, thereby "2-D image of target object is obtained by use of a camera 55 as in input image." (see Ishiyama's section [0011]).

20. Claims 53 and 58 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al., in view of McGee et al. and Ishiyama.

A per claims 53 and 58, Matusik et al. teaches a system and an associated method a single camera operable to capture a number of images (see abs. particularly "A system digitizes a three-dimensional object as a three-dimension model by ") of a calibration object means for calibrating the camera, by: determining a set of intrinsic parameters of the camera (see sections [0027-0028]) from at least one of the number of images (see abs. particularly "A system digitizes a three-dimensional object as a three-dimension model by ") of the calibration object captured by the camera (see section [0026]); and determining a set of extrinsic parameters of the camera from at least one of the number of images (see abs. particularly "A system digitizes a three-dimensional object as a three-dimension model by ") of the calibration object captured by the camera (see section [0026]), the set of extrinsic parameters comprising (see sections [0027 and 0028]) determining an object space-to-camera space transformation based at least in part on a position of at least some of the located features in solely the captured image (see abs. particularly "A system digitizes a three-dimensional object as a three-dimension model"). Matusik et al. does not specifically teach a system useful in robotics (see fig. 2, element 100) a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame (see abs.); and locating at least six features in the captured image of the target object; and using an algorithm that employs a known or determinable physical relationship between at least some of the located features.

McGee et al. (4,942,539) teaches useful in robotics (see fig. 2, element 100) a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame (see abs., wherein reference data has been reference frame; and "The offset is then transformed into the coordinate system or frame" has

been taken defined transformation; and fig. 1, has shown evidence of a camera placed above the object which has been considered as space-to-training).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., with the teaching of McGee et al., because this modification would have introduced frame into frame into Matusik's et al. teaching, thereby "The camera is calibrated to determine internal camera geometric and optical characteristics (intrinsic parameters) and the 3-D position and orientation of the camera frame relative to the coordinate system at the station 12." (see McGee's et al. col. 5, lines 54-58).

Matusik et al., and McGee et al. teach essential features of the invention substantially as claimed, but fail to teach means for estimating a pose of a target object, by: capturing a two-dimensional image of a volume containing a target object.

Ishiyama teaches means for estimating a pose of a target object (see abs., section [0001]), by: capturing a two-dimensional image of a volume containing a target object (see section [0003]).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., and McGee et al. with the teaching of Ishiyama, because this modification would have introduced frame into frame into Matusik's et al. and McGee's et al. teaching, thereby "2-D image of target object is obtained by use of a camera 55 as in input image." (see Ishiyama's section [0011]).

21. Claim 54 is rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al., McGee et al., and Ishiyama and Horn (US 20010034481)..

A per claim 54, Matusik et al. teaches a further comprising: means for training, comprising: capturing an image of a teaching object of a type of object that will be manipulated by the robot (see fig. 2, element 100); selecting a number of features from the captured image of the teaching object (see col. 3, lines 48-58, wherein retrieving has been taken as selecting). Matusik et al. does not specifically teach determining a set of object space coordinates for each of the selected features from the captured image of the teaching object; and determining an object space-to-camera space transformation defining a transformation between an object space reference frame and the camera space reference frame.

Horn (US 20010034481) teaches a set of object space coordinates for each of the selected features from the captured image of the teaching object (see section [0017], wherein a set of object...for each camera meet the set of ...); and determining an object space-to-camera space transformation defining a transformation between an object space reference frame and the camera space reference frame (see abs.).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., and McGee et al. with the teaching of Horn, because this modification would have introduced object space coordinates into Matusik's et al. and McGee et al. teaching, thereby "the camera position and field of view are also preferably selected so that the number of features, m, in each image are the same, and that the same m objects have been imaged in each image." (see Horn's section [0055]).

22. Claims 55 and 59 rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al., in view of McGee et al. and Ishiyama as applied to claims 53 and 58 above, and further in view of Nayar et al. (US 5,802,201)..

A per claims 55 and 59, Matusik et al. teaches essential features of the invention substantially as claimed, but fails to teach a system wherein the means for estimating a pose, and the means for training comprises at least one programmed computer.

Nayar et al. (US 5,802,201) teaches a system wherein the means for calibrating, the means for estimating a pose (see fig. 1, wherein the general purpose computer 170, has been considered as means for estimating pose), and the means for training comprises at least one programmed computer (see col. 1, lines 37-47, wherein it is known for the computer graphics/general purpose computer to be considered as means for holding software codes/routines and training function).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., with the teaching of Nayar et al., because this modification would have introduced computer into Matusik's et al. teaching, thereby "The foregoing operations may be performed by computer 170 executing a simple software routine." (see Nayar's et al. col. 10, lines 21-23).

A per claims 55 and 59, Matusik et al. teaches essential features of the invention substantially as claimed, but fails to teach a system wherein the means for estimating a pose, and the means for training comprises at least one programmed computer.

Nayar et al. (US 5,802,201) teaches a system wherein the means for calibrating, the means for estimating a pose (see fig. 1, wherein the general purpose computer 170, has been considered as means for estimating pose), and the means for training comprises at least one programmed computer (see col. 1, lines 37-47, wherein it is known for the computer graphics/general purpose computer to be considered as means for holding software codes/routines and training function).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., with the teaching of Nayar et al., because this modification would have introduced computer into Matusik's et al. teaching, thereby "The foregoing operations may be performed by computer 170 executing a simple software routine." (see Nayar's et al. col. 10, lines 21-23).

23. Claims 56 and 60 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matusik et al., in view of McGee et al. and Ishiyama as applied to claims 53 and 58 above, and further in view of Nayar et al..

A per claims 56 and 60, Matusik et al. and McGee et al. teach essential features of the invention substantially as claimed, but they fail to teach means for calibrating and the means for estimating a pose comprises at least one computer-readable medium storing instructions operating at least one computer.

Nayar et al. teaches means for calibrating and the means for estimating a pose (see col. 1, lines 37-47, wherein the computer graphics has been considered as means for holding software

codes and training) comprises at least one computer-readable medium storing instructions operating at least one computer (see col. 3, lines 27-32).

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify the teaching of Matusik et al., with the teaching of Nayar et al., because this modification would have introduced computer into Matusik's et al. teaching, thereby "The foregoing operations may be performed by computer 170 executing a simple software routine." (see Nayar's et al. col. 10, lines 21-23).

Allowable Subject Matter

24. Claim 49, 57 and 61 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

25. The following is a statement of reasons for the indication of allowable subject matter:

With respect claims 49, 57 and 61, the prior art of record fail to teach or fairly suggest adjusting a position of the movable portion of the robot if the number of features located in the captured image of the target object is determined to be an insufficient number of features.

26. Any inquiry concerning this communication or earlier communications from the examiner should be directed to MCDIEUNEL MARC whose telephone number is (571)272-6964. The examiner can normally be reached on 6:30-5:00 Mon-Thu.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Khoi Tran can be reached on (571) 272-6919. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

/McDieunel Marc ∴/

/KHOI TRAN/

Supervisory Patent Examiner, Art Unit 3664

Notice of References Cited	Application/Control No. 10/634,874	Applicant(s)/Patent Under Reexamination HABIBI ET AL.	
	Examiner McDieunel Marc	Art Unit 3664	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2002/0159628	10-2002	Matusik et al.	382/154
*	B	US-2003/0202691	10-2003	Beardsley, Paul	382/154
*	C	US-2002/0028418	03-2002	Farag et al.	433/29
*	D	US-7,693,325	04-2010	Pulla et al.	382/154
*	E	US-6,816,755	11-2004	Habibi et al.	700/259
*	F	US-6,853,965	02-2005	Massie et al.	703/6
*	G	US-5,802,201	09-1998	Nayar et al.	382/153
*	H	US-4,942,539	07-1990	McGee et al.	700/253
*	I	US-2004/0233461	11-2004	Armstrong et al.	356/620
*	J	US-2010/0040255	02-2010	Rhoads, Geoffrey B.	382/100
*	K	US-2001/0034481	10-2001	Horn, Mark Harold Van	600/407
*	L	US-5,633,676	05-1997	Harley et al.	348/95
*	M	US-2001/0055069	12-2001	Hudson, Edison T.	348/302

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
*10634874	10634874	HABIBI ET AL.
4*	Examiner	Art Unit
	Marc, McDieunel	3664

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/22/2007	02/09/2008	02/10/2009	08/12/2009	02/13/2010	11/26/2010			
	1	-	-	-	-	-	-			
	2	-	-	-	-	-	-			
	3	-	-	-	-	-	-			
	4	-	-	-	-	-	-			
	5	-	-	-	-	-	-			
	6	-	-	-	-	-	-			
	7	-	-	-	-	-	-			
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	30	-	-	-	-	-	-			
	31	-	-	-	-	-	-			
	32	-	-	-	-	-	-			
2	33	✓	=	=	✓	✓	✓			

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1063487 4	10634874	HABIBI ET AL.
	Examiner	Art Unit
	Marc, McDieunel	3664

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/22/2007	02/09/2008	02/10/2009	08/12/2009	02/13/2010	11/26/2010			
3	34	✓	=	=	✓	✓	✓			
4	35	✓	=	=	✓	✓	✓			
5	36	✓	=	=	✓	✓	✓			
6	37	✓	=	=	✓	✓	✓			
7	38	✓	=	=	✓	✓	✓			
8	39	✓	=	=	✓	O	✓			
9	40	✓	=	=	✓	✓	✓			
10	41	✓	=	=	✓	✓	✓			
11	42	✓	=	=	✓	✓	✓			
12	43	✓	=	=	✓	✓	✓			
13	44	✓	=	=	✓	✓	✓			
14	45	✓	=	=	✓	✓	✓			
15	46	✓	=	=	✓	✓	✓			
16	47	✓	=	=	✓	✓	✓			
16	48	✓	-	-	-	-	✓			
17	49	✓	=	=	✓	✓	O			
1	50	✓	=	=	✓	✓	✓			
18	51	✓	=	=	✓	✓	✓			
19	52	✓	=	=	✓	✓	✓			
20	53	✓	=	=	✓	✓	✓			
21	54	✓	=	=	✓	✓	✓			
22	55	✓	=	=	✓	✓	✓			
23	56	✓	=	=	✓	✓	✓			
24	57	✓	=	=	✓	✓	O			
25	58	✓	=	=	✓	✓	✓			
26	59	✓	=	=	✓	✓	✓			
27	60	✓	=	=	✓	✓	✓			
28	61	✓	=	=	✓	✓	O			

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
10634874	10634874	HABIBI ET AL.
	Examiner	Art Unit
	Marc, McDieunel	3664

SEARCHED

Class	Subclass	Date	Examiner
700	245,246,253,257,258,259,279	11/26/10	MM
318	568.13,568.15.568.16,640	11/26/10	MM
901	6,14,17,46,47	11/26/10	MM
29	218,407.1,702,714,720	11/26/10	MM
348	42,94,154,190,,191,287,291,552	11/26/10	MM
382	154,103,106,154,276,293,295,298	11/26/10	MM

SEARCH NOTES

Search Notes	Date	Examiner
Palm inventor search	11/26/10	MM
West search see attached listings	11/26/10	MM
NPL search see attached listings	11/26/10	MM
PLU search	11/26/10	MM
Consulted with SPE Khoi, for "adjusting a position of the movable portion of the robot if the number of features located in the captured image of the target object is determined to be an insufficient number of features"	11/26/10	MM

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	12	("20020159628" "4,942,539" "5,802,201" "20040233461" "20100040255" "20010034481").pn.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:06
L2	317	pose near0 estimation and three near2 dimensional and two near2 dimensional	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:22
L3	40	pose near0 estimation and three near2 dimensional and two near2 dimensional and target near0 object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:23

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L4	14	("20020159628" "4,942,539" "5,802,201" "20040233461" "20100040255" "20010034481" "4,729,536").pn.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:54
L5	0	camera near0 mounted same movable same portion and robot near5 effector	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:58
L6	1	camera near0 mounted same movable same portion same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:59
L7	38	camera near0 mounted and movable same portion same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 11:00

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L8	1	camera near3 mounted near5 orthogonally same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 12:54
L9	4	camera near6 orthogonally same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 12:55
L10	5	camera near10 orthogonally same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 12:55
L11	16	camera near10 orthogonally and robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 12:56

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L12	14	camera same orthogonally same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 13:02
L13	115	camera same orthogonally and robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 13:12
L14	27	adjusting near3 position same robot and insufficient and image and target and object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 14:10
S1	0	digital near0 cameara and extrinsic near0 parameters	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/23 19:46

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S2	0	cameara and extrinsic near0 parameters	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/23 19:47
S3	670	extrinsic near0 parameters	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/23 19:47
S4	494	extrinsic near0 parameters and camera	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/23 19:47
S5	249	extrinsic near0 parameters and camera and image near10 calibration	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/23 19:48

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S6	56	extrinsic near0 parameters and camera and image near10 calibration near0 object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 12:44
S7	4102	robot and manipulate and scal$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 13:04
S8	6	extrinsic near0 parameters and camera and image near10 calibration near0 object and S7	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 13:05
S9	56	extrinsic near0 parameters and camera and image near10 calibration near0 object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 14:54

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S10	1917	robot and manipulate and scal$3 and sample and features	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 14:56
S11	152	robot and manipulate and scal$3 and sample and features and reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 15:01
S12	34	robot same manipulate and scal$3 and sample and features and reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 15:32
S13	31	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 15:39

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S14	24	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3 and object and robot and manipulat$3 and frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 16:15
S15	16	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3 and object and robot and manipulat$3 and frame and six	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 16:20
S16	6	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3 and object and robot and manipulat$3 and frame and six and camera	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 17:09

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S17	6	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3 and object and robot and manipulat$3 and frame and six and camera and position and frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 17:18
S18	6	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3 and object and robot and manipulat$3 and frame and six and camera and position and frame and computer	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 17:48

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S19	8168	(700/245 1700/246 1700/253 1700/257 1700/258 1700/259 1700/279 or 29/218 129/702 129/714 129/720 129/407.1 129/407.04 or 318/568.13 l 318/568.15 1318/568.16 1318/640 or 348/42 1348/94 1348/154 1348/1901 348/291 1348/287552 or 901/6 1901/14 1901/17 1901/46 1901/47 or 414/730 1414/737 or 382/154). ccls.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 20:52
S20	117	("4871252" or "5999881" or "4949277" or "4980762" or "5016110" or "5177563" or "5295778" or "5300869" or H001378 or "5696674" or "5819304" or	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 20:54

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		"5870303" or "6081370" or "6096999" or "4273505" or "4299386" or "4307891" or "4312432" or "4359815" or "4421450" or "4479754" or "4479717" or "4480170" or "4484855" or "4488173" or "4494874" or "4502830" or "4556360" or "4568238" or "4574655" or "4576537" or "4582277" or "4594001" or "4624621" or "4627511" or "4762459" or "4764077" or "4779804" or "4782567" or					

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		"4783904" or "4789417" or "4815901" or "4818858" or "4865514" or "4875273" or "4875823" or "4886375" or "4934504" or "4942539" or "4943889").pn.				
S21	961	camera and orthogonal near0 axes and rotation and translation	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 08:53
S22	171	camera and orthogonal near0 axes and rotation and translation and reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 08:53

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S23	0	camera and orthogonal near0 axes and rotation and translation and reference near0 frame and space near6 training	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 08:54
S24	23	camera and orthogonal near0 axes and rotation and translation and reference near0 frame and space and training	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 08:54
S25	209	scale near0 factor and framegrabber	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:11
S26	2	scale near0 factor same framegrabber	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:11

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S27	2	scale near0 factor same framegrabber and resampling	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:12
S28	0	scale near0 factor same framegrabber and sampling	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:12
S29	2	scale near0 factor same framegrabber and focal near0 length	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:13
S30	2	scale near0 factor same framegrabber and camera	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:13

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S31	2	scale near0 factor same framegrabber and lens	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:13
S32	2	scale near0 factor same framegrabber and distortion	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:14
S33	354	object near0 space near0 coordinate	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:51
S34	3	object near0 space near0 coordinate and select$3 near0 feature	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:52

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S35	60	object near0 space near0 coordinate and image and teaching	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:53
S36	30	object near0 space near0 coordinate and select$3 near10 image and teaching	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 11:00
S38	0	robot same mov$3 near3 camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:39
S39	1	robot same mov$3 near10 camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:39

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S40	0	robot same mov10 near10 camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:39
S41	0	robot same orient$3 near10 camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:40
S42	0	robot same camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:40
S43	24	camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:41

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S44	0	camera near0 orthogonally and robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:41
S45	2	camera and object near0 space near0 reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:05
S46	80	camera and object near6 space near10 reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:06
S47	56	camera and object near6 space near5 reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:06

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S48	0	("20020159628" "4,942,539" "5,802,201" "20040233461" "20100040255" "20010034481").pn. and position near3 orientation and tool near0 frame near0 reference and transformations	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:58
S49	13	position near3 orientation and tool near0 frame near0 reference and transformations	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:58
S50	12	position near3 orientation and tool near0 frame near0 reference and transformations and object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:59

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S51	2	"20100231706".pn.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 23:15
S52	1	"20100231706".pn. and tool	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 23:15
S53	0	adjusting same robot same insufficient and image and target near0 object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:04
S54	2	adjusting same robot same insufficient and image and target and object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:04

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S55	2	adjusting same robot same insufficient and image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:05
S56	139	adjusting same robot and insufficient and image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:06
S57	104	adjusting same robot and insufficient and image and target	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:06
S58	103	adjusting same robot and insufficient and image and target and object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:06

EAST Search History (Interference)

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<This search history is empty>

11/26/10 2:18:58 PM
C:\Documents and Settings\mmarc\My Documents\EAST\Workspaces\10634874.wsp

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EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	0	unsufficient near0 cpatured near0 image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:36
L2	0	unsufficient near0 captured near0 image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:36
L3	0	unsufficient same captured near0 image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:37

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L4	82153	captured near0 image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:37
L5	75658	movable near0 portion	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:37
L6	429	4 and 5	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:38
L7	184142	location and insufficient	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:38

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L8	82	6 and 7	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:38
L9	259484	robot$6	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:39
L10	9	8 and 9	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:39
S1	0	digital near0 cameara and extrinsic near0 parameters	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/23 19:46

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S2	0	cameara and extrinsic near0 parameters	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/23 19:47
S3	670	extrinsic near0 parameters	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/23 19:47
S4	494	extrinsic near0 parameters and camera	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/23 19:47
S5	249	extrinsic near0 parameters and camera and image near10 calibration	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/23 19:48

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S6	56	extrinsic near0 parameters and camera and image near10 calibration near0 object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 12:44
S7	4102	robot and manipulate and scal$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 13:04
S8	6	extrinsic near0 parameters and camera and image near10 calibration near0 object and S7	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 13:05
S9	56	extrinsic near0 parameters and camera and image near10 calibration near0 object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 14:54

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S10	1917	robot and manipulate and scal$3 and sample and features	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 14:56
S11	152	robot and manipulate and scal$3 and sample and features and reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 15:01
S12	34	robot same manipulate and scal$3 and sample and features and reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 15:32
S13	31	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 15:39

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S14	24	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3 and object and robot and manipulat$3 and frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 16:15
S15	16	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3 and object and robot and manipulat$3 and frame and six	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 16:20
S16	6	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3 and object and robot and manipulat$3 and frame and six and camera	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 17:09

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S17	6	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3 and object and robot and manipulat$3 and frame and six and camera and position and frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 17:18
S18	6	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3 and object and robot and manipulat$3 and frame and six and camera and position and frame and computer	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 17:48

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S19	8168	(700/245 1700/246 1700/253 1700/257 1700/258 1700/259 1700/279 or 29/218 129/702 129/714 129/720 129/407.1 129/407.04 or 318/568.13 | 318/568.15 1318/568.16 1318/640 or 348/42 1348/94 1348/154 1348/1901 348/291 1348/287552 or 901/6 1901/14 1901/17 1901/46 1901/47 or 414/730 1414/737 or 382/154). ccls.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 20:52
S20	117	("4871252" or "5999881" or "4949277" or "4980762" or "5016110" or "5177563" or "5295778" or "5300869" or H001378 or "5696674" or "5819304" or "5870303" or	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 20:54

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		"6081370" or "6096999" or "4273505" or "4299386" or "4307891" or "4312432" or "4359815" or "4421450" or "4479754" or "4479717" or "4480170" or "4484855" or "4488173" or "4494874" or "4502830" or "4556360" or "4568238" or "4574655" or "4576537" or "4582277" or "4594001" or "4624621" or "4627511" or "4762459" or "4764077" or "4779804" or "4782567" or "4783904" or "4789417" or					

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		"4815901" or "4818858" or "4865514" or "4875273" or "4875823" or "4886375" or "4934504" or "4942539" or "4943889").pn.				
S21	961	camera and orthogonal near0 axes and rotation and translation	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 08:53
S22	171	camera and orthogonal near0 axes and rotation and translation and reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 08:53
S23	0	camera and orthogonal near0 axes and rotation and translation and reference near0 frame and space near6 training	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 08:54

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S24	23	camera and orthogonal near0 axes and rotation and translation and reference near0 frame and space and training	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 08:54
S25	209	scale near0 factor and framegrabber	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:11
S26	2	scale near0 factor same framegrabber	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:11
S27	2	scale near0 factor same framegrabber and resampling	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:12

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S28	0	scale near0 factor same framegrabber and sampling	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:12
S29	2	scale near0 factor same framegrabber and focal near0 length	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:13
S30	2	scale near0 factor same framegrabber and camera	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:13
S31	2	scale near0 factor same framegrabber and lens	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:13

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S32	2	scale near0 factor same framegrabber and distortion	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:14
S33	354	object near0 space near0 coordinate	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:51
S34	3	object near0 space near0 coordinate and select$3 near0 feature	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:52
S35	60	object near0 space near0 coordinate and image and teaching	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:53

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S36	30	object near0 space near0 coordinate and select$3 near10 image and teaching	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 11:00
S38	0	robot same mov$3 near3 camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:39
S39	1	robot same mov$3 near10 camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:39
S40	0	robot same mov10 near10 camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:39

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S41	0	robot same orient$3 near10 camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:40
S42	0	robot same camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:40
S43	24	camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:41
S44	0	camera near0 orthogonally and robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:41

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S45	2	camera and object near0 space near0 reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:05
S46	80	camera and object near6 space near10 reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:06
S47	56	camera and object near6 space near5 reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:06
S48	0	("20020159628" "4,942,539" "5,802,201" "20040233461" "20100040255" "20010034481").pn. and position near3 orientation and tool near0 frame near0 reference and	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:58

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		transformations				
S49	13	position near3 orientation and tool near0 frame near0 reference and transformations	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:58
S50	12	position near3 orientation and tool near0 frame near0 reference and transformations and object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:59
S51	2	"20100231706".pn.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 23:15
S52	1	"20100231706".pn. and tool	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 23:15

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S53	0	adjusting same robot same insufficient and image and target near0 object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:04
S54	2	adjusting same robot same insufficient and image and target and object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:04
S55	2	adjusting same robot same insufficient and image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:05
S56	139	adjusting same robot and insufficient and image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:06

ABB Inc. Exhibit 1002, Page 926 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

S57	104	adjusting same robot and insufficient and image and target	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:06
S58	103	adjusting same robot and insufficient and image and target and object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:06
S59	12	("20020159628" "4,942,539" "5,802,201" "20040233461" "20100040255" "20010034481").pn.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:06
S60	317	pose near0 estimation and three near2 dimensional and two near2 dimensional	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:22

ABB Inc. Exhibit 1002, Page 927 of 996
ABB Inc. v. Roboticvisiontech, Inc.
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S61	40	pose near0 estimation and three near2 dimensional and two near2 dimensional and target near0 object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:23
S62	14	("20020159628" "4,942,539" "5,802,201" "20040233461" "20100040255" "20010034481" "4,729,536").pn.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:54
S63	0	camera near0 mounted same movable same portion and robot near5 effector	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:58
S64	1	camera near0 mounted same movable same portion same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:59

ABB Inc. Exhibit 1002, Page 928 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

S65	38	camera near0 mounted and movable same portion same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 11:00
S66	1	camera near3 mounted near5 orthogonally same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 12:54
S67	4	camera near6 orthogonally same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 12:55
S68	5	camera near10 orthogonally same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 12:55

ABB Inc. Exhibit 1002, Page 929 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

S69	16	camera near10 orthogonally and robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 12:56
S70	14	camera same orthogonally same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 13:02
S71	115	camera same orthogonally and robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 13:12
S72	27	adjusting near3 position same robot and insufficient and image and target and object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 14:10

EAST Search History (Interference)

<This search history is empty>

ABB Inc. Exhibit 1002, Page 930 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

12/4/10 8:42:38 AM
C:\Documents and Settings\mmarc\My Documents\EAST\Workspaces\10634874.wsp

ABB Inc. Exhibit 1002, Page 931 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Doc code :IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (03-08)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	10634874
	Filing Date	2003-08-06
	First Named Inventor	Babak Habibi
	Art Unit	3664
	Examiner Name	McDieunel Marc
	Attorney Docket Number	170154.401C1

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	10634874
	Filing Date	2003-08-06
	First Named Inventor	Babak Habibi
	Art Unit	3664
	Examiner Name	McDieunel Marc
	Attorney Docket Number	170154.401C1

	1	Wilson, et al., "Relative End-Effector Control Using Cartesian Position Based Visual Servoing," IEEE Transactions on Robotics and Automation, 12(5):684-696, October 1996.	☐
	2	"3D Robot Guidance with a Single Camera," ISRA Vision Systems AG, Machine Vision for Robot Guidance, Nashville, Tennessee, October 5, 2004.	☐

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EXAMINER SIGNATURE

Examiner Signature	/McDieunel Marc/ (09/21/2010)	Date Considered	09/21/2010

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

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PTO/SB/08a (03-08)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
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	First Named Inventor	Babak Habibi
	Art Unit	3664
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	Attorney Docket Number	170154.401C1

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	10634874
	Filing Date	2003-08-06
	First Named Inventor	Babak Habibi
	Art Unit	3664
	Examiner Name	McDieunel Marc
	Attorney Docket Number	170154.401C1

	1	Wilson, et al., "Relative End-Effector Control Using Cartesian Position Based Visual Servoing," IEEE Transactions on Robotics and Automation, 12(5):684-696, October 1996.	☐
	2	"3D Robot Guidance with a Single Camera," ISRA Vision Systems AG, Machine Vision for Robot Guidance, Nashville, Tennessee, October 5, 2004.	☐

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EXAMINER SIGNATURE

Examiner Signature	/McDieunel Marc/ (12/04/2010)	Date Considered	12/04/2010

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.M./

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	Babak Habibi et al.
Application No.	:	10/634,874
Filed	:	August 6, 2003
For	:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS
Examiner	:	McDieunel Marc
Art Unit	:	3664
Docket No.	:	810112.401C1
Date	:	June 15, 2011

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

FEE DEFICIENCY AUTHORIZATION FORM

Commissioner for Patents:

Applicants hereby authorize the Director to charge any deficiencies in fees due by way of the enclosed papers only under 37 CFR 1.16 and 1.17 to Deposit Account No. 19-1090.

Respectfully submitted,

SEED Intellectual Property Law Group PLLC

/Jeremiah J. Baunach/
Jeremiah J. Baunach
Registration No. 44,527

701 Fifth Avenue, Suite 5400
Seattle, Washington 98104
Phone: (206) 622-4900
Fax: (206) 682-6031

1913749_1.DOC

ABB Inc. Exhibit 1002, Page 936 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Electronic Patent Application Fee Transmittal

Application Number:	10634874
Filing Date:	06-Aug-2003
Title of Invention:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS
First Named Inventor/Applicant Name:	Babak Habibi
Filer:	Jeremiah J. Baunach/Yvette Chriscaden
Attorney Docket Number:	810112.401C1

Filed as Small Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 3 months with $0 paid	2253	1	555	555

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
		Total in USD ($)		**555**

Electronic Acknowledgement Receipt

EFS ID:	10313193
Application Number:	10634874
International Application Number:	
Confirmation Number:	7619
Title of Invention:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS
First Named Inventor/Applicant Name:	Babak Habibi
Customer Number:	00500
Filer:	Jeremiah J. Baunach/Yvette Chriscaden
Filer Authorized By:	Jeremiah J. Baunach
Attorney Docket Number:	810112.401C1
Receipt Date:	15-JUN-2011
Filing Date:	06-AUG-2003
Time Stamp:	18:03:14
Application Type:	Utility under 35 USC 111(a)

Payment information:

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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Extension of Time	34_810112_401C1_3month_EOT.pdf	78325 49e2d96307c6d0fc2636cd073bf4d257ee80d77e	no	1
Warnings:					
Information:					
2	Applicant Arguments/Remarks Made in an Amendment	34_810112_401C1_Response.pdf	114174 a8903d61d50a926b5bc49319b375b37c5aab1764	no	9
Warnings:					
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3	Miscellaneous Incoming Letter	34_810112_401C1_FDA.pdf	45004 26a3a2feeb6a0cb4f179c38d02ea47072b353f8f	no	1
Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	30699 d172b5f489bb91ca0e029504b9f1a7d67e3bb047	no	2
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		Total Files Size (in bytes):	268202		

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<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a) FY 2009 (Fees pursuant to the Consolidated Appropriations Act, 2005 (H.R. 4818).)	Docket Number 810112.401C1
Application Number 10/634,874	Filed August 6, 2003
For METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS	
Art Unit 3664	Examiner McDieunel Marc

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

	Fee	Small Entity Fee	
☐ One month (37 CFR 1.17(a)(1))	$130	$65	$_____
☐ Two months (37 CFR 1.17(a)(2))	$490	$245	$_____
☒ Three months (37 CFR 1.17(a)(3))	$1110	$555	$555
☐ Four months (37 CFR 1.17(a)(4))	$1730	$865	$_____
☐ Five months (37 CFR 1.17(a)(5))	$2350	$1175	$_____

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☒ The Director is hereby authorized to charge the above fees, or credit any overpayment, to Deposit Account Number 19-1090.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the ☐ applicant/inventor.

☐ assignee of record of the entire interest. See 37 CFR 3.71
Statement under 37 CFR 3.73(b) is enclosed (Form PTO/SB/96).

☒ attorney or agent of record. Registration No. 44,527

☐ attorney or agent under 37 CFR 1.34.
Registration number if acting under 37 CFR 1.34. _____ .

/Jeremiah J. Baunach/	June 15, 2011
Signature	Date
Jeremiah J. Baunach	206-622-4900
Typed or printed name	Telephone Number

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required.

SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450. 1913711_1.DOC

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	Babak Habibi et al.
Application No.	:	10/634,874
Filed	:	August 6, 2003
For	:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS

Examiner	:	McDieunel Marc
Art Unit	:	3664
Docket No.	:	810112.401C1
Date	:	June 15, 2011

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

RESPONSE

Commissioner for Patents:

In response to the Office Action dated December 15, 2010, please extend the period of time for response 3 months, to expire on June 15, 2011. Enclosed are a Petition for an Extension of Time and the requisite fee.

This is a Response to the Office Action mailed December 15, 2010, in which a three (3) month Shortened Statutory Period for Response has been set, due to expire March 15, 2011. Thirty-two (32) claims, including four (4) independent claims, were paid for in the application. The Director is authorized to charge any additional fees due by way of this Amendment, or credit any overpayment, to our Deposit Account No. 19-1090. Claims 33-47 and 49-61 are pending.

Applicants thank the Examiner for indicating that claims 49, 57, and 61 contain allowable subject matter.

Objections

The amendment filed June 5, 2009 was objected to because it allegedly introduces new matter. The Office alleges on page 3, in section 7 of the Office action that the phrase "using only the single captured image" of claim 50 does not have any support in the specification. Applicants respectfully disagree.

Applicants direct the Examiner to the following sections of the application as-filed:

The title of the application is "METHOD AND APPARATUS FOR ***SINGLE IMAGE*** 3D VISION GUIDED ROBOTICS" (emphasis added).

Page 1, lines 11-13 of the application state, "The invention relates to the field of vision guided robotics, and more particularly to a method and apparatus for ***single image*** three dimensional vision guided robotics." (emphasis added).

Page 9, lines 1-2 of the application state, "Selection from the ***object's image*** of at least 5 features, and determining the position of the features in ***the image***" (emphasis added).

Page 12, line 29 of the application states, "***an*** image of the object is captured" (emphasis added).

Page 16, line 16-17 of the application state, "For instance, the formation of a ***single image*** may be accomplished…" (emphasis added).

Page 16, line 20 of the application state, "A ***single image*** is then formed…" (emphasis added).

As shown above, the application as-filed repeatedly refers to use of just a single image. Thus, support exists in the application as-filed for "using only the single captured image," as recited in claim 50.

The abstract was objected to because a web address should allegedly not be in the Abstract. However, Applicants submit a web address does not appear in the Abstract. The web address to which the Examiner is referring appears in the description portion of the specification on page 6, line 11. Applicants are not aware of any particular restrictions on web addresses appearing in the description portion of the specification.

Therefore, Applicants respectfully request the objections be withdrawn.

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IPR2023-01426

Rejections Under 35 U.S.C. § 112, First Paragraph

Claim 50 was rejected under 35 U.S.C. § 112, first paragraph, as allegedly failing to comply with the written description requirement. The Examiner alleges that the phrase "using only the single captured image" of claim 50 does not have any support in the specification. As shown above, the application as-filed repeatedly refers to use of just a single image. Thus, support exists in the application as-filed for "using only the single captured image" as recited in claim 50.

Therefore, Applicants respectfully request the rejection be withdrawn.

Rejections Under 35 U.S.C. § 103

Claims 33-35, 38, 41, and 42 were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent Publication No. 2002/0159628 to Matusik et al. (hereinafter "Matusik") in view of U.S. Patent No. 4,942,539 issued to McGee et al. (hereinafter "McGee"). Claims 36 and 37 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Matusik in view of McGee and further in view of U.S. Patent No. 5,802,201 issued to Nayar et al. (hereinafter "Nayar"). Claim 39 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Matusik in view of McGee and further in view of U.S. Patent Publication No. 2004/0233461 to Armstrong et al. (hereinafter "Armstrong") and U.S. Patent Publication No. 2010/0040255 to Rhoads. Claim 40 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Matusik in view of McGee and further in view of Armstrong. Claim 43 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Matusik in view of McGee and further in view of U.S. Patent Publication No. 2001/0034481 to Horn. Claim 44 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Matusik in view of McGee and Horn and further in view of Nayar. Claims 45-47 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Matusik in view of McGee and Horn and further in view of U.S. Patent Publication No. 2010/0231706 to Maguire, Jr. Claim 50 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Matusik in view of Horn and further in view of U.S. Patent No. 6,584,375 to Bancroft et al. (hereinafter "Bancroft") and U.S. Patent Publication No. 2001/0033685 to Ishiyama. Claims 51 and 52 were rejected under 35 U.S.C. § 103(a) as being unpatentable over

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ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Matusik in view of Horn, Bancroft and Ishiyama and further in view of U.S. Patent Publication No. 2001/0055069 to Hudson.

Applicants respectfully traverse the rejections. Claim 50 is independent so will be discussed before the claims that depend therefrom. Claim 50 recites (emphasis added):

> 50. A method useful in three-dimensional pose estimation for use with a single camera mounted to a movable portion of a robot, the method comprising:
>
> capturing a two-dimensional image of a volume containing a target object;
>
> locating a number of features in the captured image of the target object; and
>
> ***determining an object space-to-camera space transformation for the target object based at least in part on a position of at least some of the located features using only the single captured image*** and an algorithm that employs a known or determinable physical relationship between at least some of the located features.

The Office states that Matusik does not teach certain limitations which are purportedly taught by the secondary reference Horn. Office Action, page 16, third paragraph. In particular, the Office appears to rely on Horn for teaching determining an object space-to-camera space transformation for the target object based at least in part on a position of at least some of the located features using only the single captured image. Office Action, page 16, third paragraph. Applicants respectfully disagree. To the contrary, Horn describes using first and second captured images as opposed to "only the single captured image" as recited in claim 50, and does not mention anything about camera space.

In particular, the Abstract of Horn states (emphasis added):

> Methods, systems and computer program products are provided for determining an obscured contact point based on a visible portion of an acoustic sensor of a medical device contacting a patient by ***acquiring a first image*** containing an upper surface of the acoustic sensor from a first viewpoint ***and a second image*** containing the upper surface of the acoustic sensor from a second viewpoint different from the first viewpoint.

Relevant portions of the above language also appear in paragraph 9 of Horn:

> These and other objects of the present invention are provided by methods, systems and computer program products which determine an obscured contact point based on a visible portion of an acoustic sensor of a medical device contacting a patient by ***acquiring a first image*** containing an upper surface of the acoustic sensor from a first viewpoint ***and a second image*** containing the upper

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surface of the acoustic sensor from a second viewpoint different from the first viewpoint.

Furthermore, Horn does not mention anything about camera space, let alone "determining an object space-to-camera space transformation," as recited in claim 50. Horn states in paragraph 9 that "the centroid may be determined in three dimensional space by determining the centroid of the acoustic sensor in each image and then determining the location [of the centroid] in three dimensional space from the locations in the images." Horn does not differentiate any three dimensional coordinate system belonging to the camera versus a three dimensional coordinate system belonging to the object of Horn (i.e., the acoustic sensor).

Therefore Horn does not teach or suggest "determining an object space-to-camera space transformation for the target object based at least in part on a position of at least some of the located features using only the single captured image," as recited in claim 50.

Also, there is no teaching, motivation or suggestion to combine the teachings of Matusik and Horn. The Office states that a modification of Matusik to include the alleged teachings of Horn above "would have introduced object space coordinates into Matusik's et al. teaching, thereby 'the camera position and field of view are also preferably selected ***so that the number of features, m, in each image are the same***, and that the same m objects have been imaged in each image.' (see Horn's section [0055])" (emphasis added). Office Action, page 16, last paragraph. However, even if Horn could introduce "object space coordinates" to the system of Matusik that were not already made use of in Matusik, it is unclear why the system of Matusik would benefit by having the number of features be the same in every image. In fact, the system of Matusik works by taking different images of a single object while rotating it on a turntable (see Abstract of Matusik), so the number of features in every image would necessarily not be the same for each and every position of the turntable of Matusik in order to capture the different texture data of the object appearing at various angles completely surrounding the object. In sum, there is no teaching, motivation or suggestion to combine the teachings of Matusik and Horn, nor does the Office offer any sufficient reason. See MPEP 2141[1].

[1] ("The key to supporting any rejection under 35 U.S.C. 103 is the clear articulation of the reason(s) why the claimed invention would have been obvious. The Supreme Court in *KSR* noted that the analysis supporting a rejection under 35 U.S.C. 103 should be made explicit. The Court quoting *In re Kahn,* 441 F.3d 977, 988, 78 USPQ2d 1329, 1336 (Fed. Cir. 2006), stated that "'[R]ejections on obviousness cannot be sustained by mere

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The other references cited by the Office (Bancroft, McGee, Nayar, Armstrong, Rhoads, Maguire, Jr., Bancroft, Ishiyama, and Hudson) do not cure the deficiencies above of Matusik Horn, and the Office does not allege that these references disclose such elements (i.e., "determining an object space-to-camera space transformation for the target object based at least in part on a position of at least some of the located features using only the single captured image"). Also, the Office provides no teaching, motivation or suggestion to combine the system of Matusik as modified by the teachings of Horn and Bancroft (in support of the rejection of claim 50) with the references McGee, Nayar, Armstrong, Rhoads, Maguire, Jr., Ishiyama, or Hudson.

Therefore, claim 50 is allowable over the references cited by the Office.

Claims 33-47, 51, and 52 depend from claim 50 and are therefore also allowable over the references cited by the Office by virtue of their dependencies for at least the reasons above and also for the additional novel and nonobvious features recited therein.

Claims 53 and 58 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Matusik in view of McGee and Ishiyama. Claim 54 was rejected under 35 U.S.C. § 103(a) as being unpatentable over Matusik, McGee, Ishiyama and Horn. Claims 55 and 59 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Matusik in view of McGee and Ishiyama and further in view of Nayar. Claims 56 and 60 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Matusik in view of McGee and Ishiyama and further in view of Nayar.

Applicants respectfully traverse the rejections. Claim 53 recites (emphasis added):

> 53. An apparatus useful in robotics, the apparatus comprising:
>
> a single camera operable to capture a number of images of a calibration object;
>
> means for calibrating the camera, by:
>
> determining a set of intrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera; and

---

conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.'" *KSR*, 550 U.S. at 398, 82 USPQ2d at 1396.").

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> determining a set of extrinsic parameters of the camera from at least one of the number of images of the calibration object captured by the camera, the set of extrinsic parameters comprising a camera space-to-training space transformation defining a transformation between a camera space reference frame and a training space reference frame; and
>
> means for estimating a pose of a target object, by:
>
> capturing a two-dimensional image of a volume containing a target object; and
>
> locating at least six features in the captured image of the target object; and
>
> determining an object space-to-camera space transformation based at least in part on a position of at least some of the located features in ***solely the captured image*** using an algorithm that employs a known or determinable physical relationship between at least some of the located features.

The Office appears to rely on Matusik for teaching determining an object space-to-camera space transformation based at least in part on a position of at least some of the located features ***in solely the captured image***. Office Action, page 19, lines11-13. Applicants respectfully disagree. To the contrary, Matusik describes extracting object shape and texture data from multiple images, i.e., "first and second set of images" (Matusik, Abstract) as opposed to "features ***in solely the captured image***" as recited in claim 53.

The other references cited by the Office (McGee, Horn, Bancroft, Nayar, Armstrong, Rhoads, Maguire, Jr., Bancroft, Ishiyama, and Hudson) do not cure the deficiencies above of Matusik. Therefore, claim 53 is allowable over the references cited by the Office.

Claims 54-56 depend from claim 53 and are therefore also allowable over the references cited by the Office by virtue of their dependencies for at least the reasons above and also for the additional novel and nonobvious features recited therein.

Claim 58 recites, *inter alia*, "determining an object space-to-camera space transformation based at least in part on a position of at least some of the located features using the captured ***image without any additional captured images***" (emphasis added). This language is similar to the features of claim 53 discussed above regarding "solely the captured image," and is thus allowable over the references cited by the Office for at least the same reasons above as for claim 53.

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Claims 59-60 depend from claim 58 and are therefore also allowable over the references cited by the Office by virtue of their dependencies for at least the reasons above and also for the additional novel and nonobvious features recited therein.

Conclusion

Applicants respectfully submit that the pending claims are in condition for allowance. Any remarks in support of patentability of one claim should not be imputed to any other claim, even if similar terminology is used. Any remarks referring to only a portion of a claim should not be understood to base patentability on that portion; rather, patentability must rest on each claim taken as a whole. Applicants do not acquiesce to each of the Examiner's rejections and to each of the Examiner's assertions regarding what the cited references show or teach, even if not expressly discussed herein.

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If the undersigned attorney has overlooked a relevant teaching in any of the references, the Examiner is requested to point out specifically where such teaching may be found. In light of the above remarks, Applicants respectfully submit that all pending claims are allowable. Applicants, therefore, respectfully request that the Examiner reconsider this application and timely allow all pending claims. The Examiner is encouraged to contact the undersigned by telephone to discuss the above and any other distinctions between the claims and the applied references, if desired. If the Examiner notes any informalities in the claims, the Examiner is encouraged to contact the undersigned by telephone to expediently correct such informalities.

Respectfully submitted,

SEED Intellectual Property Law Group PLLC

/Jeremiah J. Baunach/
Jeremiah J. Baunach
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UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

500 7590 09/08/2011

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

EXAMINER
MARC, MCDIEUNEL

ART UNIT	PAPER NUMBER
3667	

DATE MAILED: 09/08/2011

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/634,874	08/06/2003	Babak Habibi	810112.401C1	7619

TITLE OF INVENTION: METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$755	$300	$0	$1055	12/08/2011

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PTOL-85 (Rev. 02/11)

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PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

500 7590 09/08/2011

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/634,874	08/06/2003	Babak Habibi	810112.401C1	7619

TITLE OF INVENTION: METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$755	$300	$0	$1055	12/08/2011

EXAMINER	ART UNIT	CLASS-SUBCLASS
MARC, MCDIEUNEL	3667	700-245000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____

2 _____

3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:

☐ Issue Fee

☐ Publication Fee (No small entity discount permitted)

☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**

☐ A check is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.

☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

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ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/634,874	08/06/2003	Babak Habibi	810112.401C1	7619

500 7590 09/08/2011

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

EXAMINER	
MARC, MCDIEUNEL	

ART UNIT	PAPER NUMBER
3667	

DATE MAILED: 09/08/2011

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 372 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 372 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 02/11)

ABB Inc. Exhibit 1002, Page 953 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No.	Applicant(s)	
	10/634,874	HABIBI ET AL.	
	Examiner	Art Unit	
	MCDIEUNEL MARC	3667	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *06/15/2011*.

2. ☒ The allowed claim(s) is/are *33-47 and 49-61*.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
      1. ☐ Certified copies of the priority documents have been received.
      2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
      3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
      1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☒ Interview Summary (PTO-413), Paper No./Mail Date *08/30/2011* .
7. ☒ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

Examiner-Initiated Interview Summary	Application No.	Applicant(s)	
	10/634,874	HABIBI ET AL.	
	Examiner	Art Unit	
	MCDIEUNEL MARC	3667	

All participants (applicant, applicant's representative, PTO personnel):

(1) *MCDIEUNEL MARC*. (3)_____.

(2) *Frank Abramonte, Reg., 38,066*. (4)_____.

Date of Interview: *30 August 2011*.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☒ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.
If Yes, brief description: _____.

Issues Discussed ☒101 ☐112 ☐102 ☐103 ☐Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: *50*.

Identification of prior art discussed: *None*.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

-- by a processor -- has been inserted after the word "determining" line 6 of claim 50.

Applicant recordation instructions: It is not necessary for applicant to provide a separate record of the substance of interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☐ Attachment

/McDieunel Marc/ Examiner, Art Unit 3667	

ABB Inc. Exhibit 1002, Page 956 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

EXAMINER'S AMENDMENT

1. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with Frank Abramonte, Reg., No. 38,066 on 08/30/2011.

The application has been amended as follows:

In claim 50, line 6, after the word "determining" inserted -- by a processor --.

Allowable Subject Matter

2. Claims 33-47 and 49-61 are allowed in light of the remark on pages 2-6, filed 06/15/2011.

3. Any inquiry concerning this communication or earlier communications from the examiner should be directed to McDieunel Marc whose telephone number is (571) 272-6964. The examiner can normally be reached on Mon. - Thu..

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, James P. Trammell can be reached on (571) 272-6712.

The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/McDieunel Marc ∴/

/James P Trammell/

Supervisory Patent Examiner, Art Unit 3667

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10634874	HABIBI ET AL.
	Examiner	**Art Unit**
	Marc, McDieunel	3667

ORIGINAL		INTERNATIONAL CLASSIFICATION	
CLASS	SUBCLASS	CLAIMED	NON-CLAIMED
700	245	G 0 6 F 19 / 00 (2011.01.01)	

CROSS REFERENCE(S)

CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
700	246	253	257	258	259
318	568.13	568.15	568.16	640	
29	702	714	720		
901	6	14	17	46	47

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1		17	2	33	17	49								
	2		18	3	34	1	50								
	3		19	4	35	18	51								
	4		20	5	36	19	52								
	5		21	6	37	20	53								
	6		22	7	38	21	54								
	7		23	8	39	22	55								
	8		24	9	40	23	56								
	9		25	10	41	24	57								
	10		26	11	42	25	58								
	11		27	12	43	26	59								
	12		28	13	44	27	60								
	13		29	14	45	28	61								
	14		30	15	46										
	15		31	16	47										
	16		32		48										

Marc, McDieunel (Assistant Examiner)	08/27/2011 (Date)	**Total Claims Allowed:** 28	
/JAMES TRAMMELL/ Supervisory Patent Examiner.Art Unit 3667 (Primary Examiner)	09/06/2011 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1

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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
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	Examiner	**Art Unit**
	Marc, McDieunel	3667

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/22/2007	02/09/2008	02/10/2009	08/12/2009	02/13/2010	11/26/2010	08/27/2011		
	1	-	-	-	-	-	-	-		
	2	-	-	-	-	-	-	-		
	3	-	-	-	-	-	-	-		
	4	-	-	-	-	-	-	-		
	5	-	-	-	-	-	-	-		
	6	-	-	-	-	-	-	-		
	7	-	-	-	-	-	-	-		
	8	-	-	-	-	-	-	-		
	9	-	-	-	-	-	-	-		
	10	-	-	-	-	-	-	-		
	11	-	-	-	-	-	-	-		
	12	-	-	-	-	-	-	-		
	13	-	-	-	-	-	-	-		
	14	-	-	-	-	-	-	-		
	15	-	-	-	-	-	-	-		
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	18	-	-	-	-	-	-	-		
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	21	-	-	-	-	-	-	-		
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	29	-	-	-	-	-	-	-		
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	31	-	-	-	-	-	-	-		
	32	-	-	-	-	-	-	-		
2	33	✓	=	=	✓	✓	✓	=		
3	34	✓	=	=	✓	✓	✓	=		
4	35	✓	=	=	✓	✓	✓	=		
5	36	✓	=	=	✓	✓	✓	=		

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Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
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	Examiner	**Art Unit**
	Marc, McDieunel	3667

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	09/22/2007	02/09/2008	02/10/2009	08/12/2009	02/13/2010	11/26/2010	08/27/2011		
6	37	✓	=	=	✓	✓	✓	=		
7	38	✓	=	=	✓	✓	✓	=		
8	39	✓	=	=	✓	O	✓	=		
9	40	✓	=	=	✓	✓	✓	=		
10	41	✓	=	=	✓	✓	✓	=		
11	42	✓	=	=	✓	✓	✓	=		
12	43	✓	=	=	✓	✓	✓	=		
13	44	✓	=	=	✓	✓	✓	=		
14	45	✓	=	=	✓	✓	✓	=		
15	46	✓	=	=	✓	✓	✓	=		
16	47	✓	=	=	✓	✓	✓	=		
	48	✓	-	-	-	-	✓	-		
17	49	✓	=	=	✓	✓	O	=		
1	50	✓	=	=	✓	✓	✓	=		
18	51	✓	=	=	✓	✓	✓	=		
19	52	✓	=	=	✓	✓	✓	=		
20	53	✓	=	=	✓	✓	✓	=		
21	54	✓	=	=	✓	✓	✓	=		
22	55	✓	=	=	✓	✓	✓	=		
23	56	✓	=	=	✓	✓	✓	=		
24	57	✓	=	=	✓	✓	O	=		
25	58	✓	=	=	✓	✓	✓	=		
26	59	✓	=	=	✓	✓	✓	=		
27	60	✓	=	=	✓	✓	✓	=		
28	61	✓	=	=	✓	✓	O	=		

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Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	10634874	HABIBI ET AL.
	Examiner	Art Unit
	Marc, McDieunel	3667

SEARCHED

Class	Subclass	Date	Examiner
700	245,246,253,257,258,259,279	11/26/10	MM
318	568.13,568.15.568.16,640	11/26/10	MM
901	6,14,17,46,47	11/26/10	MM
29	218,407.1,702,714,720	11/26/10	MM
348	42,94,154,190,,191,287,291,552	11/26/10	MM
382	154,103,106,154,276,293,295,298	11/26/10	MM

SEARCH NOTES

Search Notes	Date	Examiner
Palm inventor search	11/26/10	MM
West search see attached listings	11/26/10	MM
NPL search see attached listings	11/26/10	MM
PLU search	11/26/10	MM
Consulted with SPE Khoi, for "adjusting a position of the movable portion of the robot if the number of features located in the captured image of the target object is determined to be an insufficient number of features"	11/26/10	MM
US-PGPUB;USPAT;USOCR;EPO;JOP;DERWENT;IBM_TDB, see attached listings	8/27/11	MM

INTERFERENCE SEARCH

Class	Subclass	Date	Examiner
318	568.13	8/27/11	MM

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	55563	single near0 image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/08/27 11:24
L2	649	single near0 image with 3D	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/08/27 11:26
L3	1	scale near0 factor and framegrabber and L2	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2011/08/27 11:27
S1	0	digital near0 cameara and extrinsic near0 parameters	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/23 19:46

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S2	0	cameara and extrinsic near0 parameters	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/23 19:47
S3	670	extrinsic near0 parameters	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/23 19:47
S4	494	extrinsic near0 parameters and camera	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/23 19:47
S5	249	extrinsic near0 parameters and camera and image near10 calibration	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/23 19:48
S6	56	extrinsic near0 parameters and camera and image near10 calibration near0 object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 12:44

S7	4102	robot and manipulate and scal$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 13:04
S8	6	extrinsic near0 parameters and camera and image near10 calibration near0 object and S7	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 13:05
S9	56	extrinsic near0 parameters and camera and image near10 calibration near0 object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 14:54
S10	1917	robot and manipulate and scal$3 and sample and features	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 14:56
S11	152	robot and manipulate and scal$3 and sample and features and reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 15:01

S12	34	robot same manipulate and scal$3 and sample and features and reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 15:32
S13	31	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 15:39
S14	24	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3 and object and robot and manipulat$3 and frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 16:15
S15	16	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3 and object and robot and manipulat$3 and frame and six	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 16:20

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S16	6	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3 and object and robot and manipulat$3 and frame and six and camera	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 17:09
S17	6	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3 and object and robot and manipulat$3 and frame and six and camera and position and frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 17:18
S18	6	robot same manipulate and scal$3 and sample and features and reference near0 frame and image and select$3 and object and robot and manipulat$3 and frame and six and camera and position and frame and computer	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 17:48

S19	8168	(700/245 1700/246 1700/253 1700/257 1700/258 1700/259 1700/279 or 29/218 129/702 129/714 129/720 129/407.1 129/407.04 or 318/568.13 I 318/568.15 1318/568.16 1318/640 or 348/42 1348/94 1348/154 1348/1901 348/291 1348/287552 or 901/6 1901/14 1901/17 1901/46 1901/47 or 414/730 1414/737 or 382/154).ccls.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 20:52
S20	117	("4871252" or "5999881" or "4949277" or "4980762" or "5016110" or "5177563" or "5295778" or "5300869" or H001378 or "5696674" or "5819304" or "5870303" or "6081370" or "6096999" or	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/24 20:54

		"4273505" or "4299386" or "4307891" or "4312432" or "4359815" or "4421450" or "4479754" or "4479717" or "4480170" or "4484855" or "4488173" or "4494874" or "4502830" or "4556360" or "4568238" or "4574655" or "4576537" or "4582277" or "4594001" or "4624621" or "4627511" or "4762459" or "4764077" or "4779804" or "4782567" or "4783904" or "4789417" or "4815901" or "4818858" or "4865514" or "4875273" or "4875823" or					

		"4886375" or "4934504" or "4942539" or "4943889").pn.				
S21	961	camera and orthogonal near0 axes and rotation and translation	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 08:53
S22	171	camera and orthogonal near0 axes and rotation and translation and reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 08:53
S23	0	camera and orthogonal near0 axes and rotation and translation and reference near0 frame and space near6 training	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 08:54
S24	23	camera and orthogonal near0 axes and rotation and translation and reference near0 frame and space and training	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 08:54

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S25	209	scale near0 factor and framegrabber	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:11
S26	2	scale near0 factor same framegrabber	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:11
S27	2	scale near0 factor same framegrabber and resampling	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:12
S28	0	scale near0 factor same framegrabber and sampling	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:12
S29	2	scale near0 factor same framegrabber and focal near0 length	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:13

S30	2	scale near0 factor same framegrabber and camera	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:13
S31	2	scale near0 factor same framegrabber and lens	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:13
S32	2	scale near0 factor same framegrabber and distortion	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:14
S33	354	object near0 space near0 coordinate	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:51
S34	3	object near0 space near0 coordinate and select$3 near0 feature	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:52

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S35	60	object near0 space near0 coordinate and image and teaching	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 10:53
S36	30	object near0 space near0 coordinate and select$3 near10 image and teaching	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 11:00
S38	0	robot same mov$3 near3 camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:39
S39	1	robot same mov$3 near10 camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:39
S40	0	robot same mov10 near10 camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:39

S41	0	robot same orient$3 near10 camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:40
S42	0	robot same camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:40
S43	24	camera near0 orthogonally	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:41
S44	0	camera near0 orthogonally and robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 12:41
S45	2	camera and object near0 space near0 reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:05

S46	80	camera and object near6 space near10 reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:06
S47	56	camera and object near6 space near5 reference near0 frame	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:06
S48	0	("20020159628" "4,942,539" "5,802,201" "20040233461" "20100040255" "20010034481").pn. and position near3 orientation and tool near0 frame near0 reference and transformations	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:58
S49	13	position near3 orientation and tool near0 frame near0 reference and transformations	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:58

S50	12	position near3 orientation and tool near0 frame near0 reference and transformations and object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 22:59
S51	2	"20100231706".pn.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 23:15
S52	1	"20100231706".pn. and tool	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/25 23:15
S53	0	adjusting same robot same insufficient and image and target near0 object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:04
S54	2	adjusting same robot same insufficient and image and target and object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:04

S55	2	adjusting same robot same insufficient and image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:05
S56	139	adjusting same robot and insufficient and image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:06
S57	104	adjusting same robot and insufficient and image and target	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:06
S58	103	adjusting same robot and insufficient and image and target and object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 00:06
S59	12	("20020159628" "4,942,539" "5,802,201" "20040233461" "20100040255" "20010034481").pn.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:06

S60	317	pose near0 estimation and three near2 dimensional and two near2 dimensional	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:22
S61	40	pose near0 estimation and three near2 dimensional and two near2 dimensional and target near0 object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:23
S62	14	("20020159628" "4,942,539" "5,802,201" "20040233461" "20100040255" "20010034481" "4,729,536").pn.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:54
S63	0	camera near0 mounted same movable same portion and robot near5 effector	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:58

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S64	1	camera near0 mounted same movable same portion same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 10:59
S65	38	camera near0 mounted and movable same portion same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 11:00
S66	1	camera near3 mounted near5 orthogonally same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 12:54
S67	4	camera near6 orthogonally same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 12:55
S68	5	camera near10 orthogonally same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 12:55

ABB Inc. Exhibit 1002, Page 979 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

S69	16	camera near10 orthogonally and robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 12:56
S70	14	camera same orthogonally same robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 13:02
S71	115	camera same orthogonally and robot	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 13:12
S72	27	adjusting near3 position same robot and insufficient and image and target and object	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/11/26 14:10
S73	0	unsufficient near0 cpatured near0 image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:36

ABB Inc. Exhibit 1002, Page 980 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

S74	0	unsufficient near0 captured near0 image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:36
S75	0	unsufficient same captured near0 image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:37
S76	82153	captured near0 image	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:37
S77	75658	movable near0 portion	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:37
S78	429	S76 and S77	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:38

S79	184142	location and insufficient	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:38
S80	82	S78 and S79	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:38
S81	259484	robot$6	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:39
S82	9	S80 and S81	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT; IBM_TDB	OR	ON	2010/12/04 08:39

EAST Search History (Interference)

<This search history is empty>

8/27/11 11:28:20 AM
C:\Documents and Settings\mmarc\My Documents\EAST\Workspaces\10634874.wsp

ABB Inc. Exhibit 1002, Page 982 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

BIB DATA SHEET

CONFIRMATION NO. 7619

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
10/634,874	08/06/2003	700	3667	810112.401C1

APPLICANTS

Babak Habibi, North Vancouver, CANADA;
Simona Pescaru, North Vancouver, CANADA;
Mohammad Sameti, Coquitlam, CANADA;
Remus Florinel Boca, North Vancouver, CANADA;

**** CONTINUING DATA ***************************

This application is a CIP of 10/153,680 05/24/2002 PAT 6,816,755

**** FOREIGN APPLICATIONS ***************************

CANADA 2,369,845 01/31/2002

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **** ** SMALL ENTITY **

11/12/2003

Foreign Priority claimed ☑ Yes ☐ No 35 USC 119(a-d) conditions met ☑ Yes ☐ No Verified and Acknowledged /MCDIEUNEL MARC/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		CANADA	7	~~32~~ 28	~~2~~ 3

ADDRESS

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104
UNITED STATES

TITLE

METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS

FILING FEE RECEIVED		
653	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

ABB Inc. Exhibit 1002, Page 983 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

500 7590 09/08/2011
SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/634,874	08/06/2003	Babak Habibi	810112.401C1	7619

TITLE OF INVENTION: METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	$755	$300	$0	$1055	12/08/2011

EXAMINER	ART UNIT	CLASS-SUBCLASS
MARC, MCDIEUNEL	3667	700-245000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 Seed IP Law Group PLLC
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: RoboticVISIONTech LLC
(B) RESIDENCE: (CITY and STATE OR COUNTRY): Great Falls, Virginia

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☒ Issue Fee
☒ Publication Fee (No small entity discount permitted)
☒ Advance Order - # of Copies 3

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
☐ A check is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 19-1090 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____ Date December 6, 2011

Typed or printed name Frank Abramonte Registration No. 38,066

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

ABB Inc. Exhibit 1002, Page 984 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Electronic Patent Application Fee Transmittal

Application Number:	10634874
Filing Date:	06-Aug-2003
Title of Invention:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS
First Named Inventor/Applicant Name:	Babak Habibi
Filer:	Frank Abramonte/Sandy Clayton
Attorney Docket Number:	810112.401C1

Filed as Small Entity

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	2501	1	870	870
Publ. Fee- early, voluntary, or normal	1504	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
Printed copy of patent - no color	8001	3	3	9
		Total in USD ($)		**1179**

Electronic Acknowledgement Receipt

EFS ID:	11550490
Application Number:	10634874
International Application Number:	
Confirmation Number:	7619
Title of Invention:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS
First Named Inventor/Applicant Name:	Babak Habibi
Customer Number:	500
Filer:	Frank Abramonte/Sandy Clayton
Filer Authorized By:	Frank Abramonte
Attorney Docket Number:	810112.401C1
Receipt Date:	06-DEC-2011
Filing Date:	06-AUG-2003
Time Stamp:	14:17:42
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Deposit Account
Payment was successfully received in RAM	$1179
RAM confirmation Number	671
Deposit Account	191090
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)

1	Issue Fee Payment (PTO-85B)	401C1_Issue_Fee.pdf	99637 1d90bafee6abc63708afaaa36d6c8814ac5ed96f	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	33646 bbad9f5dfc5247bbac457a9456f3a996f9fd0241	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	133283	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/634,874	01/10/2012	8095237	810112.401C1	7619

500 7590 12/21/2011

SEED INTELLECTUAL PROPERTY LAW GROUP PLLC
701 FIFTH AVE
SUITE 5400
SEATTLE, WA 98104

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 525 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Babak Habibi, North Vancouver, CANADA;
Simona Pescaru, North Vancouver, CANADA;
Mohammad Sameti, Coquitlam, CANADA;
Remus Florinel Boca, North Vancouver, CANADA;

ABB Inc. Exhibit 1002, Page 989 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent No.	:	8,095,237 B2
Issue Date	:	January 10, 2012
Inventors	:	Babak Habibi et al.
		Docket No. : 810112.401C1
		Date : June 13, 2012

Mail Stop Certificate of Correction
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REQUEST FOR CERTIFICATE OF CORRECTION

Commissioner for Patents:

A certificate of correction is respectfully requested in the above-identified patent. The following error has been made:

In the claims, column 11, line 54, issued claim 1, "1. A useful in three-dimensional pose estimation for use" is incorrect. As set forth in the Amendment filed June 5, 2009, with the United States Patent and Trademark Office, the correct line should read, --1. A method useful in three-dimensional pose estimation for use--. Issued claim 1 appeared as claim 50 during prosecution.

ABB Inc. Exhibit 1002, Page 990 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

Attached is the certificate of correction, which indicates the correction to be made, by reference to the column and line numbers in the printed patent. Because the error was made by the Patent Office, no fee is necessary. However if the error is determined to be our error, the Director is hereby authorized to charge payment of any fees associated with this communication to Deposit Account No. 19-1090.

Respectfully submitted,
SEED Intellectual Property Law Group PLLC

/Frank Abramonte/
Frank Abramonte
Registration No. 38,066

FXA:kdh

Enclosure:
Certificate of Correction

SEED Intellectual Property Law Group PLLC
701 Fifth Avenue, Suite 5400
Seattle, Washington 98104-7092
Phone: (206) 622-4900
Fax: (206) 682-6031
2200388_1

ABB Inc. Exhibit 1002, Page 991 of 996
ABB Inc. v. Roboticvisiontech, Inc.
IPR2023-01426

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO : 8,095,237 B2
APPLICATION NO. : 10/634,874
DATED : January 10, 2012
INVENTORS : Babak Habibi et al.

It is certified that an error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 11, Line 54:

"1. A useful in three-dimensional pose estimation for use" should read,

--1. A method useful in three-dimensional pose estimation for use--.

MAILING ADDRESS OF SENDER:
Frank Abramonte
Seed Intellectual Property Law Group PLLC
701 Fifth Avenue, Suite 5400
Seattle, Washington 98104

PATENT NO. 8,095,237 B2

No. of additional copies: 0

SEND TO: Attention Certificate of Corrections Branch, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450

Electronic Acknowledgement Receipt

EFS ID:	13003841
Application Number:	10634874
International Application Number:	
Confirmation Number:	7619
Title of Invention:	METHOD AND APPARATUS FOR SINGLE IMAGE 3D VISION GUIDED ROBOTICS
First Named Inventor/Applicant Name:	Babak Habibi
Customer Number:	500
Filer:	Frank Abramonte/Kyle Hill
Filer Authorized By:	Frank Abramonte
Attorney Docket Number:	810112.401C1
Receipt Date:	13-JUN-2012
Filing Date:	06-AUG-2003
Time Stamp:	15:44:38
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Certificate of Correction	810112_401C1_Request_for_Certificate_of_Correction_w_PTOSB44.pdf	137576 1383da72e28bc07b504186a978dadfa204b45435	no	3

Warnings:	
Information:	

Total Files Size (in bytes):	137576

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO.	: 8,095,237 B2
APPLICATION NO.	: 10/634874
DATED	: January 10, 2012
INVENTOR(S)	: Babak Habibi et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 11, Line 54:

"1. A useful in three-dimensional pose estimation for use" should read,

--1. A method useful in three-dimensional pose estimation for use--.

Signed and Sealed this

Seventeenth Day of July, 2012

David J. Kappos

Director of the United States Patent and Trademark Office

AO 120 (Rev. 08/10)

TO:	**Mail Stop 8** **Director of the U.S. Patent and Trademark Office** **P.O. Box 1450** **Alexandria, VA 22313-1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court District of Delaware on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
	9/22/2022	District of Delaware

PLAINTIFF	DEFENDANT
ROBOTICVISIONTECH, INC.	ABB INC.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	US 6,816,755 B2	11/9/2004	Roboticvisiontech Inc.
2	US 7,336,814 B2	2/26/2008	Roboticvisiontech Inc.
3	US 8,095,237 B2	1/10/2012	Roboticvisiontech Inc.
4			
5			

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director **Copy 3—Upon termination of action, mail this copy to Director**
Copy 2—Upon filing document adding patent(s), mail this copy to Director **Copy 4—Case file copy**