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By: /Peter J. Gutierrez, III/
Peter J. Gutierrez, III, Reg. No. 56,732

US UTILITY APPLICATION TRANSMITTAL

Sir:

Transmitted herewith for filing is the patent application of

Inventor(s): **Borja Ibarz Gabardos**
Jean-Baptiste Passot

For: **SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION**

Included herewith are:

- (X) Specification in thirty-six (36) pages, including twenty (20) claims and abstract.
- (X) Thirteen (13) figures on twelve (12) sheet(s) of informal drawings.
- (X) Application Data Sheet (7 pages).
- (X) Applicant claims small entity status. (See 37 CFR 1.27)

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Respectfully Submitted,

GAZDZINSKI & ASSOCIATES, PC

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By: /Peter J. Gutierrez, III/

Peter J. Gutierrez, III
Registration No. 56,732
Attorney of Record
16644 West Bernardo Drive, Suite 201
San Diego, CA 92127
Telephone: (858) 675-1670
Facsimile: (858) 675-1674

**SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN
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Background**Technological Field**

[0002] The present application relates generally to robotics, and more specifically to systems and methods for dynamic route planning in autonomous navigation.

Background

[0003] Robotic navigation can be a complex problem. In some cases, robots can determine a route to travel. By way of illustration, a robot can learn routes demonstrated by a user (e.g., the user can control a robot along a route and/or can upload a map containing a route). As another illustration, a robot can plan its own route in an environment based on its knowledge of the environment (e.g., a map). However, a challenge that can occur is that after a robot determines a route, features of the environment can change. For example, items can fall into the path of the route and/or parts of the environment can change. Current robots may not be able to make real time adjustments to its planned path in response to these changes (e.g., blockages). In such situations, current robots may stop, collide into objects, and/or make sub-optimal adjustments to its route. Accordingly, there is a need for improved systems and methods for autonomous navigation, including systems and methods for dynamic route planning.

Summary

[0004] The foregoing needs are satisfied by the present disclosure, which provides

for, *inter alia*, apparatus and methods for dynamic route planning in autonomous navigation. Example implementations described herein have innovative features, no single one of which is indispensable or solely responsible for their desirable attributes. Without limiting the scope of the claims, some of the advantageous features will now be summarized.

[0005] In a first aspect, a robot is disclosed. In one exemplary implementation, the robot includes: one or more sensors configured to collect data about an environment including detected points on one or more objects in the environment; and a controller configured to: create a map of the environment based at least in part on the collected data, determine a route in the map in which the robot will travel, generate one or more route poses on the route, wherein each route pose comprises a footprint indicative of poses of the robot along the route and each route pose has a plurality of points disposed therein, determine forces on each of the plurality of points of each route pose, the forces comprising repulsive forces from one or more of the detected points on the one or more objects and attractive forces from one or more of the plurality of points on others of the one or more route poses, reposition one or more route poses in response to the forces on each point of the one or more route poses, and perform interpolation between one or more route poses to generate a collision-free path between the one or more route poses for the robot to travel.

[0006] In one variant, the one or more route poses form a sequence in which the robot travels along the route; and the interpolation comprises a linear interpolation between sequential ones of the one or more route poses.

[0007] In another variant, the interpolation generates one or more interpolation route poses having substantially similar footprints to the footprint of each route pose. In another variant, the determination of the forces on each point of the one or more route poses further comprises computing a force function that associates, at least in part, the forces on each point of each route pose with one or more characteristics of objects in the environment.

[0008] In another variant, the one or more characteristics includes one or more of distance, shape, material, and color. In another variant, the force function associates zero repulsive force exerted by a first detected point on a first object where a distance between the first point and a second point of a first route pose is above a predetermined distance threshold.

[0009] In another variant, the footprint of each route pose has substantially similar

size and shape as the footprint of the robot.

[0010] In another variant, the robot comprises a floor cleaner.

[0011] In a second aspect, a method for dynamic navigation of a robot is disclosed. In one exemplary implementation, the method includes: generating a map of the environment using data from one or more sensors; determining a route on the map, the route including one or more route poses, each route pose comprising a footprint indicative at least in part of a pose and a shape of the robot along the route and each route pose having a plurality of points disposed therein; computing repulsive forces from a point on an object in the environment onto the plurality of points of a first route pose of the one or more route poses; repositioning the first route pose in response to at least the repulsive force; and performing an interpolation between the repositioned first route pose and another of the one or more route poses.

[0012] In one variant, determining attractive forces from a point on another of the one or more route poses exerted on the plurality of points of the first route pose. In another variant, detecting a plurality of objects in the environment with the one or more sensors, each of the plurality of objects having detected points; and defining a force function, the force function computing repulsive forces exerted by each of the detected points of the plurality of objects on the plurality of points of the first route pose, wherein each repulsive force is a vector.

[0013] In another variant, repositioning the first route pose includes calculating the minimum of the force function.

[0014] In another variant, the repositioning of the first route pose includes translating and rotating the first route pose.

[0015] In another variant, interpolation includes: generating an interpolation route pose having a footprint substantially similar to a shape of the robot; and determining a translation and rotation of the interpolation route pose based at least on a collision-free path between the translated and rotated first route pose and the another of the one or more route poses.

[0016] In another variant, the method further comprising computing a magnitude of the repulsive forces as proportional to a distance between the point on the object and each of the plurality of points of the first route pose if the point on the object is outside of the footprint of the first route pose.

[0017] In another variant, computing a magnitude of the repulsive forces as inversely proportional to a distance between the point on the object and each of the plurality of points of the first route pose if the point on the object is inside the footprint of the first route pose.

[0018] In another variant, the method further includes computing the torque forces onto the plurality of points of the first route pose due to the repulsive forces.

[0019] In a third aspect, a non-transitory computer-readable storage apparatus is disclosed. In one embodiment, the non-transitory computer-readable storage apparatus has a plurality of instructions stored thereon, the instructions being executable by a processing apparatus to operate a robot. The instructions are configured to, when executed by the processing apparatus, cause the processing apparatus to: generate a map of the environment using data from one or more sensors; determine a route on the map, the route including one or more route poses, each route pose comprising a footprint indicative at least in part of a pose and a shape of the robot along the route and each route pose having a plurality of points disposed therein; and compute repulsive forces from a point on an object in the environment onto the plurality of points of a first route pose of the one or more route poses.

[0020] In one variant, the instructions when executed by the processing apparatus, further cause the processing apparatus to determine attractive forces from a point on another of the one or more route poses exerted on the plurality of points of the first route pose.

[0021] In another variant, the instructions when executed by the processing apparatus, further cause the processing apparatus to determine torque forces from a point on another of the one or more route poses exerted on the plurality of points of the first route pose.

[0022] These and other objects, features, and characteristics of the present disclosure, as well as the methods of operation and functions of the related elements of structure and the combination of parts and economies of manufacture, will become more apparent upon consideration of the following description and the appended claims with reference to the accompanying drawings, all of which form a part of this specification, wherein like reference numerals designate corresponding parts in the various figures. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only and are not intended as a definition of the limits of the disclosure. As used in the specification and in the claims, the singular form of “a”, “an”, and “the” include plural

referents unless the context clearly dictates otherwise.

Brief Description of the Drawings

[0023] The disclosed aspects will hereinafter be described in conjunction with the appended drawings, provided to illustrate and not to limit the disclosed aspects, wherein like designations denote like elements.

[0024] FIG. 1 illustrates various side elevation views of exemplary body forms for a robot in accordance with principles of the present disclosure.

[0025] FIG. 2A is a diagram of an overhead view of a robot navigating a path in accordance with some implementations of this disclosure.

[0026] FIG. 2B illustrates an overhead view of a user demonstrating a route to a robot before the robot autonomously travels a route in an environment.

[0027] FIG. 3 is a functional block diagram of a robot in accordance with some principles of this disclosure.

[0028] FIG. 4A is a top view diagram illustrating the interaction between a robot and an obstacle in accordance with some implementations of this disclosure.

[0029] FIG. 4B is a diagram of a global layer, intermediate layer, and local layer in accordance with implementations of the present disclosure.

[0030] FIG. 4C is a process flow diagram of an exemplary method for dynamic route planning in accordance with some implementations of this disclosure.

[0031] FIG. 4D illustrates an overhead view of route poses along with repulsive forces exerted by objects in accordance with some implementations of the present disclosure.

[0032] FIG. 4E illustrates an overhead view showing attractive forces between route poses in accordance with some implementations of the present disclosure.

[0033] FIG. 5 is an overhead view of a diagram showing interpolation between route poses in accordance with some implementations of this disclosure.

[0034] FIG. 6 is a process flow diagram of an exemplary method for operation of a robot in accordance with some implementations of this disclosure.

[0035] FIG. 7 is a process flow diagram of an exemplary method for operation of a robot in accordance with some implementations of this disclosure.

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Detailed Description

[0037] Various aspects of the novel systems, apparatuses, and methods disclosed herein are described more fully hereinafter with reference to the accompanying drawings. This disclosure can, however, be embodied in many different forms and should not be construed as limited to any specific structure or function presented throughout this disclosure. Rather, these aspects are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art. Based on the teachings herein, one skilled in the art should appreciate that the scope of the disclosure is intended to cover any aspect of the novel systems, apparatuses, and methods disclosed herein, whether implemented independently of, or combined with, any other aspect of the disclosure. For example, an apparatus can be implemented or a method can be practiced using any number of the aspects set forth herein. In addition, the scope of the disclosure is intended to cover such an apparatus or method that is practiced using other structure, functionality, or structure and functionality in addition to or other than the various aspects of the disclosure set forth herein. It should be understood that any aspect disclosed herein can be implemented by one or more elements of a claim.

[0038] Although particular aspects are described herein, many variations and permutations of these aspects fall within the scope of the disclosure. Although some benefits and advantages of the preferred aspects are mentioned, the scope of the disclosure is not intended to be limited to particular benefits, uses, and/or objectives. The detailed description and drawings are merely illustrative of the disclosure rather than limiting, the scope of the disclosure being defined by the appended claims and equivalents thereof.

[0039] The present disclosure provides for improved systems and methods for dynamic route planning in autonomous navigation. As used herein, a robot can include mechanical or virtual entities configured to carry out complex series of actions automatically. In some cases, robots can be machines that are guided by computer programs or electronic circuitry. In some cases, robots can include electro-mechanical components that are configured for navigation, where the robot can move from one location to another. Such

navigating robots can include autonomous cars, floor cleaners, rovers, drones, carts, and the like.

[0040] As referred to herein, floor cleaners can include floor cleaners that are manually controlled (e.g., driven or remote control) and/or autonomous (e.g., using little to no user control). For example, floor cleaners can include floor scrubbers that a janitor, custodian, or other person operates and/or robotic floor scrubbers that autonomously navigate and/or clean an environment. Similarly, floor cleaners can also include vacuums, steamers, buffers, mop, polishers, sweepers, burnishers, etc.

[0041] Detailed descriptions of the various implementations and variants of the system and methods of the disclosure are now provided. While many examples discussed herein are in the context of robotic floor cleaners, it will be appreciated that the described systems and methods contained herein can be used in other robots. Myriad other example implementations or uses for the technology described herein would be readily envisaged by those having ordinary skill in the art, given the contents of the present disclosure.

[0042] Advantageously, the systems and methods of this disclosure at least: (i) provide for dynamic route planning in an autonomously navigating robot; (ii) enhance efficiency in navigating environments, which can allow for improved and/or efficient utilization of resources (e.g., energy, fuel, cleaning fluid, etc.) usage; and (iii) provide computational efficiency which can reduce consumption of processing power, energy, time, and/or other resources in navigating robots. Other advantages are readily discernable by one having ordinary skill given the contents of the present disclosure.

[0043] For example, many current robots that can autonomously navigate are programmed to navigate a route and/or path to a goal. In order to navigate these routes, these robots can create a path plan (e.g., a global solution). Also, these robots can have localized plans in a small area around it (e.g., in the order of a few meters), where the robot can determine how it will navigate around obstacles detected by its sensors (typically with basic commands to turn when an object is detected). The robot can then traverse the space in the pattern and avoid obstacles detected by its sensors by, e.g., stopping, slowing down, deviating left or right, etc. However, in many current applications, such traversal and avoidance can be complicated and robots can either have undesirable results (e.g., stoppages or collisions) and/or not be able to navigate through more complex situations. In some cases,

such current applications can also be computationally expensive and/or slow to run, causing robots to act unnaturally.

[0044] Advantageously, using systems and methods disclosed herein, robots can deviate from its programming, following more efficient paths and/or making more complex adjustments to avoid obstacles. In some implementations described herein, such movements can be determined in a more efficient, faster way, that also appears more natural as a robot plans more complex paths.

[0045] A person having ordinary skill in the art would appreciate that a robot, as referred to herein, can have a number of different appearances/forms. FIG. 1 illustrates various side elevation views of exemplary body forms for a robot in accordance with principles of the present disclosure. These are non-limiting examples meant to further illustrate the variety of body forms, but not to restrict robots described herein to any particular body form. For example, body form 100 illustrates an example where the robot is a stand-up shop vacuum. Body form 102 illustrates an example where the robot is a humanoid robot having an appearance substantially similar to a human body. Body form 104 illustrates an example where the robot is a drone having propellers. Body form 106 illustrates an example where the robot has a vehicle shape having wheels and a passenger cabin. Body form 108 illustrates an example where the robot is a rover.

[0046] Body form 110 can be an example where the robot is a motorized floor scrubber. Body form 112 can be a motorized floor scrubber having a seat, pedals, and a steering wheel, where a user can drive body form 112 like a vehicle as body form 112 cleans, however, body form 112 can also operate autonomously. Other body forms are further contemplated, including industrial machines that can be robotized, such as forklifts, tugs, boats, planes, etc.

[0047] FIG. 2A is a diagram of an overhead view of robot 202 navigating a path 206 in accordance with some implementations of this disclosure. Robot 202 can autonomously navigate through environment 200, which can comprise various objects 208, 210, 212, 218. Robot 202 can start at an initial location and end at an end location. As illustrated, the initial position and the end position are substantially the same, illustrating a substantially closed loop. However, in other cases, the initial location and the end location may not be substantially the same, forming an open loop.

[0048] By way of illustration, in some implementations, robot 202 can be a robotic floor cleaner, such as a robotic floor scrubber, vacuum cleaner, steamer, mop, burnisher, sweeper, and the like. Environment 200 can be a space having floors that are desired to be cleaned. For example, environment 200 can be a store, warehouse, office building, home, storage facility, etc. One or more of objects 208, 210, 212, 218 can be shelves, displays, objects, items, people, animals, or any other entity or thing that may be on the floor or otherwise impede the robot's ability to navigate through environment 200. Route 206 can be the cleaning path traveled by robot 202 autonomously. Route 206 can follow a path that weaves between objects 208, 210, 212, 218 as illustrated in example route 206. For example, where objects 208, 210, 212, 218 are shelves in a store, robot 202 can go along the aisles of the store and clean the floors of the aisles. However, other routes are also contemplated, such as, without limitation, weaving back and forth along open floor areas and/or any cleaning path a user could use to clean the floor (e.g., if the user is manually operating a floor cleaner). In some cases, robot 202 can go over a portion a plurality of times. Accordingly, routes can overlap on themselves. Accordingly, route 206 is meant merely as illustrative examples and can appear differently as illustrated. Also, as illustrated, one example of environment 200 is shown, however, it should be appreciated that environment 200 can take on any number of forms and arrangements (e.g., of any size, configuration, and layout of a room or building) and is not limited by the example illustrations of this disclosure.

[0049] In route 206, robot 202 can begin at the initial location, which can be robot 202's starting point. Robot 202 can then clean along route 206 autonomously (e.g., with little or no control from a user) until it reaches an end location, where it can stop cleaning. The end location can be designated by a user and/or determined by robot 202. In some cases, the end location can be the location in route 206 after which robot 202 has cleaned the desired area of floor. As previously described, route 206 can be a closed loop or an open loop. By way of illustrative example, an end location can be a location for storage for robot 202, such as a temporary parking spot, storage room/closet, and the like. In some cases, the end location can be the point where a user training and/or programming tasks for robot 202 stopped training and/or programming.

[0050] In the context of floor cleaners (e.g., floor scrubbers, vacuum cleaners, etc.), robot 202 may or may not clean at every point along route 206. By way of illustration, where

robot 202 is a robotic floor scrubber, the cleaning system (e.g., water flow, cleaning brushes, etc.) of robot 202 may only be operating in some portions of route 206 and not others. For example, robot 202 may associate certain actions (e.g., turning, turning on/off water, spraying water, turning on/off vacuums, moving vacuum hose positions, gesticulating an arm, raising/lowering a lift, moving a sensor, turning on/off a sensor, etc.) with particular positions and/or trajectories (e.g., while moving in a certain direction or in a particular sequence along route 206) along the demonstrated route. In the context of floor cleaners, such association may be desirable when only some areas of the floor are to be cleaned but not others and/or in some trajectories. In such cases, robot 202 can turn on a cleaning system in areas where a user demonstrated for robot 202 to clean, and turn off the cleaning system otherwise.

[0051] FIG. 2B illustrates an overhead view of a user demonstrating route 216 to robot 202 before robot 202 autonomously travels route 206 in environment 200. In demonstrating route 216, a user can start robot 202 at an initial location. Robot 202 can then weave around objects 208, 210, 212, 218. Robot 202 can stop at an end location, as previously described. In some cases (and as illustrated), autonomously navigated route 206 can be exactly the same as demonstrated route 216. In some cases, route 206 might not be precisely the same as route 216, but can be substantially similar. For example, as robot 202 navigates route 206, robot 202 uses its sensors to sense where it is in relationship to its surrounding. Such sensing may be imprecise in some instances, which may cause robot 202 to not navigate the precise route that had been demonstrated and robot 202 had been trained to follow. In some cases, small changes to environment 200, such as the moving of shelves and/or changes in the items on the shelves, can cause robot 202 to deviate from route 216 when it autonomously navigates route 206. As another example, as previously described, robot 202 can avoid objects by turning around them, slowing down, etc. when autonomously navigating route 206. These objects might not have been present (and avoided) when the user demonstrated route 216. For example, the objects may be temporarily and/or transient items, and/or may be transient and/or dynamic changes to the environment 200. As another example, the user may have done a poor job demonstrating route 216. For example, the user may have crashed and/or bumped into a wall, shelf, object, obstacle, etc. As another example, an obstacle may have been present while the user had demonstrated route 216, but no longer

there when robot 202 autonomously navigates route 206. In these cases, robot 202 can store in memory (e.g., memory 302) one or more actions that it can correct, such as crashing and/or bumping to a wall, shelf, object, obstacle, etc. When robot 202 then autonomously navigates demonstrated route 216 (e.g., as route 206), robot 202 can correct such actions and not perform them (e.g., not crash and/or bump into a wall, shelf, object, obstacle, etc.) when it is autonomously navigating. In this way, robot 202 can determine not to autonomously navigate at least a portion of a navigable route, such as a demonstrated route. In some implementations, determining not to autonomously navigate at least a portion of the navigable route includes determining when to avoid an obstacle and/or object.

[0052] As previously mentioned, as a user demonstrates route 216, the user can turn on and off the cleaning system of robot 202, or perform other actions, in order to train robot 202 where (e.g., at what position), and/or along what trajectories, to clean along route 216 (and subsequently when robot 202 autonomously cleans route 206). The robot can record these actions in memory 302 and later perform them when autonomously navigating. These actions can include any actions that robot 202 may perform, such as turning, turning on/off water, spraying water, turning on/off vacuums, moving vacuum hose positions, gesticulating an arm, raising/lowering a lift, moving a sensor, turning on/off a sensor, etc.

[0053] FIG. 3 is a functional block diagram of a robot 202 in accordance with some principles of this disclosure. As illustrated in FIG. 3, robot 202 can include controller 304, memory 302, user interfaces unit 308, exteroceptive sensors unit 306, proprioceptive sensors unit 310, and communications unit 312, as well as other components and subcomponents (e.g., some of which may not be illustrated). Although a specific implementation is illustrated in FIG. 3, it is appreciated that the architecture may be varied in certain implementations as would be readily apparent to one of ordinary skill given the contents of the present disclosure.

[0054] Controller 304 can control the various operations performed by robot 202. Controller 304 can include one or more processors (e.g., microprocessors) and other peripherals. As used herein, processor, microprocessor, and/or digital processor can include any type of digital processing device such as, without limitation, digital signal processors (“DSPs”), reduced instruction set computers (“RISC”), general-purpose (“CISC”) processors, microprocessors, gate arrays (e.g., field programmable gate arrays (“FPGAs”)),

programmable logic device (“PLDs”), reconfigurable computer fabrics (“RCFs”), array processors, secure microprocessors, specialized processors (e.g., neuromorphic processors), and application-specific integrated circuits (“ASICs”). Such digital processors may be contained on a single unitary integrated circuit die, or distributed across multiple components.

[0055] Controller 304 can be operatively and/or communicatively coupled to memory 302. Memory 302 can include any type of integrated circuit or other storage device configured to store digital data including, without limitation, read-only memory (“ROM”), random access memory (“RAM”), non-volatile random access memory (“NVRAM”), programmable read-only memory (“PROM”), electrically erasable programmable read-only memory (“EEPROM”), dynamic random-access memory (“DRAM”), Mobile DRAM, synchronous DRAM (“SDRAM”), double data rate SDRAM (“DDR/2 SDRAM”), extended data output (“EDO”) RAM, fast page mode RAM (“FPM”), reduced latency DRAM (“RLDRAM”), static RAM (“SRAM”), “flash” memory (e.g., NAND/NOR), memristor memory, pseudostatic RAM (“PSRAM”), etc. Memory 302 can provide instructions and data to controller 304. For example, memory 302 can be a non-transitory, computer-readable storage medium having a plurality of instructions stored thereon, the instructions being executable by a processing apparatus (e.g., controller 304) to operate robot 202. In some cases, the instructions can be configured to, when executed by the processing apparatus, cause the processing apparatus to perform the various methods, features, and/or functionality described in this disclosure. Accordingly, controller 304 can perform logical and arithmetic operations based on program instructions stored within memory 302.

[0056] In some implementations, exteroceptive sensors unit 306 can comprise systems and/or methods that can detect characteristics within and/or around robot 202. Exteroceptive sensors unit 306 can comprise a plurality and/or a combination of sensors. Exteroceptive sensors unit 306 can include sensors that are internal to robot 202 or external, and/or have components that are partially internal and/or partially external. In some cases, exteroceptive sensors unit 306 can include exteroceptive sensors such as sonar, LIDAR, radar, lasers, cameras (including video cameras, infrared cameras, 3D cameras, etc.), time of flight (“TOF”) cameras, antenna, microphones, and/or any other sensor known in the art. In some implementations, exteroceptive sensors unit 306 can collect raw measurements (e.g.,

currents, voltages, resistances gate logic, etc.) and/or transformed measurements (e.g., distances, angles, detected points in obstacles, etc.). Exteroceptive sensors unit 306 can generate data based at least in part on measurements. Such data can be stored in data structures, such as matrices, arrays, etc. In some implementations, the data structure of the sensor data can be called an image.

[0057] In some implementations, proprioceptive sensors unit 310 can include sensors that can measure internal characteristics of robot 202. For example, proprioceptive sensors unit 310 can measure temperature, power levels, statuses, and/or any other characteristic of robot 202. In some cases, proprioceptive sensors unit 310 can be configured to determine the odometry of robot 202. For example, proprioceptive sensors unit 310 can include proprioceptive sensors unit 310, which can comprise sensors such as accelerometers, inertial measurement units (“IMU”), odometers, gyroscopes, speedometers, cameras (e.g. using visual odometry), clock/timer, and the like. Odometry to facilitate autonomous navigation of robot 202. This odometry can include robot 202’s position (e.g., where position includes robot’s location, displacement and/or orientation, and can sometimes be interchangeable with the term pose as used herein) relative to the initial location. In some implementations, proprioceptive sensors unit 310 can collect raw measurements (e.g., currents, voltages, resistances gate logic, etc.) and/or transformed measurements (e.g., distances, angles, detected points in obstacles, etc.). Such data can be stored in data structures, such as matrices, arrays, etc. In some implementations, the data structure of the sensor data can be called an image.

[0058] In some implementations, user interfaces unit 308 can be configured to enable a user to interact with robot 202. For example, user interfaces 308 can include touch panels, buttons, keypads/keyboards, ports (e.g., universal serial bus (“USB”), digital visual interface (“DVI”), Display Port, E-Sata, Firewire, PS/2, Serial, VGA, SCSI, audioport, high-definition multimedia interface (“HDMI”), personal computer memory card international association (“PCMCIA”) ports, memory card ports (e.g., secure digital (“SD”) and miniSD), and/or ports for computer-readable medium), mice, rollerballs, consoles, vibrators, audio transducers, and/or any interface for a user to input and/or receive data and/or commands, whether coupled wirelessly or through wires. User interfaces unit 308 can include a display, such as, without limitation, liquid crystal display (“LCDs”), light-emitting diode (“LED”) displays,

LED LCD displays, in-plane-switching (“IPS”) displays, cathode ray tubes, plasma displays, high definition (“HD”) panels, 4K displays, retina displays, organic LED displays, touchscreens, surfaces, canvases, and/or any displays, televisions, monitors, panels, and/or devices known in the art for visual presentation. In some implementations user interfaces unit 308 can be positioned on the body of robot 202. In some implementations, user interfaces unit 308 can be positioned away from the body of robot 202, but can be communicatively coupled to robot 202 (e.g., via communication units including transmitters, receivers, and/or transceivers) directly or indirectly (e.g., through a network, server, and/or a cloud).

[0059] In some implementations, communications unit 312 can include one or more receivers, transmitters, and/or transceivers. Communications unit 312 can be configured to send/receive a transmission protocol, such as BLUETOOTH®, ZIGBEE®, Wi-Fi, induction wireless data transmission, radio frequencies, radio transmission, radio-frequency identification (“RFID”), near-field communication (“NFC”), infrared, network interfaces, cellular technologies such as 3G (3GPP/3GPP2), high-speed downlink packet access (“HSDPA”), high-speed uplink packet access (“HSUPA”), time division multiple access (“TDMA”), code division multiple access (“CDMA”) (e.g., IS-95A, wideband code division multiple access (“WCDMA”), etc.), frequency hopping spread spectrum (“FHSS”), direct sequence spread spectrum (“DSSS”), global system for mobile communication (“GSM”), Personal Area Network (“PAN”) (e.g., PAN/802.15), worldwide interoperability for microwave access (“WiMAX”), 802.20, long term evolution (“LTE”) (e.g., LTE/LTE-A), time division LTE (“TD-LTE”), global system for mobile communication (“GSM”), narrowband/frequency-division multiple access (“FDMA”), orthogonal frequency-division multiplexing (“OFDM”), analog cellular, cellular digital packet data (“CDPD”), satellite systems, millimeter wave or microwave systems, acoustic, infrared (e.g., infrared data association (“IrDA”)), and/or any other form of wireless data transmission.

[0060] As used herein, network interfaces can include any signal, data, or software interface with a component, network, or process including, without limitation, those of the FireWire (e.g., FW400, FW800, FWS800T, FWS1600, FWS3200, etc.), universal serial bus (“USB”) (e.g., USB 1.X, USB 2.0, USB 3.0, USB Type-C, etc.), Ethernet (e.g., 10/100, 10/100/1000 (Gigabit Ethernet), 10-Gig-E, etc.), multimedia over coax alliance technology (“MoCA”), Coaxsys (e.g., TVNET™), radio frequency tuner (e.g., in-band or OOB, cable

modem, etc.), Wi-Fi (802.11), WiMAX (e.g., WiMAX (802.16)), PAN (e.g., PAN/802.15), cellular (e.g., 3G, LTE/LTE-A/TD-LTE/TD-LTE, GSM, etc.), IrDA families, etc. As used herein, Wi-Fi can include one or more of IEEE-Std. 802.11, variants of IEEE-Std. 802.11, standards related to IEEE-Std. 802.11 (e.g., 802.11 a/b/g/n/ac/ad/af/ah/ai/aj/aq/ax/ay), and/or other wireless standards.

[0061] Communications unit 312 can also be configured to send/receive a transmission protocol over wired connections, such as any cable that has a signal line and ground. For example, such cables can include Ethernet cables, coaxial cables, Universal Serial Bus (“USB”), FireWire, and/or any connection known in the art. Such protocols can be used by communications unit 312 to communicate to external systems, such as computers, smart phones, tablets, data capture systems, mobile telecommunications networks, clouds, servers, or the like. Communications unit 312 can be configured to send and receive signals comprising of numbers, letters, alphanumeric characters, and/or symbols. In some cases, signals can be encrypted, using algorithms such as 128-bit or 256-bit keys and/or other encryption algorithms complying with standards such as the Advanced Encryption Standard (“AES”), RSA, Data Encryption Standard (“DES”), Triple DES, and the like. Communications unit 312 can be configured to send and receive statuses, commands, and other data/information. For example, communications unit 312 can communicate with a user operator to allow the user to control robot 202. Communications unit 312 can communicate with a server/network in order to allow robot 202 to send data, statuses, commands, and other communications to the server. The server can also be communicatively coupled to computer(s) and/or device(s) that can be used to monitor and/or control robot 202 remotely. Communications unit 312 can also receive updates (e.g., firmware or data updates), data, statuses, commands, and other communications from a server for robot 202.

[0062] In some implementations, one or the components and/or subcomponents can be instantiated remotely from robot 202. For example, mapping and localization units 262, may be located in a cloud and/or connected to robot 202 through communications unit 312. Connections can be direct and/or through a server and/or network. Accordingly, implementations of the functionality of this disclosure should also be understood to include remote interactions where data can be transferred using communications unit 312, and one or more portions of processes can be completed remotely.

[0063] FIG. 4A is a top view diagram illustrating the interaction between robot 202 and an obstacle 402 in accordance with some implementations of this disclosure. In navigating route 216, robot 202 can encounter obstacle 402. Obstacle 402 can impede the path of robot 202, which is illustrated as route portion 404. If robot were to continue following on route portion 404, it may collide with obstacle 402. However, in some circumstances, using exteroceptive sensors unit 306 and/or proprioceptive sensors unit 310, robot 202 can stop before colliding with obstacle 402.

[0064] This interaction with obstacle 402 illustrates advantages of implementations in accordance with the present disclosure. FIG. 4B is a diagram of global layer 406, intermediate layer 408, and local layer 410 in accordance with implementations of the present disclosure. Global layer 406, intermediate layer 408, and local layer 410 can be hardware and/or software layers instantiated in one or more of memory 302 and/or controller 304. Global layer 406 can include software and/or hardware that implements global mapping and routing. For example, the high-level mapping can include a map of environment 200. The map can also include a representation of route 216, allowing robot 202 to navigate the space in environment 200.

[0065] In some implementations, global layer 406 can include a global planner. In this way, global layer 406 can determine one or more of: the location of robot 202 (e.g., in global coordinates such as two-dimensional coordinates, three-dimensional coordinates, four-dimensional coordinates, etc.); the path robot 202 should take to reach its goal; and/or higher-level (e.g., long-range) planning. In this way, robot 202 can determine its general path and/or direction to travel from one location to another.

[0066] Local layer 410 includes software and/or hardware that implements local planning. For example, local layer 410 can include short-range planning configured for maneuvering in local constraints of motion. Local layer 410 can process data received from exteroceptive sensors unit 306 and determine the presence and/or positioning of obstacles and/or objects near robot 202. For example, if an object is within range of a sensor of exteroceptive sensors unit 306 (e.g., a LIDAR, sonar, camera, etc.), robot 202 can detect the object. The local layer 410 can compute and/or control motor functionality to navigate around objects, such by controlling actuators to turn, move forward, reverse, etc. In some cases, processing in local layer 410 can be computationally intensive. For example, local

layer 410 can receive data from sensors of exteroceptive sensors unit 306 and/or proprioceptive sensors unit 310. Local layer 410 can then determine motor functions to avoid an object detected by exteroceptive sensors unit 306 (e.g., using a motor to turn a steering column left and right, and/or using a motor to push the robot forward). The interplay of local layer 410 and global layer 406 can allow robot 202 to make local adjustments while still moving generally along a route to its goal.

[0067] However, in some circumstances, it can be desirable to make adjustments at a finer level than what would be computed by global layer 406, yet not at the computationally intensive level of precise motor functions of local layer 410. Accordingly, intermediate layer 408 can include hardware and/or software that can determine intermediate adjustments of robot 202 as it navigates around objects.

[0068] In intermediate layer 408, robot 202 can plan how to avoid objects and/or obstacles in its environment. In some cases, intermediate layer 408 can be initialized with at least a partial path and/or route from a global path planner from global layer 406.

[0069] Because objects (e.g., obstacles, walls, etc.) present things in which robot 202 could collide, objects and/or obstacles can put forth a repulsive force on robot 202. In some cases, by objects repulsing robot 202, robot 202 can navigate along a collision-free path around those objects and/or obstacles.

[0070] FIG. 4C is a process flow diagram of an exemplary method 450 for dynamic route planning in accordance with some implementations of this disclosure. In some implementations, method 450 can be performed by intermediate layer 408 and/or by controller 304. Block 452 can include obtaining a route containing one or more route poses. In some cases, this route can be created by robot 202 and/or uploaded onto robot 202. In some cases, the route can be passed from global layer 406 to intermediate layer 408. Block 454 can include selecting a first route pose. Block 456 can include, for the first route pose, determining repulsive forces from objects in the environment. Block 458 can include, for the first route pose, determining attractive forces from other route poses. Block 460 can include determining the translation and/or rotation of the first route pose due to the repulsive forces and attractive forces. Block 462 can include performing interpolation to account for the translated and/or rotated route pose. This process and others will be illustrated throughout this disclosure.

[0071] By way of illustration, FIG. 4D illustrates route poses 414 and 416 along with repulsive forces exerted by objects in accordance with some implementations of the present disclosure. For example, the points on a route can be discretized locations along the path, such as route poses, illustrating the pose of robot 202 throughout its route. In some cases, such discretized locations can also have associated probabilities, such as particles or bubbles. Route poses can identify the position and/or orientation that robot 202 would travel on the route. In a planar application, the route pose can include (x, y, θ) coordinates. In some cases, θ can be the heading of the robot in the plane. The route poses can be regularly or irregularly spaced on robot 202's route. In some cases, intermediate layer can obtain the route containing one or more route poses from global layer 406, as described in block 452 of method 450. In some implementations, route poses can form a sequence, wherein robot 202 travels between sequential route poses on a route. For example, route poses 414 and 416 could be a sequence of route poses where robot 202 travels to route pose 414 and then to route pose 416.

[0072] By way of illustrative example, route poses 414 and 416 illustrate discretized locations along the route portion 404. This illustrative example shows route poses 414 and 416 as shaped as robot 202, with substantially similar footprints. The footprints of route poses 414 and 416 can be adjusted in size depending on how conservative one desires to be with respect to robot collisions. A smaller footprint can present higher likelihoods of a collision, but such a smaller footprint can allow robot 202 to clear more areas that it should be able to as it autonomously navigates. A larger footprint might decrease the likelihood of a collision, but robot 202 would not go through some places autonomously that it otherwise should be able to. The footprint can be predetermined by a footprint parameter that sets the size (e.g., scales) of the footprint of robot 202, as illustrated in route poses (e.g., route poses 414 and 416). In some cases, there can be a plurality of footprint parameters that control the sizes of route poses of robot 202 asymmetrically.

[0073] In FIG. 4D, while route poses 414 and 416 are illustrated and described, it should be appreciated by someone having ordinary skill in the art that there can be any number of route poses throughout a route, and the descriptions of the implementations of this disclosure can be applied to those route poses. Advantageously, having route poses 414 and 416 shaped like robot 202 (e.g., a footprint of robot 202) can allow robot 202 to determine

places in which robot 202 can fit while travelling. The footprint parameter(s) can be used to adjust how robot 202 projects itself. For example, a larger footprint used in route poses 414 and/or 416 can be more conservative in that it can cause, at least in part, robot 202 to travel further away from objects. In contrast, a smaller footprint can cause, at least in part, robot 202 to travel closer to objects. Route poses (e.g., route poses 414 and 416) can be of different sizes from one another. By way of illustration, it may be desirable for robot 202 to be more conservative in certain scenarios, such as on turns. Accordingly, in this illustration, the footprint of route poses on turns can be larger than the footprint of route poses on straightaways. Such dynamic reshaping of route poses can be performed by making the size of the route poses dependent on the rotation of the route pose relative to other route poses, or the changes in translation and/or rotation of route pose. One or more of the route poses on a route (e.g., route poses 414 and/or 416) can also be a different shape other than the shape of robot 202. For example, the route poses can be circular, square, triangular, and/or any other shape.

[0074] As described in block 454 from method 450, one can observe either route poses 414 or 416 as a first route pose. However, for purposes of illustration, and to illustrate the breadth of the described implementations of this disclosure, route poses 414 and 416 will be described together.

[0075] Points along objects (e.g., points determined by mapping, detecting by sensors of exteroceptive sensors unit 306, etc.) can exert a repulsive force on route poses of robot 202 (e.g., route poses 414 and 416). In this way, the objects can, conceptually, prevent robot 202 from colliding into them. In some cases, these points can represent at least in part poses and/or sets of poses. For example, arrows 412 illustrate repulsive forces from points along object 210.

[0076] In some implementations, the forces exerted by points by objects may be uniform in that each point on route poses 414 and 416 can have substantially similar forces exerted on them. However, in other implementations, the forces exerted by points of objects on route poses 414 and 416 may not be uniform and may vary based on a force function.

[0077] By way of illustration, a force function (e.g., a repulsive force function) can in some cases determine at least in part the repulsive force exerted on a point on route poses 414 or 416 by an object. For example, the force functions can be used in block 456 of method

450 to determine the repulsive forces from objects in the environment for a first route pose (e.g., a first route pose of route poses 414 and 416). In some implementations, the force function can be dependent on characteristics of where an object appears relative to route poses 414 and 416. The force function can then represent the force experienced by points route poses 414 and 416 (e.g., one or more points on the surface of route poses 414 and 416, the center of route poses 414 and 416, the center of mass of route poses 414 and 416, and/or any point of and/or around route poses 414 and 416). Because the forces can be dependent on their direction and magnitudes, repulsive forces (and/or attractive forces) can be vectors. In some cases, repulsive forces can exert rotational forces on a route pose, which can manifest in torque forces.

[0078] For example, repulsion forces and torque forces can be calculated at n different poses along a path. In some cases, these n different poses can be associated with route poses. Each pose can consist of m points in a footprint. In some cases, these m points can be points on the route poses.

[0079] In some cases, a plurality of points can define the body of robot 202 as reflected in route poses 414 and 416, providing representative coverage over a portion of the body of robot 202 and/or substantially all of robot 202. For example, 15-20 points can be distributed throughout the surface and/or interior of robot 202 and be reflected in route poses 414 and 416. However, in some cases, there can be fewer points. FIG. 4F illustrates example points on route pose 414, such as point 418. Each point can experience, at least in part, the forces (e.g., repulsive forces) placed on it by objects in the surrounding of route poses 414.

[0080] Advantageously, by having a plurality of points on the body of route poses 414 and 416 that can experience forces, points of route poses 414 and 416 can translate and/or rotate relative to one another, causing, at least in part, repositioning (e.g., translation and/or rotation) of route poses 414 and 416. These translations and/or rotations of route poses 414 and 416 can cause deformations of the route navigated by robot 202.

[0081] Torsion forces can occur when different points on a route pose experience different magnitudes and directions of forces. Accordingly, the torsion force can cause the route poses to rotate. In some cases, predetermined parameters can define at least in part the torsion experienced by route poses 414 and 416. For example, a predetermined torsion parameter can include a multiplier for the rotational forces experience on a point on route

poses 414 or 416. This predetermined torsion parameter can be indicative of force due to misalignment of route poses 414 or 416 and the path. In some cases, the predetermined torsion parameter may vary based on whether the force is repulsive or cohesive.

[0082] Returning to FIG. 4D, a characteristic on which the force function depends in part can be a position of a point on an object relative to route poses 414 and 416. Distance can be determined based at least in part on sensors of exteroceptive sensors unit 306. As a first example, the repulsive force exerted onto route poses 414 and 416 from a point on an object exterior to robot 202 (e.g., not within the footprint of route poses 414 and 416 such as points on obstacles 210 and 212 as illustrated) can be characterized at least in part by the function $r(d) \propto 1/d$, where r is the repulsion of a point on an object and d is the distance between the point on an object and a point on route pose 414 or route pose 416. In this way, the repulsion of a point on an object is inversely proportional to the distance between the point on the object and the point on route pose 414 or route pose 416. Advantageously, such a function allows objects close to route poses 414 and 416 to exert more repulsion, and thereby potentially more strongly influence the course of robot 202 to avoid a collision than objects further away.

[0083] In some cases, a predetermined repulsive distance threshold can be put on the distance between a point on route pose 414 and route pose 416 and a point on an object. This predetermined repulsive distance threshold can be indicative at least in part of the maximum distance between a points on either route pose 414 and route pose 416 and a point on an object in which the point on the object can exert a repulsive force (and/or a torsion force) on points on either route poses 414 and 416. Accordingly, when a point on an object is a distance (e.g., from a point on either route pose 414 and route pose 416) that is above (or equal to and/or above, depending on the definition of the threshold), the repulsive force and/or torsion force can be zero or substantially zero. Advantageously, having a predetermined repulsive distance threshold can, in some cases, prevent some points on objects from exerting forces on points on route poses 414 and 416. In this way, when there is a predetermined repulsive distance, robot 202 can get closer to certain objects and/or not be influenced by further away objects.

[0084] As a second example, the repulsive force exerted onto route poses 414 and 416 from a point on the interior of route poses 414 and 416 (e.g., within the footprint of route

poses 414 and 416). For example, object 402 has portion 420 that appears interior to route pose 416. In these cases, a different force function can be exerted by points of object 402 in portion 420 onto points of route pose 416 in portion 420. In some implementations, this force can be characterized at least in part by the function $r(d) \propto d$, where the variables are as described above. Advantageously, by having a different force function defined for interior objects, route pose 416 can move asymmetrically causing rotations.

[0085] In some implementations, the force function can also depend on other characteristics of objects, such as shape, material, color, and/or any other characteristic of the object. These characteristics can be determined by one or more of sensors of exteroceptive sensors 306 in accordance with known methods in the art. Advantageously, taking into account characteristics can be further informative of how robot 202 should navigate around objects. In some instances, the cost map can be used to compute additional repulsion values based on these characteristics.

[0086] For example, the shape of an object can be indicative at least in part of an associated repercussion of collision. By way of illustration, a humanoid shape may be indicative of a person. As such, an object detected with this shape can place a greater repulsive force on route poses 414 and 416 in order to push the path further away from the humanoid shape. As another example, the shape of an object can be indicative in part of increased damage (e.g., to the object or robot 202) if a collision occurred. By way of illustration, pointed objects, skinny objects, irregular objects, predetermined shapes (e.g., vase, lamp, display, etc.) and/or any other shape can be indicative at least in part of resulting in increased damage. Size may be another characteristic of shape that can be taken into account. For example, smaller objects may be more fragile in the event of a collision, but larger objects could cause more damage to robot 202. In the case of size, force functions can take into account the size of the objects so that the points on those objects repulse points on route poses 414 and 416 proportionally as desired. By way of illustration, if route pose 414 is between a larger object and a smaller object, if points of the larger object have a relatively larger repulsive force as defined at least in part on the force function, route pose 414 will be pushed relatively closer to the smaller object. If the points of the smaller object have a relatively larger repulsive force as defined at least in part on the force function, route pose 414 will be pushed relatively closer to the larger object. Accordingly, the repulsive force on

route poses 414 and 416 can be adjusted based at least in part on the shape. The shape can be detected at least in part by sensors of exteroceptive sensors unit 306. As another illustrative example, walls can be identified in a cost map, and a repulsive force can be associated with walls due to their size and shape.

[0087] In some implementations, the force function can also depend on the material of the objects. For example, certain materials can be indicative at least in part of more damage if a collision occurred. By way of illustration, glass, porcelain, mirrors, and/or other fragile material can prove to be more damaging in the event of a collision. In some cases, such as in the case of mirrors, the material can sometimes cause errors in the sensors of exteroceptive sensor units 306. Accordingly, in some cases, it may be desirable for robot 202 to navigate further away from such objects, which can be reflected in the force function (e.g., increasing the repulsion force exerted by points on objects of some materials versus other materials).

[0088] In some implementations, color can be detected by sensors of exteroceptive sensor units 306. The force function can be dependent at least in part on the color of an object and/or points on an object. For example, certain objects in an environment may be a certain color (e.g., red, yellow, etc.) to indicate at least in part that robot 202 (or in some cases people) should be cautious of those objects. Accordingly, in some cases, it may be desirable for robot 202 to navigate further away from such objects, which can be reflected in the force function.

[0089] In some implementations, the force function can be dependent on other factors, such as the location of an object. For example, certain areas of a map (e.g., as passed from global layer 406) can have characteristics. By way of illustration, some areas of the map (e.g., a cost map) can be areas in which robot 202 should not pass. There can also be places where robot 202 cannot go into because they are not accessible (such as into an object). Accordingly, in some cases, the force function can be adjusted to account for such places. In some implementations, the force function can cause points in those places to exert no force (or substantially no force) on points on route poses 414 and 416. Advantageously, no force can be reflective of regions where robot 202 would not go (e.g., inside objects and the like). In contrast, in some implementations, such places can be treated as obstacles,

exerting a repulsive force on route poses 414 and 416. Advantageously, having such a repulsion force can keep robot 202 from attempting to enter such areas.

[0090] In some implementations, not all forces on route poses 414 and 416 are repulsive. For example, points on route poses (e.g., route poses 414 and 416) can exert attractive (e.g., cohesive) forces, which can, at least in part, pull route poses towards each other. FIG. 4E illustrates attractive forces between route poses 414 and 416 in accordance with some implementations of the present disclosure. The arrows are indicative at least in part that route poses are drawn towards each other along route portion 404. Advantageously, the cohesive force between route poses can cause, at least in part, robot 202 towards following a path substantially similar to the path planned by global layer 406 (e.g., a route substantially similar to an original route, such as an originally demonstrated route that robot 202 should follow in the absence of objects around which to navigate).

[0091] The cohesive force can be set by a force function (e.g., a cohesive force function), which can be dependent on characteristics of the path, such as the spacing distance between route poses/particles, the smoothness of the path, how desirable it is for robot 202 to follow a path, etc. In some cases, the cohesive force function can be based at least in part on a predetermined cohesion multiplier, which can determine at least in part the force pulling route poses together. A lower predetermined cohesion multiplier can reduce the cohesive strength of route portion 404 (e.g., draw of route poses towards it) and, in some cases, may cause a loss in smoothness of the path travelled by robot 202. In some cases, only sequential route poses exert cohesive forces on the points of one another. In other cases, all route poses exert cohesive forces on one another. In still other cases, some route poses exert cohesive forces on others. The determination of which route poses are configured to exert cohesive forces on one another can depend on a number of factors, which may vary on a case-by-case basis. For example, if a route is circular, it may be desirable for all route poses to exert cohesive forces on one another to tighten the circle. As another example, if the route is complex, then it may be desirable for certain complex paths to only have sequential route poses exert cohesive forces on one another. This limitation may allow robot 202 to make more turns and/or have more predictable results because other positioned route poses will not unduly influence it. Ones between the aforementioned examples in complexity may have some of the route poses exerting cohesive forces. As another example, the number of route

poses may also be a factor. Having a lot of route poses on a route may cause unexpected results if all of them exert cohesive forces on one another. If there are fewer route poses, this might not be a problem, and all or some of the route poses can exert forces. In some cases, there can be a predetermined cohesive force distance threshold, where if a point on a first route pose is distance that is more than the predetermined cohesive force distance threshold (or more than or equal to, depending on how it is defined) from a point on a second route pose, the cohesive force can be zero or substantially zero.

[0092] In some implementations the cohesive force function and the repulsive force function can be the same force function. In other implementations, the cohesive force function and the repulsive force functions are separate. The cohesive force function can be used to determine the attractive forces from other route poses in accordance with block 458 from method 450. In some implementations, both the cohesive forces and repulsive forces can result in torsion (e.g., causing rotation) of a route pose.

[0093] As described with reference to intermediate layer 408, route poses 414 and 416 can experience different attractive and repulsive forces. In some implementations, the forces can be stored in arrays. For example, there can be an array of forces indicative of repulsion, torsion, cohesion, etc.

[0094] In some cases, forces can be toggled, such as by using an on/off parameter that can turn on or off any individual force and/or group of forces from a point. For example, the on/off parameter can be binary wherein one value turns the force on and another turns the force off. In this way, some forces can be turned off, such as based on the distance an object is from a route pose, whether a point is in the interior of an object or no go zone, distance between route poses, etc.

[0095] On the balance, the net forces on route poses 414 and 416 can reposition one or more of route poses 414 and 416. For example, route poses 414 and 416 can be displaced. Route poses 414 and 416 can displace (e.g., translated and/or rotated) until their net forces, in any direction, are substantially zero and/or minimized. In this way, route poses 414 and 416 can be displaced to locations indicative at least in part to an adjusted route for robot 202 to travel to avoid objects (e.g., obstacle 402). The translation and/or rotation of a route pose due to the repulsive forces and attractive forces can be determined in accordance with block 460 of method 450.

[0096] There can be different adjustments made to determining the displacement of route poses 414 and 416. For example, in some cases, instead of considering all forces on route poses 414 and 416, attractive forces may only be considered. Advantageously, such a system can allow robot 202 to stick to static paths. Based at least in part on the displacement of route poses 414 and 416, robot 202 can set a new path for the route planner. In the new path, the trajectory can be representative of a point on robot 202, such as the center of robot 202, as robot 202 travels the path.

[0097] After robot 202 determines the displacement of route poses 414 and 416, robot 202 can determine a path to travel. For example, based on the positions (e.g., locations and/or orientations) of route poses 414 and 416, robot 202 can determine the path to navigate to and/or between route poses 414 and 416, and/or any other route poses from its present location. In some cases, robot 202 will travel between consecutive (e.g., sequential) route poses in order, defining at least in part a path. For example, this determination can be based at least in part on an interpolation between route poses taking into account the path robot 202 can travel between those points. In many cases, linear interpolation can be used. By using performing interpolation, robot 202 can account for the translated and/or rotated route pose in accordance with block 462 in method 450.

[0098] FIG. 5 is an overhead view of a diagram showing interpolation between route poses 414 and 416 in accordance with some implementations of this disclosure. Based on forces placed on route poses 414 and 416, as described herein, route poses 414 and 416 have displaced. As illustrated, route pose 414 has both translated and rotated. The translation can be measured in standard units, such as inches, feet, meters, or any other unit of measurement (e.g., measurements in the metric, US, or other system of measurement) and/or relative/non-absolute units, such as ticks, pixels, percentage of range of a sensor, and the like. Rotation can be measured in degrees, radians, etc. Similarly, route pose 416 has also been translated and/or rotated. Notably, both route poses 414 and 416 clear obstacle 402. Since route poses 414 and 416 represent discretized locations along a path travelled by robot 202, robot 202 can interpolate between them to determine the path it should take. Interpolated poses 502A – 502D illustrate a path travelled between route poses 414 and 416. Notably, robot 202 may also interpolate other paths (not illustrated) to move to route poses and/or between route poses.

[0099] Interpolated poses 502A – 502D can have associated footprints substantially similar to the footprints of one or more of route poses 414 and 416. In some cases, as illustrated in FIG. 5, interpolated poses 502A – 502D can be interpolated route poses. Accordingly, interpolated poses 502A – 502D can represent the position and/or orientation that robot 202 would be along a route. Advantageously, this can allow the interpolated path to guide robot 202 to places where robot 202 would fit. Moreover, interpolated poses 502A – 502D can be determined such that there is no overlap between the footprint of any one of interpolated poses 502 – 502D and an object (e.g., obstacle 402, object 210, or object 212), thereby avoiding collisions.

[00100] Interpolated poses 502A – 502D can also be determined taking into account the rotation and/or translation to get from route pose 414 to route pose 416. For example, robot 202 can determine the pose of route pose 414 and the pose of route pose 416. Robot 202 can then find the difference between the poses of route poses 414 and route poses 416, and then determine how to get from the pose of route pose 414 to the pose of route pose 416. For example, robot 202 can distribute the rotation and translation between interpolated poses 502A – 502D such that robot 202 would rotate and translate from route pose 414 to route pose 416. In some cases, robot 202 can distribute the rotation and translation substantially equally between interpolated poses 502A – 502D. For example, if there are N number of interpolation positions, robot 202 can divide the difference in location and rotation of the poses of route poses 414 and 416 substantially evenly across those N number of interpolation positions. Alternatively, robot 202 can divide the difference in location and/or rotation of the poses of route poses 414 and 416 un-evenly across those N number of interpolation positions. Advantageously, even division can allow for robot 202 to travel smoothly from route pose 414 to route pose 416. However, un-even division can allow robot 202 to more easily account for and avoid objects by allowing finer movements in some areas as compared to others. For example, in order to avoid an object in which interpolated poses 502A – 502D comes near, robot 202 would have to make a sharp turn. Accordingly, more interpolated poses around that turn may be desirable in order to account for the turn. In some cases, the number of interpolation positions can be dynamic, and more or fewer than N number of interpolation positions can be used as desired.

[00101] FIG. 6 is a process flow diagram of an exemplary method 600 for operation of a robot in accordance with some implementations of this disclosure. Block 602 includes creating a map of the environment based at least in part on collected data. Block 604 includes determining a route in the map in which the robot will travel. Block 606 includes generating one or more route poses on the route, wherein each route pose comprises a footprint indicative of poses of the robot along the route and each route pose has a plurality of points therein. Block 608 includes determining forces on each of the plurality of points of each route pose, the forces comprising repulsive forces from one or more of the detected points on the one or more objects and attractive forces from one or more of the plurality of points on others of the one or more route poses. Block 610 includes repositioning each route pose in response to the forces on each point of each route pose. Block 612 includes perform interpolation between the one or more repositioned route poses to generate a collision-free path between the one or more route poses for the robot to travel.

[00102] FIG. 7 is a process flow diagram of an exemplary method 700 for operation of a robot in accordance with some implementations of this disclosure. Block 702 includes generating a map of the environment using data from one or more sensors. Block 704 includes determining a route on the map, the route including one or more route poses, each route pose comprising a footprint indicative at least in part of a pose, size, and shape of the robot along the route and each route pose having a plurality of points therein. Block 706 includes computing repulsive forces from a point on an object in the environment onto the plurality of points of a first route pose of the one or more route poses. Block 708 includes repositioning the first route pose in response to at least the repulsive force. Block 710 includes performing an interpolation between the repositioned first route pose and another of the one or more route poses.

[00103] As used herein, computer and/or computing device can include, but are not limited to, personal computers (“PCs”) and minicomputers, whether desktop, laptop, or otherwise, mainframe computers, workstations, servers, personal digital assistants (“PDAs”), handheld computers, embedded computers, programmable logic devices, personal communicators, tablet computers, mobile devices, portable navigation aids, J2ME equipped devices, cellular telephones, smart phones, personal integrated communication or entertainment devices, and/or any other device capable of executing a set of instructions and

processing an incoming data signal.

[00104] As used herein, computer program and/or software can include any sequence or human or machine cognizable steps which perform a function. Such computer program and/or software may be rendered in any programming language or environment including, for example, C/C++, C#, Fortran, COBOL, MATLAB™, PASCAL, Python, assembly language, markup languages (e.g., HTML, SGML, XML, VoXML), and the like, as well as object-oriented environments such as the Common Object Request Broker Architecture (“CORBA”), JAVA™ (including J2ME, Java Beans, etc.), Binary Runtime Environment (e.g., BREW), and the like.

[00105] As used herein, connection, link, transmission channel, delay line, and/or wireless can include a causal link between any two or more entities (whether physical or logical/virtual), which enables information exchange between the entities.

[00106] It will be recognized that while certain aspects of the disclosure are described in terms of a specific sequence of steps of a method, these descriptions are only illustrative of the broader methods of the disclosure, and may be modified as required by the particular application. Certain steps may be rendered unnecessary or optional under certain circumstances. Additionally, certain steps or functionality may be added to the disclosed implementations, or the order of performance of two or more steps permuted. All such variations are considered to be encompassed within the disclosure disclosed and claimed herein.

[00107] While the above detailed description has shown, described, and pointed out novel features of the disclosure as applied to various implementations, it will be understood that various omissions, substitutions, and changes in the form and details of the device or process illustrated may be made by those skilled in the art without departing from the disclosure. The foregoing description is of the best mode presently contemplated of carrying out the disclosure. This description is in no way meant to be limiting, but rather should be taken as illustrative of the general principles of the disclosure. The scope of the disclosure should be determined with reference to the claims.

[00108] While the disclosure has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive. The disclosure is not limited to the disclosed

embodiments. Variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed disclosure, from a study of the drawings, the disclosure and the appended claims.

[00109] It should be noted that the use of particular terminology when describing certain features or aspects of the disclosure should not be taken to imply that the terminology is being re-defined herein to be restricted to include any specific characteristics of the features or aspects of the disclosure with which that terminology is associated. Terms and phrases used in this application, and variations thereof, especially in the appended claims, unless otherwise expressly stated, should be construed as open ended as opposed to limiting. As examples of the foregoing, the term “including” should be read to mean “including, without limitation,” “including but not limited to,” or the like; the term “comprising” as used herein is synonymous with “including,” “containing,” or “characterized by,” and is inclusive or open-ended and does not exclude additional, unrecited elements or method steps; the term “having” should be interpreted as “having at least;” the term “such as” should be interpreted as “such as, without limitation;” the term “includes” should be interpreted as “includes but is not limited to;” the term “example” is used to provide exemplary instances of the item in discussion, not an exhaustive or limiting list thereof, and should be interpreted as “example, but without limitation;” adjectives such as “known,” “normal,” “standard,” and terms of similar meaning should not be construed as limiting the item described to a given time period or to an item available as of a given time, but instead should be read to encompass known, normal, or standard technologies that may be available or known now or at any time in the future; and use of terms like “preferably,” “preferred,” “desired,” or “desirable,” and words of similar meaning should not be understood as implying that certain features are critical, essential, or even important to the structure or function of the present disclosure, but instead as merely intended to highlight alternative or additional features that may or may not be utilized in a particular embodiment. Likewise, a group of items linked with the conjunction “and” should not be read as requiring that each and every one of those items be present in the grouping, but rather should be read as “and/or” unless expressly stated otherwise. Similarly, a group of items linked with the conjunction “or” should not be read as requiring mutual exclusivity among that group, but rather should be read as “and/or” unless expressly stated otherwise. The terms “about” or “approximate” and the like are synonymous and are used to

indicate that the value modified by the term has an understood range associated with it, where the range can be $\pm 20\%$, $\pm 15\%$, $\pm 10\%$, $\pm 5\%$, or $\pm 1\%$. The term “substantially” is used to indicate that a result (e.g., measurement value) is close to a targeted value, where close can mean, for example, the result is within 80% of the value, within 90% of the value, within 95% of the value, or within 99% of the value. Also, as used herein “defined” or “determined” can include “predefined” or “predetermined” and/or otherwise determined values, conditions, thresholds, measurements, and the like.

WHAT IS CLAIMED IS:

1. A robot comprising:
 - one or more sensors configured to collect data about an environment including detected points on one or more objects in the environment; and
 - a controller configured to:
 - create a map of the environment based at least in part on the collected data;
 - determine a route in the map in which the robot will travel;
 - generate one or more route poses on the route, wherein each route pose comprises a footprint indicative of poses of the robot along the route and each route pose has a plurality of points disposed therein;
 - determine forces on each of the plurality of points of each route pose, the forces comprising repulsive forces from one or more of the detected points on the one or more objects and attractive forces from one or more of the plurality of points on others of the one or more route poses;
 - reposition one or more route poses in response to the forces on each point of the one or more route poses; and
 - perform interpolation between one or more route poses to generate a collision-free path between the one or more route poses for the robot to travel.
2. The robot of Claim 1, wherein:
 - the one or more route poses form a sequence in which the robot travels along the route; and
 - the interpolation comprises a linear interpolation between sequential ones of the one or more route poses.
3. The robot of Claim 1, wherein the interpolation generates one or more interpolation route poses having substantially similar footprints to the footprint of each route pose.
4. The robot of Claim 1, wherein the determination of the forces on each point of the one or more route poses further comprises a computation of a force function that associates, at least in part, the forces on each point of each route pose with one or more characteristics of objects in the environment.
5. The robot of Claim 4, wherein the one or more characteristics includes one or

more of distance, shape, material, and color.

6. The robot of Claim 4, wherein:

the force function associates zero repulsive force exerted by a first detected point on a first object where a distance between the first detected point and a second point of a first route pose is above a predetermined distance threshold.

7. The robot of Claim 1, wherein the footprint of each route pose has substantially similar size and shape as the footprint of the robot.

8. The robot of Claim 1, wherein the robot comprises a floor cleaner.

9. A method for dynamic navigation of a robot in an environment, comprising:
generating a map of the environment using data from one or more sensors;
determining a route on the map, the route including one or more route poses, each route pose comprising a footprint indicative at least in part of a pose and a shape of the robot along the route and each route pose having a plurality of points disposed therein;
computing repulsive forces from a point on an object in the environment onto the plurality of points of a first route pose of the one or more route poses;
repositioning the first route pose in response to at least the repulsive forces; and
performing an interpolation between the repositioned first route pose and another of the one or more route poses.

10. The method of Claim 9, further comprising determining attractive forces from a point on another of the one or more route poses exerted on the plurality of points of the first route pose.

11. The method of Claim 9, further comprising:
detecting a plurality of objects in the environment with the one or more sensors, each of the plurality of objects having detected points; and
defining a force function, the force function computing repulsive forces exerted by each of the detected points of the plurality of objects on the plurality of points of the first route pose, wherein each repulsive force comprises a vector.

12. The method of Claim 11, wherein repositioning the first route pose comprises calculating a minimum of the force function.

13. The method of Claim 9, wherein the repositioning of the first route pose comprises translating and rotating the first route pose.

14. The method of Claim 9, wherein the interpolation comprises:
generating an interpolation route pose having a footprint substantially similar to the shape of the robot; and
determining a translation and rotation of the interpolation route pose based at least on a collision-free path between the translated and rotated first route pose and the another of the one or more route poses.
15. The method of Claim 9, further comprising computing a magnitude of the repulsive forces as proportional to a distance between the point on the object and each of the plurality of points of the first route pose if the point on the object is outside of the footprint of the first route pose.
16. The method of Claim 9, further comprising computing a magnitude of the repulsive forces as inversely proportional to a distance between the point on the object and each of the plurality of points of the first route pose if the point on the object is inside the footprint of the first route pose.
17. The method of Claim 9, further comprising computing the torque forces onto the plurality of points of the first route pose due to the repulsive forces.
18. A non-transitory computer-readable storage apparatus having a plurality of instructions stored thereon, the instructions being executable by a processing apparatus to operate a robot, the instructions configured to, when executed by the processing apparatus, cause the processing apparatus to:
generate a map of an environment using data from one or more sensors;
determine a route on the map, the route comprising one or more route poses, each route pose comprising a footprint indicative at least in part of a pose and a shape of the robot along the route and each route pose having a plurality of points disposed therein; and
compute repulsive forces from a point on an object in the environment onto the plurality of points of a first route pose of the one or more route poses.
19. The non-transitory computer-readable storage apparatus of Claim 18, further comprising one or more instructions, which when executed by the processing apparatus, further cause the processing apparatus to determine attractive forces from a point on another of the one or more route poses exerted on the plurality of points of the first route pose.
20. The non-transitory computer-readable storage apparatus of Claim 18, further

comprising one or more instructions, which when executed by the processing apparatus, further cause the processing apparatus to determine torque forces from a point on another of the one or more route poses exerted on the plurality of points of the first route pose.

**SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN
AUTONOMOUS NAVIGATION**Abstract of the Disclosure

Systems and methods for dynamic route planning in autonomous navigation are disclosed. In some exemplary implementations, a robot can have one or more sensors configured to collect data about an environment including detected points on one or more objects in the environment. The robot can then plan a route in the environment, where the route can comprise one or more route poses. The route poses can include a footprint indicative at least in part of a pose, size, and shape of the robot along the route. Each route pose can have a plurality of points therein. Based on forces exerted on the points of each route pose by other route poses, objects in the environment, and others, each route poses can reposition. Based at least in part on interpolation performed on the route poses (some of which may be repositioned), the robot can dynamically route.

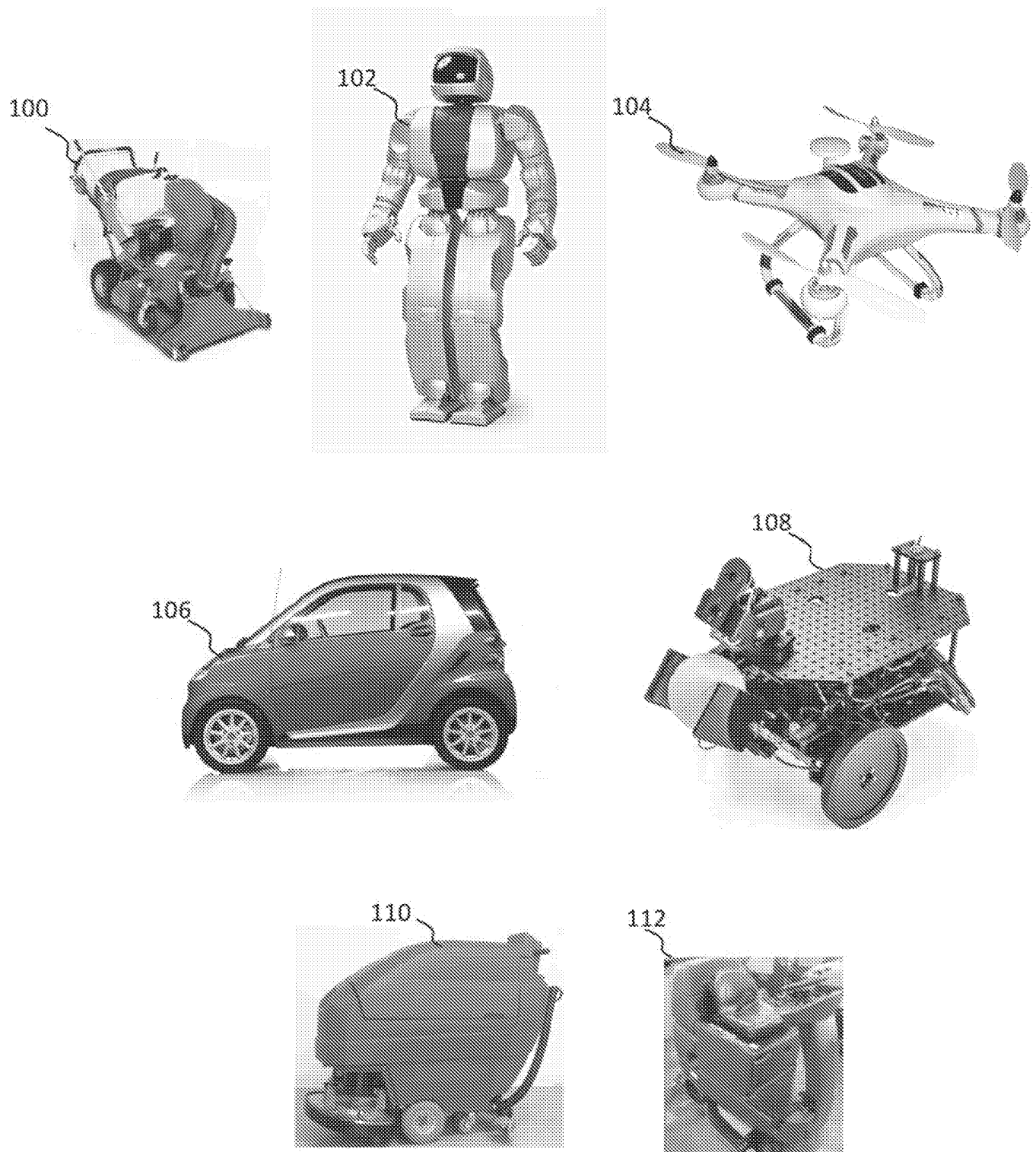


FIG. 1

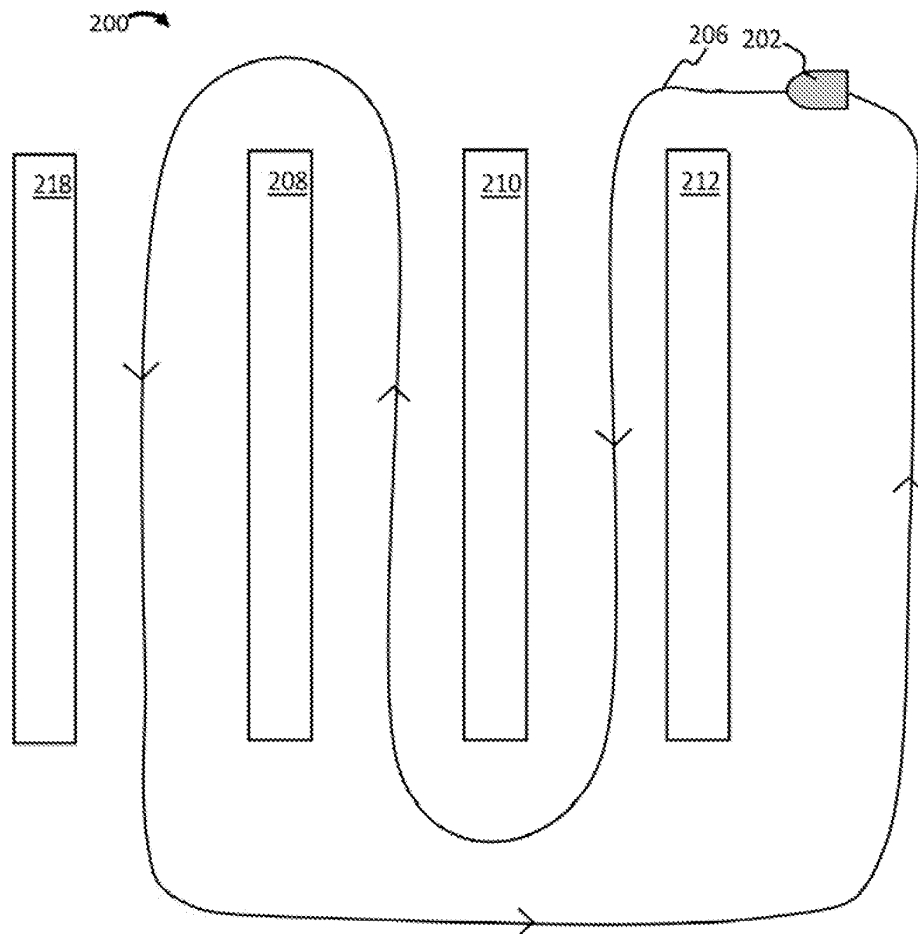


FIG. 2A

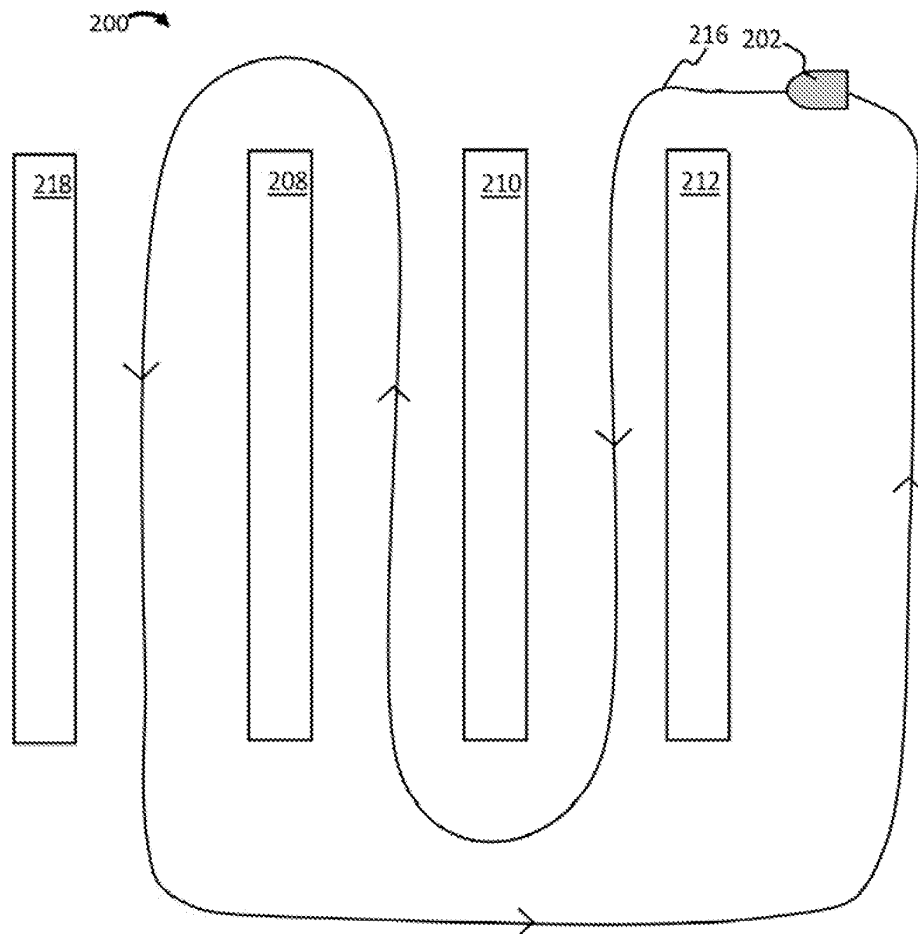


FIG. 2B

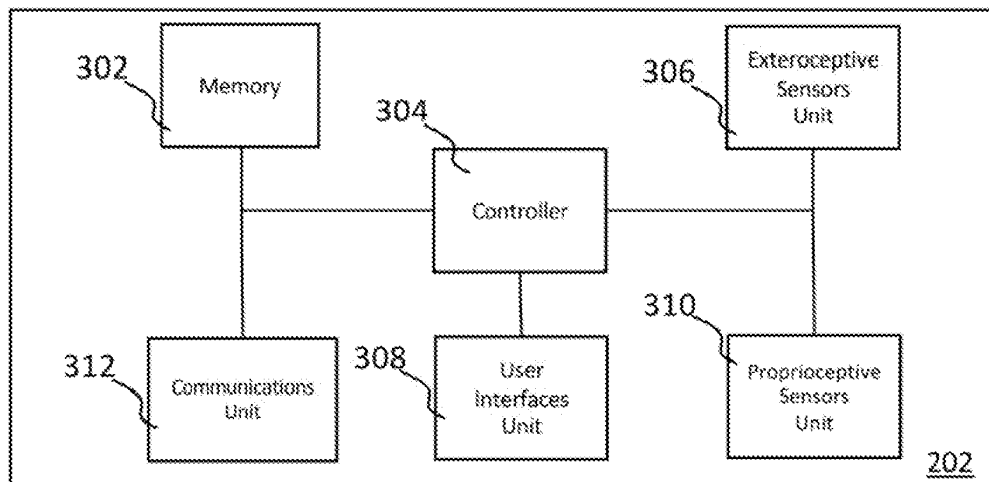


FIG. 3

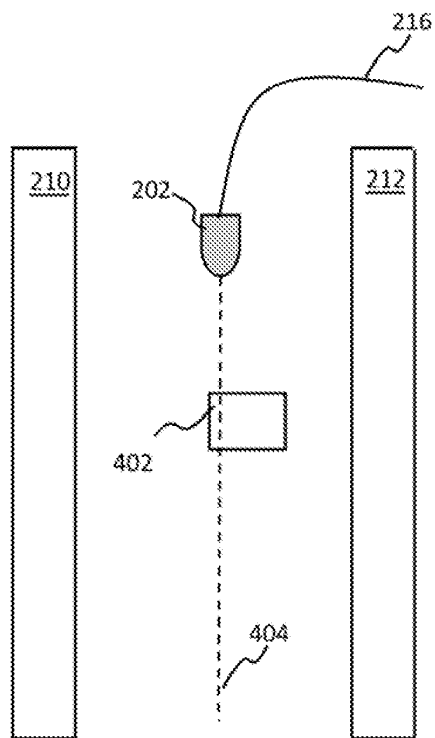


FIG. 4A

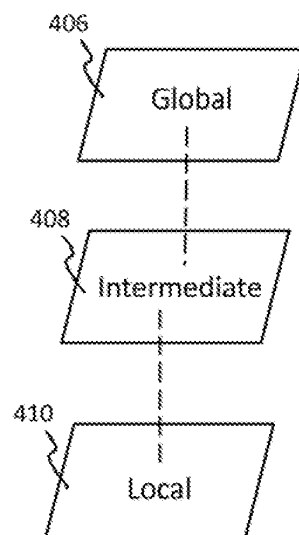


FIG. 4B

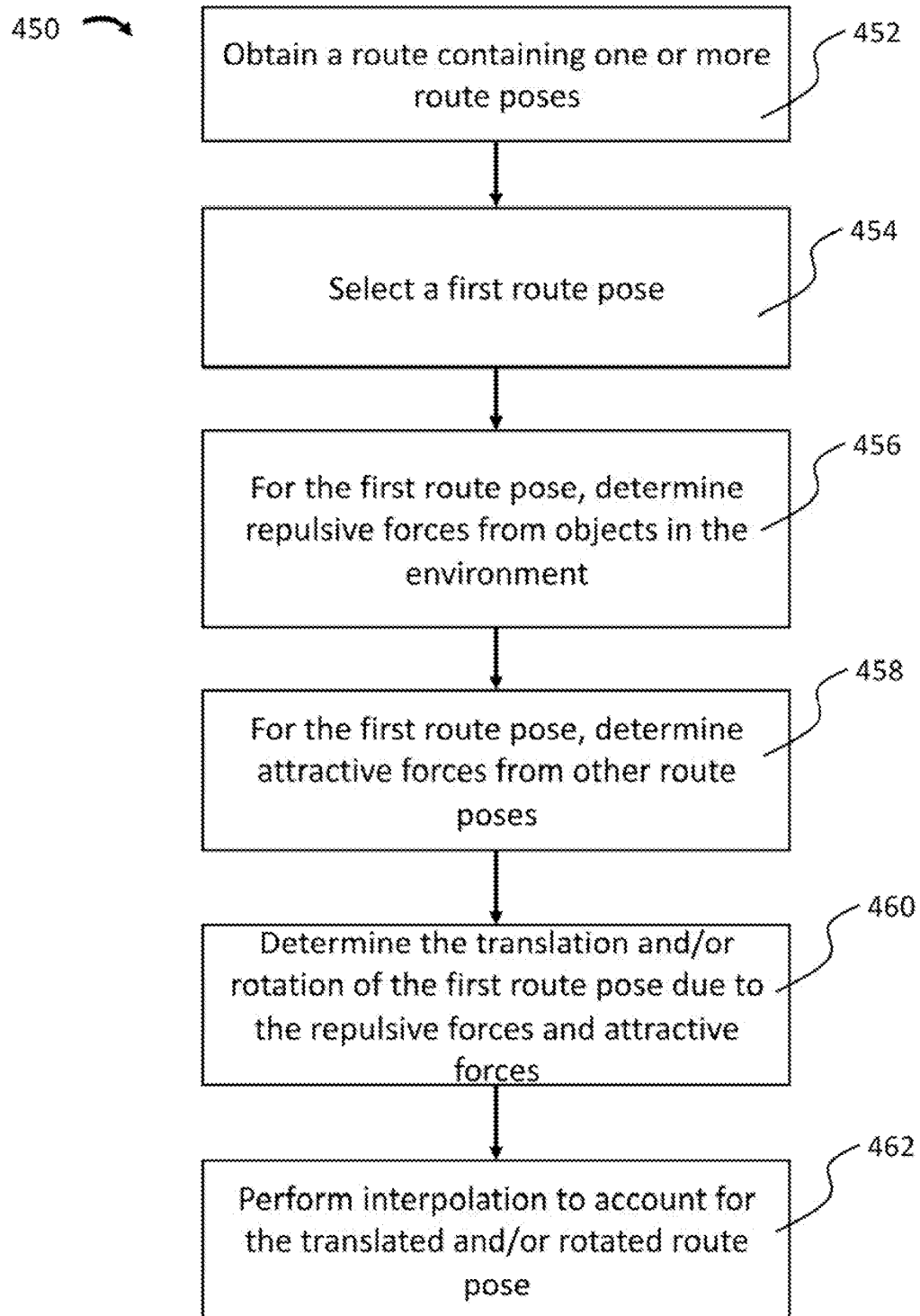


FIG. 4C

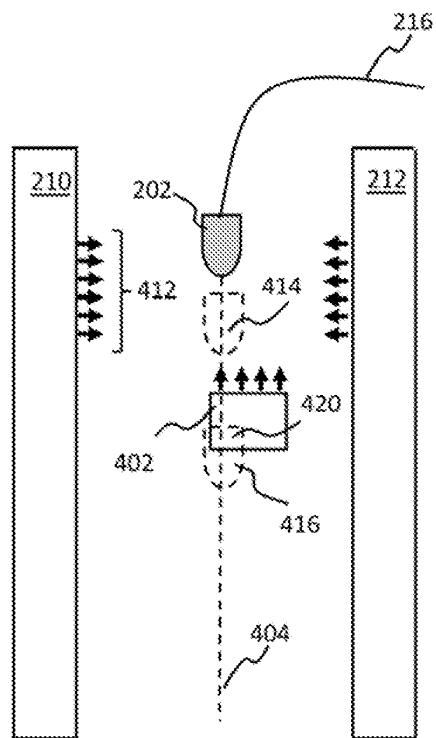


FIG. 4D



FIG. 4E

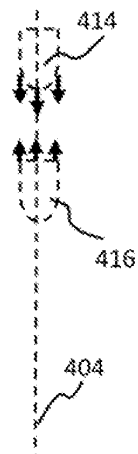


FIG. 4F

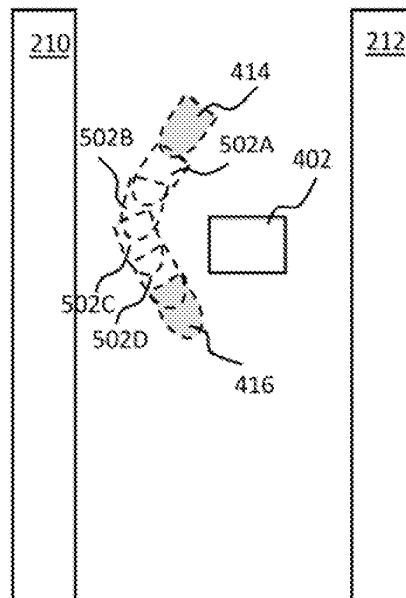


FIG. 5

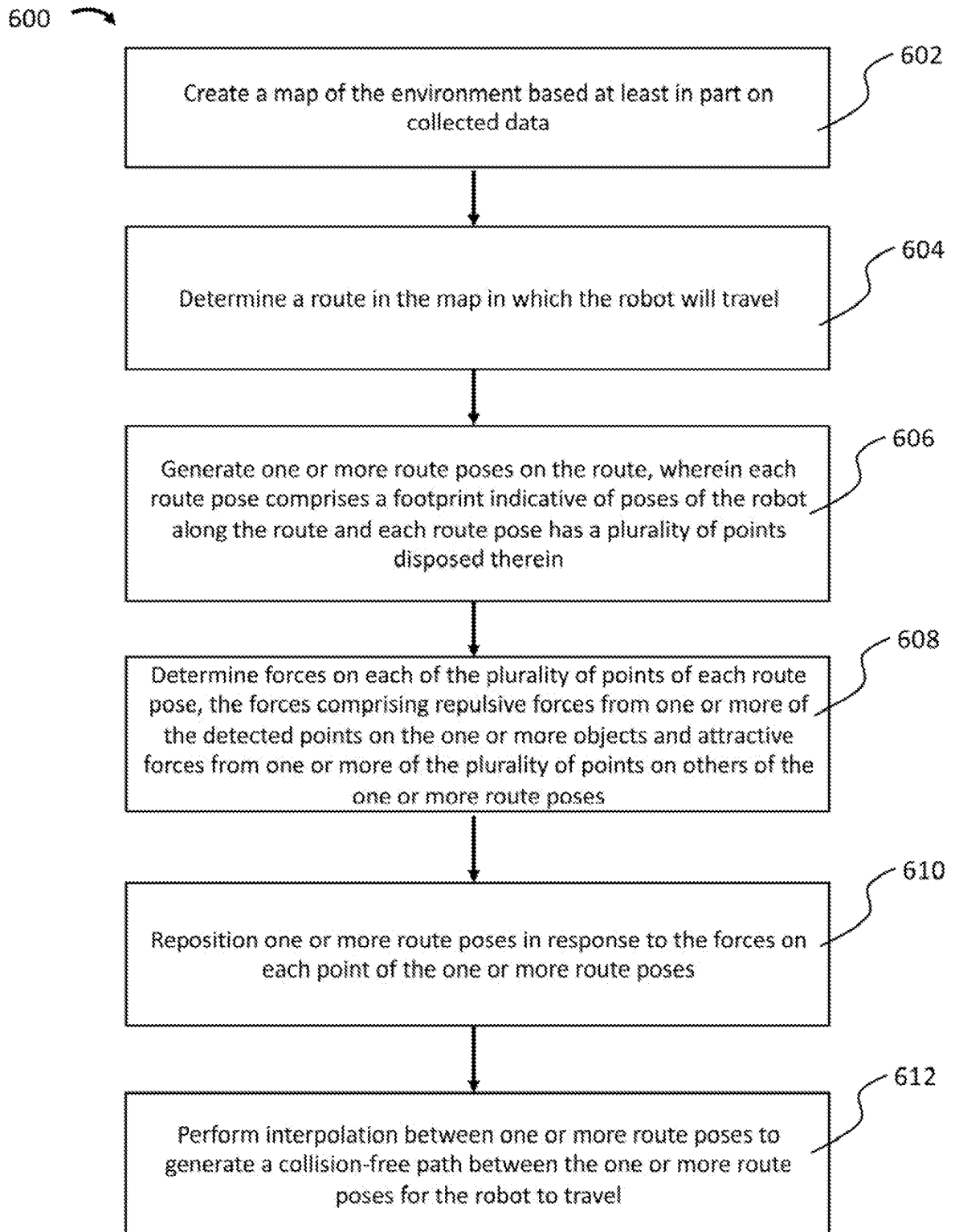


FIG. 6

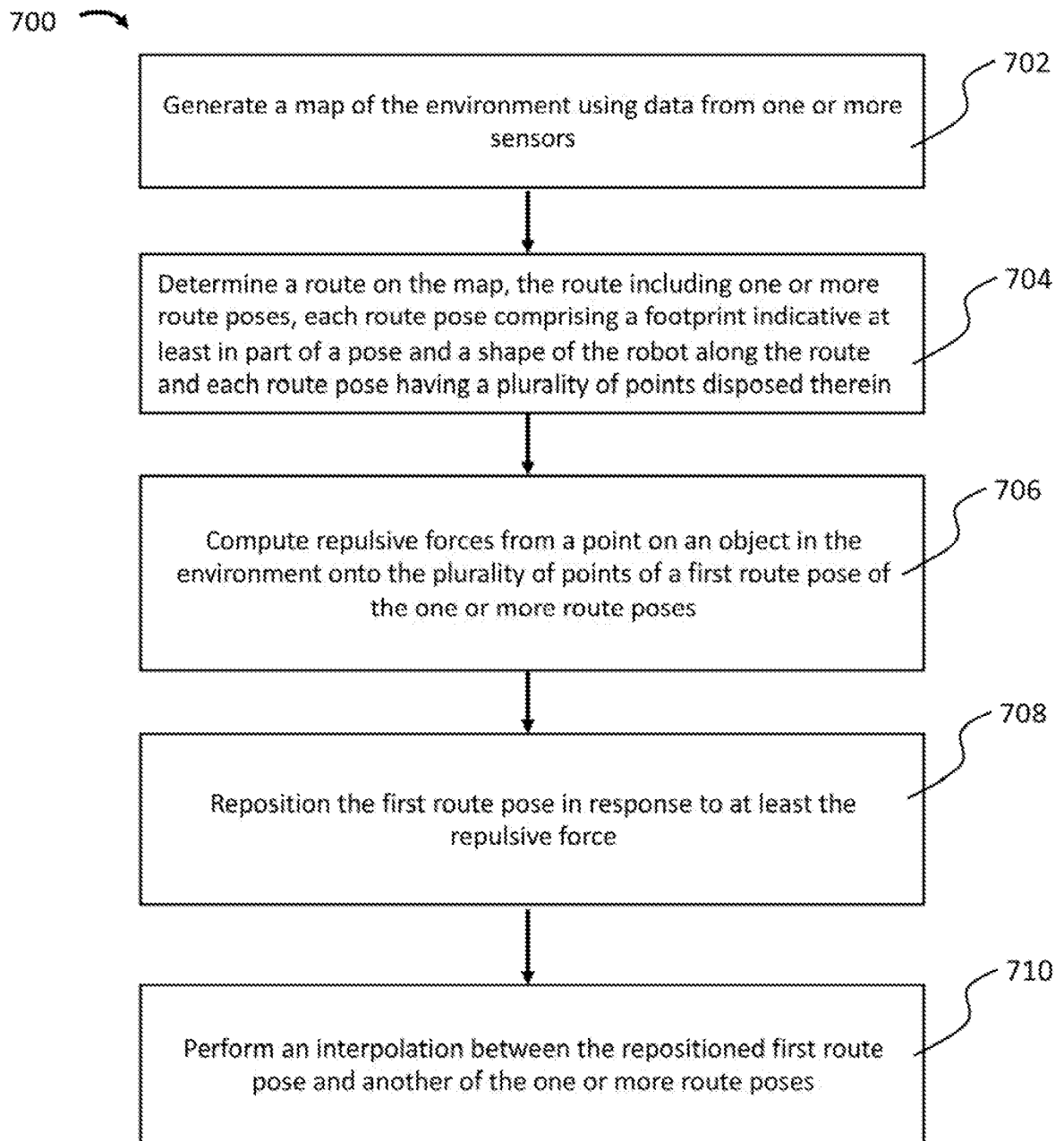


FIG. 7

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	BRAIN.134A/BC201609A
		Application Number	
Title of Invention	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

☐	Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)
--------------------------	---

Inventor Information:

Inventor 1					Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Borja	Ibarz	Gabardos			
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service						
City	La Jolla	State/Province	CA	Country of Residence	US	
Mailing Address of Inventor:						
Address 1		8011 Paseo del Ocaso				
Address 2						
City	La Jolla	State/Province	CA			
Postal Code	92037	Country	US			
Inventor 2					Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Jean-Baptiste		Passot			
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service						
City	Solana Beach	State/Province	CA	Country of Residence	US	
Mailing Address of Inventor:						
Address 1		930 Via Mil Cumbres, Unit #172				
Address 2						
City	Solana Beach	State/Province	CA			
Postal Code	92075	Country	US			
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button.						Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	BRAIN.134A/BC201609A
		Application Number	
Title of Invention	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION		

☐ An Address is being provided for the correspondence information of this application.

Customer Number	132059		
Email Address	Docket@gazpat.com	Add Email	Remove Email

Application Information:

Title of the Invention	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION		
Attorney Docket Number	BRAIN.134A/BC201609A	Small Entity Status Claimed	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	12	Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

Request Not to Publish. I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
Customer Number	132059		

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	BRAIN.134A/BC201609A
		Application Number	
Title of Invention	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status				Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)	
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button.				

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)¹ the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Application Number	Country ¹	Filing Date (YYYY-MM-DD)	Remove	Access Code ¹ (if applicable)
Additional Foreign Priority Data may be generated within this form by selecting the Add button.				

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013. ☐ NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.
--

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	BRAIN.134A/BC201609A
		Application Number	
Title of Invention	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	BRAIN.134A/BC201609A
		Application Number	
Title of Invention	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION		

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.			
Applicant 1			
If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.			
Clear			
☐ Assignee	☐ Legal Representative under 35 U.S.C. 117	☐ Joint Inventor	
☒ Person to whom the inventor is obligated to assign.		☐ Person who shows sufficient proprietary interest	
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:			
Name of the Deceased or Legally Incapacitated Inventor:			
If the Applicant is an Organization check here. ☒			
Organization Name	BRAIN CORPORATION		
Mailing Address Information For Applicant:			
Address 1	9401 Waples Street, Suite 100		
Address 2			
City	San Diego	State/Province	CA
Country	US	Postal Code	92121
Phone Number		Fax Number	
Email Address			
Additional Applicant Data may be generated within this form by selecting the Add button.			

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	BRAIN.134A/BC201609A
		Application Number	
Title of Invention	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION		

Assignee 1				
Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.				
If the Assignee or Non-Applicant Assignee is an Organization check here. ☐				
Prefix	Given Name	Middle Name	Family Name	Suffix
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Address 1				
Address 2				
City		State/Province		
Country ⁱ		Postal Code		
Phone Number		Fax Number		
Email Address				
Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.				

Signature:

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). However, if this Application Data Sheet is submitted with the **INITIAL** filing of the application and either box A or B is **not** checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Peter J. Gutierrez, III/		Date (YYYY-MM-DD)	2016-11-02
First Name	Peter	Last Name	Gutierrez	Registration Number
56.732				
Additional Signature may be generated within this form by selecting the Add button.				

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	BRAIN.134A/BC201609A
		Application Number	
Title of Invention	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION		

This collection of information is required by 37 CFR 1.76. 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 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet 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.**

Electronic Patent Application Fee Transmittal				
Application Number:				
Filing Date:				
Title of Invention:		SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION		
First Named Inventor/Applicant Name:		Borja Ibarz Gabardos		
Filer:		Peter John Gutierrez III/Brandi Manzano		
Attorney Docket Number:		BRAIN.134A/BC201609A		
Filed as Small Entity				
Filing Fees for Utility under 35 USC 111(a)				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
UTILITY FILING FEE (ELECTRONIC FILING)	4011	1	70	70
UTILITY SEARCH FEE	2111	1	300	300
UTILITY EXAMINATION FEE	2311	1	360	360
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				730

Electronic Acknowledgement Receipt	
EFS ID:	27399695
Application Number:	15341612
International Application Number:	
Confirmation Number:	3389
Title of Invention:	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION
First Named Inventor/Applicant Name:	Borja Ibarz Gabardos
Customer Number:	132059
Filer:	Peter John Gutierrez III/Brandi Manzano
Filer Authorized By:	Peter John Gutierrez III
Attorney Docket Number:	BRAIN.134A/BC201609A
Receipt Date:	02-NOV-2016
Filing Date:	
Time Stamp:	15:59:23
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$ 730
RAM confirmation Number	110316INTEFSW00002640501423
Deposit Account	501423
Authorized User	Brandi Manzano
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.17 (Patent application and reexamination processing fees) 37 CFR 1.19 (Document supply fees)	

37 CFR 1.21 (Miscellaneous fees and charges)					
File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	Transmittal.pdf	92515	no	2
			c09f6a45f42d9a2ade2b444d550c88111e6d1e4		
Warnings:					
Information:					
2	Specification	Spec.pdf	221049	no	36
			277500f08d8d4041266e7099c0a0d12c36a224db		
Warnings:					
Information:					
3	Drawings-only black and white line drawings	Figures.pdf	674131	no	12
			e2c4fa49ddf438e0081b9d857529097a88cadfd9		
Warnings:					
Information:					
4	Application Data Sheet	ADS.pdf	1894442	no	7
			1349cbfd4d1a2fd430d328fce83273d543abbb0f0b		
Warnings:					
Information:					
This is not an USPTO supplied ADS fillable form					
5	Fee Worksheet (SB06)	fee-info.pdf	35123	no	2
			817fe87b95f0dd823a5f8a727f2be29191cc4b5		
Warnings:					
Information:					
Total Files Size (in bytes):			2917260		

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.

SCORE Placeholder Sheet for IFW Content

Application Number: 15341612

Document Date: 11/02/2016

The presence of this form in the IFW record indicates that the following document type was received in electronic format on the date identified above. This content is stored in the SCORE database.

- Drawings – Other than Black and White Line Drawings

Since this was an electronic submission, there is no physical artifact folder, no artifact folder is recorded in PALM, and no paper documents or physical media exist. The TIFF images in the IFW record were created from the original documents that are stored in SCORE.

To access the documents in the SCORE database, refer to instructions below.

At the time of document entry (noted above):

- Examiners may access SCORE content via the eDAN interface.
- Other USPTO employees can bookmark the current SCORE URL (<http://Score.uspto.gov/ScoreAccessWeb/>).
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Document code: WFEE

United States Patent and Trademark Office
Sales Receipt for Accounting Date: 11/29/2016

MTEKLEMI	SALE	#00000010	Mailroom Dt:	11/02/2016	501423	15341612
		01	FC : 2051	70.00 DA		



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

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/341,612	11/02/2016	Borja Ibarz Gabardos	BRAIN.134A/BC201609A

CONFIRMATION NO. 3389

INFORMAL NOTICE



132059
Gazdzinski & Associates, PC
16644 West Bernardo Drive
Suite 201
San Diego, CA 92127

Date Mailed: 11/30/2016

INFORMATIONAL NOTICE TO APPLICANT

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):
Borja Ibarz Gabardos
Jean-Baptiste Passot

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at (571) 272-4000 or (571) 272-4200 or 1-888-786-0101.

/t/e/



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

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
15/341,612	11/02/2016		800	BRAIN.134A/BC201609A	20	3

CONFIRMATION NO. 3389

FILING RECEIPT



132059
Gazdzinski & Associates, PC
16644 West Bernardo Drive
Suite 201
San Diego, CA 92127

Date Mailed: 11/30/2016

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Borja Ibarz Gabardos, La Jolla, CA;
Jean-Baptiste Passot, Solana Beach, CA;

Applicant(s)

BRAIN CORPORATION, San Diego, CA

Power of Attorney: None

Domestic Applications for which benefit is claimed - None.

A proper domestic benefit claim must be provided in an Application Data Sheet in order to constitute a claim for domestic benefit. See 37 CFR 1.76 and 1.78.

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.) - None.

Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 11/28/2016

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 15/341,612**

Projected Publication Date: 05/03/2018

Non-Publication Request: No

Early Publication Request: No

**** SMALL ENTITY ****

Title

SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

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Title 35, United States Code, Section 184
Title 37, Code of Federal Regulations, 5.11 & 5.15

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This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875						Application or Docket Number 15/341,612			
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	70		N/A			
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A	300		N/A			
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	360		N/A			
TOTAL CLAIMS (37 CFR 1.16(j))	20	minus 20 = *	x 40	= 0.00	OR				
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3	minus 3 = *	x 210	= 0.00					
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 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).			0.00					
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00					
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	730		TOTAL			
APPLICATION AS AMENDED - PART II									
(Column 1)		(Column 2)		(Column 3)		SMALL ENTITY		OR OTHER THAN SMALL ENTITY	
AMENDMENT A	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))					OR			
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					OR			
TOTAL ADD'L FEE					OR	TOTAL ADD'L FEE			
AMENDMENT B	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))					OR			
	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 found in the appropriate box in column 1.									

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	
				15/341,612	
				Filing Date	
				11-02-2016	
				First Named Inventor	
				Ibarz Gabardos Borja	
				Art Unit	
				Unknown	
				Examiner Name	
				Unknown	
Sheet 1 of 14				Attorney Docket Number	
				BRAIN.134A/BC201609A	

U. S. PATENT DOCUMENTS					
Examiner Initials*	Cite No. ¹	Document Number	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		Number-Kind Code ² (if known)			
	001	US-4638445	01-20-1987	MATTABONI; Paul J.	
	002	US-4763276	08-09-1988	PERREIRRA; Noel D. et al.	
	003	US-4852018	07-25-1989	GROSSBERG; Stephen et al.	
	004	US-5121497	06-09-1992	KERR; Randal H. et al.	
	005	US-5280179	01-18-1994	PRYOR; Timothy R. et al.	
	006	US-5446356	08-29-1995	KIM; Sang-Gwon	
	007	US-5602761	02-11-1997	SPOERRE; Julie K. et al.	
	008	US-5612883	03-18-1997	SHAFFER; Gary K. et al.	
	009	US-5673367	09-30-1997	BUCKLEY; Theresa M.	
	010	US-5719480	02-17-1998	BOCK; Otmar et al.	
	011	US-5841959	11-24-1998	GUIREMAND; Harry A.	
	012	US-5994864	11-30-1999	INOUE; Yasuyuki et al.	
	013	US-6124694	09-26-2000	BANCROFT; Allen J. et al.	
	014	US-6169981	01-02-2001	WERBOS; Paul J.	
	015	US-6243622	06-05-2001	YIM; Mark H. et al.	
	016	US-6366293	04-02-2002	HAMILTON; Jeffrey L. et al.	
	017	US-6442451	08-27-2002	LAPHAM; John R.	
	018	US-6560511	05-06-2003	YOKOO; Naohiro et al.	
	019	US-6584375	06-24-2003	BANCROFT; Allen et al.	
	020	US-6636781	10-21-2003	SHEN; Wei-Min et al.	
	021	US-6697711	02-24-2004	YOKONO; Jun et al.	

Examiner Signature		Date Considered	
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*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. ¹ Applicant's unique citation designation number (optional). ² See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. ³ Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). ⁴ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁵ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁶ Applicant is to place a check mark here if English language Translation is attached. 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 2 hours 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, 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 (1-800-786-9199) and select option 2.

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Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	
				15/341,612	
				Filing Date	
				11-02-2016	
				First Named Inventor	
				Ibarz Gabardos Borja	
				Art Unit	
				Unknown	
				Examiner Name	
				Unknown	
				Attorney Docket Number	
				BRAIN.134A/BC201609A	
Sheet	2	of	14		

U. S. PATENT DOCUMENTS					
Examiner Initials*	Cite No. ¹	Document Number	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		Number-Kind Code ² (if known)			
	022	US-6760645	07-06-2004	KAPLAN; Frederic et al.	
	023	US-6812846	11-02-2004	GUTTA; Srinivas et al.	
	024	US-6961060	11-01-2005	MOCHIZUKI; Yoshiyuki et al.	
	025	US-7002585	02-21-2006	WATANABE; Atsushi et al.	
	026	US-7148644	12-12-2006	YOURLO; Zhenya Alexander et al.	
	027	US-7243334	07-10-2007	BERGER; Kenneth A. et al.	
	028	US-7342589	03-11-2008	MISEROCCHI; Nathan P.	
	029	US-7668605	02-23-2010	BRAUN; Scott D. et al.	
	030	US-8145492	03-27-2012	FUJITA; Masahiro	
	031	US-8364314	01-29-2013	ABDALLAH; Muhammad E. et al.	
	032	US-8380348	02-19-2013	NEKI; Norio et al.	
	033	US-8380652	02-19-2013	FRANCIS Jr.; Anthony G.	
	034	US-8419804	04-16-2013	HERR; Hugh M. et al.	
	035	US-8423225	04-16-2013	HILLMAN Jr.; Henry L. et al.	
	036	US-8452448	05-28-2013	PACK; Robert T. et al.	
	037	US-8515162	08-20-2013	CHENG; Ting-Yuan	
	038	US-8639035	01-28-2014	SHIBA; Hisashi	
	039	US-8639644	01-28-2014	HICKMAN; Ryan et al.	
	040	US-8679260	03-25-2014	HILLMAN Jr.; Henry L. et al.	
	041	US-8793205	07-29-2014	FISHER; Dmitry et al.	

Examiner Signature		Date Considered	
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*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. ³ Applicant's unique citation designation number (optional). ² See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. ³ Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). ⁴ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁵ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁶ Applicant is to place a check mark here if English language Translation is attached. 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 2 hours 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, 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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Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	
				15/341,612	
				Filing Date	
				11-02-2016	
				First Named Inventor	
				Ibarz Gabardos Borja	
				Art Unit	
				Unknown	
				Examiner Name	
				Unknown	
				Attorney Docket Number	
				BRAIN.134A/BC201609A	
Sheet	3	of	14		

U. S. PATENT DOCUMENTS					
Examiner Initials*	Cite No. ¹	Document Number	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		Number-Kind Code ² (if known)			
	042	US-8924021	12-30-2014	DARIUSH; Behzad et al.	
	043	US-8958911	02-17-2015	WONG; Cheuk Wah et al.	
	044	US-8958912	02-17-2015	BLUMBERG; Bruce et al.	
	045	US-8958937	02-17-2015	HILLMAN Jr.; Henry L. et al.	
	046	US-9008840	04-14-2015	PONULAK; Filip et al.	
	047	US-9015093	04-21-2015	COMMONS; Michael Lamport	
	048	US-9144907	09-29-2015	SUMMER; Matthew D. et al.	
	049	US-9242372	01-26-2016	LAURENT; Patryk et al.	
	050	US-20020158599	10-31-2002	FUJITA; Masahiro et al.	
	051	US-20020175894	11-28-2002	GRILLO; Vince	
	052	US-20020198854	12-26-2002	BERENJI; Hamid R. et al.	
	053	US-20030023347	01-30-2003	KONNO; Reizo et al.	
	054	US-20030025082	02-06-2003	BREWINGTON; James Gabriel et al.	
	055	US-20030108415	06-12-2003	HOSEK; Martin et al.	
	056	US-20030144764	07-31-2003	YOKONO; Jun et al.	
	057	US-20030220714	11-27-2003	NAKAMURA; Yoshihiko et al.	
	058	US-20040030449	02-12-2004	SOLOMON; Neal	
	059	US-20040036437	02-26-2004	ITO; Masato	
	060	US-20040051493	03-18-2004	FURUTA; Takayuki et al.	
	061	US-20040167641	08-26-2004	KAWAI; Masakazu et al.	

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Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	15/341,612
				Filing Date	11-02-2016
				First Named Inventor	Ibarz Gabardos Borja
				Art Unit	Unknown
				Examiner Name	Unknown
				Attorney Docket Number	BRAIN.134A/BC201609A
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		Number-Kind Code ² (if known)			
	062	US-20040172166	09-02-2004	LAPSTUN; Paul et al.	
	063	US-20040172168	09-02-2004	WATANABE; Atsushi et al.	
	064	US-20040267404	12-30-2004	DANKO; George	
	065	US-20050008227	01-13-2005	DUAN; Baofu et al.	
	066	US-20050065651	03-24-2005	AYERS; Joseph et al.	
	067	US-20050069207	03-31-2005	ZAKRZEWSKI; Radoslaw Romuald et al.	
	068	US-20050125099	06-09-2005	MIKAMI; Tatsuo et al.	
	069	US-20060207419	09-21-2006	OKAZAKI; Yasunao et al.	
	070	US-20060250101	11-09-2006	KHATIB; Oussama et al.	
	071	US-20070074177	03-29-2007	KURITA; Shigeru et al.	
	072	US-20070151389	07-05-2007	PRISCO; Giuseppe et al.	
	073	US-20070200525	08-30-2007	KANAOKA; Katsuya	
	074	US-20070255454	11-01-2007	DARIUSH; Behzad et al.	
	075	US-20070260356	11-08-2007	KOCK; Sonke et al.	
	076	US-20080040040	02-14-2008	GOTO; Takanori et al.	
	077	US-20080097644	04-24-2008	KAZNOV; Viktor et al.	
	078	US-20080112596	05-15-2008	RHOADS; Geoffrey B. et al.	
	079	US-20080140257	06-12-2008	SATO; Takashi et al.	
	080	US-20080319929	12-25-2008	KAPLAN; Frederic et al.	
	081	US-20090037033	02-05-2009	PHILLIPS; Emilie et al.	
	082	US-20090231359	09-17-2009	BASS II; Robert Leon et al.	

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				Art Unit	Unknown
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		Number-Kind Code ² (if known)			
	083	US-20090234501	09-17-2009	ISHIZAKI; Takehiro	
	084	US-20090265036	10-22-2009	JAMIESON; Josef et al.	
	085	US-20090272585	11-05-2009	NAGASAKA; Kenichiro	
	086	US-20100114372	05-06-2010	KNUTH Jr.; David M. et al.	
	087	US-20100152896	06-17-2010	KOMATSU; Mayumi et al.	
	088	US-20100152899	06-17-2010	CHANG; Chu-Yin et al.	
	089	US-20100228264	09-09-2010	ROBINSON; David et al.	
	090	US-20100286824	11-11-2010	SOLOMON; Neal	
	091	US-20100305758	12-02-2010	NISHI; Hiroji et al.	
	092	US-20100312730	12-09-2010	WENG; Juvang et al.	
	093	US-20110026770	02-03-2011	BROOKSHIRE; Jonathan David	
	094	US-20110035188	02-10-2011	MARTINEZ-HERAS JOSE ANTONIO . et al.	
	095	US-20110060460	03-10-2011	OGA; Junichiro et al.	
	096	US-20110067479	03-24-2011	DAVIS; Donald R. et al.	
	097	US-20110144802	06-16-2011	JANG; Jung Soon	
	098	US-20110158476	06-30-2011	FAHN; Chin-Shyurng et al.	
	099	US-20110160906	06-30-2011	ORITA; Atsuo et al.	
	100	US-20110160907	06-30-2011	ORITA; Atsuo	
	101	US-20110196199	08-11-2011	DONHOWE; Caitlin Q. et al.	
	102	US-20110218676	09-08-2011	OKAZAKI; Yasunao	
	103	US-20110244919	10-06-2011	ALLER; Joshua V. et al.	

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		Number-Kind Code ² (if known)			
	104	US-20110282169	11-17-2011	GRUDIC; Gregory Zlatko et al.	
	105	US-20110296944	12-08-2011	CARTER; Troy Alexander et al.	
	106	US-20120008838	01-12-2012	GUYON; Isabelle et al.	
	107	US-20120017232	01-19-2012	HOFFBERG; Linda Irene et al.	
	108	US-20120045068	02-23-2012	KIM; Jinsung et al.	
	109	US-20120079670	04-05-2012	YOON; Sang Sik et al.	
	110	US-20120143495	06-07-2012	DANTU; Ramanamurthy	
	111	US-20120144242	06-07-2012	VICHARE; Nikhil M. et al.	
	112	US-20120150777	06-14-2012	SETOGUCHI; Hisao et al.	
	113	US-20120209432	08-16-2012	FLEISCHER; Jason G. et al.	
	114	US-20120221147	08-30-2012	GOLDBERG; Randal P. et al.	
	115	US-20120303091	11-29-2012	IZHIKEVICH; Eugene M.	
	116	US-20120303160	11-29-2012	ZIEGLER; Andrew et al.	
	117	US-20120308076	12-06-2012	PIEKNIIEWSKI; Filip Lukasz et al.	
	118	US-20120308136	12-06-2012	IZHIKEVICH; Eugene M. et al.	
	119	US-20130000480	01-03-2013	KOMATSU; Mayumi et al.	
	120	US-20130044139	02-21-2013	HERNANDEZ; Esteban Carlos	
	121	US-20130066468	03-14-2013	CHOI; Mun-Taek et al.	
	122	US-20130096719	04-18-2013	SANDERS; Adam M. et al.	

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				Ibarz Gabardos Borja	
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				Unknown	
Sheet 7 of 14				Attorney Docket Number	
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		Number-Kind Code ² (if known)			
	123	US-20130116827	05-09-2013	INAZUMI; Mitsuhiro	
	124	US-20130173060	07-04-2013	YOO; Su Jung et al.	
	125	US-20130206170	08-15-2013	SVENDSEN; Selma et al.	
	126	US-20130218339	08-22-2013	MAISONNIER; Bruno et al.	
	127	US-20130245829	09-19-2013	OHTA; Hiromichi et al.	
	128	US-20130274924	10-17-2013	CHUNG; Seung-Nyung et al.	
	129	US-20130310979	11-21-2013	HERR; Hugh M. et al.	
	130	US-20130325775	12-05-2013	SINYAVSKIY; Oleg et al.	
	131	US-20130346347	12-26-2013	PATTERSON; Anna et al.	
	132	US-20140016858	01-16-2014	RICHERT; Micah	
	133	US-20140081895	03-20-2014	COENEN; Oliver et al.	
	134	US-20140089232	03-27-2014	BUIBAS; Marius et al.	
	135	US-20140114479	04-24-2014	OKAZAKI; Yasunao	
	136	US-20140187519	07-03-2014	COOKE; John P. et al.	
	137	US-20140190514	07-10-2014	LAMON; Pierre et al.	
	138	US-20140276951	09-18-2014	HOURTASH; Arjang et al.	
	139	US-20140277718	09-18-2014	IZHIKEVICH; Eugene et al.	
	140	US-20140350723	11-27-2014	PRIETO; Robert et al.	
	141	US-20140358828	12-04-2014	PHILLIPPS; Kelly D. et al.	
	142	US-20140371907	12-18-2014	PASSOT; Jean-Baptiste et al.	
	143	US-20140371912	12-18-2014	PASSOT; Jean-Baptiste et al.	

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	144	US-20150032258	01-29-2015	PASSOT; Jean-Baptiste et al.	
	145	US-20150094850	04-02-2015	PASSOT; Jean-Baptiste et al.	
	146	US-20150094852	04-02-2015	LAURENT; Patryk et al.	
	147	US-20150120128	04-30-2015	ROSENSTEIN; Michael T. et al.	
	148	US-20150127155	05-07-2015	PASSOT; Jean-Baptiste et al.	
	149	US-20150185027	07-02-2015	KIKKERI; Harshavardhana et al.	
	150	US-20150204559	07-23-2015	HOFFBERG; Steven M. et al.	
	151	US-20150213299	07-30-2015	SOLANO; Ferrández José Vicente et al.	
	152	US-20150306761	10-29-2015	O'CONNOR; Peter et al.	
	153	US-20150317357	11-05-2015	HARMSSEN; Jeremiah et al.	
	154	US-20150339589	11-26-2015	FISHER; Dmitry	
	155	US-20160057925	03-03-2016	LETSKY; Michael Todd	
	156	US-20160075026	03-17-2016	SISBOT; Emrah Akin et al.	

FOREIGN PATENT DOCUMENTS						
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		Country Code ² Number ⁴ Kind Code ⁵ (if known)				
	001	WO-0167749-A2	09-13-2001	SARNOFF CORP [US]		☐
	002	WO-2014196925-A1	12-11-2014	CTRLWORKS PTE LTD [SG]		☐
	003	WO-2015047195-A1	04-02-2015	CTRLWORKS PTE LTD [SG]		☐

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				Filing Date	11-02-2016
				First Named Inventor	Ibarz Gabardos Borja
				Art Unit	Unknown
				Examiner Name	Unknown
Sheet	10	of	14	Attorney Docket Number	BRAIN.134A/BC201609A

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	001	ASENSIO et al., "Robot Learning Control Based on Neural Network Prediction" ASME 8th Annual Dynamic Systems and Control Conference joint with the JSME 11th Motion and Vibration Conference 2012 [Retrieved on: Jun. 24, 2014]. Retrieved from internet: http://msc.berkeley.edu/wjchen/publications/DSC12.sub.--8726.sub.--FI-.pdf <http://>.	☐
	002	Bouganis, Alexandros, et al., "Training a Spiking Neural Network to Control a 4-DoF Robotic Arm based on Spike Timing-Dependent Plasticity", Proceedings of WCCI 2010 IEEE World Congress on Computational Intelligence, COB, Barcelona, Spain, July, 18-23, 2010, pages 4104-4111.	☐
	003	BROWN, et al., "Detecting Problems In Buildings Using Infrared Cameras, Fluke Digital Library, retrieved on 06-08-2015 from the Web address: www.fluke.com/library .	☐
	004	COUPARD, Pierre-Philippe, An Availabot-like computer-controlled push puppet for Linux, https://web.archive.org/web/20081106161941/http://myspace.voo.be/pcoupard/push_puppet_to_y/ , 2008.	☐
	005	"Detection of ArUco Markers" accessed 6-20-16, available at the following Web address: http://docs.opencv.org/3.1.0/d5/dae/tutorial_aruco_detection.html#gsc.tab=0 .	☐
	006	Hardware and Software Platform for Mobile Manipulation R&D, 2012, https://web.archive.org/web/20120128031010/http://www.willowgarage.com/pages/pr2/design .	☐
	007	HEIKKILA J., et al., "A Four-Step Camera Calibration Procedure with Implicit Image Correction," Computer Vision and Pattern Recognition, 1997, Proceedings, 1997 IEEE Computer Society Conference on, San Juan, 1997, pp. 1106-1112.	☐
	008	Hopkins, Chasing Water with Thermal Imaging, Infrared Training Center, 2011.	☐

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	009	HUNT, et al., "Detection of Changes in Leaf Water Content Using Near-and Middle-Infrared Reflectance, " Journal of Remote Sensing of Environment, 1989, Vol. 30 (1), pp.43-54.	☐	
	010	JAIN, Learning Trajectory Preferences for Manipulators via Iterative Improvement, 2013, Advances in Neural Information Processing Systems 26 (NIPS 2013).	☐	
	011	JOSHI, Blog Post from Perpetual Enigma Website, "Understanding Camera Calibration" posted 5-31-14, accessed 6-20-16 at the following Web address: https://prateekvjoshi.com/2014/05/31/understanding-camera-calibration/ .	☐	
	012	Kalman Filter; wikipedia.	☐	
	013	KASABOV, "Evolving Spiking Neural Networks for Spatio-and Spectro-Temporal Pattern Recognition", IEEE 6th International Conference Intelligent Systems 2012 [Retrieved on Jun 24, 2014], Retrieved from the Internet: http://ncs.ethz.ch/projects/evospike/publications/evolving-spiking-neural-networks-for-spatio-and-spectro-temporal-pattern-recognition-plenary-talk-ieee-is/view .	☐	
	014	MAESEN, et al., "Tile Tracker: A Practical and Inexpensive Positioning System for Mobile AR Applications" pp.1-8.	☐	
	015	PR2 User Manual, October 5, 2012.	☐	
	016	RAHMAN, et al., "An Image Based Approach to Compute Object Distance, "International Journal of Computational Intelligence Systems, 2008, Vol. 1 (4), pp. 304-315.	☐	
	017	ROSEBROCK, Tutorial "Find Distance from Camera to Object/marker using Python and OpenCV" 1-19-15, accessed 6-20-16 at the following Web address: http://www.pyimagesearch.com/2015/01/19/find-distance-camera-objectmarker-using-python-opencv/ .	☐	

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	018	Rosenhahn, et al., Pose Estimation in Conformal Geometric Algebra Part I: The Stratification of Mathematical Spaces, Journal of Mathematical Imagine and Vision 22:27-48, 2005.	☐	
	019	Steele, The Human Touch Makes Robots Deft, November 6, 2013, Cornell Chronicle. http://www.news.cornell.edu/stories/2013/11/human-touch-makes-robots-deft .	☐	
	020	Thermal Imaging for Moisture and Restoration, retrieved on 2016-04-05 from the following Web address: www.flir.com/home .	☐	
	021	TORRALBA, et al., "Depth Estimation from Image Structure," Journal of IEEE Transactions on Pattern Analysis and Machine Intelligence, 2002, Vol. 24 (9), pp. 1226-1238.	☐	
	022	TRIGGS, "Camera Pose and Calibration from 4 or 5 known 3D Points," 7th International Conference on Computer Vision (ICCV '99), IEEE Computer Society, 1999, Vol. 1, pp.278-284.	☐	
	023	Tutorial "Camera Calibration with OpenCV" accessed 6-20-16 from the following Web address http://docs.opencv.org/2.4/doc/tutorials/calib3d/camera_calibration/camera_calibration.html .	☐	
	024	UNCC Machine Lab Wiki Documentation "ROS and Camera Calibration" accessed 6-20-16 at the following Web address: http://visionlab.uncc.edu/dokuwiki/ros_and_camera_calibration#aruco_-_augmented_reality_library_from_the_university_of_cordoba .	☐	
	025	Video "TECNALIA-Limaccio Autonomous Cleaning Robot", published 2-22-13, available at the following Web address: http://www.youtube.com/watch?v=4GJ00EBbBfQ&sns=em .	☐	
	026	WAN, et al., "Automatic Navigation System with Multiple Sensors," IFIP International Federation for Information Processing, Volume 259, Computer and Computing Technologies in Agriculture, 2008, Vol. 2, pp. 769-776.	☐	

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	027	Wikipedia Page "Pose (Computer Vision)" accessed 6-20-16, available at the following Web address: https://en.wikipedia.org/wiki/Pose_(computer_vision) .	☐
	028	ZHANG, A Flexible New Technique for Camera Calibration, last updated 12-5-9, Technical Report MSR-TR-98-71, December 2, 1998.	☐

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(71) Applicant: SARNOFF CORPORATION [US/US]; 201 Washington Road, CN 5300, Princeton, NJ 08543-5300 (US).

(72) Inventors: SAWHNEY, Harpreet, Singh; 17 Melville Road, West Windsor, NJ 08550 (US). KUMAR, Rakesh;

966 Ridge Road, Monmouth Junction, NJ 08852 (US). HSU, Steve; 1134 Country Mill Drive, Cranbury, NJ 08512 (US). SAMARASEKERA, Supun; 24 Blackstone Drive, Princeton, NJ 08540 (US).

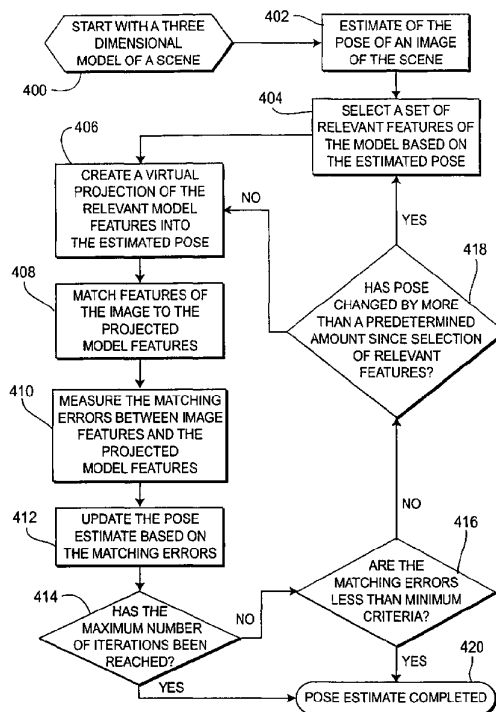
(74) Agents: NIGON, Kenneth, N.; Ratner & Prestia, 301 One Westlakes (Berwyn), P.O. Box 980, Valley Forge, PA 19482-0980 et al. (US).

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(54) Title: A METHOD OF POSE ESTIMATION AND MODEL REFINEMENT FOR VIDEO REPRESENTATION OF A THREE DIMENSIONAL SCENE



(57) Abstract: The present invention is embodied in a video flash-light method. This method creates virtual images of a scene using a dynamically updated three-dimensional model of the scene and at least one video sequence of images. An estimate of the camera pose is generated by comparing a present image to the three-dimensional model. Next, relevant features of the model are selected based on the estimated pose. The relevant features are then virtually projected onto the estimated pose and matched to features of the image. Matching errors are measured between the relevant features of the virtual projection and the features of the image. The estimated pose is then updated to reduce these matching errors. The model is also refined with updated information from the image. Meanwhile, a viewpoint for a virtual image is selected. The virtual image is then created by projecting the dynamically updated three-dimensional model onto the selected virtual viewpoint.

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A METHOD OF POSE ESTIMATION AND MODEL REFINEMENT FOR VIDEO
REPRESENTATION OF A THREE DIMENSIONAL SCENE

[0001] This application claims the benefit of the filing date of the Provisional application 60/187,557 filed March 7, 2000, the contents of which are incorporated herein by reference.

[0002] The present invention is directed toward the domain of image processing, in particular toward the creation and manipulation of three dimensional scene models and virtual images of the scene seen from arbitrary viewpoints.

BACKGROUND OF THE INVENTION

[0003] Tremendous progress in the computational capability of integrated electronics and increasing sophistication in the algorithms for smart video processing has lead to special effects wizardry, which creates spectacular images and otherworldly fantasies. It is also bringing advanced video and image analysis applications into the mainstream. Furthermore, video cameras are becoming ubiquitous. Video CMOS cameras costing only a few dollars are already being built into cars, portable computers and even toys. Cameras are being embedded everywhere, in all variety of products and systems just as microprocessors are.

[0004] At the same time, increasing bandwidth on the Internet and other delivery media has brought widespread use of camera systems to provide live video imagery of remote locations. In order to provide coverage of live video imagery of a remote site, it is often desirable to create representations of the environment to allow realistic viewer movement through the site. The environment consists of static parts (building, roads, trees, etc.) and dynamic parts (people, cars, etc.). The geometry of the static parts of the environment can be modeled offline using a number of well-established techniques. None of these techniques has yet provided a completely automatic solution for modeling relatively complex environments, but because the static parts do not change, offline, non-real time, interactive modeling may suffice for some applications. A number of commercially available systems (GLMX, PhotoModeler, etc.) provide interactive tools for modeling environments and objects.

[0005] For arbitrary 3D scenes, various modeling approaches have been proposed, such as image-based rendering, light fields, volume rendering, and superquadrics plus

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shape variations. For general modeling of static scenes, site models are known to provide a viable option. In the traditional graphics pipeline based rendering, scene and object models stored as polygonal models and scene graphs are rendered using Z-buffering and texture mapping. The complexity of such rendering is dependent on the complexity of the scene. Standard graphics pipeline hardware has been optimized for high performance rendering.

[0006] However, current site models do not include appearance representations that capture the changing appearance of the scene. Also these methods generally seek to create a high quality model from scratch, which in practice necessitates constrained motion, instrumented cameras, or interactive techniques to obtain accurate pose and structure. The pose of the camera defines both its position and orientation. The dynamic components of a scene cannot, by definition, be modeled once and for all. Even for the static parts, the appearance of the scene changes due to varying illumination and shadows, and through modifications to the environment. For maintaining up-to-date appearance of the static parts of the scene, videos provide a cost-effective and viable source of current information about the scene, but unless the cameras are fixed, the issue of obtaining accurate pose information remains.

[0007] Between a pair of real cameras, virtual viewpoints may be created by tweening images from the two nearest cameras. Optical flow methods are commonly used by themselves to create tweened images. Unfortunately, the use of only traditional optical flow methods can lead to several problems in creating a tweened image. Particularly difficult are the resolution of large motions, especially of thin structures, for example the swing of a baseball bat; and occlusion/deocclusions, for example between a person's hands and body. The body of work on structure from motion may be pertinent to 3D-scene modeling. Purely image-driven methods, however, tend to drift away from metric accuracy over extended image sequences, because there is no constraint to tie down the estimated structure to the coordinate system of the real world. That constraint must come from physical measurements like GPS, or surveyed landmarks, or from a prior scene model with shape and/or texture information. The problem of loss of metric accuracy is particularly acute for analysis and control of a remote scene in which use of such

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constraint indicia is not practical, for example to control a remote vehicle on Mars or underground.

SUMMARY OF THE INVENTION

[0009] The present invention is embodied in a method of accurately estimating a pose of a camera within a scene using a three dimensional model of the scene. The exemplary method begins by generating an initial estimate of the camera pose. Next, a set of relevant features of the three-dimensional model based on the estimate of the pose is selected. A virtual projection of this set of relevant features as seen from the estimated pose is then created. The virtual projection of the set of relevant features is matched to features of the received image and matching errors between the features of the image and the features of the projection are measured. The estimate of the pose is then updated to reduce the matching errors.

[0010] A second embodiment of the present invention is method of refining a three dimensional model of a scene using an image of the scene taken by a camera, which may have an unknown pose. First the image is compared to the three dimensional model of the scene to generate an estimate of the camera pose. The three dimensional model of the scene is then updated based on data from the image and the estimated pose.

[0011] Another embodiment of the present invention is a method of accurately estimating a position of remote vehicle using a three dimensional model and an image from a camera having a known orientation relative to the remote vehicle. The image is compared to the three dimensional model of the scene to generate an initial estimate of the pose. A set of relevant features of the three dimensional model are selected and matched to features of the image. Matching errors are then measured and used to update the estimate of the pose. The position of the remote vehicle is determined using the estimated pose and the orientation of the camera. The three dimensional model may then be updated based on data from the image and the estimate of the pose.

[0012] Yet another embodiment of the present invention is a method of refining a three dimensional model of a scene containing an object using a plurality of images of the scene. First, a first image and a second image are compared to the three dimensional model of the scene to generate first and second pose estimates. Then, the first image and the second image are compared to one another to generate relative pose constraints. The

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first pose and the second pose are updated based on these relative pose constraints. Two sets of relevant features of the three-dimensional model corresponding to the first pose and the second pose are selected. These sets of relevant features are then matched to features in the first and second images, and two sets of matching errors are measured. The position estimate of the object within the three-dimensional model is then updated to reduce the two sets of matching errors.

[0013] The present invention is also embodied in a method of creating a textured three-dimensional model of a scene using a plurality of images of the scene. First a polyhedral model the scene including a plurality of polygonal surfaces is created. Each polygonal surface in the polyhedral model is larger than a predetermined size. One polygonal surface is then separated into a plurality of portions. For a selected portion, a subset of images containing that portion of the polygonal surface is identified. The corresponding section of the selected image is then projected onto the selected portion of the polygonal surface in the textured three-dimensional model as a local color map.

[0014] The present invention is also embodied in a video flashlight method of creating a dynamic sequence of virtual images of a scene using a dynamically updated three dimensional model of the scene. The three dimensional model is updated using a video sequence of images of the scene as described with regard to the second embodiment of the present invention. Meanwhile a viewpoint of a virtual image is selected. The virtual image is then created by projecting the dynamic three-dimensional model onto the virtual viewpoint.

BRIEF DESCRIPTION OF THE FIGURES

[0015] Figure 1 is a top plan drawing of several cameras viewing a scene.

[0016] Figure 2 is a perspective drawing of a polyhedral model of the scene in Figure 1.

[0017] Figure 3 is a drawing illustrating selection of relevant features from the polyhedral model of Figure 2.

[0018] Figure 4 is a flowchart illustrating an embodiment of the present invention to accurately estimate the pose of an image of a scene using a three dimensional model of the scene.

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[0019] Figure 5 is a flowchart illustrating an embodiment of the present invention to update a three dimensional model of a scene using an image of the scene with an unknown pose.

[0020] Figure 6 is a perspective drawing illustrating the use of epipolar geometry to determine the relative pose of two images.

[0021] Figure 7 is a flowchart illustrating an embodiment of the present invention to update a three dimensional model of a scene using a pair of images of the scene with unknown poses.

[0022] Figure 8 is a top plan drawing illustrating a remote vehicle with a mounted camera viewing the scene from Figure 1.

[0023] Figure 9 is a flowchart illustrating an embodiment of the present invention to accurately estimate the position of a remote vehicle within a scene using a three dimensional model of the scene and an image of the scene.

[0024] Figure 10 is a perspective drawing of a surface from Figure 2 illustrating the separation of the surface into approximately equal sized portions used in an exemplary hybrid three dimensional model according to the present invention.

[0025] Figure 11 is a flowchart illustrating an embodiment of the present invention to create a hybrid three-dimensional model of a scene.

[0026] Figure 12 is a perspective drawing of a scene illustrating an exemplary video flashlight method of the present invention.

[0027] Figure 13 is a flowchart illustrating an embodiment of the present invention to create virtual images of a scene and a dynamic three-dimensional model of the scene using a video flashlight method.

DETAILED DESCRIPTION OF THE INVENTION

[0028] The present invention embodies systems and methods for processing one or more video streams, for the purposes of progressively constructing and refining a 3D- scene model, geolocating objects, and enhanced visualization of dynamic scenes. One embodiment of the present invention is a progressive strategy to model construction and refinement, starting with a coarse model and incrementally refining it with information

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derived from freely moving video cameras, thereby increasing the spatial fidelity and temporal currentness of the model.

[0029] Figure 1 is a top plan drawing showing several cameras **108**, which may be stationary or may be in motion. The cameras view an exemplary scene **100**, containing three objects, cube **102**, star prism **104**, and cylinder **106**.

[0030] Figure 2 is a perspective drawing of an exemplary polyhedral model of scene **100** from Figure 1. All objects in this model are all represented as polyhedra composed of planar polygonal surfaces **200**, even a curved object, such as cylinder **106**. To accomplish such a polyhedral representation, the modeled representation of cylinder **106** contains artificial edge boundaries **204**. Also shown in Figure 2 are dotted lines **202**, which represent edge boundaries that are hidden in the illustrated view of the model. While this model is shown as an image of a physical scene, it is contemplated that the model may be a mathematical representation of the scene, stored in a data file.

[0031] A first exemplary embodiment of the present invention is a method of automatic pose estimation and registration of video to an existing polyhedral scene model, which may or may not have texture information suitable for registration. The method of this embodiment may be used to estimate camera pose with respect to textured or untextured models, by optimizing the fit between line segments projected from model to image and the gradients of image intensity. This method may be combined with interframe prediction to continuously track a video stream.

[0032] Figure 4 is a flowchart illustrating this exemplary embodiment of the present invention. The method begins with a three dimensional model of the scene, **400**, such as that shown in Figure 2. The first step, **402**, is to generate an initial, rough estimate of the pose of an image by comparing the image to the three dimension model of the scene. Numerous methods may be used to obtain this initial estimate. In an interactive system, a user can set the pose for the first frame. Physical measurements from position/attitude sensors mounted on the camera platform may be another source. Alternatively, when processing a sequence of frames, the estimated pose of the previous frame may be used as the initial pose, or the pose can be predicted from the previous frame's estimated pose based on assumed motion. Interframe alignment may also be used to assist with prediction and with overcoming ambiguity. One method for determining an

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initial pose estimate may be to extract corresponding 2D feature points from a pair of successive images using an optical flow technique. In order to support large displacements, flow estimation may be initialized with the 2D projective motion field estimated by a global parametric motion algorithm. Methods for flow estimation of this type are described in U.S. Patent number 5,629,988, entitled "SYSTEM AND METHOD FOR ELECTRONIC IMAGE STABILIZATION". Next, each selected feature point is mapped into its corresponding 3D point in the world view by using the current estimated pose and the current shape model. The initial pose estimate is then determined from the set of 3D and 2D correspondences. This may be done, for example, using the Random Sample Consensus (RANSAC) method of robust least squares fitting. Even though the current pose and shape model may include significant errors, these errors should be reduced in the process of refining the image to model alignment.

[0033] Next a set of relevant features is selected from the three dimensional model based on the estimate of the pose, step **404**. The existing model may be considered a collection of untextured polygonal faces. Face edges in the model imply discontinuities in surface normal and/or material properties in the actual 3D scene, which generally induce brightness edges in an image. Although the subject invention is described in terms of brightness edges, it is contemplated that other types of edges may be used such as those defined by changes in color or texture on an appropriately colored and/or textured model. Because they are relatively easy to identify, an exemplary alignment method selects 3D line segments from the model as relevant features.

[0034] Figure 3 is a drawing illustrating selection of relevant features **302** from the polyhedral model of Figure 2. Figure 3 is drawn to have the same pose as that used for the perspective drawing of Figure 2. Given an initial pose estimate, occluded fragments of model features, dotted lines **202** in Figure 2, may be deleted by known methods, such as a Z-buffer hidden line removal process.

[0035] Because many models of objects, such as buildings, may be constructed for various applications besides pose estimation (e.g. architecture), many model edges will not induce brightness edges in the image. Even after occluded edge fragments are suppressed, a model may contain clutter such as edges occluded by unmodeled objects, edges of structures that are semantically but not geometrically significant, edges between

faces meeting at a shallow angle. Pose estimation may be adversely affected if too much model clutter happens to fall close to image edges. Therefore, it is important to cull the edges of the polyhedral model to keep those most likely to induce brightness edges.

[0036] Additionally, multiple local minima in pose estimation may be caused by closely spaced edges in either the model or the image even if they correspond to brightness edges in the image. Therefore, once the possible relevant features of the model have been identified, a projection of these features as they appear in the estimated pose is created, step **406** in Figure 4, and projected model features are culled out if any similarly oriented projected model edge lies near it. Projected model features may also be culled if image texture analysis reveals the presence of multiple image edges within a predetermined distance. This culling may be dynamically adapted to the current level of uncertainty, so that as pose becomes better known, more edges can be included for increased pose estimation accuracy.

[0037] Application-dependent heuristics for this culling may be applied, for example, keeping only model edges common to exactly two faces, keeping edges only at large dihedral angles, ignoring edges which are too close together, and ignoring edges near and on the ground (terrain faces may be annotated in the given model). In Figure 3 the dotted lines **300** represent features which have been ignored in this exemplary pose as too close to other lines. Also missing are the artificial edge boundaries **204** from the model shown in Figure 2, as the their dihedral angles have been determined to be too small.

[0038] While the pose, and hence occlusions, may change during the optimization process, it may suffice to cull model edges once when initializing the optimization and afterwards only if the pose changes significantly. This determination, based on the change in the estimated pose in the exemplary method of Figure 4, is shown as step **418**. If the pose of the camera has changed by more than a threshold amount since the features were selected from the model, step **418** jumps to step **404** to select a new set of features. The process of pose refinement desirably leads toward smaller changes in the estimated pose. Therefore, often the estimate of pose will quickly become approximately correct. In this instance, step **418** branches to step **406** and same set of relevant features will be used throughout the remaining pose refinement.

[0039] It is noted that, though the embodiments of the present invention mostly disclose the measurement and reduction of matching errors, one of skill in the art may easily practice the present invention by, instead, measuring and increasing matching scores without substantially altering the invention.

[0040] Next, the virtual projection of the relevant features is matched to brightness features in the image, step **408**. Additionally, color and/or texture edges may be used to generate image features, not just brightness edges. Matching errors are generated to indicate the goodness of the fit, step **410**. The estimated pose is then updated based on these matching errors, step **412**. The matching error calculation may be accomplished by many methods, including a number of image processing methods used for image warping and mosaic construction.

[0041] In the case of an already-textured model, constructed from a previous set of images, the matching of image intensity patterns in the image to the textured model may be accomplished following the teachings of U.S. Patent Application number 09/075462, entitled "METHOD AND APPARATUS FOR PERFORMING GEO-SPATIAL REGISTRATION" and U.S. Provisional Application number 60/141460, entitled "GEO-SPATIAL REGISTRATION USING EUCLIDEAN REPRESENTATION".

[0042] One difficulty that may arise is that an image may have brightness edges that are close together, causing local minima in the objective function. Also, if the given polyhedral model does not agree with veridical scene structure, no pose can simultaneously align all edge features well. Projected model features may get stuck at the wrong image edge, preventing progress towards the correct pose.

[0043] Several approaches to mitigate this problem exist. One exemplary method is to use any of a number of discrete search schemes. Perturbing the pose estimate, either at the initial estimate, step **402**, or during refinement, step **412**, is one method that may increase the likelihood of finding the global minimum. These perturbations in pose estimate may be generated by explicitly perturbing the pose parameters. Alternatively, they may be generated in a data-driven fashion, as in RANSAC, wherein pose hypotheses are estimated from many randomly chosen subsets of the model features.

[0044] For video sequences, interframe registration may be used to yield constraints on relative poses of neighboring frames, which, in turn, may allow poses of a

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collection of frames to be determined unambiguously. If a set of nearby frames collectively views a larger set of edges than any single frame, simultaneously exploiting image-to-model constraints in multiple frames may help to disambiguate pose. An exemplary embodiment of the present invention aligns the three dimensional model to a mosaic, virtual wide-angle image, from a virtual rigid rig of cameras. Suppose that a pose estimate has been predicted for one frame, but that this pose estimate is ambiguous due to a paucity of relevant model edges. For each of the remaining frames, interframe prediction may be used to obtain pose estimates. These pose estimates may then be treated as a virtual rigid rig of cameras. The total image-to-model error of the mosaic, virtual wide-angle image, created from these frames is then minimized. This method is particularly useful for scenes in which the features are relatively static.

[0045] Mismatched features may also occur because the attributes being measured are not sufficiently discriminating. For example, a projected model feature may be matched equally well to an image edge of equal length, an image edge of longer length, or a series of short image edges. Many different methods for matching image features tuned to scale and orientation are known in the art. One method that may be used is pyramid processing. Both the image and the model may be processed into a pyramid of resolution levels. As the estimated pose becomes more accurate (i.e. the matching errors decrease), the resolution level, and number of features retained, may be increased.

[0046] The matching errors may also be optimized with respect to the estimated pose via steepest descent. The natural representation of an infinitesimal change in the pose parameters as a translation and a cross product for small rotation, however, unweighted steepest descent tends to work slowly when the energy surface is highly anisotropic, and may get stuck in local minima. To solve this problem, the current pose estimate may be iteratively incremented by moving in the gradient direction in the space of an orthogonalized incremental pose parameter. In that space, a unit step in any direction causes the RMS change in line segment points of image features to be 1 pixel.

[0047] One of the properties that may be desirable for the matching errors is a degree of robustness against outliers. Desirably this robustness includes both poorly fitting lines and model clutter, i.e. a spurious model feature that has no true matching image feature. If the projected feature lies far from any image feature, it contributes little

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to the calculation of the gradient of estimated pose. To reduce the chance that a projected model line segment, whether an artifact of model clutter or a valid feature, would be attracted to a falsely matching image feature, dissimilarly oriented model and image edges may be ignored by using an oriented energy image tuned to the angle of the model line.

[0048] Many different methods for generating a measure of local edge strength within an image tuned to scale and orientation are known. In an embodiment of the present invention, an oriented energy image including the oriented energy at a selected angle may be computed as follows. The source image is differentiated in the selected direction and smoothed in a perpendicular direction. The magnitude of the latter is smoothed in the selected direction. This method responds to both step edges and impulses. For computational efficiency, the orientation may be quantized to multiples of 45° and scaled to powers of 2, as in a pyramid.

[0049] Unfortunately, the robustness of this method may mean that, if the error in initial estimate of pose causes many model line segments to be projected far from their corresponding image features, the steepest descent may not move towards the true pose. An exemplary method to increase the capture range and speed convergence is to vary the scale of the energy image from coarse to fine resolution during the optimization process. The scale may desirably be tuned for each model line, commensurate with the expected amount of uncertainty in the location of predicted feature with respect to the actual corresponding image edge.

[0050] It has been found that the capture range of coarse-to-fine pose estimation may be reasonably large for low complexity images, and limited only by the presence of multiple local minima in matching errors when the image has lots of edges. Thus, it may be desirable to exploit interframe constraints to ensure stable tracking over a sequence, such as by using prediction to initialize estimated pose in the correct minimum basin, or by multiframe alignment. Intelligent selection of a subset of model features is also critical.

[0051] Also, the orientation tuning may be very broad in the oriented energy pyramid described above. The solution may be to add more discriminating feature attributes to the representation. The measure of the matching errors may be improved, for example, by using sharper orientation tuning.

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[0052] Alternatively, in an outdoor site modeling application, the camera may only see a small part of the model at a time. Thus, there may be individual images that contain little texture or few model edges, so that matching features may be difficult and the pose may be undetermined. One method to overcome this difficulty is to combine several images to form a mosaic that is warped to the coordinate system of the current image. This composite image may be used in the algorithm, in place of the individual image, to determine the pose of the camera at the position of the current image.

[0053] The process of pose refinement shown in steps **406**, **408**, **410**, and **412** may be repeated until a set number of iterations have occurred, step **414**, or until the matching errors fall below a set criteria, step **416** (alternatively, the matching score, if used, may exceed a predetermined level).

[0054] Figure 5 is a flowchart illustrating an embodiment of the present invention to update a three dimensional model of a scene using an image of the scene with an unknown pose. This method begins with several steps that are similar to those described above with regard to Figure 4. As in the exemplary embodiments described with regard to Figure 4, the embodiment illustrating in Figure 5 begins with a three dimensional model of the scene, **500**. This starting model may be very rudimentary and limited in its scope. As images are aligned and information from these images used to update the model, the detail and range of the model may both be increased.

[0055] Still following the outline of Figure 4, the image is compared to the three dimensional model of the scene to generate an initial estimate of the pose, step **502**. A set of relevant features are selected from the three dimensional model based on this pose estimate, step **504**. The relevant features of the model are then projected and matched to features in the image to generate matching errors, step **506**. Next, the estimated pose is updated based on the matching errors, step **508**. Once again as previously described, the pose refinement process, shown in Figure 5 as steps **504**, **506**, and **508**, may be repeated until a set number of iterations have occurred, step **510**, or until the matching errors fall below a set criteria, step **512** (alternatively, if an embodiment employing a matching score is used, step **512** may query if the matching score exceeds a predetermined level). Step **514** determines whether the pose estimate indicates that the pose of the camera has changed so much from the initial pose in which the current relevant features were selected

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that it may be desirable to reselect a new set of relevant model features to be used for continued pose refinement.

[0056] Once the pose estimate is completed, as evidenced by a 'yes' answer to the query of either step **510** or step **512**, the data from the image is used to update the three dimensional model, step **516**. This update may include: the refinement of object placement within the scene; the additions of textural or fine structural detail to surfaces of objects; temporal updating of dynamic processes, such as changing illumination, or objects in motion; and the spatial extension of the scene being modeled. A number of methods to project image data onto a corresponding three dimensional model, such as a simple ray tracing method, are known in the art and may be used in step **516**. For many of these methods it is desirable to use two, or more, images simultaneously, particularly to assist with refining object placement and identifying objects in motion. Figure 6 is a perspective drawing illustrating a plane in the scene, **600**, and the poses of two images, **602** and **604**, of the scene, both of which include object **606**. Significant work has been done using the epipolar geometry shown in Figure 6 for image processing and mosaic construction. In this Figure, the epipole is shown as the line O – O'. The epipolar geometry of a scene may also be used to place constraints on the relative pose of images **602** and **604** even if the location of object **606** within the scene is not known. Additionally, plane plus parallax methods may be used to generate relative pose constraints between images. A detailed discussion of some of these methods is provided in U.S. Patent number 6,192,145, entitled "METHOD AND APPARATUS FOR THREE-DIMENSIONAL SCENE PROCESSING USING PARALLAX GEOMETRY OF PAIRS OF POINTS".

[0058] Figure 7 is a flowchart illustrating another exemplary embodiment of the present invention. This exemplary method is similar to that previously described with regard to Figure 5, but uses multiple images of the scene with unknown poses to update a three dimensional model of a scene. Although the exemplary method shown in Figure 7 only employs two images at a time, it is contemplated that three or more images may be simultaneously used in this embodiment. The images may be successive images from a moving source, or they may be concurrently generated images from multiple sources. The parallel paths in Figure 7, such as steps **702** and **704**, represent parallel processes,

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which may occur as multi-threaded tasks within the image processing hardware of the present invention. It may be desirable for these tasks to be performed concurrently by parallel processors to increase processing speed.

[0059] As in previously described embodiments of the present invention, this embodiment begins with a three dimension model of a scene, **700**, and the first and second images are compared to the three dimensional model of the scene, steps **702** and **704** respectively, to generate pose estimates. These pose estimates may be initial pose estimates, or may be refined as described in previous embodiments of the present invention. If the pose estimates are refined, it may be desirable for the matching error criteria to be less precise than in previous embodiments.

[0060] Next, the first and second image are compared to one another, step **706**, to generate constraints on the relative poses of the two images. A number of methods exist to generate relative pose constraints as described above with respect to Figure 6, such as optical flow, RANSAC, epipolar geometry calculations, and plane plus parallax. Relative pose constraints can also be generated due to the known motion of a single camera, or known spatial relationships between multiple cameras. The pose estimates are then updated to accommodate the relative pose constraints, step **708**. While it is often desirable to minimize the individual image to model mismatches when the pose estimates are being updated, this update should result in pose estimates that fit within the relative pose constraints generated in step **706**.

[0061] Next, sets of relevant features from the three dimensional model, corresponding to the first image and the second image, are selected based on the updated poses, steps **710** and **712** respectively. These sets of relevant features may be selected by any of the previously disclosed methods. The corresponding set of relevant features is next projected to the estimated pose of the first image, matched to the first image and first image matching errors are measured, step **714**. The same procedure is followed for the second image in step **716**.

[0062] The three dimensional model is updated using the matching errors from both images to improve the position estimate of objects within the model, step **718**. The matching errors are jointly minimized with respect to position estimate for both images to refine the placement of known objects in the scene model. Further iterations may be used

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to improve the model refinement, and possibly the estimated camera poses as well. These iterations may start by once again estimating the image poses, steps **702** and **704**, or with the selection of sets of relevant model features, steps **710** and **712**.

[0063] The use of more than two images at a time may also increase the accuracy of object placement. To help overcome errors in estimating object placement when the estimates of camera pose are inaccurate, or vice versa, parameters may be estimated jointly in multiple frames, akin to bundle adjustment in structure from motion. For further stability, inconsistency of poses with respect to interframe alignments should also be penalized, e.g. uncertainties in the relative pose constraints of corresponding points in frame pairs may be used to weight the importance of matching errors for various images.

[0064] This is a 3D generalization of the method disclosed in U.S. Patent number 6,078,701, entitled "METHOD AND APPARATUS FOR PERFORMING LOCAL TO GLOBAL MULTI-FRAME ALIGNMENT TO CONSTRUCT MOSAIC IMAGES".

[0065] In addition, refinement of object placement may be extended to more general deformations by using an additional set of parameters to describe known sizes and relationships of parts of objects.

[0066] One possible use of the present invention is illustrated in Figures 8 and 9. This application of the present invention involves using current video from a camera mounted on a remote vehicle to locate the vehicle relative to objects in a three dimensional model. An additional application for the present invention may be to extend and refine a three dimensional model of an area as the area is explored by the remote vehicle possibly beyond the range of the scene originally covered by the model. Numerous applications in robotics exist for such methods. These methods may be particularly useful for the exploration of places in which other location techniques, such as GPS, are not practical, including underground, deep-sea, and interplanetary exploration.

[0067] Figure 8 is a top plan drawing of remote vehicle **800**, with mounted camera **802**, viewing the scene from Figure 1. In this exemplary sketch, the camera is turned so that at least a portion of each object in the scene, cube **102**, star prism **104**, and cylinder **106**, is visible (shown as surfaces **804**). Although both the remote vehicle and the camera may be independently moveable, the position and angular orientation of camera **802** relative to remote vehicle **800** are assumed to be known, or at least measurable.

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[0068] Figure 9 is a flowchart illustrating an exemplary embodiment of the present invention to accurately estimate the position of a remote vehicle within a scene using a three dimensional model of the scene and an image of the scene. As previously described, the method begins with a three dimension model and an image from a camera having an orientation relative to the remote vehicle, **900** that can be determined. The next seven steps, **902, 904, 906, 908, 910, 912, and 914**, involve estimating and refining the camera pose with respect to the three dimensional model. These steps are the same as steps **502, 504, 506, 508, 510, 512, and 514** in the flowchart of Figure 5.

[0069] Once the pose of the camera mounted on the vehicle has been accurately estimated with respect to the scene, the position and orientation of the remote vehicle relative to the scene in the three dimensional model may be determined, step **916**. Because the mounted camera may be adjusted to rotate, tilt or zoom, parameters controlling these functions may need to be examined to determine the orientation of the camera relative to the remote vehicle.

[0070] The pose of the camera may be used independently of the position and orientation of the vehicle to update the model. At step **918**, the three dimensional model is updated based on data from the image and its estimated pose, step **918**, similarly to step **516** in Figure 5. Finally, the camera orientation, and possibly its position, relative to the remote vehicle are determined, step **920** to fix the position of the vehicle. The process begins again at step **902** when another image is taken.

[0071] In addition to the large-scale model refinement of object placement previously discussed with regard to Figure 7, an exemplary embodiment of the present invention may be used for detailed refinement of a three dimensional model, including definition of local surface shape and texture. The true shape of the surfaces in the scene may differ from the planar surfaces given by the given polyhedral model, even after refinement of object placement. For example, between the time of model construction and acquisition of the current video, the existing objects may have changed, and objects may be added or deleted. Some scene objects, especially natural objects like trees, may be absent from the model, or unsatisfactorily represented, because they are hard to represent using simple polyhedra. This can be clearly seen for the polyhedral model of cylinder **106** in Figure 2.

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[0072] In another exemplary embodiment of the present invention, an untextured model, such as the previous mentioned polyhedral model, may be populated with pixels from a series of images of the scene, such as video sequences, using the estimated camera poses and corresponding estimated object placements. The brightness of an object in the scene may be approximated as being constant, independent of the viewpoint, and each surface pixel may be assigned a color value that is most typical of all the given images.

[0073] As part of this embodiment polygonal surfaces of a polyhedral three-dimensional model may be separated into approximately equally sized portions. This may allow for better mapping of surface detail from a series of images onto the model, particularly for surfaces that are only partially visible in some of the images. Figure 10 shows a perspective drawing of surface **200**, from Figure 2, which has been separated into approximately equal sized portions **1000**. Surface detail **1002** for one portion, which may be added to the polyhedral model, is also shown. By adding surface detail to a polyhedral model of the scene in this manner, a hybrid three-dimensional model of the scene may be created.

[0074] Figure 11 is a flowchart illustrating an exemplary embodiment of the present invention to create such a hybrid three dimensional model of a scene using a series of images of the scene. The first step is to create a polyhedral model the scene, step **1100**. The polyhedral model desirably includes a plurality of polygonal surfaces, which are larger than a predetermined size for surface portions. Any standard technique for creating the model may be used. The rough shape and placement of objects in the polyhedral model may be refined according to the techniques of either of the flowcharts in Figures 5 and 7 using previous, possibly low resolution, images of the scene and/or the series of images to be employed for adding surface detail to the model. It is also important to determine the camera poses of the series of images. The poses may be known, or may be determined by one of the methods described above.

[0076] Next a polygonal face is selected from the polyhedral model for determination of surface details, step **1102**. The selection may be predetermined to sweep the analysis from one side of the model to its opposite side, or it may be based on a determination of scene areas in the images where the modeled shape appears to differ significantly from the existing model. The latter selection method is most useful when

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refinement of surface details is desirably to be performed only in those areas of the model that deviate from the images by an amount greater than a certain threshold.

[0077] At this point, it may be desirable to estimate and represent a refined surface shape as a height map associated with the selected planar surface. Given the previously determined camera poses, these height maps may be estimated by dense 3D estimation techniques from two or more observed images. The outcome of this process is a hybrid shape representation that augments the polyhedral model with local shape variation.

[0078] Several relevant techniques are previously disclosed: U.S. Patent number 5,963,664, entitled "METHOD AND SYSTEM FOR IMAGE COMBINATION USING A PARALLAX BASED TECHNIQUE", U.S. Patent number 5,259,040, entitled "METHOD FOR DETERMINING SENSOR MOTION AND SCENE STRUCTURE AND IMAGE PROCESSING SYSTEM THEREFOR", and U.S. Patent Application number 09/384118, entitled "METHOD AND APPARATUS FOR PROCESSING IMAGES". First, a batch of images is co-registered using the previously determined poses and shape model. Next, using change detection, regions are segmented out where the image alignment is consistently incorrect. In the detected change regions, the residual misalignment may be estimated, i.e. flow constrained along the epipolar lines. By progressing from coarse to fine image scale, such an estimation algorithm can handle a large amount of parallax, which may occur in areas of significant discrepancy between the given shape model and the actual 3D structure of the scene. Finally, the last step is to convert the resulting parallax magnitude to metric height.

[0079] In the cited patents and applications, it is recommended to sum up the image intensity errors over all pixels, between each inspection frame and a single designated reference frame. However, if the batch contains frames taken from widely disparate viewpoints, the appearance change may be large even if well aligned. Therefore, it may be desirable to sum up intensity errors only between adjacent images, or consecutive frames, if the series of images are a video sequence. A larger subset of images, or frames, may also be used, but it is often desirable for this subset to be selected to have viewpoints within a predetermined range.

[0080] If the batch of images used in the foregoing computation covers a sufficiently large range of views, the estimated shape may be very accurate; however,

occlusion and deocclusion areas cannot be well represented using a depth map with respect to one reference view. In practice, a smaller batch of images may produce a shape estimate good enough to align and synthesize viewpoints in the vicinity of the source data. It is contemplated that an alternative may be to use the parallax estimation methods to independently estimate and represent shape within a series of overlapping batches of images, each with its own reference view. Each such estimate would be stored in a hybrid scene representation consisting of a polyhedral model plus view-dependent local shape variations.

[0081] Whether a height map of the local surface shape has been constructed or not, a separate texture map is next constructed for each polyhedral face in the model. The local height map may assist in this construction, but is not a necessary step. The first step of this process, step 1104 in Figure 11, is to separate the selected polygonal surface into portions of approximately the predetermined size for surface portions. This predetermined size may be as small as a single element within the model, or it may be as large as the entire polygonal surface. Next one of these portions is selected, step 1106. Z-buffering may be used to detect and discard those images which are occluded by some other face, leaving a subset of images which contain the selected surface portion, step 1108.

[0082] To determine the color value for a portion X on the surface, X is mapped to every image in the subset, using object placement parameters for the surface, camera pose parameters and, if available, the previously estimated height maps. One method, possibly the simplest, is to combine the color values from the pixels in the subset of images corresponding to X. This may be done by averaging the color values, blending the color values or performing another mathematical function on the color values of the various images in the subset.

[0083] These methods of combining the color values ignore the possibly unequal quality of the images. The highest resolution, and most frontal view, of the face gives the most information about the surface appearance. Image resolution (e.g. in pixels/meter) can be assessed by the smaller singular value, μ , of the Jacobian dU_i/dX_i , where X_i is measured in a 2D face-aligned coordinate system and U_i is the position in the i^{th} image

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corresponding to X. Thus, the image having the maximum value of μ may be selected at step 1110, and its color value(s) projected from pixel(s) U_i to portion X, step 1112.

[0084] The color and brightness at corresponding points in different images may not be identical, due to camera gain variations and non-Lambertian surface materials. Abruptly switching between different source images while computing the appearance of a single face may cause seams to appear in the texture map. Accordingly, it may be desirable to use pixel values from a single image to map texture onto a given surface of the model, if possible.

[0085] Alternatively, once it has been determined that all of the portions of a given surface have been mapped, step 1114, any artifacts caused by using multiple images to generate the texture maps of the portions of a single surface may be mitigated through multi-resolution blending of the portions, step 1116, as taught in U.S. Patent number 6,075,905, entitled "METHOD AND APPARATUS FOR MOSAIC IMAGE CONSTRUCTION". This step may also be employed when a single image is used to map texture onto all of the portions of a given surface of the model.

[0086] The foregoing method to create a surface texture map of a hybrid three dimensional model may be used whether the scene is initially modeled by planar faces alone or by a model of planar faces plus shape variations. In the generalized representation using view-dependent local shape, texture may be recovered for each local reference view. The result would be a 3D-scene model with view-dependent shape and texture.

[0087] One exemplary method to synthesize a new image from a novel viewpoint may be to interpolate the shape and texture of two or more nearby reference views closest to the desired viewpoint, according to the teachings of U.S. Patent Application number 08/917402, entitled "METHOD AND SYSTEM FOR RENDERING AND COMBINING IMAGES TO FORM A SYNTHESIZED VIEW OF A SCENE CONTAINING IMAGE INFORMATION FROM A SECOND IMAGE".

[0088] Figure 12 is a perspective drawing of a scene, 1200, illustrating an exemplary video flashlights method of the present invention, which may be employed to synthesize an image from a novel viewpoint using a dynamic three dimensional model, such as those previously described with regard to the flowcharts of Figures 5, 7, and 11.

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The exemplary scene, **1200**, is being filmed by video cameras **1202**, which may be in motion. At any given time, images from these cameras contain only a portion of the scene, **1204**.

[0089] It has been previously demonstrated that current video images of a semi-urban environment can be aligned in near real-time to site models. The textured models can then be rendered using graphics pipeline processors. A visual metaphor for this process of combining models with videos is that of video flashlights '*illuminating*' portions **1204** of the model. The multiple camera views at a given time instant may be considered as video flashlights capturing the appearance of the scene from their respective viewpoints. The multiple appearances are coherently combined with the model to provide multiple users the ability to navigate through the environment while viewing the current appearance as derived from the video flashlights.

[0090] Figure 13 is a flowchart illustrating an exemplary embodiment of the present invention to create virtual images of a scene and a dynamic three-dimensional model of the scene using this video flashlight method.

[0091] This exemplary method involves two concurrent processes. Both of these processes start from a preexisting three dimensional model of the scene, **1300**. The first of these processes, updating the model using the incoming video data, is exemplified in Figure 13 as steps **1302**, **1304**, **1306** and **1308**. Any of the methods previously described above for updating a three dimensional model may be used. This dynamic updating process is continuous, so that the model may contain the most currently available data.

[0092] The second process is the creation of output image sequence(s) based on the dynamic three-dimensional model. This process involves the selection of a virtual viewpoint, step **1310**, and projection of the current model onto the selected viewpoint, step **1312**. The viewpoint selection may be controlled manually, set to track a feature, or object, in the model, or may follow a predetermined pattern. Projection of a three dimensional model to form an image as seen from selected point may be performed by a number of well known methods, such as Z-buffering.

[0093] Surveillance provides one possible application of this embodiment of the present invention. In a surveillance application using simultaneously deployed moving cameras, it may be difficult for a human operator to fuse and interpret real-time video

streams displayed on separate viewing screens. The relationship of the streams to the larger environment is not evident from the images, which may be unstable and narrow in field of view. Ideally, a visualization should portray the world as if the user were actually looking at the live scene, decoupled from the paths of the cameras that are collecting the imagery.

[0094] An exemplary embodiment of the present invention registers all video frames to the model so that images from several cameras at the same time instant can be projected onto the model, like flashlights illuminating the scene, which may then be rendered for any user-selected viewpoint. In this context of the scene model, it may become easy to interpret the imagery and the dynamic events taking place in all streams at once.

[0095] It is contemplated that the three dimensional model may be constructed to be devoid of moving objects and/or objects that are difficult to model onto polyhedra. These objects may appear in the video flashlights. In a virtual imaging system of this design, it may be desirable to make control of the video flashlight(s) responsive to movement of the virtual viewpoint(s).

[0096] Additionally, it is contemplated that the methods previously described may be carried out within a general purpose computer system instructed to perform these functions by means of a computer-readable medium. Such computer-readable media include; integrated circuits, magnetic and optical storage media, as well as audio-frequency, radio frequency, and optical carrier waves.

[0097] The embodiments of the present invention have been described with regard to polyhedral and hybrid three-dimensional models since they are appropriate for urban scenes dominated by planar structures, a present domain of application. Also, this format is well supported by software tools and graphics hardware. It is understood that those skilled in the art may find it advantageous to use other three dimensional models with these methods. Such use does not depart from the scope of the present invention. In the same vein, it will be understood by those skilled in the art that many modifications and variations may be made to the foregoing preferred embodiment without substantially altering the invention.

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What is Claimed:

- 1 1. A method for accurately estimating a pose of a camera within a
2 scene using a three dimension model of the scene, comprising the steps of:
 - 3 (a) generating an initial estimate of the pose;
 - 4 (b) selecting a set of relevant features of the three
5 dimensional model based on the initial estimate of the pose;
 - 6 (c) creating a virtual projection of the set of relevant
7 features responsive to the initial estimate of the pose;
 - 8 (d) matching a plurality of features of an image received
9 from the camera to the virtual projection of the set of relevant
10 features and measuring a plurality of matching errors; and
 - 11 (e) updating the estimate of the pose to reduce the
12 plurality of matching errors.
- 1 2. A method for accurately estimating a pose of an image of a scene
2 using a three dimension model of the scene, comprising the steps of:
 - 3 (a) performing a pyramid decomposition of the image to
4 generate a set of pyramid levels of the image;
 - 5 (b) selecting one pyramid level from the set of pyramid
6 levels;
 - 7 (c) generating an estimate of the pose using the selected
8 pyramid level;
 - 9 (d) selecting a set of relevant features of the three
10 dimensional model based on the estimate of the pose;
 - 11 (e) creating a virtual projection of the set of relevant
12 features responsive to the estimate of the pose;
 - 13 (f) matching a plurality of features of the selected
14 pyramid level to the virtual projection of the set of relevant features
15 and measuring a plurality of matching errors;
 - 16 (g) updating the estimate of the pose to reduce the
17 plurality of matching errors; and
 - 18 (h) repeating to steps (e), (f), and (g) using the updated
19 estimate of the pose until the plurality of matching errors are less

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20 than predetermined matching criteria which is responsive to the
21 selected pyramid level.

1 3. A method for refining a three dimensional model of a scene using an
2 image of the scene taken by a camera having an unknown pose, comprising the steps of:

3 (a) comparing the image to the three dimension model of
4 the scene to generate an estimate of the pose; and

5 (b) updating the three dimensional model of the scene
6 based on data from the image and the estimate of the pose.

1 4. A method for accurately estimating a position of remote vehicle
2 using a three dimension model and an image from a camera having a known orientation
3 relative to the remote vehicle, comprising the steps of:

4 (a) comparing the image to the three dimension model of
5 the scene to generate an estimate of the pose;

6 (b) selecting a set of relevant features of the three
7 dimensional model based on the estimate of the pose;

8 (c) matching a plurality of features of the image to the
9 set of relevant features and measuring a plurality of matching
10 errors;

11 (d) updating the estimate of the pose based on the
12 plurality of matching errors; and

13 (e) determining the position of the remote vehicle based
14 on the estimate of the pose and the orientation of the camera.

1 5. A method for refining a three dimension model of a scene
2 containing an object using a plurality of images of the scene, each image including the
3 object, comprising the steps of:

4 (a) comparing a first image of the plurality of images to
5 the three dimension model of the scene to generate an estimate of a
6 first viewpoint corresponding to the first image;

7 (b) comparing a second image of the plurality of images
8 to the three dimension model of the scene to generate an estimate of
9 a second viewpoint corresponding to the second image;

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- 10 (c) selecting a first set of relevant features of the three
11 dimensional model based on the first viewpoint;
- 12 (d) matching a plurality of first features of the first image
13 to the first set of relevant features and measuring a plurality of first
14 matching errors;
- 15 (e) selecting a second set of relevant features of the three
16 dimensional model based on the second viewpoint;
- 17 (f) matching a plurality of second features of the second
18 image to the second set of relevant features and measuring a
19 plurality of second matching errors; and
- 20 (g) updating a position estimate of the object within the
21 three dimensional model of the scene based on the plurality of first
22 matching errors and the plurality of second matching errors.
- 1 6. A method for refining a three dimension model of a scene
2 containing an object using a plurality of images of the scene, each image including the
3 object, comprising the steps of:
- 4 (a) selecting a subset of images from the plurality of
5 images of the scene, the subset of frames containing at least two of
6 the images;
- 7 (b) determining a plurality of approximate relative
8 viewpoints of the subset of images;
- 9 (c) comparing each image in the subset of images to the
10 three dimensional model to generate a subset of estimated viewpoints
11 corresponding to the subset of images, the subset of estimated
12 viewpoints constrained by the plurality of approximate relative
13 viewpoints;
- 14 (d) selecting a set of relevant features of the three
15 dimensional model corresponding to each estimated viewpoint;
- 16 (e) matching a plurality of features of the each image in
17 the subset of images to the corresponding set of relevant features
18 and measuring a plurality of matching errors; and

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- 19 (f) updating a position estimate of the object within the
20 three dimensional model of the scene based on the plurality of
21 matching errors.
- 1 7. A method for creating a hybrid three dimension model of a scene
2 using a plurality of images of the scene, comprising the steps of:
- 3 (a) creating a polyhedral model the scene including at
4 least one polygonal surface;
- 5 (b) determining a first set of images containing at least a
6 section of a first polygonal surface; and
- 7 (c) comparing a plurality of images selected from the
8 first set of images to generate a local surface shape map
9 corresponding to the first polygonal surface.
- 1 8. A method for creating a textured three dimension model of a scene
2 using a plurality of images of the scene, comprising the steps of:
- 3 (a) creating a polyhedral model the scene including at
4 least one polygonal surface;
- 5 (b) identifying at least one portion of the one polygonal
6 surface;
- 7 (c) determining a first subset of images containing the at
8 least one portion of the one polygonal surface;
- 9 (d) selecting at least one selected image of the first subset
10 of images;
- 11 (e) projecting a corresponding section of each of the at
12 least one selected image onto the at least one portion of the one
13 polygonal surface of the textured three dimension model as a local
14 color map;
- 15 (f) repeating steps (c), (d), and (e) for each remaining
16 portion of the one polygonal surface of the polyhedral model
- 1 9. A method for creating a dynamic sequence of virtual images of a
2 scene using a dynamically updated three dimension model of the scene, comprising the
3 steps of:

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- 4 (a) updating the three dimension model using a video
5 sequence of images of the scene including the steps of;
6 (a1) determining a present viewpoint of a
7 present image of the video sequence of images;
8 (a2) determining a relevant portion of the three
9 dimensional model corresponding to the present image of the
10 video sequence of images;
11 (a3) updating the relevant portion of the three
12 dimensional model by projecting the present image onto the
13 relevant portion of the three dimension model;
14 (b) selecting a first virtual viewpoint of a first virtual
15 image of the dynamic sequence of virtual images;
16 (c) creating the first virtual image by projecting the
17 dynamic three dimensional model onto the first virtual viewpoint;
18 and
19 (d) repeating steps (b) and (c) for each remaining virtual
20 image of the dynamic sequence of virtual images.
- 1 10. A computer readable medium adapted to instruct a general purpose
2 computer to update a three dimensional model of a scene using the three dimensional
3 model of the scene, an image received from a camera having an unknown pose, the
4 method comprising the steps of:
5 (a) generating an estimate of the pose;
6 (b) selecting a set of relevant features of the three
7 dimensional model based on the estimate of the pose;
8 (c) creating a virtual projection of the set of relevant
9 features responsive to the estimate of the pose;
10 (d) matching a plurality of features of an image received
11 from the camera to the virtual projection of the set of relevant
12 features and measuring a plurality of matching errors;
13 (e) updating the estimate of the pose to reduce the
14 plurality of matching errors; and

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- 15 (f) updating the three dimensional model of the scene
16 based on data from the image and the estimate of the pose.
- 1 11. An automatic three-dimensional model updating apparatus for
2 accurately estimating a point of view of an image of a scene, relative to a three-
3 dimensional model of the scene, and updating the three-dimensional model comprising:
- 4 (a) estimating means for providing an estimate of the
5 point of view of the image;
- 6 (b) relevant feature selecting means for selecting a set of
7 relevant features of the three dimensional model based on the
8 estimate of the point of view;
- 9 (c) virtual projection means for creating a virtual
10 projection of the set of relevant features responsive to the estimate
11 of the point of view;
- 12 (d) matching means for matching a plurality of features
13 of the image to the virtual projection of the set of relevant features;
- 14 (e) measurement means for measuring a plurality of
15 matching errors;
- 16 (f) point of view refinement means for updating the
17 estimate of the point of view to reduce the plurality of matching
18 errors; and
- 19 (g) model refinement means, responsive to the estimated
20 point of view and to the image, for updating the three-dimensional
21 model.

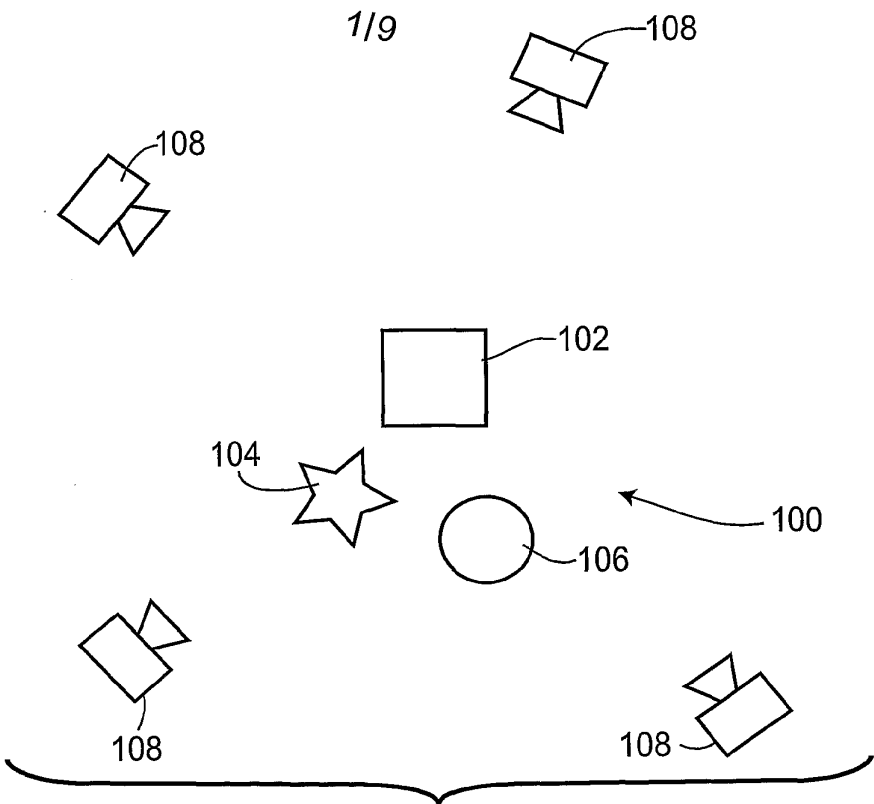
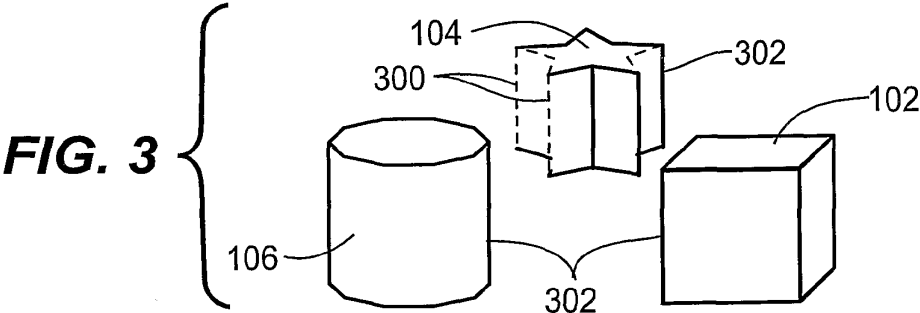
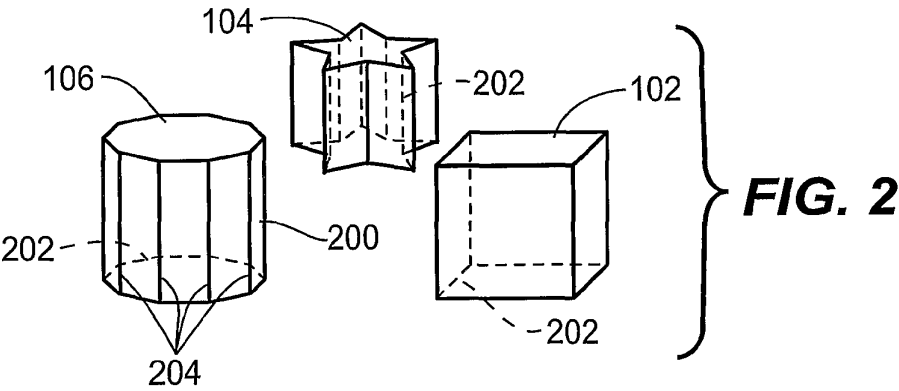
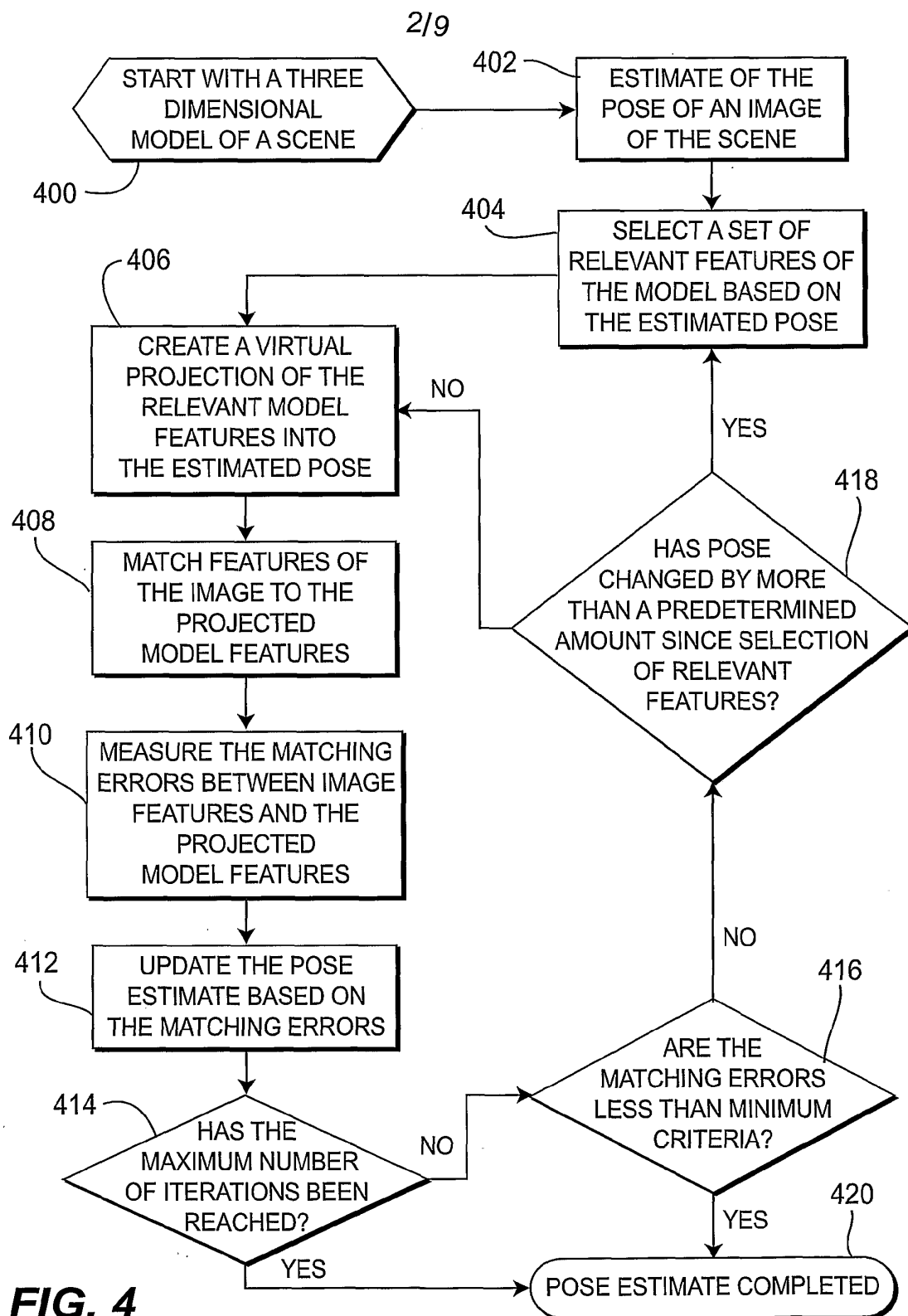


FIG. 1

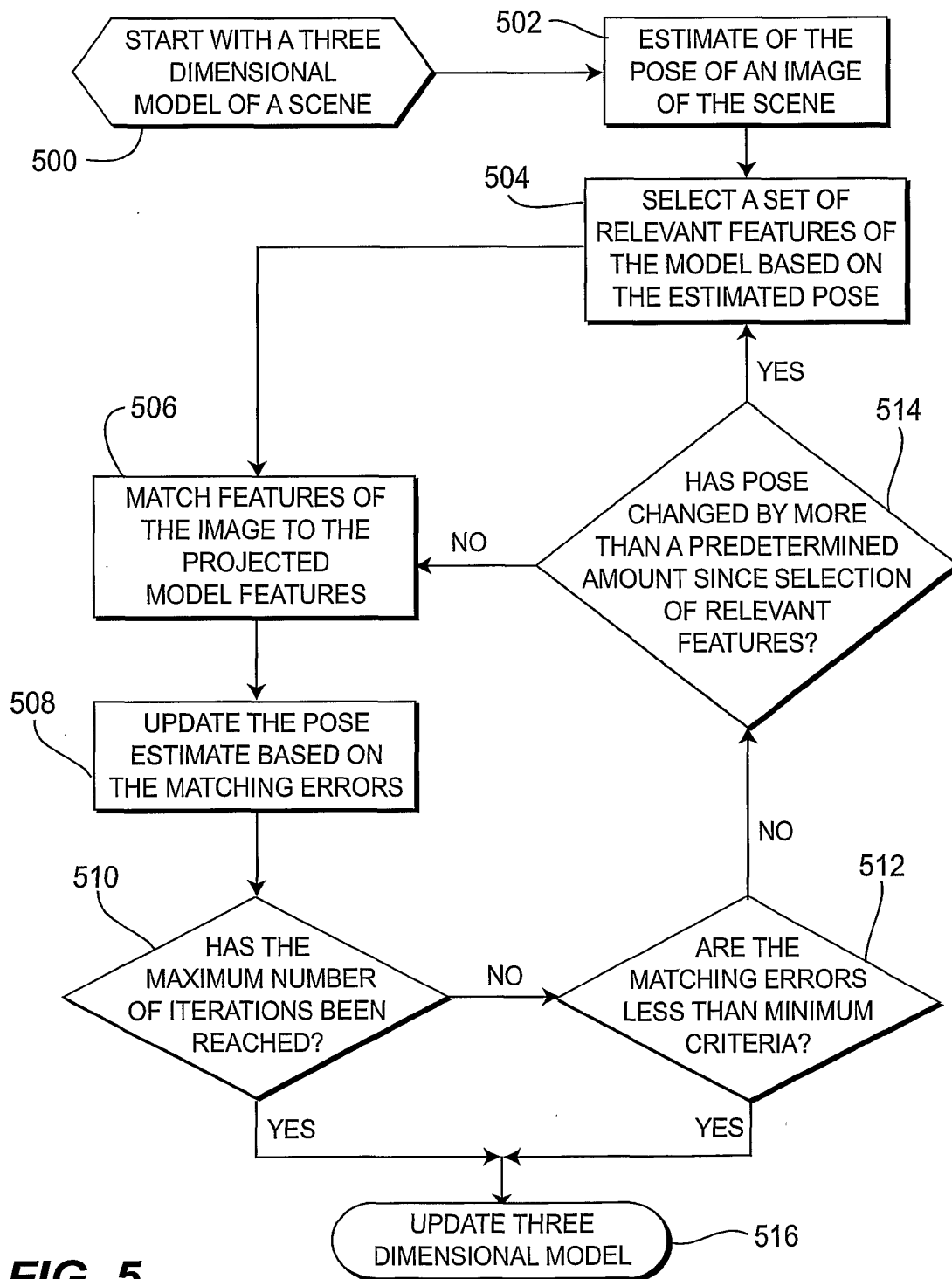


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**FIG. 5**

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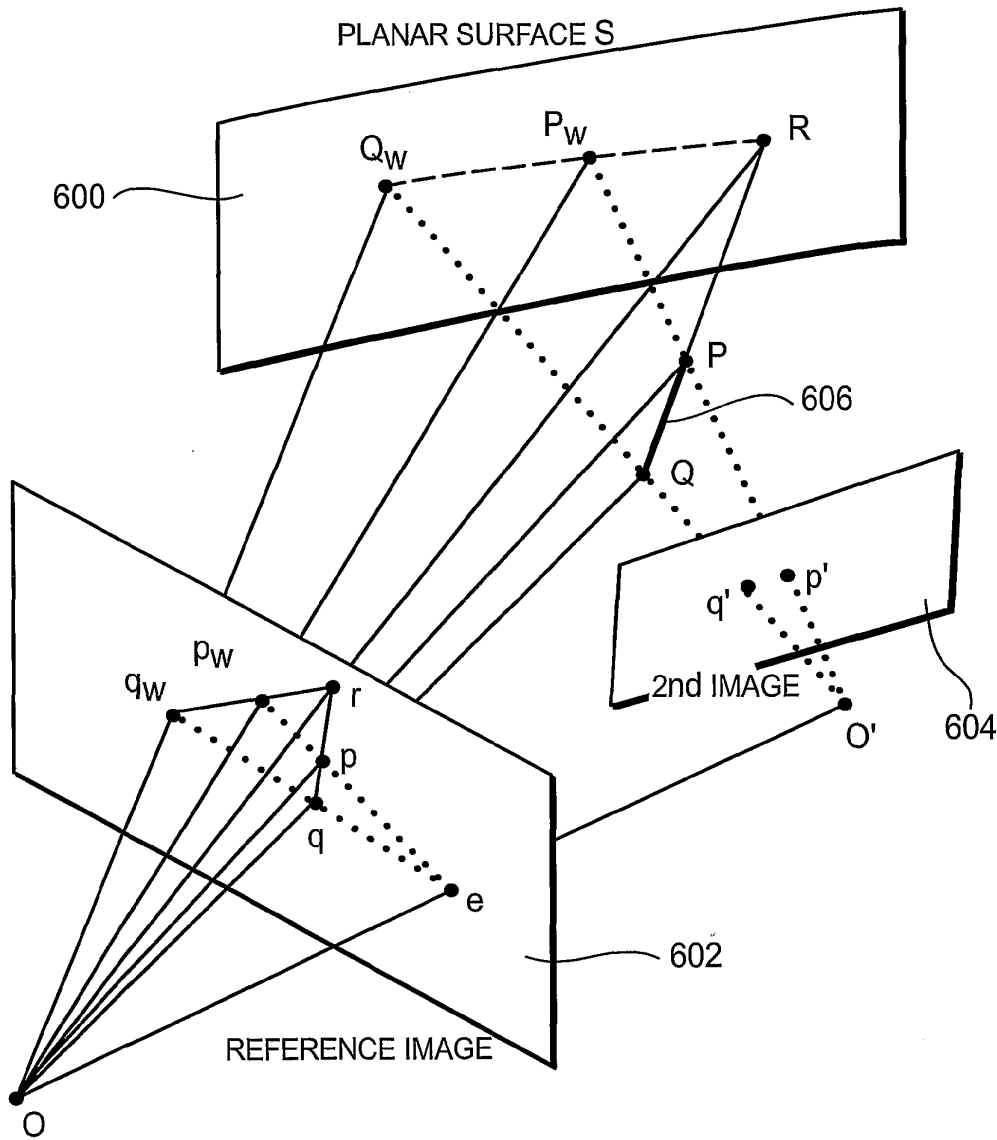
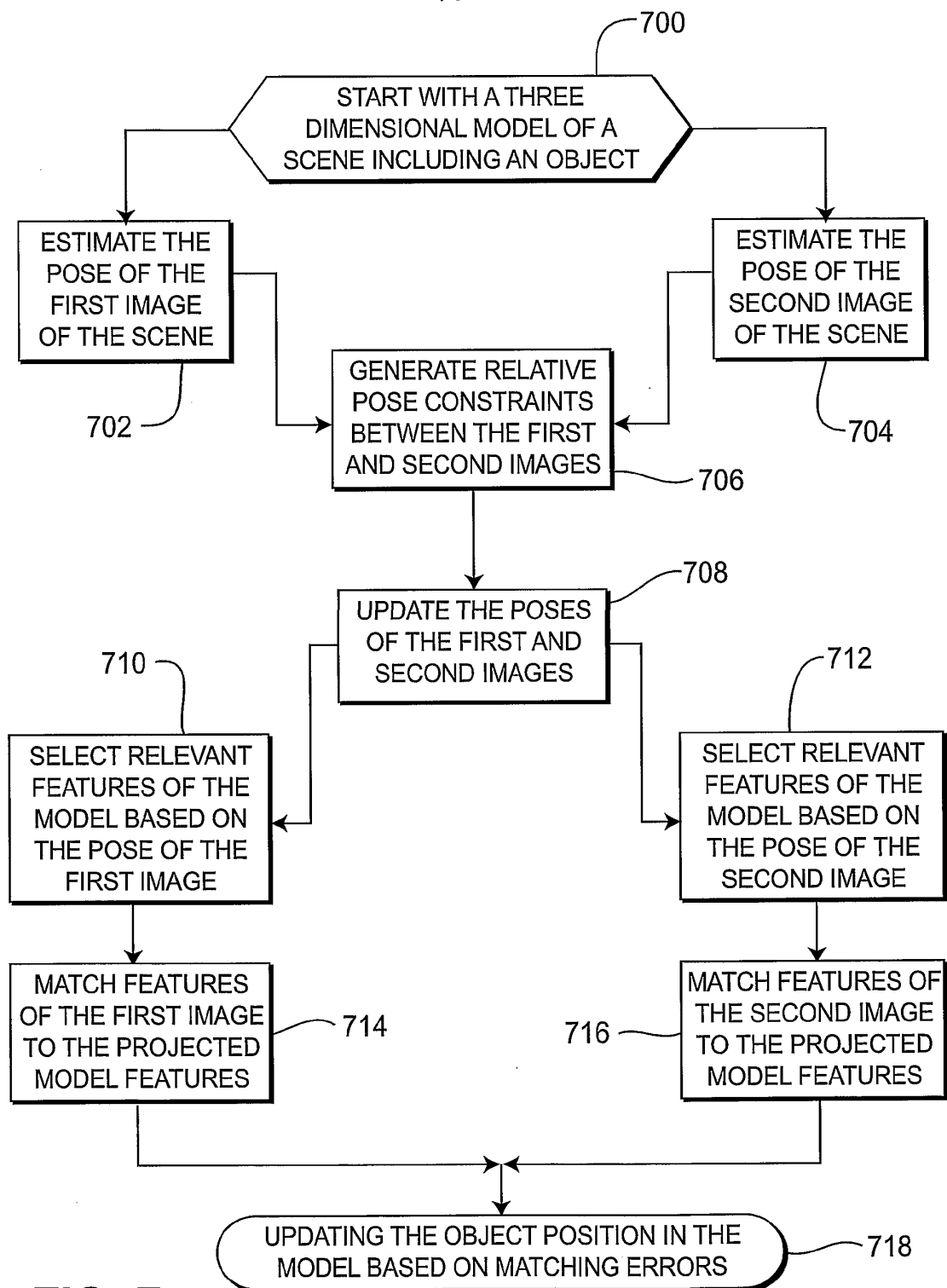


FIG. 6

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**FIG. 7**

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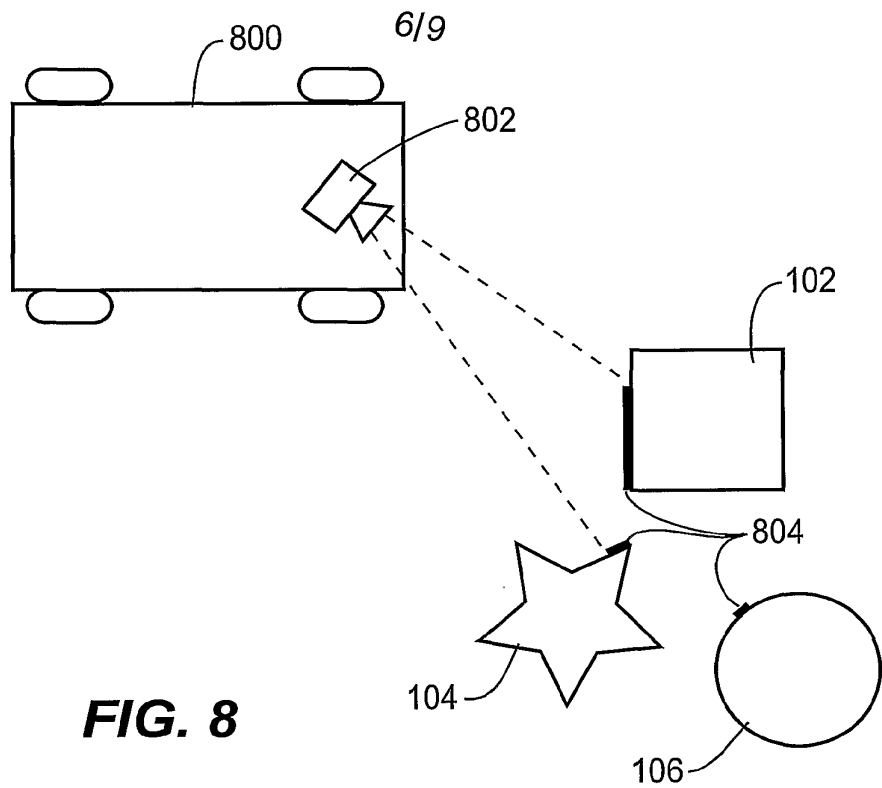


FIG. 8

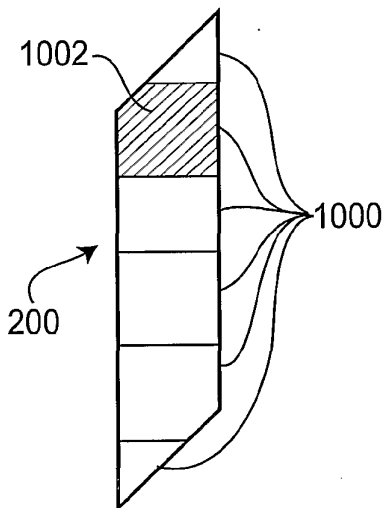


FIG. 10

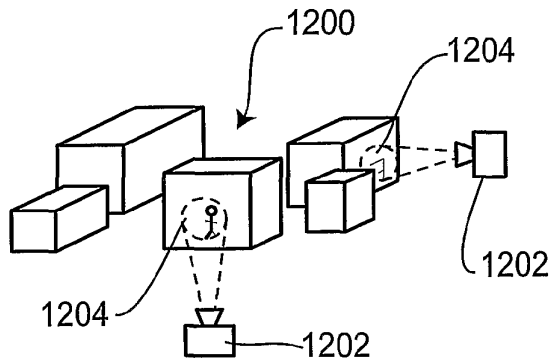
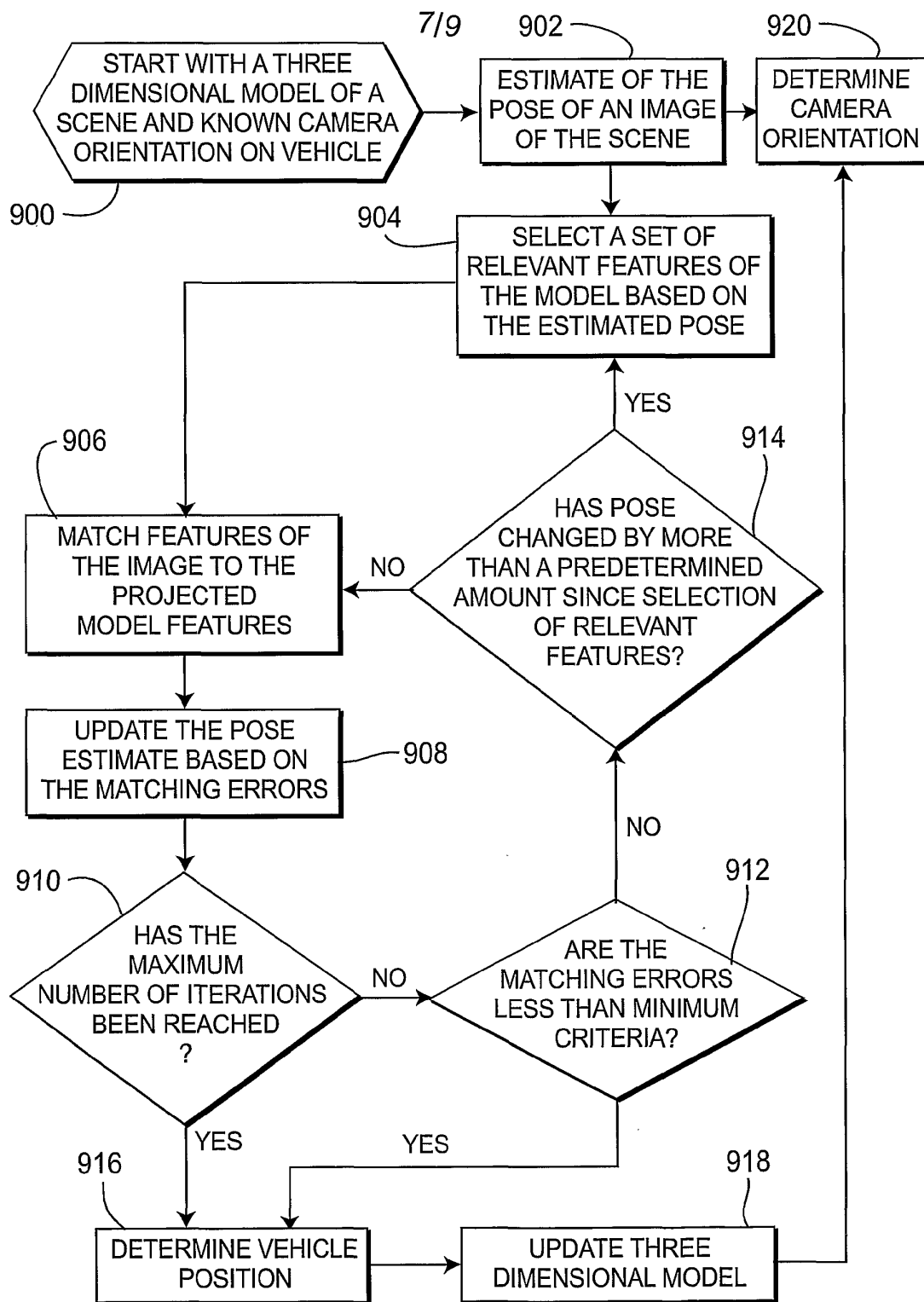
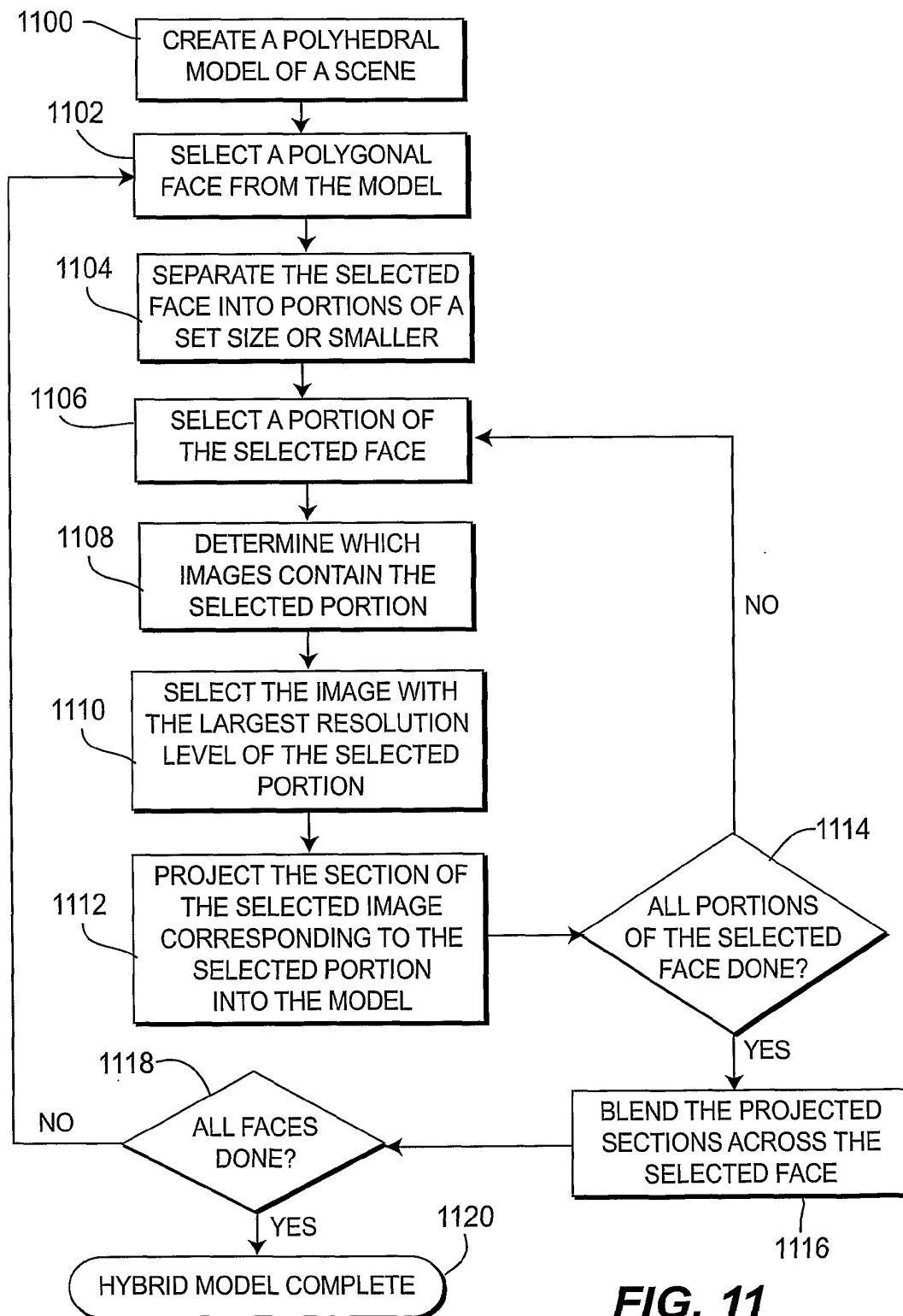


FIG. 12

**FIG. 9**

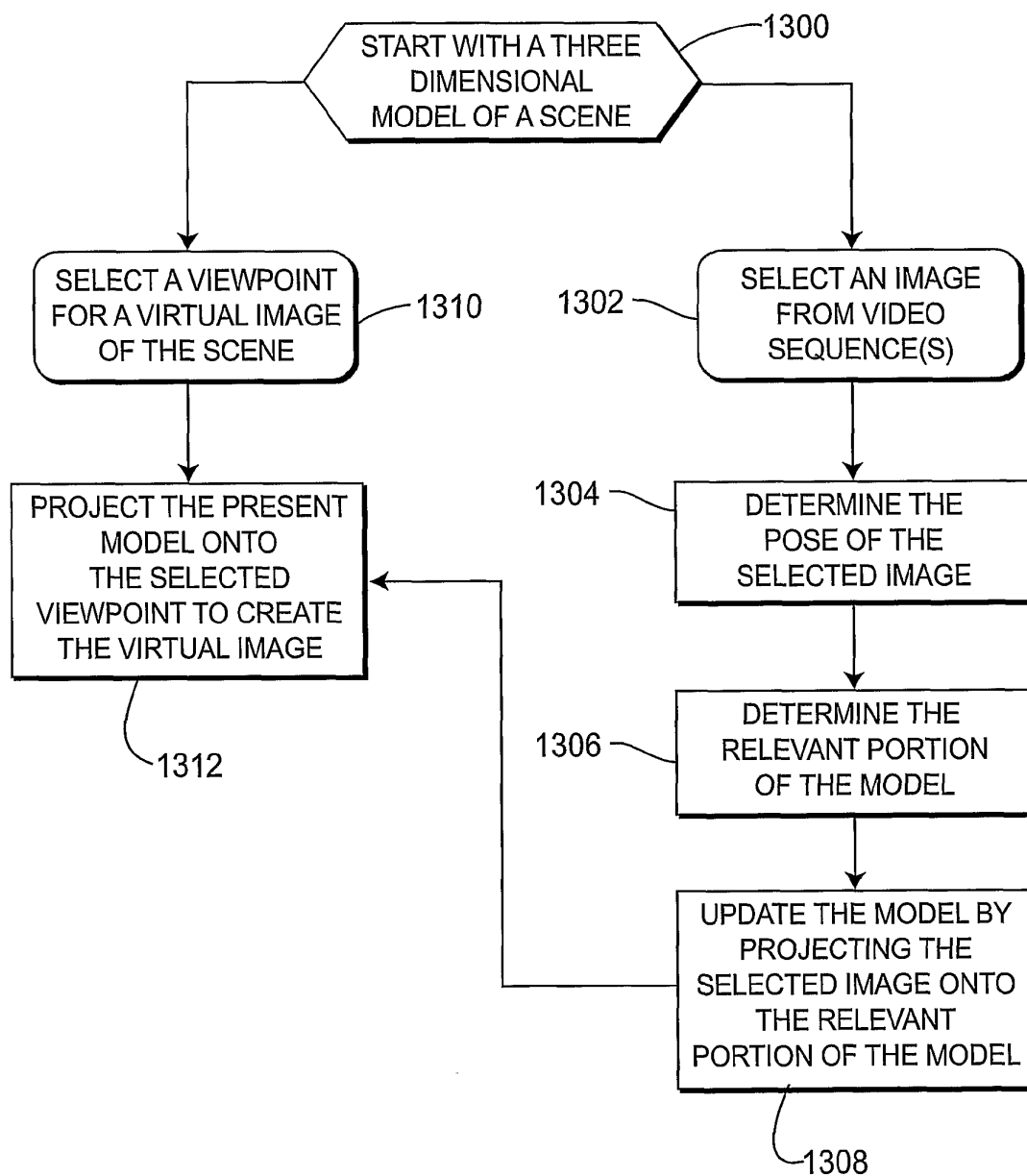
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**FIG. 11**

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**FIG. 13**

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- (71) Applicant: CTRLWORKS PTE. LTD. [SG/SG]; Unit 113C, Block 2, Innovation Centre, 18 Nanyang Drive, Singapore 637723 (SG).
- (72) Inventors: SIM, Kai; c/o Unit 113C, Block 2, Innovation Centre, 18 Nanyang Drive, Singapore 637723 (SG). CHENG, Calvin; c/o Unit 113C, Block 2, Innovation Centre, 18 Nanyang Drive, Singapore 637723 (SG).
- (74) Agent: MU, Jun; Rodyk & Davidson LLP, P.O. Box 462, Robinson Road Post Office, Singapore 900912 (SG).
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Declarations under Rule 4.17:

- as to the identity of the inventor (Rule 4.17(i))
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- of inventorship (Rule 4.17(iv))

[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR OFFBOARD NAVIGATION OF A ROBOTIC DEVICE

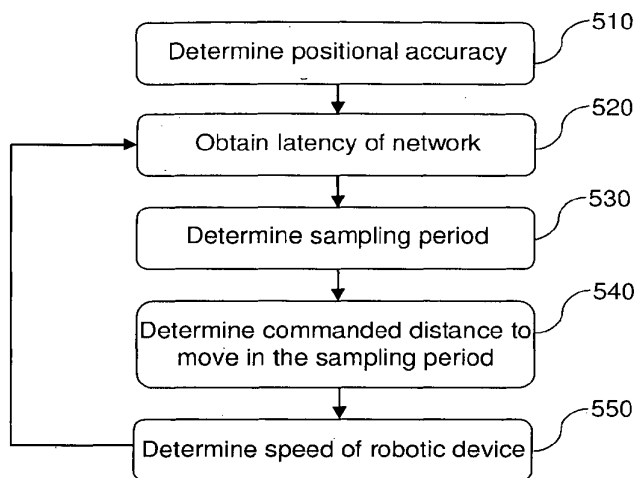


Fig. 5

(57) Abstract: There is provided a method and apparatus for offboard navigation of a robotic device. The method comprising defining a threshold value of a positional accuracy of the robotic device, calculating latency of a network through which the robotic device and a server communicate, the latency of the network being a difference between sending sensor data from the robotic device to the server and receiving processed data corresponding to the 10 sent sensor data by the robotic device from the server, and determining speed of the robotic device based on the threshold value of the positional accuracy of the robotic device and the latency of the network.



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METHOD AND APPARATUS FOR OFFBOARD NAVIGATION OF A ROBOTIC DEVICE**Field of the Invention**

- 5 The present invention relates to offboard navigation of a robotic device, and particularly, relates to adaptive offboard navigation that responds to changes in network conditions.

Background

- 10 Autonomous navigation is a key enabler for the widespread use of robotic devices in the consumer market and industry. These robotic devices move around a place to perform tasks relying on sensors and navigation systems without any human direction.

- However, to achieve such navigation with a satisfactory level of accuracy is costly as it is computationally intensive and demanding in terms of processing load and power required to provide navigation commands in real time. Traditionally, navigation systems are provided on the robotic devices so that the robotics devices are capable of working independently by performing all navigation processing onboard. Thus, there is a trend to use more powerful computers and bigger batteries onboard. However, this approach results in higher costs. Besides the increase in cost, another disadvantage of this approach is the increase in the size of the robotic devices which may make these robotic devices unsuitable for applications where the size is one of the main concerns.

- While existing Autonomous Guided Vehicles (AGVs) used in many industries are simpler, extensive, expensive and inflexible modifications to the building infrastructure are required for these vehicles to work. For example, one type of the AGVs has to follow markers or wires installed in the floor when navigating a place.

- Another approach is to couple the robotic devices to a remote server via a communication link and harness the processing power of the server. The remote server may be, for example, a cloud-computing platform, and the communication link may be a wireless network. Thus, the navigation processing may be performed offboard entirely at the remote server, or be split into a mixture of onboard and offboard processing. As the majority of the computation can be allocated to the remote server or distributed among a group of remote servers equipped with powerful processors, minimum processing can be performed at the robotic devices adopting offboard navigation. Examples of the minimum processing at the robotic devices include transmitting sensor data obtained by the sensors

of the robotic devices to the server and receiving navigation command and/or positional information from the remote sensor.

5 This approach addresses the cost and size issues, but it is subject to actual network conditions as there is always a delay in transmitting and receiving signals between the robotic devices and the remote server which affects the positional accuracy of the robotic devices.

Fig. 1 shows an ideal situation of the offboard navigation in which no latency of the network L exists ($L=0$). A robotic device 100 sends the sensor data obtained by its sensors to a server 110 via a wireless network at successive timings $t_0, t_1, t_2, \dots$. The sensor data is processed by the server 110 which calculates the actual position of the robotic device 100 and then sends this positional information or navigation command such as the distance and the direction to move, to the robotic device 100. Thus, the robotic device 100 is commanded to move based on its actual position and the destination or planned route. In the ideal situation where there is no latency of the network (similar to onboard navigation) the robotic device 100 receives the positional information or navigation command nearly at the same timings $t_0, t_1, t_2, \dots$, assuming that the processing time of the server 110 is insignificant and negligible. Therefore, the navigation command is always given based on the actual current position of the robotic device 100 and thus the positional accuracy of the robotic device 100 is comparable to the onboard navigation. Fig. 3 illustrates the positional accuracy of the robotic device 100 as the maximum difference or error between the actual position 300 and an estimated position 300' of the robotic device 100. For example, if the robotic device 100 makes use of its odometry information to estimate its own position 300' (as shown in Fig. 3) while moving according to the navigation command, the positional accuracy of the robotic device 100 is the odometry error accumulated in a sampling period T , which is the period between two consecutive timings. The odometry error is defined as the difference between the commanded distance to be moved and the actual distance moved by the robotic device 100.

30 However, in reality, the positional accuracy of the robotic device is affected by the latency of the network ($L>0$). As shown in Fig. 2, there is always a difference between the time (for example, $t=t_0$) at which a packet of sensor data is sent from the robotic device 100 to the server 110 and the time (for example, $t=t_3$) at which a packet of the processed data corresponding to the sensor data sent at $t=t_0$ is received by the robotic device 100 from the server 100 and this difference t_3-t_0 is defined as the latency of the network.

Therefore, during the period from t_3 to t_4 , the robotic device 100 moves according to the navigation command received at t_3 which corresponds to the sensor data and the actual position of the robotic device 100 at $t=t_0$, but not the navigation command corresponding to its current position at t_3 . Therefore, the positional accuracy of the robotic device 100 is affected due to the latency of the network.

The latency of the network between the robotic devices and the server is mainly influenced by the amount of sensor data and network bandwidth both of which are susceptible to environmental changes. While the positional error of the robotic devices due to the latency of the network may not be significant in good network conditions where L is low, the accumulation of this error may become intolerable in slow network conditions where L is high, especially if the robotic devices move at a high speed.

Therefore, there is a need to have an offboard navigation method and apparatus which give a certainty in the positional accuracy of the navigation by considering the delay caused by the communication network between the robotic devices and the remote sever.

Summary

In accordance with one aspect of the present invention, there is provided a method for offboard navigation of a robotic device, the method comprising: defining a threshold value of a positional accuracy of the robotic device, calculating latency of a network through which the robotic device and a server communicate, the latency of the network being a difference between sending sensor data from the robotic device to the server and receiving processed data corresponding to the sent sensor data by the robotic device from the server, and determining speed of the robotic device based on the threshold value of the positional accuracy of the robotic device and the latency of the network.

Determining the speed of the robotic device may comprise setting a sampling period in accordance to the latency of the network, the sampling period being a difference between two consecutive sendings of the sensor data from the robotic device to the server and determining a commanded displacement to be moved by the robotic device in the sampling period.

Determining the commanded displacement to be moved by the robotic device in the sampling period may comprise determining a desired displacement to be moved by the

robotic device in the sampling period according to characteristics of odometry error of the robotic device and obtaining a positional error to be offset in the sampling period.

5 The characteristics of the odometry error of the robotic device may be represented by a profile curve of the odometry error of the robotic device calibrated in advance.

The threshold value of the positional accuracy of the robotic device may be determined based on the environment in which the robotic device operates.

10 The speed of the robotic device may be determined to be inversely proportional to the latency of the network.

The method may further comprise driving the robotic device to move at a speed equal to or less than the determined speed.

15 In accordance with another aspect of the present invention, there is provided an apparatus for offboard navigation, the apparatus comprising: a server, and a robotic device configured to move according to navigation command received from the server, the robotic device comprising sensors configured to obtain sensor data, an interface
20 configured to receive a threshold value of a positional accuracy of the robotic device, and a processor configured to calculate latency of a network through which the robotic device and the server communicate, the latency of the network being a difference between sending sensor data from the robotic device to the server and receiving processed data
25 corresponding to the sent sensor data by the robotic device from the server, and to determine speed of the robotic device based on the threshold value of the positional accuracy of the robotic device and the latency of the network.

30 The robotic device may further comprise an odometer configured to estimate the position of the robotic device.

The server may be configured to process the sensor data sent from the robotic device to obtain positional information of the robotic device corresponding to the sent sensor data and send the positional information to the robotic device.

35 The processor may be further configured to set a sampling period in accordance to the latency of the network, the sampling period being a difference between two consecutive sendings of the sensor data from the robotic device to the server and to determine a commanded displacement to be moved by the robotic device in the set sampling period.

The processor may be further configured to determine a desired displacement to be moved by the robotic device in the sampling period according to characteristics of odometry error of the robotic device and obtain a positional error to be offset in the sampling period to determine the commanded displacement to be moved as the desired displacement to be moved offset by the positional error.

The characteristics of the odometry error of the robotic device may be represented by a profile curve of the odometry error of the robotic device calibrated in advance.

The threshold value of the position accuracy of the robotic device may be determined based on the environment in which the robotic device operates.

The speed of the robotic device may be determined to be inversely proportional to the latency of the network.

The robotic device is driven to move at a speed equal to or less than the determined speed.

Brief Description of the Drawings

Embodiments of the method and the apparatus will now be described with reference to the accompanying figures in which:

Fig. 1 shows an ideal situation of offboard navigation where the latency of a network is zero.

Fig. 2 shows a real situation of offboard navigation where the latency of the network exists.

Fig. 3 illustrates a positional accuracy of a robotic device.

Fig. 4 is a schematic diagram of an example of an apparatus of offboard navigation.

Fig. 5 is a flowchart illustrating an example of a method of offboard navigation.

Fig. 6 shows an example of a profile curve of an odometry error of a robotic device used in the exemplary apparatus of offboard navigation.

Fig. 7 shows a simple run-time example illustrating the method of offboard navigation.

Fig. 8 shows values of parameters at different timings according to the run-time example illustrated in Fig. 7.

5

Detailed Description

Fig. 4 illustrates an exemplary apparatus 400 of offboard navigation that responds to changes in network conditions. The apparatus 400 comprises a robotic device 410
10 coupled to a server 430 via a communication link such as a wireless network 440. The server 430 may be any type of device capable of receiving and sending data, and may comprise powerful processors suitable for navigation processing. The server 430 may be a cloud-computing platform so that the processing load is distributed among the cloud. Navigation applications having a user interface may also be installed at the server 430 so
15 that a user is able to configure parameters related to offboard navigation at the server 430 and monitor the entire navigation process.

As illustrated, the robotic device 410 comprises a plurality of sensors 412, a processor 414, an interface 418 and an odometer 420.

20

The plurality of sensors 412 may be any type of sensor capable of obtaining data surrounding the robotic device 410 or data of the environment in which the robotic device 410 operates. The sensor data obtained are then transmitted to the server 430 for navigation processing in order to derive the actual position of the robotic device 410
25 and/or the navigation command to be sent to the robotic device 410.

The processor 414 is used to perform processing required at the robotic device 410 such as interacting with the other components of the robotic device 410 and performing routine functions. For example, it monitors the gathering of the sensor data obtained by the plurality of sensors 412, gives instruction to send sensor data to the server 430 at
30 appropriate timings through the wireless network 440, monitors the positional information of the robotic device 410 and/or the navigation command received and instructs the motors (not shown) of the robotic device 410 to move according to the navigation command. If the server 430 is configured to send only the positional information of the robotic device 410 to the robotic device 410, the processor 414 also performs calculation
35 to derive the navigation command, i.e. commanded distance to be moved. It is assumed

that the server 430 only send the positional information of the robotic device 410 for simplicity in the description below.

5 Besides the above functions, the processor 414 also determines speed of the robotic device 410 with respect to latency of the wireless network 440 to achieve a satisfactory positional accuracy of the robotic device 410.

10 After the robotic device 410 starts to move according to the navigation command, the odometer 420 is used to measure the distance or displacement travelled by the robotic device 410. The navigation command is considered to be completed when the distance indicated in the odometer 420 corresponds to that of the navigation command. As discussed earlier, an odometry error occurs in the process and contributes to the positional error of the robotic device 410.

15 The interface 418 is configured to accept a user input, for example, accepting values of operating parameters used by the robotic device 410 in the navigation that are input by the user.

20 Fig. 5 shows the flowchart of the method of offboard navigation using the exemplary apparatus 400.

The positional accuracy or the maximum positional error A of the robotic device 410 is first defined based on the environment in which the robotic device 410 operates 510. For example, a maximum error of 50 cm may be allowed in an ordinary office corridor before the robotic device 410 crashes against the walls of the corridor, while a maximum error of 10 meters may be allowed in a large open plaza. When the maximum positional error allowed is defined, its value can be input into the robotic device 410 by the user as one of the operating parameters through the interface 418 of the robotic device 410 at the start of the navigation. Alternatively, its value can be loaded into the robotic device 410 through the server 430. The user may input the value at a user interface coupled to the server 430, for example, a user interface of a navigation application installed in the server or accessed by the server via wired communications. Such user interface may also be used for monitoring the performance of the offboard navigation and configuring operating parameters of the robotic device 410.

35

The latency of the wireless network 440 between the robotic device 410 and the server 430, L, is then obtained by the processor 414 of the robotic device 410, 520. The

processor 414 obtains the time stamp at which a packet of the sensor data is sent from the robotic device 410 to the server 430 and the time stamp at which a packet of processed data corresponding to the former sensor data is received by the robotic device 410 from the server 430, and then calculates the difference between these two time stamps as the latency of the network. The latency of the network may be determined immediately before the start of the navigation by the processor 414 which causes test sensor data to be sent to the server 430 and obtains the latency of the network when the robotic device 410 receives processed data of the test sensor data. During navigation, the latency of the network is determined dynamically. It may be defined as the period from sending the sensor data to receiving the positional information corresponding to the sensor data at the robotic device 410. Alternatively, during navigation, the robotic device 410 may be configured to send out a special packet of data independent from the sensor data, and obtain the latency of the network when receiving the response corresponding to this special packet of data from the server 430. To remove random short-term fluctuations in the network 440, a moving average of a number of successive values of the latency of the network can be used.

In accordance to the calculated value L of the latency of the network, a sampling period T is set by the processor 414, 530. The sampling period is defined as a period between two consecutive timings of sending the sensor data from the robotic device 410 and it may be set such that with the latest calculated value L of the latency of the network, the positional information corresponding to the movement of the robotic device 410 in the previous but one sampling period should be received by the robotic device 410 before or at the start of the movement in a particular sampling period. Fig. 7 is referred to for the illustration of the sampling period. As shown in Fig. 7, the exemplary robotic device 410 travels in a straight line. The sensor data from the robotic devices 410 are configured to be sent at successive timings $t_0, t_1, t_2, \dots$, where T_n is the period between two consecutive timings t_{n-1} and t_n . With a known value L of the latency of the network, T_2 is set such that the positional information corresponding to the movement of the robotic device 410 in T_1 is received by the robotic device 410 before or at the start of T_3 (represented by a dotted line arrow 710 in Fig. 7). The positional information corresponding to the movement of the robotic device 410 in T_1 is derived based on the sensor data sent from the robotic device 410 at $t=t_1$ by the server 430 (represented by a solid line arrow 720 in Fig. 7). Therefore, the value T of the sampling period has to be greater than or equal to the latest value L of the latency of the network ($T \geq L$). For example, the sampling period may be set to be the summation of the worst-case value of the latency of the network calculated so far and a pre-defined time buffer.

When the sampling period is set in accordance to the calculated latency of the network, at the time instance $t=t_n$, the robotic device 410 receives the positional information representing its position at $t=t_{n-1}$ and sends the sensor data representing its current position at $t=t_n$.

As the latency of the network is constantly fluctuating during navigation due to the varying network conditions, the sampling period T may also fluctuate during navigation.

The navigation command or the commanded distance to be moved by the robotic device 410 in the set sampling period is then determined with reference to the odometry error of the robotic device 410, 540.

A profile curve of the odometry error of the robotic device 410 is used to determine the desired distance to be moved by the robotic device 410 in the sampling period. This profile curve is calibrated in advance by plotting the odometry error accumulated against the distance moved by the robotic device 410. An example of the profile curve 600 is shown in Fig. 6 where the relationship between the odometry error and the distance moved is non-linear and the odometry error is unbounded over the distance. As shown in the exemplary profile curve 600, a movement of 10 cm of the robotic device 410 causes an error of up to 1cm and a movement of 100 cm causes an error of up to 20cm.

For example, if it is decided that 20cm is the positional accuracy or maximum positional error with respect to a given environment, the positional error allowed in one sampling period T is determined to be 10 cm, which is 20 cm divided by 2 as the odometry error is propagated through two consecutive sampling periods. Based on the calibrated profile curve of the odometry error, the robotic device 410 can only move 50cm before the odometry error exceeds 10cm. Thus, the desired distance to be moved by the robotic device 410 during the sampling period T is determined as 50cm.

As discussed earlier, if the robotic device 410 makes use of its odometry information to estimate its own position while moving according to the navigation command, the odometry error which is the difference between the commanded distance to be moved and the actual distance moved by the robotic device 410 is accumulated in the sampling period. As the sampling period is set such that the sensor data corresponding to the actual position of the robotic device 410 at $t=t_n$ is sent to the server at $t=t_n$ and the actual position of the robotic device 410 at $t=t_n$ is sent back to the robotic device 410 before or at

$t=t_{n+1}$, the odometry error E_{n-1} accumulated in the sampling period T_{n-1} is known by the robotic device 410 at $t=t_{n+1}$. To offset the odometry error E_{n-1} , the commanded distance to be moved determined at $t=t_{n+1}$ is determined to be the desired distance to be moved corrected by the odometry error E_{n-1} . Thus, the odometry error E_{n-1} accumulated in the sampling period T_{n-1} is reset in the sampling period T_{n+1} , i.e. the odometry error is propagated through two consecutive sampling periods.

The speed of the robotic device 410 in the sampling period is derived as the commanded distance divided by the sampling period 550. The process from obtaining the latency of the network 520 to determining the speed of the robotic device 410, 550, continues during navigation.

The profile curve of the odometry error of the robotic device 410 is stored in a memory device (not shown) of the robotic device 410 and is accessed by the processor 414 when determining the desired distance to be moved by the robotic device 410 in the sampling period. The processor 414 determines the commanded distance to be moved based on the desired distance taking into consideration of the odometry error accumulated in the previous but one sampling period, and then calculates the speed of the robotic device 410 at the start of the sampling period.

Therefore, the speed S of the robotic device 410 is derived by the processor 414 in accordance to the defined threshold value A (maximum allowable value) of the positional error of the robotic device 410 and the calculated value L of the latency of the network. In order for the robotic device 410 to have a positional accuracy equal to or less than the threshold value A , the robotic device 410 is driven to travel at a speed equal to or less than the derived speed S .

The speed of the robotic device 410 is determined dynamically during the navigation so that a change in network condition, i.e. a change in the latency of the network will result in an adjustment of the speed of the robotic device 410.

A simple run-time example showing a first few sampling periods of the navigation is described with reference to Fig. 7 and Fig. 8. The exemplary robotic device 410 in Fig. 7 travels in a straight line. The sensor data from the robotic devices 410 are configured to be sent at successive timings $t_0, t_1, t_2, \dots$, where T_n is the period between two consecutive timings t_{n-1} and t_n . In the example, T is set to the latest calculated value of the latency of the network for simplicity in illustration.

The desired distance to be moved by the robotic device 410 in the period T_n is denoted as D_n . The actual position at the time instant $t=t_n$ is denoted as $X(t_n)$ and the starting position at the starting time $t=t_0$ is $X(t_0)=0$.

5

Fig. 8 shows the desired distance and the commanded distance to be moved by the robotic device 410 in the sampling cycle T_n , the actual distance moved in the sampling cycle T_n , the desired position and the actual position of the robotic device 410, and the positional error of the robotic device 410 at different timings $t_0, t_1, t_2 \dots$

10

At $t=t_0$, the robotic device 410 derives the desired distance D_1 to be moved based on the sampling period set according to the latency of the network and the positional accuracy input by a user according to its operating environment. The commanded distance to be moved is the same as the desired distance D_1 as there is no positional information received.

15

At $t=t_1$, the actual distance that has been moved by the robotic device 410 is D_1+E_1 , where E_1 denotes the odometry error accumulated in the sampling period T_1 , i.e. from t_0 to t_1 . Therefore, the actual position of the robotic device 410 at $t=t_1$ is $X(t_1)=D_1+E_1$ and the corresponding positional error is $E(t_1)=E_1$. The robotic device 410 sends the sensor data representing its current position to the server 430 and derives the desired distance D_2 to be moved in the sampling period T_2 , i.e. from t_1 to t_2 . The commanded distance to be moved is D_2 as the robotic device 410 only receives the positional information, corresponding to the sensor data sent at $t=t_0$, at $t=t_1$.

25

The robotic device 410 is commanded to move a distance of D_2 in the sampling period T_2 at $t=t_1$, but the actual distance moved is D_2+E_2 . Thus, at $t=t_2$, the actual position of the robotic device 410 is $X(t_2)=D_1+D_2+E_1+E_2$ and the corresponding positional error is $E(t_2)=E_1+E_2$.

30

At $t=t_2$, the robotic device 410 sends the sensor data representing its current position to the server 430 and receives the positional information corresponding to the sensor data sent at $t=t_1$ (represented by the dotted line arrow 710), which means that the actual position of the robotic device $X(t_1)$ at $t=t_1$ is considered in deriving the commanded distance to be moved from t_2 to t_3 (in the sampling period T_3). To compensate the odometry error E_1 accumulated during the sampling period T_1 , the commanded distance is determined to be D_3-E_1 at $t=t_2$.

35

From t_2 to t_3 , the actual distance moved is $D_3 - E_1 + E_3$. Thus, the actual position of the robotic device 410 at $t=t_3$ is $X(t_3) = D_1 + D_2 + D_3 + E_2 + E_3$, and the corresponding positional accuracy is $E_2 + E_3$.

5

Therefore, at any time t , the positional error of the robotic device 410 is the odometry error of the robotic device 410 accumulated over two consecutive sampling periods which are set in accordance to the calculated L of the latency of the network. If the threshold value A of positional accuracy is known, the value E of the odometry error allowed in one sampling period can be derived. For a known E , at the start of a particular sampling period, the desired distance and the commanded distance are determined with reference to the calibrated profile curve of the odometry error of the robotic device 410 and the odometry error accumulated in the previous but one sampling period. Therefore, the speed S can be derived based on a given A and calculated L .

15

In reality, the robotic device is able to move in any direction, and thus the positional accuracy and the speed of the robotic device may be two dimensional vectors.

The example above illustrates the relationship among the latency of the network L , the average positional accuracy A of the robotic device, and the average speed S of the robotic device. A trade-off exists between the speed of the robotic device and its localization accuracy when navigation processing is performed offboard due to the latency of the network. In addition, the odometry error accumulates with the distance travelled, but can be reset to keep it within a certain boundary.

25

In slow network conditions where the value of L is high, the speed of the robotic devices can be reduced so that the accumulated odometry error is reduced, and the robotic devices will still have an acceptable positional accuracy. Conversely, in good network conditions where the value of L is low, the speed of the robotic devices can be increased as the positional updates are so frequent that the accumulated odometry error can never become significant, and the robotic devices will still have an acceptable positional accuracy. Theoretically, the robotic devices need not ever come to a complete stop even if the network speed is very slow, and still have an acceptable positional accuracy.

Although the description above focuses on achieving an acceptable positional accuracy of the robotic device, these three variables, L , A and S , can be manipulated through the above-mentioned relationship to optimize at least one of these variables. For example,

the speed of the robotic device can be adjusted dynamically based on the latency of the network, given that the positional accuracy of the robotic device is fixed. Alternatively, the latency of the network L may be reduced by sending less sensor data so that the speed of the robotic devices can be increased, if the positional accuracy could be relaxed.

5

Whilst there has been described in the foregoing description embodiments of the present invention, it will be understood by those skilled in the technology concerned that many variations or modifications in details of design or construction may be made without departing from the present invention.

10

Claims

1. A method for offboard navigation of a robotic device, the method comprising:
defining a threshold value of a positional accuracy of the robotic device;
5 calculating latency of a network through which the robotic device and a server
communicate, the latency of the network being a difference between sending sensor data
from the robotic device to the server and receiving processed data corresponding to the
sent sensor data by the robotic device from the server; and
determining speed of the robotic device based on the threshold value of the
10 positional accuracy of the robotic device and the latency of the network.
2. The method according to claim 1, wherein determining the speed of the robotic
device comprises setting a sampling period in accordance to the latency of the network,
the sampling period being a difference between two consecutive sendings of the sensor
15 data from the robotic device to the server.
3. The method according to claim 2, wherein determining the speed of the robotic
device further comprises determining a commanded displacement to be moved by the
robotic device in the sampling period.
20
4. The method according to claim 3, wherein determining the commanded
displacement to be moved by the robotic device in the sampling period comprises
determining a desired displacement to be moved by the robotic device in the sampling
period according to characteristics of odometry error of the robotic device and obtaining a
25 positional error to be offset in the sampling period.
5. The method according to claim 4, wherein the characteristics of the odometry error
of the robotic device is represented by a profile curve of the odometry error of the robotic
device calibrated in advance.
30
6. The method according to any one of the preceding claims, wherein the threshold
value of the positional accuracy of the robotic device is determined based on the
environment in which the robotic device operates.
- 35 7. The method according to any one of the preceding claims, wherein the speed of
the robotic device is determined to be inversely proportional to the latency of the network.

8. The method according to any one of the preceding claims, further comprising driving the robotic device to move at a speed equal to or less than the determined speed.
9. An apparatus for offboard navigation, the apparatus comprising:
- 5 a server; and
- a robotic device configured to move according to navigation command received from the server,
- the robotic device comprising
- sensors configured to obtain sensor data;
- 10 an interface configured to receive a threshold value of a positional accuracy of the robotic device; and
- a processor configured to
- calculate latency of a network through which the robotic device and the server communicate, the latency of the network being a difference a
- 15 difference between sending sensor data from the robotic device to the server and receiving processed data corresponding to the sent sensor data by the robotic device from the server, and
- determine speed of the robotic device based on the threshold value of the positional accuracy of the robotic device and the latency of the
- 20 network.
10. The apparatus according to claim 9, wherein the robotic device further comprises an odometer configured to estimate the position of the robotic device.
- 25 11. The apparatus according to claim 9 or 10, wherein the server is configured to process the sensor data sent from the robotic device to obtain positional information of the robotic device corresponding to the sent sensor data and send the positional information to the robotic device.
- 30 12. The apparatus according to any one of claims 9 to 11, wherein the processor is further configured to
- set a sampling period in accordance to the latency of the network, the sampling period being a difference between two consecutive sendings of the sensor data from the robotic device to the server; and
- 35 determine a commanded displacement to be moved by the robotic device in the set sampling period.

13. The apparatus according to claim 12, wherein the processor is further configured to determine a desired displacement to be moved by the robotic device in the sampling period according to characteristics of odometry error of the robotic device and obtain a positional error to be offset in the sampling period to determine the commanded displacement to be moved as the desired displacement to be moved offset by the positional error.
14. The apparatus according to claim 13, wherein the characteristics of the odometry error of the robotic device is represented by a profile curve of the odometry error of the robotic device calibrated in advance.
15. The apparatus according to any one of claims 9 to 14, wherein the threshold value of the position accuracy of the robotic device is determined based on the environment in which the robotic device operates.
16. The apparatus according to any one of claims 9 to 15, wherein the speed of the robotic device is determined to be inversely proportional to the latency of the network.
17. The apparatus according to any one of claims 9 to 15, wherein the robotic device is driven to move at a speed equal to or less than the determined speed.

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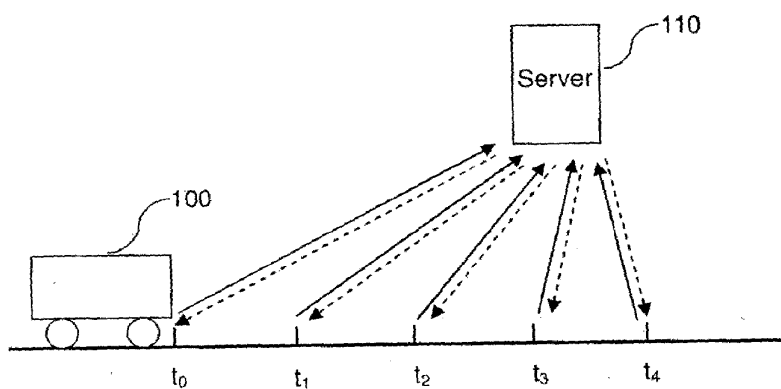


Fig. 1

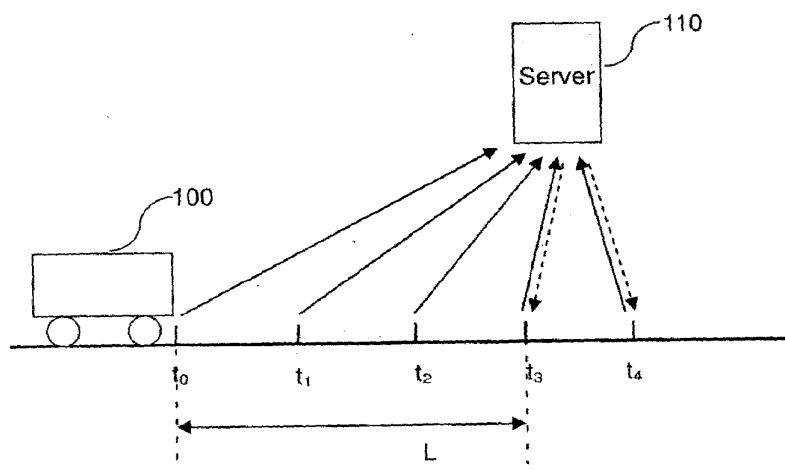


Fig 2

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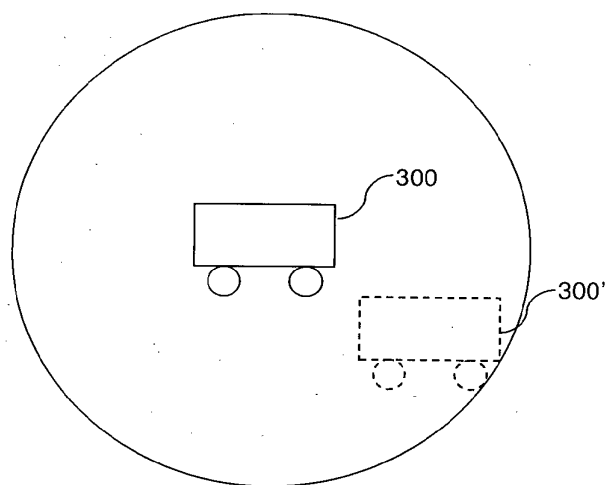


Fig. 3

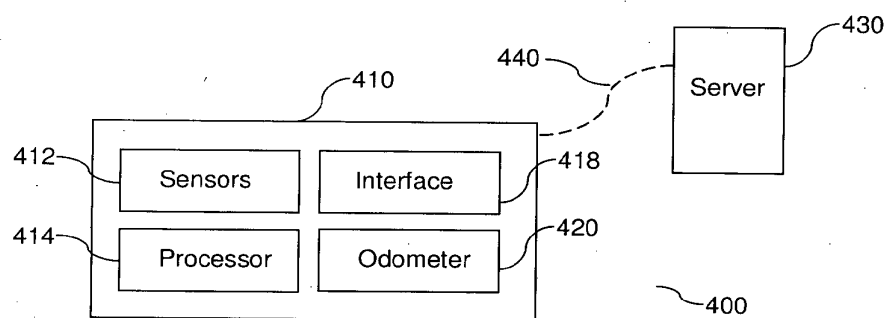


Fig. 4

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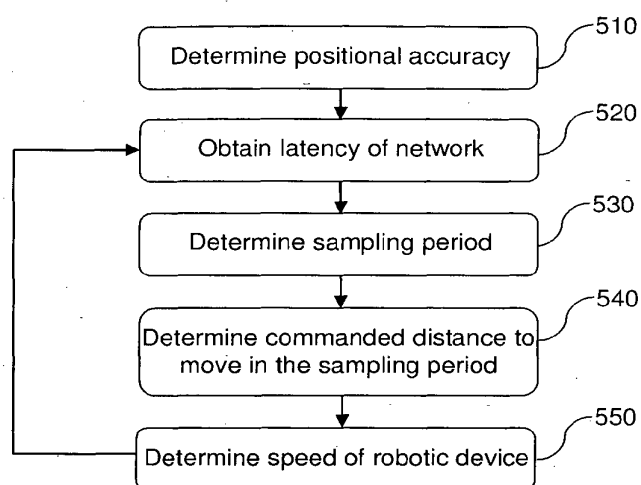


Fig. 5

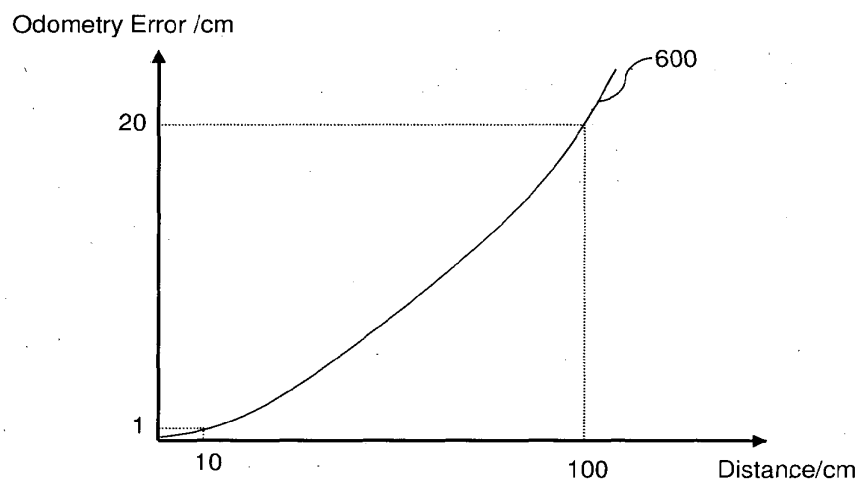


Fig. 6

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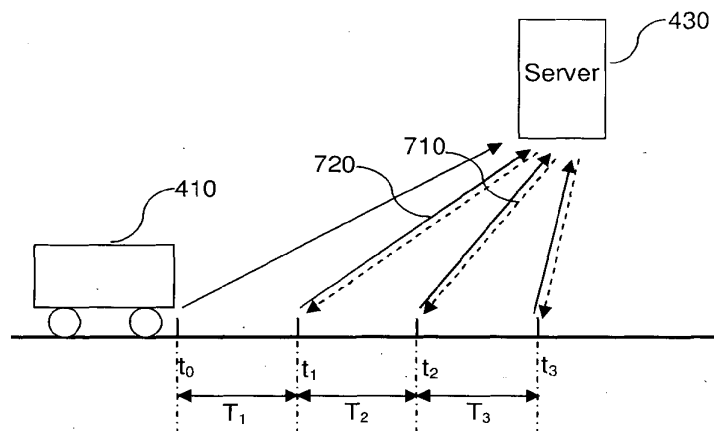


Fig. 7

t	Desired Distance	Commanded Distance to Move from t_n to t_{n+1}	Actual Distance Moved from t_{n-1} to t_n	Desired Position	Actual Position	Positional Error
t_0	D_1	D_1	-	0	0	0
t_1	D_2	D_2	$D_1 + E_1$	D_1	$D_1 + E_1$	E_1
t_2	D_3	$D_3 - E_1$	$D_2 + E_2$	$D_1 + D_2$	$D_1 + D_2 + E_1 + E_2$	$E_1 + E_2$
t_3	D_4	$D_4 - E_2$	$D_3 - E_1 + E_3$	$D_1 + D_2 + D_3$	$D_1 + D_2 + D_3 + E_2 + E_3$	$E_2 + E_3$

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG2013/000262

A. CLASSIFICATION OF SUBJECT MATTER

G01C 21/00 (2006.01) G01S 19/00 (2010.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

GOOGLE PATENTS: offboard navigation robot threshold latency speed

GOOGLE SCHOLAR : robotic device positional accuracy latency threshold delay

GOOGLE: robotic device positional accuracy latency threshold delay

EPOQUE:

TXTE: off-board, navigation, robot, threshold, position, accuracy, error, latency, delay, speed, network and similar terms.

INSPEC: off-board, navigation, robot, position, accuracy, threshold, network, latency, delay and similar terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	



Further documents are listed in the continuation of Box C



See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"P"	document published prior to the international filing date but later than the priority date claimed		

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Date of mailing of the international search report
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Name and mailing address of the ISA/AU

AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
Email address: pct@ipaustalia.gov.au
Facsimile No.: +61 2 6283 7999

Authorised officer

Juzer Khanbhai
AUSTRALIAN PATENT OFFICE
(ISO 9001 Quality Certified Service)
Telephone No. 0262832176

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/SG2013/000262
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GLOYE, A et al.: "Predicting away robot control latency", Technical Report B-08-03 [retrieved on 09 August 2013]. Retrieved from Internet <URL: http://web.archive.org/web/20070824191108/http://page.mi.fu-berlin.de/rojas/2003/B-08-03.pdf > published on 24 August 2007 as per Wayback Engine Whole document	1-17

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B62D 6/00 (2006.01) *G05B 13/00* (2006.01)
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- (71) Applicant: CTRLWORKS PTE. LTD. [SG/SG]; Unit 113C, Block 2, Innovation Centre, 18 Nanyang Drive, Singapore 637723 (SG).
- (72) Inventors: SIM, Kai; Blk 4, Toh Yi Drive, #07-203, Singapore 590004 (SG). MYAT, Zaw Hein; Blk 273B, Jurong West Ave 3, #13-27, Singapore 642273 (SG).
- (74) Agent: LEE, Ai Ming; c/o RODYK & DAVIDSON LLP, 80 Raffles Place #33-00 UOB Plaza 1, Singapore 048624 (SG).

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Declarations under Rule 4.17:

- as to the identity of the inventor (Rule 4.17(i))
— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

[Continued on next page]

- (54) Title: OFFBOARD NAVIGATION APPARATUS CAPABLE OF BEING COUPLED TO A MOVABLE PLATFORM

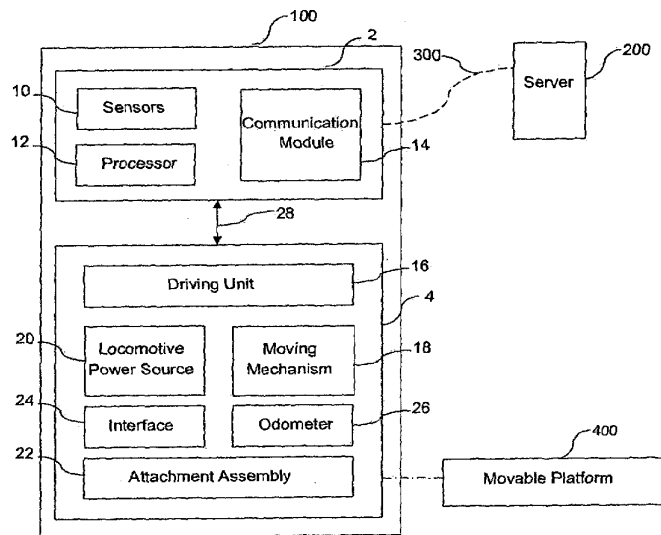


Fig. 1

(57) Abstract: An offboard navigation apparatus capable of being coupled to a movable platform used for the transportation and delivery of a load is provided, the offboard navigation apparatus comprising: a base unit configured to be capable of being attached to the movable platform and providing locomotive power to the movable platform; and a navigation unit configured to drive the base unit to navigate the movable platform, the navigation unit comprising: sensors configured to obtain sensor data; and a communication unit configured to transmit sensor data to a server and receive navigation information of the offboard navigation apparatus from the server.



— *of inventorship (Rule 4.17(iv))*

Published:

— *with international search report (Art. 21(3))*

Offboard Navigation Apparatus Capable of being Coupled to a Movable Platform

Field of the Invention

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The present invention relates to an offboard navigation apparatus capable of being coupled to a movable platform used for the transportation and delivery of a load, and particularly, relates to an offboard navigation apparatus that provides locomotive power to the movable platform to make the movable platform capable of self-navigation when being attached to the offboard navigation apparatus.

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Background

With the technology of autonomous navigation, robotic devices are widely used in the consumer market and industry. These robotic devices move around a place relying on sensors and navigation systems without any human intervention whilst it is on the move. One example of such robotic devices is the Autonomous Guided Vehicles (AGVs) used to transport articles or objects around in a premises. However, the AGVs are inflexible to re-planning as extensive, expensive and inflexible modifications to the infrastructure are required for these vehicles to work. For example, one type of the AGVs has to follow markers or wires installed in the floor when navigating a place. The AGVs are usually huge platforms built for designated purposes. Thus, their size and fixed footprint prevent them from providing services in smaller or confined areas.

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As a result, manpower is still largely employed to transport objects from one place to another in a number of industries, such as logistics, material-handling, medical, and manufacturing industries, when it is impossible or uneconomical to use the AGVs and other existing robotic devices. For example, in the hospitals, nurses or orderlies have to use trolleys to transport medical instruments and medicines to and from the wards.

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Smaller AGVs or mobile robotic devices are devised to reduce manpower needed in these circumstances. However, the size of these devices still remains quite

significant as the navigation processing is performed onboard, i.e. on the moving devices themselves, and these devices must be equipped with powerful computing facilities to provide navigation commands in real time. In addition, these devices are mainly designed for carrying the load themselves, and they are not
5 designed to work with existing general movable platforms used for transportation, such as push-carts, trolleys, wheelchairs and the like.

Therefore, it is desirable to have a navigation apparatus that is capable being attached to the existing general movable platforms used for transportation to
10 provide locomotive power to make the movable platform capable of self-navigation.

Summary

In accordance with one aspect of the present invention, there is provided an
15 offboard navigation apparatus capable of being coupled to a movable platform used for the transportation and delivery of a load, comprising: a base unit configured to be capable of being attached to the movable platform and providing locomotive power to the movable platform; and a navigation unit configured to drive the base unit to navigate the movable platform, the navigation unit
20 comprising: sensors configured to obtain sensor data; and a communication unit configured to transmit sensor data to a server and receive navigation information of the offboard navigation apparatus from the server.

The base unit may comprise an attachment assembly configured to attach the
25 offboard navigation apparatus to the moveable platform; the navigation unit may further comprise a processor to process the navigation information of the offboard navigation apparatus to provide a navigation instruction; the communication unit may be further configured to receive a navigation instruction from the server.

30 The navigation unit may be coupled directly to a driving system of the movable platform to navigate the movable platform when the movable platform itself is a self-powered platform.

The base unit may further comprise a power source; a moving mechanism configured to make the offboard navigation apparatus movable; and a driving unit driven by power supplied from the power source and configured to drive the moving mechanism.

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The driving unit may be configured to receive a navigation instruction from the navigation unit and drives the moving mechanism according to the navigation instruction.

10 The moving mechanism may be a number of wheels; the moving mechanism may be continuous tracks.

The power source may be a battery; the power source may be a combustion engine.

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The navigation unit may further comprise a processor configured to calculate a latency of a network through which the offboard navigation apparatus and the server communicate, the latency of the network being a difference between sending sensor data from the offboard navigation apparatus to the server and
20 receiving processed data corresponding to the sent sensor data by the offboard navigation apparatus from the server, and determine the speed of the offboard navigation apparatus based on a threshold value of a positional accuracy of the offboard navigation apparatus and the latency of the network.

25 The offboard navigation apparatus may further comprise an interface configured to receive the threshold value of the positional accuracy of the offboard navigation apparatus from a user.

The offboard navigation apparatus may further comprise an odometer configured
30 to estimate the position of the offboard navigation apparatus.

The speed of the offboard navigation apparatus may be determined to be inversely proportional to the latency of the network.

Brief Description of the Drawings

Embodiments of the offboard navigation apparatus will now be described with reference to the accompanying figures in which:

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Fig. 1 shows a schematic diagram of an offboard navigation apparatus according to an embodiment of the present invention, a server with which the offboard navigation apparatus communicates, and a movable platform to which the offboard navigation apparatus is attached.

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Fig. 2 is a perspective view of an example of the offboard navigation apparatus.

Fig. 3 is a perspective view of the offboard navigation apparatus of Fig. 2 and an example of the movable platform when the offboard navigation apparatus is not
15 attached to the movable platform.

Fig. 4 is a perspective view of the offboard navigation apparatus and the movable platform of Fig. 3 when the offboard navigation apparatus is attached to the
20 movable platform.

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Fig. 5 illustrates how the offboard navigation apparatus of Fig. 3 is attached to the movable platform of Fig. 3.

Detailed Description

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Fig. 1 illustrates a schematic diagram of an exemplary offboard navigation apparatus 100 working with a server 200 to navigate a movable platform 400 mainly used for the transportation and delivery of a load. The offboard navigation apparatus 100 is capable of being coupled to the movable platform 400 to drive
30 the movable platform. The offboard navigation apparatus 100 also communicates with the remote server 200 via a communication link such as a wireless network 300 (for example, WiFi, 3G, 4G, etc.) to harness the processing power of the server 200 to perform navigation processing.

The server 200 may be any type of device capable of receiving and sending data, and may comprise powerful processors suitable for navigation processing. The server 200 may be a cloud-computing platform so that the processing load is distributed among the cloud. Navigation applications having a user interface may
5 also be installed at the server 200 so that a user is able to configure parameters related to offboard navigation at the server 200 and monitor the entire navigation process.

The movable platforms 400 may be push-carts, trolleys and wheelchairs which are
10 being pushed or pulled by human. However, they are not limited to wheeled vehicles including vehicles on spherical wheels (i.e. ball-based vehicles), and they may be any platform that can be pushed or pulled from one place to another, such as platforms having sliders on the bottom surface. The movable platforms may be powered platforms, i.e. movable platforms equipped with a power source, such as
15 electric wheelchairs.

A navigation unit 2 and a base unit 4 which are electrically connected with each other by wiring 28 are included in the offboard navigation apparatus 100.

20 The navigation unit 2 configured to drive the base unit 4 comprises a plurality of sensors 10, a processor 12 and a communication module 14.

The plurality of sensors 10 may be any type of sensor capable of obtaining data surrounding the offboard navigation apparatus 100 or data of the environment in
25 which the offboard navigation apparatus 100 operates. Cameras, LIDARS or inertial measurement units or a combination of aforementioned devices may be used as the plurality of sensors 10. The sensor data obtained are then transmitted to the server 200 through the communication module 14 for navigation processing in order to derive the actual position of the offboard navigation apparatus 100.

30 The processor 12 is used to perform processing required at the navigation unit 2. As the majority of the navigation computation is allocated to the server 200 equipped with powerful processors, minimum processing, such as interacting with the other components of the navigation unit 2 and performing routine functions, is

performed by the processor 12. For example, it monitors the gathering of the sensor data obtained by the plurality of sensors 10, pre-processes the sensor data before transmitting it to the server 200, gives instruction to send sensor data to the server 200 at appropriate timings through the wireless network 300, monitors the
5 positional information or navigation information of the offboard navigation apparatus 100 received through the communication module 14 from the server 200 and provides a navigation instruction signal to the base unit 4 based on the positional information received. It may be possible for the server 200 to send the navigation instruction instead of the positional information of the offboard
10 navigation apparatus 100 to the navigation unit 2. In such cases, the processing of the positional information to provide the navigation instruction is not performed by the processor 12.

Various existing offboard navigation methodologies can be used in the offboard
15 navigation apparatus 100. The method described in the Singapore Patent Application No. 201304289-0 which provides adaptive offboard navigation that responds to changes in network conditions may be employed in the offboard navigation apparatus 100. In such cases, the processor 12 also determines the speed of the offboard navigation apparatus 100 with respect to a latency of the
20 wireless network 300 to achieve a satisfactory positional accuracy of the offboard navigation apparatus 100. To maintain a specific level of positional accuracy, the speed of the offboard navigation apparatus 100 is determined to be inversely proportional to the latency of the network 300.

25 The communication module 14 transmits the sensor data from the navigation unit 2 to the server 200 and receives the processed data for navigation from the server 200.

The base unit 4 is capable of being attached to the movable platform 400 and
30 provides locomotive power to the movable platform 400 by either pushing or pulling the movable platform 400. It comprises a driving unit 16, a moving mechanism 18, a locomotive power source 20 and an attachment assembly 22.

The base unit 4 is removably mounted to the movable platform 400 via the attachment assembly 22. A variety of mechanical means such as clamps or inserts can be used as the attachment assembly 22. The offboard navigation apparatus 100 becomes a bolt-on component of the movable platform 400 when it is rigidly
5 attached to the movable platform 400 via the attachment assembly 22, and thus makes the movable platform 400 capable of self-navigation.

The driving unit 16 of the base unit 4 receives the navigation instruction signal from the processor 12 of the navigation unit 2 through the wiring 28 and drives the
10 moving mechanism 18 according to the navigation instruction signal to move the base unit 4 (i.e. the offboard navigation apparatus 100) in a specific direction with a specific speed. The driving unit 16 is powered by the locomotive power source 20.

15 Any kind of portable power source may be used as the locomotive power source 20 to supply driving forces to the driving unit 16. For example, a battery or a relatively small combustion engine may be used. If a battery is used as the locomotive power source 20, the battery also provides power to the various electrical and/or electronic components of the offboard navigation apparatus 100.
20 If another kind of power source is used as the locomotive power source 20, a separate battery has to be provided to supply power to the various components of the offboard navigation apparatus 100.

The moving mechanism 18 may be a number of wheels. Continuous tracks, a belt
25 capable of providing motive traction, may also be used to replace the wheels as the moving mechanism 18 so that the offboard navigation apparatus 100 is suitable to move on uneven surfaces. In such cases, if the movable platform 400 to which the offboard navigation apparatus 100 is attached is also equipped with continuous tracks, the movable platform 400 is able to navigate smoothly on the
30 uneven surfaces as the tracks glide over bumps, small obstacles and trenches on the surfaces.

When the method of the Singapore Patent Application No. 201304289-0 is employed in the offboard navigation apparatus 100, an interface 24 configured to

accept a positional accuracy of the offboard navigation apparatus 100 that is input by the user and an odometer 26 used to estimate the distance or displacement travelled the offboard navigation apparatus 100 are provided. As illustrated in Fig. 1, these two components are provided in the base unit 4. It is also possible to
5 provide these two components in the navigation unit 2. Other than the conventional odometry methods for wheeled and tracked vehicles, the visual odometry method in which the distance travelled is estimated by using sequential camera images can also be used in the offboard navigation apparatus 100. At least one camera is provided in the offboard navigation apparatus 100 when visual
10 odometry method is desired.

The base unit 4 may also be provided with additional sensors as anti-collision measures to enhance safety. When the offboard navigation apparatus 100 attached to the movable platform 400 is in operation, i.e. moving according to the
15 navigation information, if an obstacle such as a person or a large object is detected by these sensors within a predefined safety distance from the base unit 4, the offboard navigation apparatus 100 may be brought to a stop for a certain period. The movement of the offboard navigation apparatus 100 is then resumed when the obstacle is no longer present within the safety distance.

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The offboard navigation apparatus 100 as shown in Fig. 1 makes the movable platform 400 capable of self-navigation when it is attached to the movable platform 400 via the attachment assembly 22. During self-navigation of the movable platform 400 in which the offboard navigation apparatus 100 become the bolt-on
25 component, the plurality of the sensors 10 of the navigation unit 2 obtains sensor data concerning the environs of the movable platform 400. The processor 12 then pre-processes the sensor data obtained and send it to the server 200 through the communication module 14. Based on the sensor data received, the server 200 performs navigation processing to calculate the positional information of the
30 offboard navigation apparatus 100 (which would be the same as the positional information of the movable platform 400) and send it back to the navigation unit 2. After receiving the positional information of the movable platform 400, the processor 12 derives the navigation instruction based on the positional information and sends a signal to the driving unit 16 of the base unit 4. The driving unit 16

powered by the locomotive power source 20 drives the moving mechanism 18 to move the offboard navigation apparatus 100 according to the navigation instruction so that the movable platform 400 is pushed or pulled to and from designated locations without any human direction and manpower.

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If the offboard navigation apparatus 100 is powered by a battery, that is, the locomotive power source 20 is a battery, the offboard navigation apparatus 100 may be configured to work with a docking station. When the battery is running low, the offboard navigation apparatus 100 may be automatically navigated to the docking station by the navigation unit 2 to charge the battery. It may also be configured to leave the docking station when the battery is fully charged so that the docking station is available to other similar offboard navigation apparatuses in the premises.

15 When the movable platform 400 is a self-powered platform, the navigation unit 2 may be coupled directly to the drive system of the movable platform 400 by sending the navigation instruction to the drive system to navigate the movable platform 400.

20 An example of the offboard navigation apparatus 100 is shown in Fig. 2, and Fig. 3 and Fig. 4 illustrate the exemplary offboard navigation apparatus 100 before and after being attached to an example of the movable platform 400 respectively. For simplicity, a trolley is presented as the example of the movable platform 400.

25 The exemplary offboard navigation apparatus 100 comprises the navigation unit 2 (a mast unit) and the base unit 4 connected by a post 3 which covers the wiring 28 between the navigation unit 2 and the base unit 4. The base unit 4 is in contact with the ground and the navigation unit 2 is arranged on top of the post 3. In such arrangement, the plurality of sensors 10 of the navigation unit 2 is not blocked by the movable platform 400 when the offboard navigation apparatus 100 is attached to the movable platform 400. Thus, the sensor data obtained is not affected by the different movable platforms 400 used. The navigation unit 2 may be disposed at other positions so long as consistent sensor data can be obtained. The processor 12 is covered in the casing of the navigation unit 2.

The driving unit 16 and the locomotive power source 20 are enclosed in the casing of the base unit 4. Two wheels are shown as the moving mechanism 18 driven by the driving unit 16.

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The attachment assembly 22 is provided on the front surface of the base unit 4 facing the movable platform 400. It is attached to the movable platform 400 through an adapter 410. The adapter 410 may not be part of the offboard navigation apparatus 100. As illustrated in Fig. 5, the attachment assembly 22 has a plate-like structure to be fastened to a corresponding connecting part of the adapter 410 with bolts and nuts. The adapter 410 grips the metal columns of the trolley 400 with bolts and nuts as well. The adapter 410 may be designed with a different mechanism for attachment to another kind of movable platform 400, providing flexibility in mounting the offboard navigation apparatus 100 to various kinds of movable platform 400 without any modification of the attachment assembly 22.

The offboard navigation apparatus 100 shown in Figs. 2 to 5 and described above is only a workable example, and various modifications can be made. For example, the adapter 410 may not be necessary and the attachment assembly 22 is attached directly to the movable platform 400. Further, a variety of mechanical means such as clamps or inserts can be used as the attachment assembly 22.

As described above, offboard navigation is employed in the offboard navigation apparatus 100 such that the majority of the processing is performed by the server 200. Therefore, the navigation unit 2 and base unit 4 can be kept relatively small and inexpensive without the requirement of powerful computational facilities in the offboard navigation apparatus 100. Further, no infrastructure modifications are required as the navigation unit 2 uses the plurality of sensors 10 to locate the offboard navigation apparatus 100 using existing features of a place.

In addition, the offboard navigation apparatus 100 is capable of being attached to any movable platforms, even small ones like ordinary trolleys, and thus provides a degree of flexibility hardly achieved by the AGVs or other existing mobile robotic

devices. It is a modular add-on autonomous kit that can be attached to any ordinary movable platform to transform it into an intelligent self-navigating platform, and the user is offered with the flexibility to decide which movable platform he or she would like to automate by simply attaching the offboard navigation apparatus
5 100 to the selected movable platform. The user is also offered with the flexibility to revert back to manual push/pull by simply removing the offboard navigation apparatus 100 from the selected movable platform.

Whilst there has been described in the foregoing description embodiments of the
10 present invention, it will be understood by those skilled in the technology concerned that many variations or modifications in details of design or construction may be made without departing from the present invention.

Claims

1. An offboard navigation apparatus capable of being coupled to a movable platform used for the transportation and delivery of a load, comprising:
 - 5 a base unit configured to be capable of being attached to the movable platform and providing locomotive power to the movable platform; and
 - a navigation unit configured to drive the base unit to navigate the movable platform,
 - the navigation unit comprising:
 - 10 sensors configured to obtain sensor data; and
 - a communication unit configured to transmit sensor data to a server and receive navigation information of the offboard navigation apparatus from the server.
- 15 2. The offboard navigation apparatus according to claim 1, wherein the base unit comprises an attachment assembly configured to attach the offboard navigation apparatus to the moveable platform.
- 20 3. The offboard navigation apparatus according to claim 1 or 2, wherein the navigation unit further comprises a processor to process the navigation information of the offboard navigation apparatus to provide a navigation instruction.
- 25 4. The offboard navigation apparatus according to claim 1 or 2, wherein the communication unit is further configured to receive a navigation instruction from the server.
- 30 5. The offboard navigation apparatus according to any one of claims 1 to 4, wherein the navigation unit is coupled directly to a drive system of the movable platform to navigate the movable platform when the movable platform is a self-powered platform.
6. The offboard navigation apparatus according to any one of claims 1 to 4, wherein the base unit further comprises
 - a power source;

a moving mechanism configured to make the offboard navigation apparatus movable; and

a driving unit driven by power supplied from the power source and configured to drive the moving mechanism.

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7. The offboard navigation apparatus according to claim 6, wherein the driving unit is configured to receive a navigation instruction from the navigation unit and drives the moving mechanism according to the navigation instruction.

10 8. The offboard navigation apparatus according to claim 6 or 7, wherein the moving mechanism is a number of wheels.

9. The offboard navigation apparatus according to claim 6 or 7, wherein the moving mechanism is continuous tracks.

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10. The offboard navigation apparatus according to any one of claims 6 to 9, wherein the power source is a battery.

11. The offboard navigation apparatus according to any one of claims 6 to 9,
20 wherein the power source is a combustion engine.

12. The offboard navigation apparatus according to any of claims 1 to 11, wherein the navigation unit further comprises a processor configured to

25 calculate a latency of a network through which the offboard navigation apparatus and the server communicate, the latency of the network being a difference between sending sensor data from the offboard navigation apparatus to the server and receiving processed data corresponding to the sent sensor data by the offboard navigation apparatus from the server, and

30 determine the speed of the offboard navigation apparatus based on a threshold value of a positional accuracy of the offboard navigation apparatus and the latency of the network.

13. The offboard navigation apparatus according to claim 12, further comprises an interface configured to receive the threshold value of the positional accuracy of the offboard navigation apparatus from a user.

5 14. The offboard navigation apparatus according to claim 12 or 13, further comprises an odometer configured to estimate the position of the offboard navigation apparatus.

10 15. The offboard navigation apparatus according to any one of claims 12 to 14, wherein the speed of the offboard navigation apparatus is determined to be inversely proportional to the latency of the network.

15

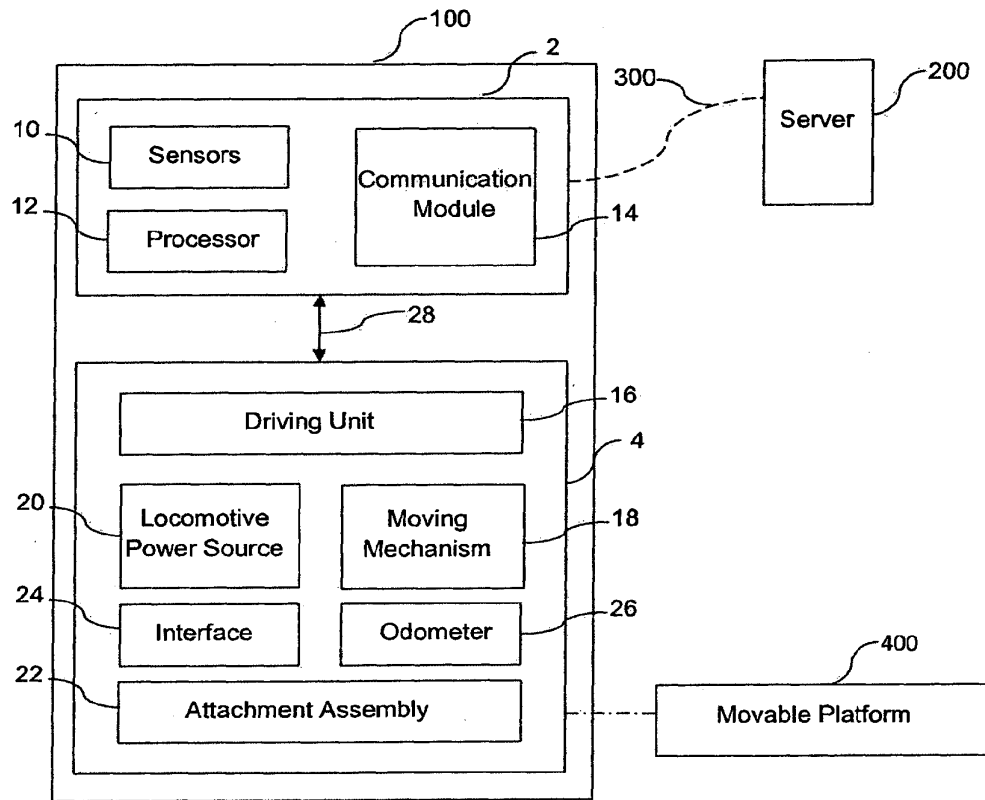


Fig. 1

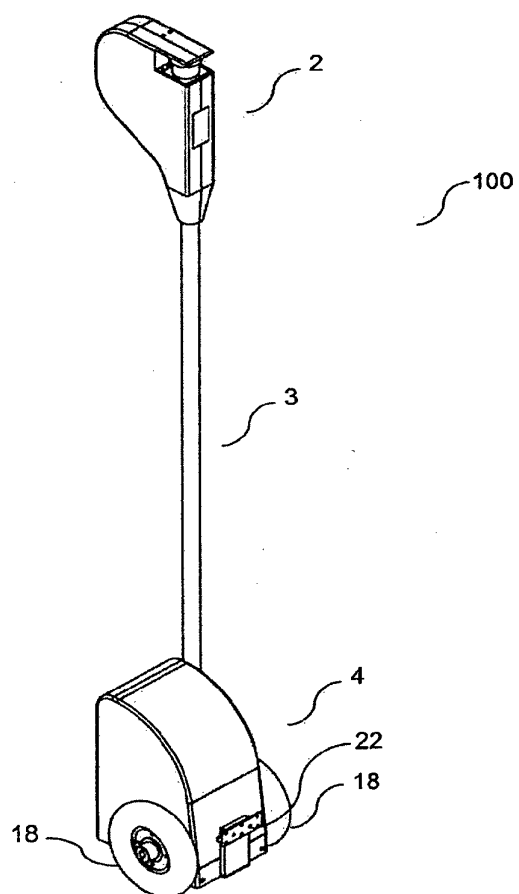


Fig. 2

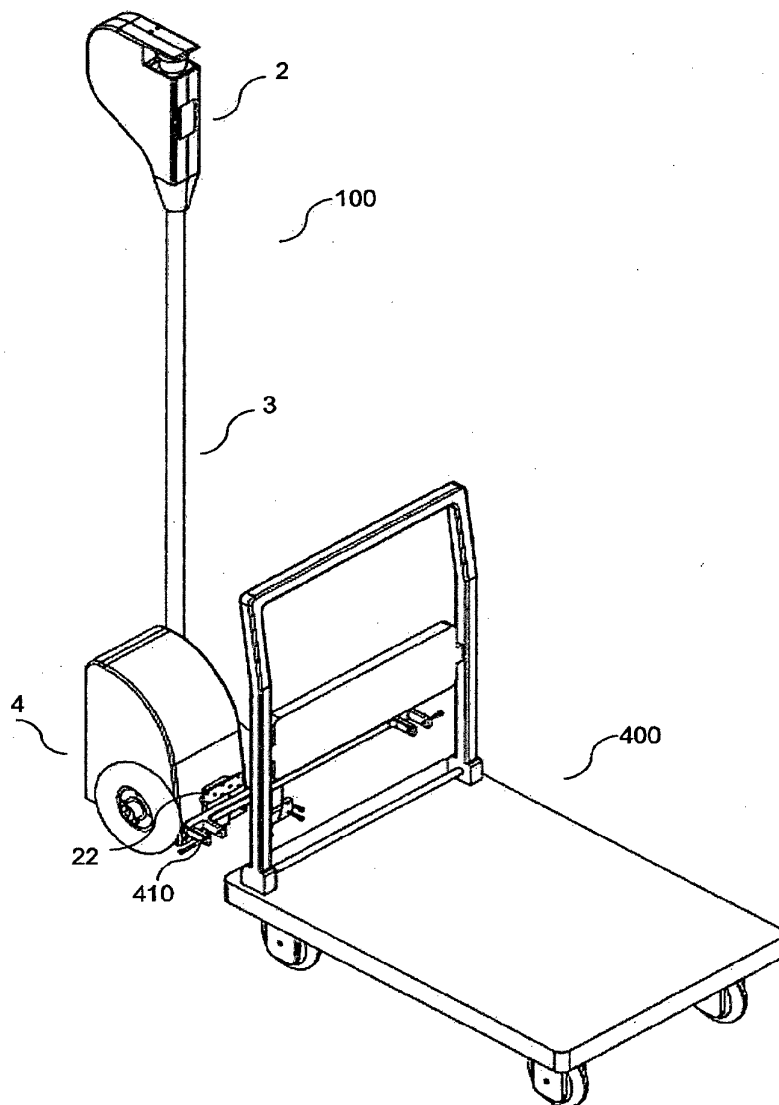


Fig. 3

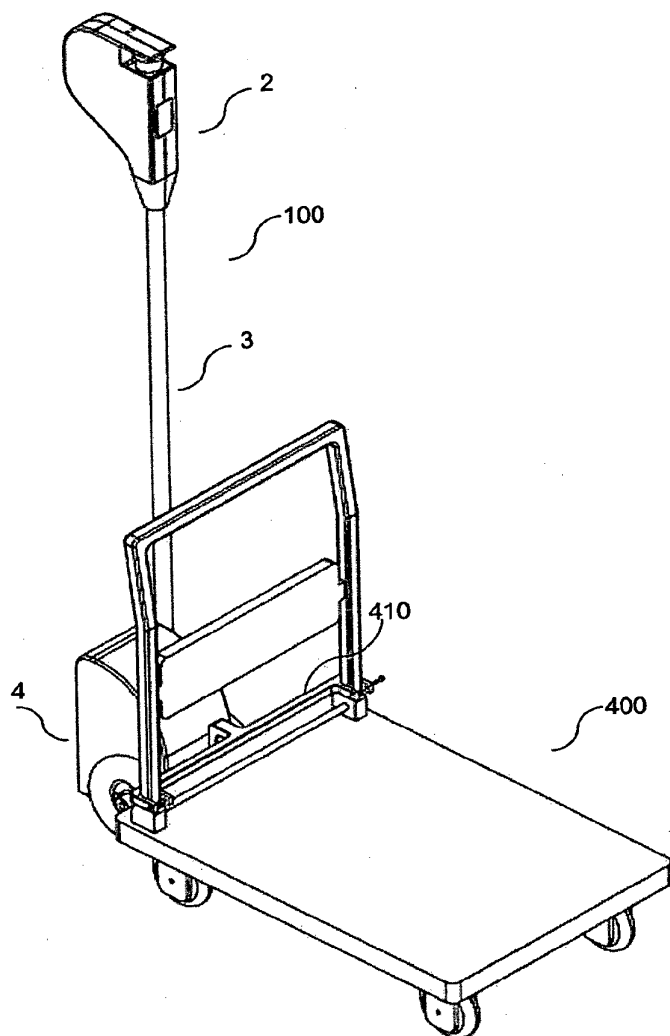


Fig. 4

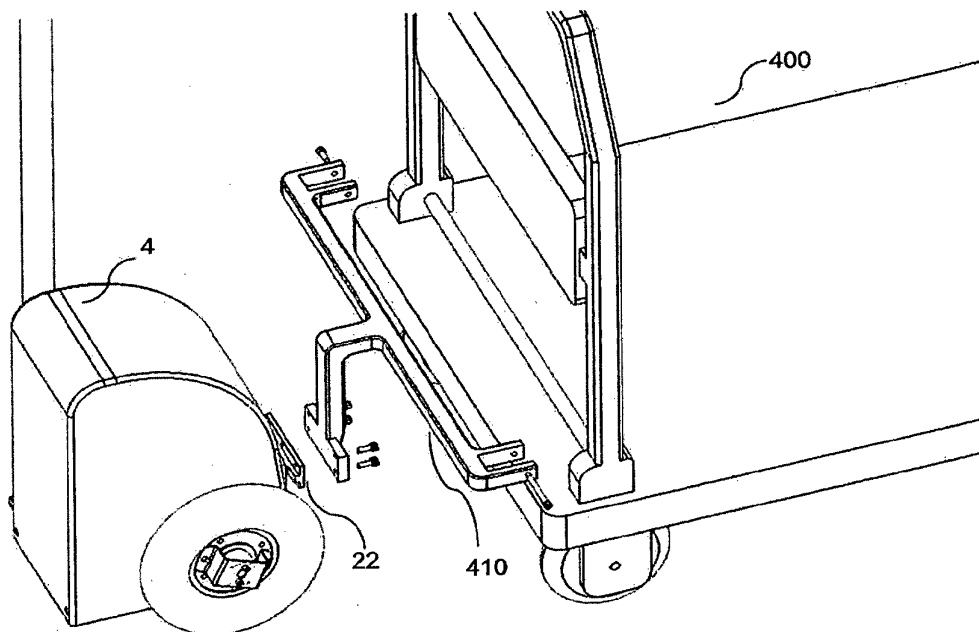


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG2014/000454

A. CLASSIFICATION OF SUBJECT MATTER

G05D 1/02 (2006.01) B62D 1/02 (2006.01) B62D 6/00 (2006.01) B62D 3/00 (2006.01) G05B 11/00 (2006.01)
G05B 13/00 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Databases: EPDOC, WPI. Searched with CPC marks G05D2201/0216, G05D2201/0206, G05D2201/0208, G05D2201/0211, B62B5/0069, G05D1/021, B66F9/063, B62B3/0612 and keywords such as autonomous guided vehicle, automatic, AGVs, trolley, cart, wheelchair, platform, tray, navigate, control, guide, detach, attach, offboard, external, sensor, detect, server, computer, position, speed, path, transport, lift, deliver, remote, antenna, radio, wifi, network and like terms. Broader IPC/CPC mark searches were also conducted by using G05D1/00, G05D3/00, G05D2201/02, G05B11/00, G05B13/00, B62D1/02, B62D3/00, A61G62/00, A01G5/04, B66F9/06, B62B3/00 (including the subclass/lower marks of each of the above IPC/CPC marks) with similar keywords as above. Search results were also crossed to English Full Text databases (TXTE) for further search with keywords as above.

Databases-Espacenet (Worldwide) and AusPat: Applicant/Inventor name search. Database-Google Patent: keywords: autonomous guided vehicle with detachable navigation unit, and like terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	Documents are listed in the continuation of Box C	



Further documents are listed in the continuation of Box C



See patent family annex

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E"	earlier application or patent but published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means	"&"	document member of the same patent family
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
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Name and mailing address of the ISA/AU

AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
Email address: pct@ipaustralia.gov.au

Authorised officer

Aisha Qi
AUSTRALIAN PATENT OFFICE
(ISO 9001 Quality Certified Service)
Telephone No. 0262832951

INTERNATIONAL SEARCH REPORT		International application No.
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		PCT/SG2014/000454
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/0093900 A1 (REEVES et al.) 09 April 2009 Figs 1-3, page 1 para [0012] — page 3 para [0026]	1-15
X	EP 1752850 A2 (RICOH COMPANY, LTD, et al.) 14 February 2007 Figs 1-17, column 8 para [0038] — column 18 para [0084]	1-15
X	US 3738443 A (KUBO) 12 June 1973 Figs 1-7, column 2 line 9 — column 4 line 47	1-15
X	US 6049745 A (DOUGLAS et al.) 11 April 2000 abstract, Figs 1-5, column 4 line 29 — column 8 line 25	1-15
X	US 2013/0162396 A1 (YANG) 27 June 2013 Figs 1-9, page 2 para [0055] — page 3 para [0068]	1-15

Form PCT/ISA/210 (fifth sheet) (July 2009)

INTERNATIONAL SEARCH REPORT		International application No.	
Information on patent family members		PCT/SG2014/000454	
This Annex lists known patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.			
Patent Document/s Cited in Search Report		Patent Family Member/s	
Publication Number	Publication Date	Publication Number	Publication Date
US 2009/0093900 A1	09 April 2009	US 7599756 B2	06 Oct 2009
		EP 2198356 A2	23 Jun 2010
		EP 2198356 B1	08 Aug 2012
		JP 2010540344 A	24 Dec 2010
		WO 2009045854 A2	09 Apr 2009
EP 1752850 A2	14 February 2007	EP 1752850 B1	03 Sep 2014
		JP 2007038818 A	15 Feb 2007
		JP 4965094 B2	04 Jul 2012
US 3738443 A	12 June 1973	JP S4919756 B1	20 May 1974
US 6049745 A	11 April 2000	AU 6152198 A	26 Aug 1998
		EP 0956523 A1	17 Nov 1999
		EP 0956523 B1	19 Dec 2001
		WO 9835276 A1	13 Aug 1998
US 2013/0162396 A1	27 June 2013	TW 201331076 A	01 Aug 2013
		TW I419805 B	21 Dec 2013
		TW 201325964 A	01 Jul 2013
		TW I424932 B	01 Feb 2014
End of Annex			

Electronic Acknowledgement Receipt	
EFS ID:	28279509
Application Number:	15341612
International Application Number:	
Confirmation Number:	3389
Title of Invention:	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION
First Named Inventor/Applicant Name:	Borja Ibarz Gabardos
Customer Number:	132059
Filer:	Peter John Gutierrez III/Chrissie McGaw
Filer Authorized By:	Peter John Gutierrez III
Attorney Docket Number:	BRAIN.134A/BC201609A
Receipt Date:	06-FEB-2017
Filing Date:	02-NOV-2016
Time Stamp:	19:01:20
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	Transmittal Letter	Transmittal.pdf	70572	no	2
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Warnings:					

Information:					
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6	Non Patent Literature	ASESIO_ROBOT_LEARNING_AS ME_2012_PGS_11_EFS.PDF	1699700	no	11
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7	Non Patent Literature	BOUGANISNEURAL_NETWORK_PROC_WCO2010_IEEE_2010_4104_EFS.PDF	813381	no	8
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9	Non Patent Literature	COUPARD_AVAILABOT.PDF	3721302	no	7
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12	Non Patent Literature	HEIKKILA97.PDF	127474	no	7
			86b2fbc1ef5112252562fba90a3abb8623b23ab3		
Warnings:					
Information:					
13	Non Patent Literature	HOPKINS_CHASWATETHERMIMAGINGINFRATRAININ_2011_EFS.PDF	10759253	no	14
			b15d223527e5ce31c6a6e30ed9e95b623fb83aa1		
Warnings:					
Information:					
14	Non Patent Literature	HUNT_JREMSENSENV_1989_30_43_EFS.PDF	3132460	no	12
			161fe4de7a75e5ecf7f1b2ce405ccde94500a03b		
Warnings:					
Information:					
15	Non Patent Literature	JAIN_LEARNTRAJECT_ADVNEUR_NIPS2013_EFS.PDF	4891644	no	8
			c8b46a70c323f0c8cd691943ba167c6e188dece		
Warnings:					
Information:					

16	Non Patent Literature	JOSHI_UNDERCAMERACALI_2014_EFS.PDF	2969181	no	5
			90d0c7c7741b9826e1922c4ada4a463eb65d319e		
Warnings:					
Information:					
17	Non Patent Literature	KALMAN_FILTER_EFS.PDF	8551921	no	32
			1f2d52c11ed78cd822e6f51dd3d9e2ee9231b1cc		
Warnings:					
Information:					
18	Non Patent Literature	KASABOV_EVOLVING_SPIKING_IEEE_2014_PGS_6_EFS.PDF	1035088	no	6
			c5fc25002037b9f6f4fe9132da6d57b701a8b18d		
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Information:					
19	Non Patent Literature	MAESEN_TILETRACKER_PRACT_AR_EFS.PDF	5847354	no	8
			68b68d3b06ae3b2932122c2d2c156839e44b39c9		
Warnings:					
Information:					
20	Non Patent Literature	PR2_USER_MANUAL_OCTOBER_5_2012_EFS.PDF	10363151	no	40
			e5d6b40489d32c79f19a778d3f3a4489badeba29		
Warnings:					
Information:					
21	Non Patent Literature	RAHMAN_JINTCOMPINTELLSYST_2008_1_304_EFS.PDF	2333675	no	9
			28acfe7a9539c4c932c83f5898d944d962daaefc		
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Information:					
22	Non Patent Literature	ROSEBROCK_PYIMAGESEARCH_2015_EFS.PDF	21026901	no	33
			08c84e2e28c6d118e44d0cd5f585630248851f9d		
Warnings:					
Information:					

23	Non Patent Literature	ROSENHAHN.PDF	1104257	no	22
			48dc12c0b0df42cf94928e76a9c637f01a2a30cc		
Warnings:					
Information:					
24	Non Patent Literature	STEELE_HUMANTOUCH_NEWS CORNELL_2013_EFS.PDF	917971	no	2
			92a5e68d954d8ca23eeccc9ca5fcab223c956598		
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25	Non Patent Literature	THERMIMAGMOISREST_05APR 2016_EFS.PDF	2047590	no	4
			32897388a00149ad785c07d7369d3b07cd0847b		
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Information:					
26	Non Patent Literature	TORRALBA_JIEEETRANSPATTA NALYMACHINTELL_2002_24_1 226_EFS.PDF	9738819	no	13
			3d6e53f36eeedd4fe0259c7a22c3c8f04e1183ec		
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Information:					
27	Non Patent Literature	TRIGGS_CAMERAPOSECALIBRA TION_3DPOINTS_EFS.PDF	3821910	no	7
			f3ec3367d65d6b211efe7a23f263f4d6957f06db		
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28	Non Patent Literature	UNCC_MACHLABWIKIDOC_RO S_2016_EFS.PDF	3179300	no	5
			7a5d7968a098143820f26f7296dba29c9d156524		
Warnings:					
Information:					
29	Non Patent Literature	WAN_AUTONAVISYSTEM_MUL TSENS_EFS.PDF	2230416	no	8
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Warnings:					
Information:					

30	Non Patent Literature	WIKIPEDIA_POSE_COMPVISION_2016_EFS.PDF	907023	no	2
			a0e2db5839f9db1e6bb4bfe751268f9ddec12838		
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Information:					
31	Non Patent Literature	ZHANG_FLEXIBLENEWTECH_1998_EFS.PDF	7976118	no	22
			058e6b4769669efc23f330393361e3538997f69f		
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32	Non Patent Literature	CameraCalib.pdf	373490	no	11
			504620033ccfa33a2bb46442a4842cd38ecfa66d		
Warnings:					
Information:					
Total Files Size (in bytes):			126798306		
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. <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.					

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Borja Ibarz Gabardos, et al.	)	<u>CUSTOMER NO. 132059</u>
			)	
Appl. No.	:	15/341,612	)	I hereby certify that this correspondence
			)	and all marked attachments are being
Filed	:	November 2, 2016	)	deposited with the United States Postal
			)	Service as first-class mail in an envelope
For	:	SYSTEMS AND METHODS	)	addressed to: Commissioner for Patents,
		FOR DYNAMIC ROUTE	)	P.O. Box 1450, Alexandria, VA 22313-
		PLANNING IN AUTONOMOUS	)	1450, on
		NAVIGATION	)	
			)	<u>February 6, 2017</u>
			)	(Date)
Examiner	:	Unknown	)	<u>/Mark I. Wang /</u>
			)	Mark I. Wang, Reg. No. 65,282
Group Art Unit:	:	Unknown	)	
			)	
			)	
			)	

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

Dear Examiner:

Applicant submits herewith an IDS citing one hundred and eighty-seven (187) references for consideration by the Office.

This Information Disclosure Statement is being filed before the mailing date of a first Office Action on the merits, and presumably no fee is required in accordance with 37 C.F.R. § 1.97(b)(3). If a first Office Action on the merits was mailed before the mailing date of this Statement, it is requested that the Commissioner charge any fees under 37 C.F.R. § 1.16 and § 1.17 to Deposit Account No. 501423.

Pursuant to 37 C.F.R. § 1.97(g) and (h), Applicant makes no representation that a search has been made or that the information cited is considered to be material to patentability. Additionally, inclusion on this list is not an admission that any of the cited documents are prior art in this application. Further, Applicant makes no representation regarding the completeness of this list or that better art does not exist.

App. No. : 15/341,612
Filed : November 2, 2016

Respectfully submitted,

GAZDZINSKI & ASSOCIATES, PC

Dated: February 6, 2017

By: /Mark I. Wang/
Mark I. Wang
Registration No. 65,282
16644 West Bernardo Drive, Suite 201
San Diego, CA 92127
Telephone: (858) 675-1670
Facsimile: (858) 675-1674

COMBINED DECLARATION AND ASSIGNMENT FOR PATENT APPLICATIONS

Title of Invention: **SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION**

As a below named inventor (hereinafter designated as the undersigned), I hereby declare that:

This declaration is directed to the application attached hereto. If the application is not attached hereto, the application is as identified by the attorney docket number as set forth above and/or the following:

U.S. Application Serial No.: 15/341,612; or
PCT International Application No.: _____
Filed on: November 2, 2016

The above-identified application was made or authorized to be made by me. I believe that I am the original inventor or an original joint inventor of a claimed invention in the application. I have reviewed and understand the contents of the above-identified application, including the claims. I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations § 1.56.

WHEREAS, **BRAIN CORPORATION**, with its principal place of business at 9401 Waples Street, Suite 100, San Diego, CA 92121, its heirs, successors, legal representatives and assigns (hereinafter designated as the Assignee) is desirous of acquiring the entire right, title and interest in and to said invention and in and to any Letters Patent(s) that may be granted therefor in the United States of America and in any foreign countries.

NOW, THEREFORE, for good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the undersigned has sold, assigned and transferred, and by these presents does (do) sell, assign and transfer unto said Assignee the full and exclusive right to the said invention in the United States of America, its territories, dependencies and possessions and the entire right, title and interest in and to any and all Letters Patent(s) which may be granted therefor in the United States of America, its territories, dependencies and possessions, and if the box above is designated, in any and all foreign countries; and to any and all divisions, reissues, re-examinations, continuations, conversions and extensions thereof, and provisional applications to which priority is claimed therefrom, for the full term or terms for which the same may be granted.

The undersigned agrees to execute all papers necessary in connection with this application and any continuing, divisional, conversion, re-exam, provisional, or reissue applications thereof and also to execute separate assignments in connection with such applications as the Assignee may deem necessary or expedient.

The undersigned agrees to execute all papers necessary in connection with any interference which may be declared concerning this application or continuation, division, conversion, re-exam, provisional, or reissue thereof or Letters Patent(s) or reissue patent issued thereon and to cooperate with the Assignee in every way possible in obtaining and producing evidence and proceeding with such interference.

GAZDZINSKI & ASSOCIATES, PC
16644 West Bernardo Drive, Suite 201, San Diego, CA 92127
Telephone: (858) 675-1670 - Facsimile: (858) 675-1674 - Email: docket@gazpat.com

COMBINED DECLARATION AND ASSIGNMENT FOR PATENT APPLICATIONS

The undersigned agrees to execute all papers and documents and to perform any act which may be necessary in connection with claims or provisions of the International Convention for the Protection of Industrial Property or similar agreements.

The undersigned agrees to perform all affirmative acts which may be necessary to obtain a grant of (a) valid United States of America patent(s) or a grant of (a) valid United States of America and any foreign patent(s) to the Assignee and to vest all rights therein hereby conveyed to said Assignee as fully and entirely as the same would have been held by the undersigned if this Assignment and sale had not been made.

The undersigned hereby authorizes and requests the Patent and Trademark Office Officials in the United States of America and in any foreign countries to issue any and all Letters Patent(s) resulting from said application or any continuing, divisional conversion or reissue applications thereof to the said Assignee, as Assignee of the entire interest, and hereby covenants that he has the full right to convey the entire interest herein assigned, and that he has not executed, and will not execute, any agreement in conflict herewith.

The undersigned hereby grants the law firm of GAZDZINSKI & ASSOCIATES, PC, Customer No. 132059, the power to insert any further identification which may be necessary or desirable in order to comply with the rules of the U.S. Patent and Trademark Office.

The undersigned hereby covenants that no assignment, sale, agreement or encumbrance has been or will be made or entered into which would conflict with this assignment.

The undersigned hereby acknowledges that any willful false statement made in this declaration is punishable under 18 U.S.C. § 1001 by fine or imprisonment of not more than five (5) years, or both.

Executed by the undersigned on the date opposite the undersigned name.

LEGAL NAME OF INVENTOR

Inventor's Name: **BORJA IBARZ GABARDOS**

Date: 3/6/78

Signature: _____

An application data sheet (PTO/AIA/14 or equivalent), including naming the entire inventive entity, must accompany this form. Use a separate form for each inventor; or check the box below and complete the attached page(s) to list additional inventors.

☒ Additional inventors are being named on the supplemental sheet attached hereto.

GAZDZINSKI & ASSOCIATES, PC

16644 West Bernardo Drive, Suite 201, San Diego, CA 92127

Telephone: (858) 675-1670 - Facsimile: (858) 675-1674 - Email: doCKET@gazpat.com

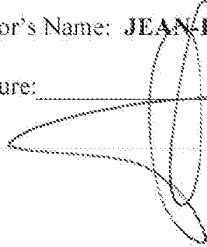
SUPPLEMENTAL SHEET FOR COMBINED DECLARATION AND ASSIGNMENT

LEGAL NAME OF JOINT INVENTOR, IF ANY

Inventor's Name: **JEAN-BAPTISTE PASSOT**

Date: 03/06/2017

Signature: _____

A handwritten signature in black ink, appearing to be 'JB Passot', written over a horizontal dotted line.

GAZDZINSKI & ASSOCIATES, PC

16644 West Bernardo Drive, Suite 201, San Diego, CA 92127

Telephone: (858) 675-1670 - Facsimile: (858) 675-1674 - Email: docket@gazpat.com

Electronic Acknowledgement Receipt	
EFS ID:	28576262
Application Number:	15341612
International Application Number:	
Confirmation Number:	3389
Title of Invention:	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION
First Named Inventor/Applicant Name:	Borja Ibarz Gabardos
Customer Number:	132059
Filer:	Peter John Gutierrez III/Chrissie McGaw
Filer Authorized By:	Peter John Gutierrez III
Attorney Docket Number:	BRAIN.134A/BC201609A
Receipt Date:	08-MAR-2017
Filing Date:	02-NOV-2016
Time Stamp:	20:15:51
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	Oath or Declaration filed	DecAssignment_signed.pdf	917522 2436d87375008938fd7c23dae1903dd3f810b52f	no	3
Warnings:					

Information:	
Total Files Size (in bytes):	917522
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. <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.	

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.

POWER OF ATTORNEY TO PROSECUTE APPLICATIONS BEFORE THE USPTO

I hereby revoke all previous powers of attorney given in the application identified in the attached statement under 37 CFR 3.73(c).

I hereby appoint:



Practitioners associated with Customer Number:

132059

OR

Practitioner(s) named below (if more than ten patent practitioners are to be named, then a customer number must be used):

Name	Registration Number

Name	Registration Number

As attorney(s) or agent(s) to represent the undersigned before the United States Patent and Trademark Office (USPTO) in connection with any and all patent applications assigned only to the undersigned, according to the USPTO assignment records or assignments documents attached to this form in accordance with 37 CFR 3.73(c).

Please change the correspondence address for the application identified in the attached statement under 37 CFR 3.73(c) to:



The address associated with Customer Number:

132059

OR

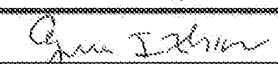
☐	Firm or Individual Name			
Address				
City		State		Zip
Country				
Telephone		Email		

Assignee Name and Address: Brain Corporation
9401 Waples Street, Suite 100
San Diego, CA 92121

A copy of this form, together with a statement under 37 CFR 3.73(c) (Form PTO/AIA/96 or equivalent) is required to be filed in each application in which this form is used. The statement under 37 CFR 3.73(c) may be completed by one of The practitioners appointed in this form, and must identify the application in which this Power of Attorney is to be filed.

SIGNATURE of Assignee of Record

The individual whose signature and title is supplied below is authorized to act on behalf of the assignee

Signature		Date	9/2/2016
Name	Dr. Eugene M. Izhikevich	Telephone	
Title	Co-founder, Chairman, and CEO of Brain Corporation		

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. 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 1.11 and 1.14. This collection is estimated to take 3 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.

Electronic Acknowledgement Receipt	
EFS ID:	28922575
Application Number:	15341612
International Application Number:	
Confirmation Number:	3389
Title of Invention:	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION
First Named Inventor/Applicant Name:	Borja Ibarz Gabardos
Customer Number:	132059
Filer:	Peter John Gutierrez III/Chrissie McGaw
Filer Authorized By:	Peter John Gutierrez III
Attorney Docket Number:	BRAIN.134A/BC201609A
Receipt Date:	13-APR-2017
Filing Date:	02-NOV-2016
Time Stamp:	16:31:34
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	Assignee showing of ownership per 37 CFR 3.73	AssignState_3_73c_.pdf	640864	no	2
			0e910077b5192c4f005b6d464d6236d5117c9c9e		
Warnings:					

Information:					
2	Power of Attorney	POA_Brain.pdf	483945	no	1
			da07d920c96cba156b8359a4bc79e8e1438f0573		
Warnings:					
Information:					
Total Files Size (in bytes):				1124809	
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. <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.					

STATEMENT UNDER 37 CFR 3.73(c)Applicant/Patent Owner: Borja Ibarz Gabardos, et al.Application No./Patent No.: 15/341,612 Filed/Issue Date: November 2, 2016Titled: SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION
BRAIN CORPORATION, a corporation

(Name of Assignee)

(Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose one of options 1, 2, 3 or 4 below):

1. ☒ The assignee of the entire right, title, and interest.
2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):
- ☐ The extent (by percentage) of its ownership interest is ____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.
- ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.

4. ☐ The recipient, via a court proceeding or the like (e.g., bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose one of options A or B below):

- 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 041921, Frame 0848, or for which a copy thereof is attached.
- B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:

1. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

2. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

[Page 1 of 2]

This collection of information is required by 37 CFR 3.73(b). 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 1.11 and 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.**

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STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

4. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____

The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____

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(s).

☒ As required by 37 CFR 3.73(c)(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.

/Mark I. Wang/

Signature

Mark I. Wang

Printed or Typed Name

April 13, 2017

Date

65,282

Title or Registration Number

[Page 2 of 2]



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

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/341,612	11/02/2016	Borja Ibarz Gabardos	BRAIN.134A/BC201609A

CONFIRMATION NO. 3389

POA ACCEPTANCE LETTER



OC000000090667747

132059
Gazdzinski & Associates, PC
16644 West Bernardo Drive
Suite 201
San Diego, CA 92127

Date Mailed: 04/17/2017

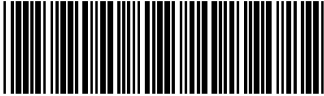
NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 04/13/2017.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at (571) 272-4000 or (571) 272-4200 or 1-888-786-0101.

/zmoguss/

<i>Index of Claims</i> 	Application/Control No. 15/341,612	Applicant(s)/Patent Under Reexamination Gabardos et al.
	Examiner RUSSELL W FREJD	Art Unit 3661

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

CLAIMS									
☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47									
CLAIM			DATE						
Final	Original	01/25/2018							
	1	=							
	2	=							
	3	=							
	4	=							
	5	=							
	6	=							
	7	=							
	8	=							
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	10	=							
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	14	=							
	15	=							
	16	=							
	17	=							
	18	=							
	19	=							
	20	=							

<i>Examiner-Initiated Interview Summary</i>	Application No. 15/341,612	Applicant(s) Gabardos et al.	
	Examiner RUSSELL W FREJD	Art Unit 3661	AIA Status Yes

All participants (applicant, applicant's representative, PTO personnel):

(1) RUSSELL FREJD - Primary Examiner. (3) ____.

(2) MARK WANG (65282) - Applicant's Rep. (4) ____.

Date of Interview: 25 January 2018.

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: 17.

Identification of prior art discussed: N/A.

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...)

See Continuation Sheet.

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

/Russell Frejd/ Primary Examiner, Art Unit 3661	
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Continuation of Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: The Examiner contacted Mr. Wang to obtain permission to correct some informalities in the claims, the specification and the abstract. In particular, claim 17 would be amended to read "computing torque forces", which would correct an antecedent problem with the phrase "computing the torque forces". The corresponding section of the specification [0018] would also be changed in like manner. The abstract would be changed to read "each route pose [ln. 9], instead of "each route poses". Mr. Wang agreed to each of the amendments, which the Examiner will implement via an Examiner's Amendment.

WEST Search History

DATE: Wednesday, January 24, 2018

Hide?	<u>Set</u> <u>Name</u>	<u>Query</u>	<u>Hit</u> <u>Count</u>
<i>Interference</i>			
<i>DB=PGPB,USPT; THES=ASSIGNEE; PLUR=YES; OP=ADJ</i>			
☐	L52	L49 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	0
☐	L51	L49 and (route same footprint same points)	0
☐	L50	L49 and (route same (pose or poses))	0
☐	L49	((autonomous guided vehicle ? or AGV ?) and (navigat \$ same map same environment))	37
☐	L48	L43 and (route with ((attractive near5 forces) or (repulsive near5 forces))).clm.	0
☐	L47	L43 and (route with footprint with points).clm.	0
☐	L46	L40 and (route same ((attractive near5 forces) or (repulsive near5 forces))).clm.	0
☐	L45	L40 and (route same footprint same points).clm.	0
☐	L44	L43 and (route same (pose or poses)).clm.	0
☐	L43	(autonomous with navigation) and (robot same map same environment).clm.	65
☐	L42	L40 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	0
☐	L41	L40 and (route same footprint same points)	0
☐	L40	L39 and (route same (pose or poses))	3
☐	L39	L38 and (autonomous with navigation) and (robot same map same environment)	189
☐	L38	((G05D1/0214 G05D1/0276 G05D2201/0203 G05D1/0088) or (G01C21/343 G01C21/3679 G01C21/3415)).cpc.	6452
<i>Prior Art</i>			
<i>DB=PGPB,USPT; THES=ASSIGNEE; PLUR=YES; OP=ADJ</i>			
☐	L37	L18 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	0
☐	L36	L18 and (route same footprint same points)	0
☐	L35	L24 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	0
☐	L34	L24 and (route same footprint same points)	0
☐	L33	L24 and (route with ((attractive near5 forces) or (repulsive near5 forces)))	0
☐	L32	L24 and (route with footprint with points)	0
☐	L31	L29 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	0
☐	L30	L29 and (route same footprint same points)	0
☐	L29	L24 and (route same (pose or poses))	14

☐	L28	L25 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	0
☐	L27	L25 and (route with ((attractive near5 forces) or (repulsive near5 forces)))	0
☐	L26	L25 and (route with footprint with points)	0
☐	L25	L24 and (route with (pose or poses))	4
☐	L24	(autonomous with navigation) and (robot same map same environment)	538
☐	L23	L19 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	0
☐	L22	L19 and (route with ((attractive near5 forces) or (repulsive near5 forces)))	0
☐	L21	L19 and (route same footprint same points)	0
☐	L20	L19 and (route with footprint with points)	0
☐	L19	L18 and (route with (pose or poses))	1
☐	L18	L5 and (autonomous with navigation) and (robot same map same environment)	139
☐	L17	L6 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	0
☐	L16	L6 and (route with ((attractive near5 forces) or (repulsive near5 forces)))	0
☐	L15	L6 and (route same footprint same points)	0
☐	L14	L6 and (route with footprint with points)	0
☐	L13	L1 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	0
☐	L12	L1 and (route with ((attractive near5 forces) or (repulsive near5 forces)))	0
☐	L11	L1 and (route same footprint same points)	0
☐	L10	L1 and (route with footprint with points)	0
☐	L9	L6 and (route same (pose or poses))	0
☐	L8	L6 and (route with (pose or poses))	0
☐	L7	Gabardos.in. and (autonomous with navigation) and (dynamic with route with planning)	0
☐	L6	L5 and (autonomous with navigation) and (dynamic with route with planning)	5
☐	L5	((((G05D1/0214)) ((G05D1/0276)) ((G05D2201/0203))) or ((G01C21/343)) ((G01C21/3679)) ((G01C21/3415))).cpc.	4677
☐	L4	L1 and (interpolat\$ same route same pose?)	0
☐	L3	L1 and (route same pose?)	1
☐	L2	L1 and (route with pose?)	0
☐	L1	(autonomous with navigation) and (dynamic with route with planning)	22

END OF SEARCH HISTORY

Notice of References Cited	Application/Control No. 15/341,612		Applicant(s)/Patent Under Reexamination Gabardos et al.	
	Examiner RUSSELL W FREJD		Art Unit 3661	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-8174568-B2	05-2012	Samarasekera; Supun	G01C21/005	348/113
*	B	US-8843244-B2	09-2014	Phillips; Emilie	G05D1/0038	701/2
*	C	US-20080059015-A1	03-2008	Whittaker; William L.	G05D1/0274	701/23
*	D	US-20160078303-A1	03-2016	Samarasekera; Supun	G01C21/005	348/47
*	E	US-20170329333-A1	11-2017	Passot; Jean-Baptiste	G05D1/0088	1/1
*	F	US-20170329347-A1	11-2017	Passot; Jean-Baptiste	G05D1/0274	1/1
	G					
	H					
	I					
	J					
	K					
	L					
	M					

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC 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.



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

NOTICE OF ALLOWANCE AND FEE(S) DUE

132059 7590 02/07/2018
Gazdzinski & Associates, PC
16644 West Bernardo Drive
Suite 201
San Diego, CALIFORNIA 92127

EXAMINER

FREJD, RUSSELL WARREN

ART UNIT

PAPER NUMBER

3661

DATE MAILED: 02/07/2018

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/341,612	11/02/2016	Borja Ibarz Gabardos	BRAIN.134A/BC201609A	3389

TITLE OF INVENTION: SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
REGULAR	SMALL	\$500	\$0.00	\$0.00	\$500	05/07/2018

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 ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

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.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: **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)

132059 7590 02/07/2018
Gazdzinski & Associates, PC
16644 West Bernardo Drive
Suite 201
San Diego, CALIFORNIA 92127

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.
15/341,612	11/02/2016	Borja Ibarz Gabardos	BRAIN.134A/BC201609A	3389

TITLE OF INVENTION: SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
REGULAR	SMALL	\$500	\$0.00	\$0.00	\$500	05/07/2018

EXAMINER	ART UNIT	CLASS-SUBCLASS
FREJD, RUSSELL WARREN	3661	701-025000

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 credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. Change in Entity Status (from status indicated above)

- ☐ Applicant certifying micro entity status. See 37 CFR 1.29
- ☐ Applicant asserting small entity status. See 37 CFR 1.27
- ☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____

Date _____

Typed or printed name _____

Registration No. _____



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UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/341,612	11/02/2016	Borja Ibarz Gabardos	BRAIN.134A/BC201609A	3389
132059 7590 02/07/2018 Gazdzinski & Associates, PC 16644 West Bernardo Drive Suite 201 San Diego, CALIFORNIA 92127				
EXAMINER FREJD, RUSSELL WARREN				
ART UNIT PAPER NUMBER 3661				
DATE MAILED: 02/07/2018				

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B 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.

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. 15/341,612	Applicant(s) Gabardos et al.	
	Examiner RUSSELL W FREJD	Art Unit 3661	AIA Status Yes

-- 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 applicant's filing on 11/2/16, and the interview conducted on 1/25/18 .
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on ____ .
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on ____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are 1-20 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

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.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
☐ 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. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date <u>2/6/17</u> 3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material ____ 4. ☒ Interview Summary (PTO-413), Paper No./Mail Date. <u>1/25/18</u> .	5. ☒ Examiner's Amendment/Comment 6. ☒ Examiner's Statement of Reasons for Allowance 7. ☐ Other ____ .
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/Russell Frejd/ Primary Examiner, Art Unit 3661	
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DETAILED ACTION

1. The following communication is in response to applicant's filing on 2-November-2016, and the interview conducted on 25-January-2018. Claims 1-20 are pending in the application. The IDS received on 6-February-2017 has been considered.

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Examiner's Amendment

2.1 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 C.F.R. 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 by Mark Wang (Reg. No. 65,282) on 25-January-2018.

2.2 In the Claims:

Claim 17 Line 1 Change "the torque forces" to --torque forces--.

2.3 In the Specification:

Paragraph [0018] Line 1 Change "the torque forces" to --torque forces--.

2.4 In the Abstract:

Line 9 Change "each route poses can reposition" to --each route pose can reposition--.

Reasons for Allowance

3.1 The following is an Examiner's Statement of Reasons for the indication of allowable subject matter. The present application is directed to a non-obvious improvement over USP Publication 2008/0059015, which provides a system for autonomous high-speed navigation of terrain by an un-manned robot. By preferably employing: a pre-planned route, path, and speed; extensive sensor-based information collection about the local environment; and information about vehicle pose, the robot evaluates the relative cost of various potential paths and thus arrives at a path to traverse the environment. The information collection about the local environment allows the robot to evaluate terrain and to identify any obstacles that may be encountered. The robot thus employs map-based data fusion in which sensor information is incorporated into a cost map, which is preferably a rectilinear grid aligned with the world coordinate system and is centered on the vehicle. The cost map is a specific map type that represents the traversability of a particular environmental area using a numeric value. The planned path and route provide information that further allows the robot to orient sensors to preferentially scan the areas of the environment where the robot will likely travel, thereby reducing the computational load placed onto the system. The computational ability of the system is further improved by using map-based syntax between various data processing modules of the present invention. By using a common set of carefully defined data types as syntax for communication, it is possible to identify new features for either path or map processing quickly and efficiently.

3.2 Claims 1-20 are considered allowable, since when reading the claims in light of the specification, as per MPEP § 2111.01, none of the references of record, either individually or in combination, disclose the specific arrangement of elements in the same combination specified in independent claims 1, 9 and 18 for dynamic navigation of a robot in an environment, specifically including:

(Claim 1) *“one or more sensors configured to collect data about an environment including detected points on one or more objects in the environment; and*

a controller configured to:

create a map of the environment based at least in part on the collected data;

determine a route in the map in which the robot will travel;

generate one or more route poses on the route, wherein each route pose comprises a footprint indicative of poses of the robot along the route and each route pose has a plurality of points disposed therein;

determine forces on each of the plurality of points of each route pose, the forces comprising repulsive forces from one or more of the detected points on the one or more objects and attractive forces from one or more of the plurality of points on others of the one or more route poses;

reposition one or more route poses in response to the forces on each point of the one or more route poses; and

perform interpolation between one or more route poses to generate a collision-free path between the one or more route poses for the robot to travel.”

The invention combines systems and methods for dynamic route planning in autonomous navigation, wherein a robot has one or more sensors configured to collect data about an environment, including detected points on one or more objects in the environment. The robot then calculates a route in the environment, the route comprising one or more route poses that can include a plurality of points therein, and a footprint indicative at least in part of a pose, size, and shape of the robot along the route. Based on forces exerted on the points of each route pose by other route poses, objects in the environment and others, each route pose can reposition. Based at least in part on interpolation performed on the route poses, some of which may be repositioned, the robot can dynamically route.

There are inventions in the field that provide similar functionality and/or have similar features, as the prior art of record shows. The examiner's search failed to find this combination of features, nor was it obvious in light of the prior art. It is for these reasons that the claims of the present application are found to be patentable over the prior art.

Dependent claims 2-8, 10-17, 19 and 20 are deemed allowable as depending either directly or indirectly from allowed independent claims 1, 9 and 18.

Response Guidelines

4.1 Any comments considered necessary by applicant **MUST** be submitted no later than the payment of the Issue Fee and, to avoid processing delays, should preferably accompany the Issue Fee. Such submissions should clearly be labeled "Comments on Statement of Reasons for Allowance".

4.2 Any response to the Examiner in regard to this allowance should be

directed to: Russell Frejd, telephone number (571) 272-3779, Monday-Friday from 0730 to 1600 ET. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Thomas Black, can be reached at telephone number (571) 272-6956.

mailed to: Commissioner of Patents and Trademarks
P.O. Box 1450, Alexandria, VA 22313-1450

faxed to: (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.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at <http://www.uspto.gov/interviewpractice>.

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Page 6

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/Russell Frejd/
Primary Examiner AU 3661



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BIB DATA SHEET

CONFIRMATION NO. 3389

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.		
15/341,612	11/02/2016	701	3661	BRAIN.134A/BC201609A		
RULE						
APPLICANTS BRAIN CORPORATION, San Diego, CA INVENTORS Borja Ibarz Gabardos, La Jolla, CA; Jean-Baptiste Passot, Solana Beach, CA; ** CONTINUING DATA ***** ** FOREIGN APPLICATIONS ***** ** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ** ** SMALL ENTITY ** 11/28/2016						
Foreign Priority claimed	☐ Yes ☒ No	☐ Met after Allowance	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
35 USC 119(a-d) conditions met	☐ Yes ☒ No		CA	12	20	3
Verified and	/RUSSELL WARREN	Initials				
Acknowledged	FREJD/ Examiner's Signature					
ADDRESS Gazdzinski & Associates, PC 16644 West Bernardo Drive Suite 201 San Diego, CA 92127 UNITED STATES						
TITLE SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION						
FILING FEE RECEIVED 800	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		

<i>Search Notes</i> 	Application/Control No. 15/341,612	Applicant(s)/Patent Under Reexamination Gabardos et al.
	Examiner RUSSELL W FREJD	Art Unit 3661

CPC - Searched*		
Symbol	Date	Examiner
G05D: 1/0214, 1/0276, 1/0088, 2201/3415	1/24/18	RF
G01C: 21/343, 21/3415	"	"
A47L: 11/4011	"	"

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
G05D: 1/0214, 1/0276, 1/0088, 2201/3415	1/24/18	RF
G01C: 21/343, 21/3415	"	"
A47L: 11/4011	"	"
WEST	"	"

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<i>Search Notes</i> 	Application/Control No. 15/341,612	Applicant(s)/Patent Under Reexamination Gabardos et al.
	Examiner RUSSELL W FREJD	Art Unit 3661

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
G05D	1/0214, 1/0276, 1/0088, 2201/3415	1/24/18	RF
G01C	21/343, 21/3415	"	"
A47L	11/4011	"	"
PGPUBS TEXT SEARCH		"	"

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Issue Classification 	Application/Control No. 15/341,612	Applicant(s)/Patent Under Reexamination Gabardos et al.
	Examiner RUSSELL W FREJD	Art Unit 3661

CPC						
Symbol					Type	Version
G05D	/	1	/	0214	F	2013-01-01
G01C	/	21	/	343	I	2013-01-01
G01C	/	21	/	3415	I	2013-01-01
G05D	/	1	/	0276	I	2013-01-01
G05D	/	1	/	0088	I	2013-01-01
A47L	/	11	/	4011	I	2013-01-01
G05D	/	2201	/	0203	A	2013-01-01

CPC Combination Sets					
Symbol				Type	Set
	/		/		

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	20	
/Russell Frejd/ Primary Examiner, Art Unit 3661	25 January 2018	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	6

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Issue Classification 	Application/Control No. 15/341,612	Applicant(s)/Patent Under Reexamination Gabardos et al.
	Examiner RUSSELL W FREJD	Art Unit 3661

INTERNATIONAL CLASSIFICATION				
CLAIMED				
G05D	/	1	/	02
G05D	/	1	/	00
G01C	/	21	/	34
A47L	/	11	/	40
NON-CLAIMED				
	/		/	

US ORIGINAL CLASSIFICATION	
CLASS	SUBCLASS
701	25

CROSS REFERENCES(S)						
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)					

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	20	
/Russell Frejd/ Primary Examiner, Art Unit 3661	25 January 2018	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	6

Issue Classification 	Application/Control No. 15/341,612	Applicant(s)/Patent Under Reexamination Gabardos et al.
	Examiner RUSSELL W FREJD	Art Unit 3661

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47																
CLAIMS																
Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final
	1		10		19											
	2		11		20											
	3		12													
	4		13													
	5		14													
	6		15													
	7		16													
	8		17													
	9		18													

NONE (Assistant Examiner) _____ (Date) _____		Total Claims Allowed: 20	
/Russell Frejd/ Primary Examiner, Art Unit 3661 (Primary Examiner) _____ (Date) _____		25 January 2018 (Date)	O.G. Print Claim(s) 1
			O.G. Print Figure 6

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Application Number	15/341,612
				Filing Date	11-02-2016
				First Named Inventor	Ibarz Gabardos Borja
				Art Unit	Unknown
				Examiner Name	Unknown
Sheet	1	of	14	Attorney Docket Number	BRAIN.134A/BC201609A

U. S. PATENT DOCUMENTS					
Examiner Initials*	Cite No. ¹	Document Number	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		Number-Kind Code ² (if known)			
	001	US-4638445	01-20-1987	MATTABONI; Paul J.	
	002	US-4763276	08-09-1988	PERREIRRA; Noel D. et al.	
	003	US-4852018	07-25-1989	GROSSBERG; Stephen et al.	
	004	US-5121497	06-09-1992	KERR; Randal H. et al.	
	005	US-5280179	01-18-1994	PRYOR; Timothy R. et al.	
	006	US-5446356	08-29-1995	KIM; Sang-Gwon	
	007	US-5602761	02-11-1997	SPOERRE; Julie K. et al.	
	008	US-5612883	03-18-1997	SHAFFER; Gary K. et al.	
	009	US-5673367	09-30-1997	BUCKLEY; Theresa M.	
	010	US-5719480	02-17-1998	BOCK; Otmar et al.	
	011	US-5841959	11-24-1998	GUIREMAND; Harry A.	
	012	US-5994864	11-30-1999	INOUE; Yasuyuki et al.	
	013	US-6124694	09-26-2000	BANCROFT; Allen J. et al.	
	014	US-6169981	01-02-2001	WERBOS; Paul J.	
	015	US-6243622	06-05-2001	YIM; Mark H. et al.	
	016	US-6366293	04-02-2002	HAMILTON; Jeffrey L. et al.	
	017	US-6442451	08-27-2002	LAPHAM; John R.	
	018	US-6560511	05-06-2003	YOKOO; Naohiro et al.	
	019	US-6584375	06-24-2003	BANCROFT; Allen et al.	
	020	US-6636781	10-21-2003	SHEN; Wei-Min et al.	
	021	US-6697711	02-24-2004	YOKONO; Jun et al.	

Examiner Signature		Date Considered	
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				Art Unit	Unknown
				Examiner Name	Unknown
Sheet	2	of	14	Attorney Docket Number	BRAIN.134A/BC201609A

U. S. PATENT DOCUMENTS					
Examiner Initials*	Cite No. ¹	Document Number	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		Number-Kind Code ² (if known)			
	022	US-6760645	07-06-2004	KAPLAN; Frederic et al.	
	023	US-6812846	11-02-2004	GUTTA; Srinivas et al.	
	024	US-6961060	11-01-2005	MOCHIZUKI; Yoshiyuki et al.	
	025	US-7002585	02-21-2006	WATANABE; Atsushi et al.	
	026	US-7148644	12-12-2006	YOURLO; Zhenya Alexander et al.	
	027	US-7243334	07-10-2007	BERGER; Kenneth A. et al.	
	028	US-7342589	03-11-2008	MISEROCCHI; Nathan P.	
	029	US-7668605	02-23-2010	BRAUN; Scott D. et al.	
	030	US-8145492	03-27-2012	FUJITA; Masahiro	
	031	US-8364314	01-29-2013	ABDALLAH; Muhammad E. et al.	
	032	US-8380348	02-19-2013	NEKI; Norio et al.	
	033	US-8380652	02-19-2013	FRANCIS Jr.; Anthony G.	
	034	US-8419804	04-16-2013	HERR; Hugh M. et al.	
	035	US-8423225	04-16-2013	HILLMAN Jr.; Henry L. et al.	
	036	US-8452448	05-28-2013	PACK; Robert T. et al.	
	037	US-8515162	08-20-2013	CHENG; Ting-Yuan	
	038	US-8639035	01-28-2014	SHIBA; Hisashi	
	039	US-8639644	01-28-2014	HICKMAN; Ryan et al.	
	040	US-8679260	03-25-2014	HILLMAN Jr.; Henry L. et al.	
	041	US-8793205	07-29-2014	FISHER; Dmitry et al.	

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				Art Unit	Unknown
				Examiner Name	Unknown
Sheet	3	of	14	Attorney Docket Number	BRAIN.134A/BC201609A

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		Number-Kind Code ² (if known)			
	042	US-8924021	12-30-2014	DARIUSH; Behzad et al.	
	043	US-8958911	02-17-2015	WONG; Cheuk Wah et al.	
	044	US-8958912	02-17-2015	BLUMBERG; Bruce et al.	
	045	US-8958937	02-17-2015	HILLMAN Jr.; Henry L. et al.	
	046	US-9008840	04-14-2015	PONULAK; Filip et al.	
	047	US-9015093	04-21-2015	COMMONS; Michael Lamport	
	048	US-9144907	09-29-2015	SUMMER; Matthew D. et al.	
	049	US-9242372	01-26-2016	LAURENT; Patryk et al.	
	050	US-20020158599	10-31-2002	FUJITA; Masahiro et al.	
	051	US-20020175894	11-28-2002	GRILLO; Vince	
	052	US-20020198854	12-26-2002	BERENJI; Hamid R. et al.	
	053	US-20030023347	01-30-2003	KONNO; Reizo et al.	
	054	US-20030025082	02-06-2003	BREWINGTON; James Gabriel et al.	
	055	US-20030108415	06-12-2003	HOSEK; Martin et al.	
	056	US-20030144764	07-31-2003	YOKONO; Jun et al.	
	057	US-20030220714	11-27-2003	NAKAMURA; Yoshihiko et al.	
	058	US-20040030449	02-12-2004	SOLOMON; Neal	
	059	US-20040036437	02-26-2004	ITO; Masato	
	060	US-20040051493	03-18-2004	FURUTA; Takayuki et al.	
	061	US-20040167641	08-26-2004	KAWAI; Masakazu et al.	

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				Art Unit	Unknown
				Examiner Name	Unknown
Sheet	4	of	14	Attorney Docket Number	BRAIN.134A/BC201609A

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		Number-Kind Code ² (if known)			
	062	US-20040172166	09-02-2004	LAPSTUN; Paul et al.	
	063	US-20040172168	09-02-2004	WATANABE; Atsushi et al.	
	064	US-20040267404	12-30-2004	DANKO; George	
	065	US-20050008227	01-13-2005	DUAN; Baofu et al.	
	066	US-20050065651	03-24-2005	AYERS; Joseph et al.	
	067	US-20050069207	03-31-2005	ZAKRZEWSKI; Radoslaw Romuald et al.	
	068	US-20050125099	06-09-2005	MIKAMI; Tatsuo et al.	
	069	US-20060207419	09-21-2006	OKAZAKI; Yasunao et al.	
	070	US-20060250101	11-09-2006	KHATIB; Oussama et al.	
	071	US-20070074177	03-29-2007	KURITA; Shigeru et al.	
	072	US-20070151389	07-05-2007	PRISCO; Giuseppe et al.	
	073	US-20070200525	08-30-2007	KANAOKA; Katsuya	
	074	US-20070255454	11-01-2007	DARIUSH; Behzad et al.	
	075	US-20070260356	11-08-2007	KOCK; Sonke et al.	
	076	US-20080040040	02-14-2008	GOTO; Takanori et al.	
	077	US-20080097644	04-24-2008	KAZNOV; Viktor et al.	
	078	US-20080112596	05-15-2008	RHOADS; Geoffrey B. et al.	
	079	US-20080140257	06-12-2008	SATO; Takashi et al.	
	080	US-20080319929	12-25-2008	KAPLAN; Frederic et al.	
	081	US-20090037033	02-05-2009	PHILLIPS; Emilie et al.	
	082	US-20090231359	09-17-2009	BASS II; Robert Leon et al.	

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				Application Number	15/341,612
				Filing Date	11-02-2016
				First Named Inventor	Ibarz Gabardos Borja
				Art Unit	Unknown
				Examiner Name	Unknown
Sheet	5	of	14	Attorney Docket Number	BRAIN.134A/BC201609A

U. S. PATENT DOCUMENTS					
Examiner Initials*	Cite No. ¹	Document Number	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		Number-Kind Code ² (if known)			
	083	US-20090234501	09-17-2009	ISHIZAKI; Takehiro	
	084	US-20090265036	10-22-2009	JAMIESON; Josef et al.	
	085	US-20090272585	11-05-2009	NAGASAKA; Kenichiro	
	086	US-20100114372	05-06-2010	KNUTH Jr.; David M. et al.	
	087	US-20100152896	06-17-2010	KOMATSU; Mayumi et al.	
	088	US-20100152899	06-17-2010	CHANG; Chu-Yin et al.	
	089	US-20100228264	09-09-2010	ROBINSON; David et al.	
	090	US-20100286824	11-11-2010	SOLOMON; Neal	
	091	US-20100305758	12-02-2010	NISHI; Hiroji et al.	
	092	US-20100312730	12-09-2010	WENG; Juvang et al.	
	093	US-20110026770	02-03-2011	BROOKSHIRE; Jonathan David	
	094	US-20110035188	02-10-2011	MARTINEZ-HERAS JOSE ANTONIO . et al.	
	095	US-20110060460	03-10-2011	OGA; Junichiro et al.	
	096	US-20110067479	03-24-2011	DAVIS; Donald R. et al.	
	097	US-20110144802	06-16-2011	JANG; Jung Soon	
	098	US-20110158476	06-30-2011	FAHN; Chin-Shyurng et al.	
	099	US-20110160906	06-30-2011	ORITA; Atsuo et al.	
	100	US-20110160907	06-30-2011	ORITA; Atsuo	
	101	US-20110196199	08-11-2011	DONHOWE; Caitlin Q. et al.	
	102	US-20110218676	09-08-2011	OKAZAKI; Yasunao	
	103	US-20110244919	10-06-2011	ALLER; Joshua V. et al.	

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				Art Unit	Unknown
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		Number-Kind Code ² (if known)			
	104	US-20110282169	11-17-2011	GRUDIC; Gregory Zlatko et al.	
	105	US-20110296944	12-08-2011	CARTER; Troy Alexander et al.	
	106	US-20120008838	01-12-2012	GUYON; Isabelle et al.	
	107	US-20120017232	01-19-2012	HOFFBERG; Linda Irene et al.	
	108	US-20120045068	02-23-2012	KIM; Jinsung et al.	
	109	US-20120079670	04-05-2012	YOON; Sang Sik et al.	
	110	US-20120143495	06-07-2012	DANTU; Ramanamurthy	
	111	US-20120144242	06-07-2012	VICHARE; Nikhil M. et al.	
	112	US-20120150777	06-14-2012	SETOGUCHI; Hisao et al.	
	113	US-20120209432	08-16-2012	FLEISCHER; Jason G. et al.	
	114	US-20120221147	08-30-2012	GOLDBERG; Randal P. et al.	
	115	US-20120303091	11-29-2012	IZHIKEVICH; Eugene M.	
	116	US-20120303160	11-29-2012	ZIEGLER; Andrew et al.	
	117	US-20120308076	12-06-2012	PIEKNIIEWSKI; Filip Lukasz et al.	
	118	US-20120308136	12-06-2012	IZHIKEVICH; Eugene M. et al.	
	119	US-20130000480	01-03-2013	KOMATSU; Mayumi et al.	
	120	US-20130044139	02-21-2013	HERNANDEZ; Esteban Carlos	
	121	US-20130066468	03-14-2013	CHOI; Mun-Taek et al.	
	122	US-20130096719	04-18-2013	SANDERS; Adam M. et al.	

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		Number-Kind Code ² (if known)			
	123	US-20130116827	05-09-2013	INAZUMI; Mitsuhiro	
	124	US-20130173060	07-04-2013	YOO; Su Jung et al.	
	125	US-20130206170	08-15-2013	SVENDSEN; Selma et al.	
	126	US-20130218339	08-22-2013	MAISONNIER; Bruno et al.	
	127	US-20130245829	09-19-2013	OHTA; Hiromichi et al.	
	128	US-20130274924	10-17-2013	CHUNG; Seung-Nyung et al.	
	129	US-20130310979	11-21-2013	HERR; Hugh M. et al.	
	130	US-20130325775	12-05-2013	SINYAVSKIY; Oleg et al.	
	131	US-20130346347	12-26-2013	PATTERSON; Anna et al.	
	132	US-20140016858	01-16-2014	RICHERT; Micah	
	133	US-20140081895	03-20-2014	COENEN; Oliver et al.	
	134	US-20140089232	03-27-2014	BUIBAS; Marius et al.	
	135	US-20140114479	04-24-2014	OKAZAKI; Yasunao	
	136	US-20140187519	07-03-2014	COOKE; John P. et al.	
	137	US-20140190514	07-10-2014	LAMON; Pierre et al.	
	138	US-20140276951	09-18-2014	HOURTASH; Arjang et al.	
	139	US-20140277718	09-18-2014	IZHIKEVICH; Eugene et al.	
	140	US-20140350723	11-27-2014	PRIETO; Robert et al.	
	141	US-20140358828	12-04-2014	PHILLIPPS; Kelly D. et al.	
	142	US-20140371907	12-18-2014	PASSOT; Jean-Baptiste et al.	
	143	US-20140371912	12-18-2014	PASSOT; Jean-Baptiste et al.	

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	144	US-20150032258	01-29-2015	PASSOT; Jean-Baptiste et al.	
	145	US-20150094850	04-02-2015	PASSOT; Jean-Baptiste et al.	
	146	US-20150094852	04-02-2015	LAURENT; Patryk et al.	
	147	US-20150120128	04-30-2015	ROSENSTEIN; Michael T. et al.	
	148	US-20150127155	05-07-2015	PASSOT; Jean-Baptiste et al.	
	149	US-20150185027	07-02-2015	KIKKERI; Harshavardhana et al.	
	150	US-20150204559	07-23-2015	HOFFBERG; Steven M. et al.	
	151	US-20150213299	07-30-2015	SOLANO; Ferrández José Vicente et al.	
	152	US-20150306761	10-29-2015	O'CONNOR; Peter et al.	
	153	US-20150317357	11-05-2015	HARMSEN; Jeremiah et al.	
	154	US-20150339589	11-26-2015	FISHER; Dmitry	
	155	US-20160057925	03-03-2016	LETSKY; Michael Todd	
	156	US-20160075026	03-17-2016	SISBOT; Emrah Akin et al.	

FOREIGN PATENT DOCUMENTS						
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		Country Code ³ Number ⁴ Kind Code ⁵ (if known)				

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		Country Code ² Number ⁴ Kind Code ⁵ (if known)				
	001	WO-0167749-A2	09-13-2001	SARNOFF CORP [US]		☐
	002	WO-2014196925-A1	12-11-2014	CTRLWORKS PTE LTD [SG]		☐
	003	WO-2015047195-A1	04-02-2015	CTRLWORKS PTE LTD [SG]		☐

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NON-PATENT LITERATURE DOCUMENTS			
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	001	ASENSIO et al., "Robot Learning Control Based on Neural Network Prediction" ASME 8th Annual Dynamic Systems and Control Conference joint with the JSME 11th Motion and Vibration Conference 2012 [Retrieved on: Jun. 24, 2014]. Retrieved from internet: http://msc.berkeley.edu/wjchen/publications/DSC12.sub.-8726.sub.-FI-.pdf <http: />, 11 pgs	☐
	002	Bouganis, Alexandros, et al., "Training a Spiking Neural Network to Control a 4-DoF Robotic Arm based on Spike Timing-Dependent Plasticity", Proceedings of WCCI 2010 IEEE World Congress on Computational Intelligence, COB, Barcelona, Spain, July, 18-23, 2010, pages 4104-4111.	☐
	003	BROWN, et al., "Detecting Problems In Buildings Using Infrared Cameras, Fluke Digital Library, retrieved on 06-08-2015 from the Web address: www.fluke.com/library , 3 pgs.	☐
	004	COUPARD, Pierre-Philippe, An Availabot-like computer-controlled push puppet for Linux, https://web.archive.org/web/20081106161941/http://myspace.voo.be/pcoupard/push_puppet_to_y/ , 2008, 7 pgs.	☐
	005	"Detection of ArUco Markers" accessed 6-20-16, available at the following Web address: http://docs.opencv.org/3.1.0/d5/dae/tutorial_aruco_detection.html#gsc.tab=0 , 18 pgs.	☐
	006	Hardware and Software Platform for Mobile Manipulation R&D, 2012, https://web.archive.org/web/20120128031010/http://www.willowgarage.com/pages/pr2/design , 4 pgs.	☐
	007	HEIKKILA J., et al., "A Four-Step Camera Calibration Procedure with Implicit Image Correction," Computer Vision and Pattern Recognition, 1997, Proceedings, 1997 IEEE Computer Society Conference on, San Juan, 1997, pp. 1106-1112.	☐
	008	Hopkins, Chasing Water with Thermal Imaging, Infrared Training Center, 2011. 14 pgs.	☐

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		Attorney Docket Number	BRAIN.134A/BC201609A

NON-PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No. ¹	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,page(s),volume-issue number(s),publisher, city and/or country where published.	T ²
	009	HUNT, et al., "Detection of Changes in Leaf Water Content Using Near-and Middle-Infrared Reflectance, " Journal of Remote Sensing of Environment, 1989, Vol. 30 (1), pp.43-54.	☐
	010	JAIN, Learning Trajectory Preferences for Manipulators via Iterative Improvement, 2013, Advances in Neural Information Processing Systems 26 (NIPS 2013), 8 pgs.	☐
	011	JOSHI, Blog Post from Perpetual Enigma Website, "Understanding Camera Calibration" posted 5-31-14, accessed 6-20-16 at the following Web address: https://prateekvjoshi.com/2014/05/31/understanding-camera-calibration/ , 5 pgs.	☐
	012	Kalman Filter; wikipedia. 32 pgs.	☐
	013	KASABOV, "Evolving Spiking Neural Networks for Spatio-and Spectro-Temporal Pattern Recognition", IEEE 6th International Conference Intelligent Systems 2012 [Retrieved on Jun 24, 2014], Retrieved from the Internet: http://ncs.ethz.ch/projects/evospike/publications/evolving-spiking-neural-networks-for-spatio-and-spectro-temporal-pattern-recognition-plenary-talk-ieee-is/view , 6 pgs.	☐
	014	MAESEN, et al., "Tile Tracker: A Practical and Inexpensive Positioning System for Mobile AR Applications" pp.1-8.	☐
	015	PR2 User Manual, October 5, 2012. 40 pgs.	☐
	016	RAHMAN, et al., "An Image Based Approach to Compute Object Distance, "International Journal of Computational Intelligence Systems, 2008, Vol. 1 (4), pp. 304-315.	☐
	017	ROSEBROCK, Tutorial "Find Distance from Camera to Object/marker using Python and OpenCV" 1-19-15, accessed 6-20-16 at the following Web address: http://www.pyimagesearch.com/2015/01/19/find-distance-camera-objectmarker-using-python-opencv/ , 33 pgs.	☐

Examiner Signature		Date Considered	
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*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. 1 Applicant's unique citation designation number (optional). 2 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 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 2 hours 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, 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 (1-800-786-9199) and select option 2.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /RF/

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	15/341,612
				Filing Date	11-02-2016
				First Named Inventor	Ibarz Gabardos Borja
				Art Unit	Unknown
				Examiner Name	Unknown
Sheet	12	of	14	Attorney Docket Number	BRAIN.134A/BC201609A

NON-PATENT LITERATURE DOCUMENTS				
Examiner Initials*	Cite No. ¹	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,page(s),volume-issue number(s),publisher, city and/or country where published.		T ²
	018	Rosenhahn, et al., Pose Estimation in Conformal Geometric Algebra Part I: The Stratification of Mathematical Spaces, Journal of Mathematical Imagine and Vision 22:27-48, 2005.	☐	
	019	Steele, The Human Touch Makes Robots Deft, November 6, 2013, Cornell Chronicle. http://www.news.cornell.edu/stories/2013/11/human-touch-makes-robots-deft , 2 pgs.	☐	
	020	Thermal Imaging for Moisture and Restoration, retrieved on 2016-04-05 from the following Web address: www.flir.com/home , 4 pgs.	☐	
	021	TORRALBA, et al., "Depth Estimation from Image Structure," Journal of IEEE Transactions on Pattern Analysis and Machine Intelligence, 2002, Vol. 24 (9), pp. 1226-1238.	☐	
	022	TRIGGS, "Camera Pose and Calibration from 4 or 5 known 3D Points," 7th International Conference on Computer Vision (ICCV '99), IEEE Computer Society, 1999, Vol. 1, pp.278-284.	☐	
	023	Tutorial "Camera Calibration with OpenCV" accessed 6-20-16 from the following Web address http://docs.opencv.org/2.4/doc/tutorials/calib3d/camera_calibration/camera_calibration.html , 11 pgs.	☐	
	024	UNCC Machine Lab Wiki Documentation "ROS and Camera Calibration" accessed 6-20-16 at the following Web address: http://visionlab.uncc.edu/dokuwiki/ros_and_camera_calibration#aruco_-_augmented_reality_library_from_the_university_of_cordoba , 5 pgs.	☐	
	025	~~Video "TECNALIA-Limaccio Autonomous Cleaning Robot", published 2-22-13, available at the following Web address: http://www.youtube.com/watch?v=4GJ00EBbBfQ&sns=em.~~	☐	
	026	WAN, et al., "Automatic Navigation System with Multiple Sensors," IFIP International Federation for Information Processing, Volume 259, Computer and Computing Technologies in Agriculture, 2008, Vol. 2, pp. 769-776.	☐	

Examiner Signature		Date Considered	
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Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	15/341,612
				Filing Date	11-02-2016
				First Named Inventor	Ibarz Gabardos Borja
				Art Unit	Unknown
				Examiner Name	Unknown
Sheet	13	of	14	Attorney Docket Number	BRAIN.134A/BC201609A

NON-PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No. ¹	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,page(s),volume-issue number(s),publisher, city and/or country where published.	T ²
	027	Wikipedia Page "Pose (Computer Vision)" accessed 6-20-16, available at the following Web address: https://en.wikipedia.org/wiki/Pose_(computer_vision) , 2 pgs.	☐
	028	ZHANG, A Flexible New Technique for Camera Calibration, last updated 12-5-9, Technical Report MSR-TR-98-71, December 2, 1998, 22 pgs.	☐

Examiner Signature	/Russell Frejd/	Date Considered	01/22/2018
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*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. 1 Applicant's unique citation designation number (optional). 2 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 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 2 hours 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, 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 (1-800-786-9199) and select option 2.

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Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	15/341,612
				Filing Date	11-02-2016
				First Named Inventor	Ibarz Gabardos Borja
				Art Unit	Unknown
				Examiner Name	Unknown
Sheet	14	of	14	Attorney Docket Number	BRAIN.134A/BC201609A

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.

- ☐ A certification statement is not submitted herewith.

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	/Mark I. Wang/	Date (YYYY-MM-DD)	2017-02-06
Name/Print	Mark I. Wang	Registration Number	65,282

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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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/341,612	11/02/2016	Borja Ibarz Gabardos	BRAIN.134A/BC201609A	3389
132059	7590	02/14/2018		
Gazdzinski & Associates, PC 16644 West Bernardo Drive Suite 201 San Diego, CA 92127			EXAMINER FREJD, RUSSELL WARREN	
			ART UNIT	PAPER NUMBER
			3661	
			MAIL DATE	DELIVERY MODE
			02/14/2018	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.



UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

Application No. : 15341612
Applicant : Gabardos
Filing Date : 11/02/2016
Date Mailed : 02/14/2018

NOTICE TO FILE CORRECTED APPLICATION PAPERS

Notice of Allowance Mailed

This application has been accorded an Allowance Date and is being prepared for issuance. The application, however, is incomplete for the reasons below.

Applicant is given two (2) months from the mail date of this Notice within which to respond. This time period for reply is extendable under 37 CFR 1.136(a) for only TWO additional MONTHS.

The informalities requiring correction are indicated in the attachment(s). If the informality pertains to the abstract, specification (including claims) or drawings, the informality must be corrected with an amendment in compliance with 37 CFR 1.121 (or, if the application is a reissue application, 37 CFR 1.173). Such an amendment may be filed after payment of the issue fee if limited to correction of informalities noted herein. See Waiver of 37 CFR 1.312 for Documents Required by the Office of Patent Publication, 1280 Off. Gaz. Patent Office 918 (March 23, 2004). In addition, if the informality is not corrected until after payment of the issue fee, for purposes of 35 U.S.C. 154(b)(1)(iv), "all outstanding requirements" will be considered to have been satisfied when the informality has been corrected. A failure to respond within the above-identified time period will result in the application being ABANDONED.

See attachment(s).

*A copy of this notice **MUST** be returned with the reply. Please address response to
"Mail Stop Issue Fee, Commissioner for Patents,
P.O. Box 1450, Alexandria, VA 22313-1450".*

/Marsha Palmer/
Publication Branch
Office of Data Management
(571) 272-4200

IDENTIFICATION OF DRAWING DEFICIENCIES

- ☐ There is a hole or the image thereof within the illustration. FIG(s)
- ☐ The illustration is penetrated or traversed by a solid or broken line that is not intended to be part of the drawing, such as a dark line caused by a flaw in the copying process. FIG(s)
- ☐ An ink stamp or the image thereof obscures part of the illustration. FIG(s)
- ☐ The drawing is marred by black smudges, obliterations, or fax/copier marks (for example, speckles or dots in a substantial portion of the drawing). FIG(s)
- ☐ Figure numbers are duplicated or missing. FIG(s)
- ☐ Drawing sheet or figure is missing. FIG(s)
- ☐ Numbers, letters, or reference characters in the drawing have been crossed out or are illegibly handwritten. FIG(s)
- ☐ The character of the lines, numbers, and letters is poor. FIG(s)
- ☐ The drawing's background shows that the original drawing was made on graph paper or other paper with a pattern or decoration. FIG(s)
- ☐ The FIG. number label is placed in a location that causes the drawing to be read upside down. FIG(s)
- ☐ Data, a reference number, or part of the drawing is truncated or missing, or a lead line has no reference number. FIG(s)
- ☐ The drawing and/or the FIG. label contain(s) foreign language. FIG(s)
- ☒ This utility application contains a photograph of a view that is capable of being illustrated as a line drawing. FIG(s) 1
- ☐ A petition under 37 CFR 1.84(a)(2) to accept color drawings has been granted, but the brief description of the drawings in the specification does not contain (or has not been amended to contain) the paragraph required by 37 CFR 1.84(a)(2)(iii).
- ☐ This reissue application contains added and/or amended drawings that are not labeled as "New" or "Amended" or "Canceled" as required by 37 CFR 1.173(b)(3). FIG(s)
- ☐ This Design reissue application contains a drawing that is labeled as "Canceled" but is not surrounded by brackets, or a drawing that is surrounded by brackets but is not labeled as "Canceled." See 37 CFR 1.173(b)(3). FIG(s)
- ☐ OTHER:
- ☐ COMMENTS:

Application No. 15341612

IDENTIFICATION OF SPECIFICATION/DRAWING INCONSISTENCIES

- ☐ On Page of the specification there is a brief description of FIG. , but the drawings filed do not include a drawing with that designation. Applicant must respond either by supplying the omitted drawing or by amending the specification to remove all references to that drawing.
- ☒ The drawings filed 11/02/2016 include FIG. 4f, but the specification's brief description of the drawings does not describe a drawing with that designation. Applicant must respond either by amending the specification to add a brief description of that drawing or by correcting the drawings to remove the drawing in question.
- ☐ In the utility application, drawings are present in the application and are referred to in the detailed description of the invention, but the specification does not contain a brief description of the several views as required by 37 CFR 1.74 and 37 CFR 1.77(b)(9).
- ☐ The design application does not contain a description of the figure or figures of the drawing as required by 37 CFR 1.153(a) and 37 CFR 1.154(b)(4).
- ☐ In the plant application, the specification does not contain a brief description of the drawing as required by 37 CFR 1.163(c)(8).
- ☐ Page of the specification refers to FIG. , but no drawing with that designation is described in the brief description of the drawings and no drawing with that designation is present in the application. Applicant must respond either by amending the specification to remove all references to that drawing, or by supplying that drawing and amending the specification to add a brief description of it.
- ☐ In the reissue application, FIG. , is labeled as "New" but is not described in the reissue specification's brief description of the drawings. Applicant must respond by amending the reissue specification's brief description of the drawings to add a brief description of the new drawing.
- ☐ OTHER:
- ☐ COMMENTS:

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Borja Ibarz Gabardos et al.

App. No. : 15/341,612

Filed : November 2, 2016

For : **SYSTEMS AND METHODS FOR
DYNAMIC ROUTE PLANNING
IN AUTONOMOUS
NAVIGATION**

Examiner : Frejd, Russell Warren

Group Art Unit: 3661

CUSTOMER NO. 132059**CERTIFICATE OF ELECTRONIC
(EFS-WEB) TRANSMISSION**

I hereby certify that this correspondence is being transmitted via the Office electronic filing system in accordance with 37 C.F.R. § 1.8(a)(1)(i)(C) from the Pacific Time Zone of the United States on the local date shown below.

April 16, 2018
(Date)

/Peter J. Gutierrez, III/
Peter J. Gutierrez, III, Reg. No. 56,732

AMENDMENT AND RESPONSE TO NOTICE OF ALLOWANCE
PURSUANT TO 37 C.F.R. § 1.312

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

Dear Sir:

Pursuant to 37 C.F.R. § 1.312, and in response to the Notice of Allowance and Fee(s) Due dated February 7, 2018 ("Notice of Allowance") and the Notice to File Corrected Application Papers dated February 14, 2018 ("Notice to Correct"), the following is provided:

Application No. : 15/341,612
Filed : November 2, 2016

IN THE DRAWINGS

One replacement drawing sheet is herein provided for the Office's consideration in replacement of one of the original drawing sheets. Specifically, an amended version of FIG. 1 has been provided herein to replace the original drawing sheet therefor. No new matter has been added.

Application No. : 15/341,612
Filed : November 2, 2016

IN THE SPECIFICATION

1. After paragraph [0031] and immediately before paragraph [0032] of Applicant's specification as filed, please add the following the text:

-- FIG. 4E illustrates example points on a route pose in accordance with some implementations of the present disclosure. --

2. At paragraph [0032] of Applicant's specification as filed, please amend the text as follows:

-- [0032] FIG. 4E [[4E]] illustrates an overhead view showing attractive forces between route poses in accordance with some implementations of the present disclosure. --

3. At paragraph [0079] of Applicant's specification as filed, please amend the text as follows:

-- [0079] In some cases, a plurality of points can define the body of robot 202 as reflected in route poses 414 and 416, providing representative coverage over a portion of the body of robot 202 and/or substantially all of robot 202. For example, 15-20 points can be distributed throughout the surface and/or interior of robot 202 and be reflected in route poses 414 and 416. However, in some cases, there can be fewer points. FIG. 4E [[4F]] illustrates example points on route pose 414, such as point 418. Each point can experience, at least in part, the forces (e.g., repulsive forces) placed on it by objects in the surrounding of route poses 414. --

4. At paragraph [0090] of Applicant's specification as filed, please amend the text as follows:

-- [0090] In some implementations, not all forces on route poses 414 and 416 are repulsive. For example, points on route poses (e.g., route poses 414 and

Application No. : 15/341,612
Filed : November 2, 2016

416) can exert attractive (e.g., cohesive) forces, which can, at least in part, pull route poses towards each other. FIG. 4F [[4E]] illustrates attractive forces between route poses 414 and 416 in accordance with some implementations of the present disclosure. The arrows are indicative at least in part that route poses are drawn towards each other along route portion 404. Advantageously, the cohesive force between route poses can cause, at least in part, robot 202 towards following a path substantially similar to the path planned by global layer 406 (e.g., a route substantially similar to an original route, such as an originally demonstrated route that robot 202 should follow in the absence of objects around which to navigate).

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Application No. : 15/341,612
Filed : November 2, 2016

IN THE CLAIMS

Please amend Claims 12 and 14 as follows:

1. (Original) A robot comprising:
one or more sensors configured to collect data about an environment including detected points on one or more objects in the environment; and
a controller configured to:
create a map of the environment based at least in part on the collected data;
determine a route in the map in which the robot will travel;
generate one or more route poses on the route, wherein each route pose comprises a footprint indicative of poses of the robot along the route and each route pose has a plurality of points disposed therein;
determine forces on each of the plurality of points of each route pose, the forces comprising repulsive forces from one or more of the detected points on the one or more objects and attractive forces from one or more of the plurality of points on others of the one or more route poses;
reposition one or more route poses in response to the forces on each point of the one or more route poses; and
perform interpolation between one or more route poses to generate a collision-free path between the one or more route poses for the robot to travel.
2. (Original) The robot of Claim 1, wherein:
the one or more route poses form a sequence in which the robot travels along the route;
and
the interpolation comprises a linear interpolation between sequential ones of the one or more route poses.
3. (Original) The robot of Claim 1, wherein the interpolation generates one or more interpolation route poses having substantially similar footprints to the footprint of each route pose.
4. (Original) The robot of Claim 1, wherein the determination of the forces on each point of the one or more route poses further comprises a computation of a force function that

Application No. : 15/341,612
Filed : November 2, 2016

associates, at least in part, the forces on each point of each route pose with one or more characteristics of objects in the environment.

5. (Original) The robot of Claim 4, wherein the one or more characteristics includes one or more of distance, shape, material, and color.

6. (Original) The robot of Claim 4, wherein:
the force function associates zero repulsive force exerted by a first detected point on a first object where a distance between the first detected point and a second point of a first route pose is above a predetermined distance threshold.

7. (Original) The robot of Claim 1, wherein the footprint of each route pose has substantially similar size and shape as the footprint of the robot.

8. (Original) The robot of Claim 1, wherein the robot comprises a floor cleaner.

9. (Original) A method for dynamic navigation of a robot in an environment, comprising:

generating a map of the environment using data from one or more sensors;

determining a route on the map, the route including one or more route poses, each route pose comprising a footprint indicative at least in part of a pose and a shape of the robot along the route and each route pose having a plurality of points disposed therein;

computing repulsive forces from a point on an object in the environment onto the plurality of points of a first route pose of the one or more route poses;

repositioning the first route pose in response to at least the repulsive forces; and

performing an interpolation between the repositioned first route pose and another of the one or more route poses.

10. (Original) The method of Claim 9, further comprising determining attractive forces from a point on another of the one or more route poses exerted on the plurality of points of the first route pose.

11. (Original) The method of Claim 9, further comprising:

detecting a plurality of objects in the environment with the one or more sensors, each of the plurality of objects having detected points; and

defining a force function, the force function computing repulsive forces exerted by each of the detected points of the plurality of objects on the plurality of points of the first route pose, wherein each repulsive force comprises a vector.

Application No. : 15/341,612
Filed : November 2, 2016

12. (Currently amended) The method of Claim 11, wherein the repositioning of the first route pose comprises calculating a minimum of the force function.

13. (Original) The method of Claim 9, wherein the repositioning of the first route pose comprises translating and rotating the first route pose.

14. (Currently amended) The method of Claim 9, wherein the performing of the interpolation comprises:

generating an interpolation route pose having a footprint substantially similar to the shape of the robot; and

determining a translation and rotation of the interpolation route pose based at least on a collision-free path between the translated and rotated first route pose and the another of the one or more route poses.

15. (Original) The method of Claim 9, further comprising computing a magnitude of the repulsive forces as proportional to a distance between the point on the object and each of the plurality of points of the first route pose if the point on the object is outside of the footprint of the first route pose.

16. (Original) The method of Claim 9, further comprising computing a magnitude of the repulsive forces as inversely proportional to a distance between the point on the object and each of the plurality of points of the first route pose if the point on the object is inside the footprint of the first route pose.

17. (Previously presented) The method of Claim 9, further comprising computing torque forces onto the plurality of points of the first route pose due to the repulsive forces.

18. (Original) A non-transitory computer-readable storage apparatus having a plurality of instructions stored thereon, the instructions being executable by a processing apparatus to operate a robot, the instructions configured to, when executed by the processing apparatus, cause the processing apparatus to:

generate a map of an environment using data from one or more sensors;

determine a route on the map, the route comprising one or more route poses, each route pose comprising a footprint indicative at least in part of a pose and a shape of the robot along the route and each route pose having a plurality of points disposed therein; and

compute repulsive forces from a point on an object in the environment onto the plurality of points of a first route pose of the one or more route poses.

Application No. : 15/341,612
Filed : November 2, 2016

19. (Original) The non-transitory computer-readable storage apparatus of Claim 18, further comprising one or more instructions, which when executed by the processing apparatus, further cause the processing apparatus to determine attractive forces from a point on another of the one or more route poses exerted on the plurality of points of the first route pose.

20. (Original) The non-transitory computer-readable storage apparatus of Claim 18, further comprising one or more instructions, which when executed by the processing apparatus, further cause the processing apparatus to determine torque forces from a point on another of the one or more route poses exerted on the plurality of points of the first route pose.

Application No. : 15/341,612
Filed : November 2, 2016

REMARKS

Claims 1 – 20 were allowed. By this paper, Applicant has amended Claims 12 and 14. Accordingly, Claims 1 – 20 are presented for examination herein.

Allowed Subject Matter

Pursuant to the Notice of Allowance, Claims 1 – 20 are allowed.

Amendment to Drawings

By this paper, Applicant has amended the drawings in response to the Notice to Correct. Applicant submits herewith a replacement sheet for FIG. 1 to submit a formalized version thereof. No new matter has been added.

Amendments to Specification

Applicant has herein amended the specification to add a brief description for one of the figures and to correct one or more editorial errors. No new matter has been added.

Other Remarks

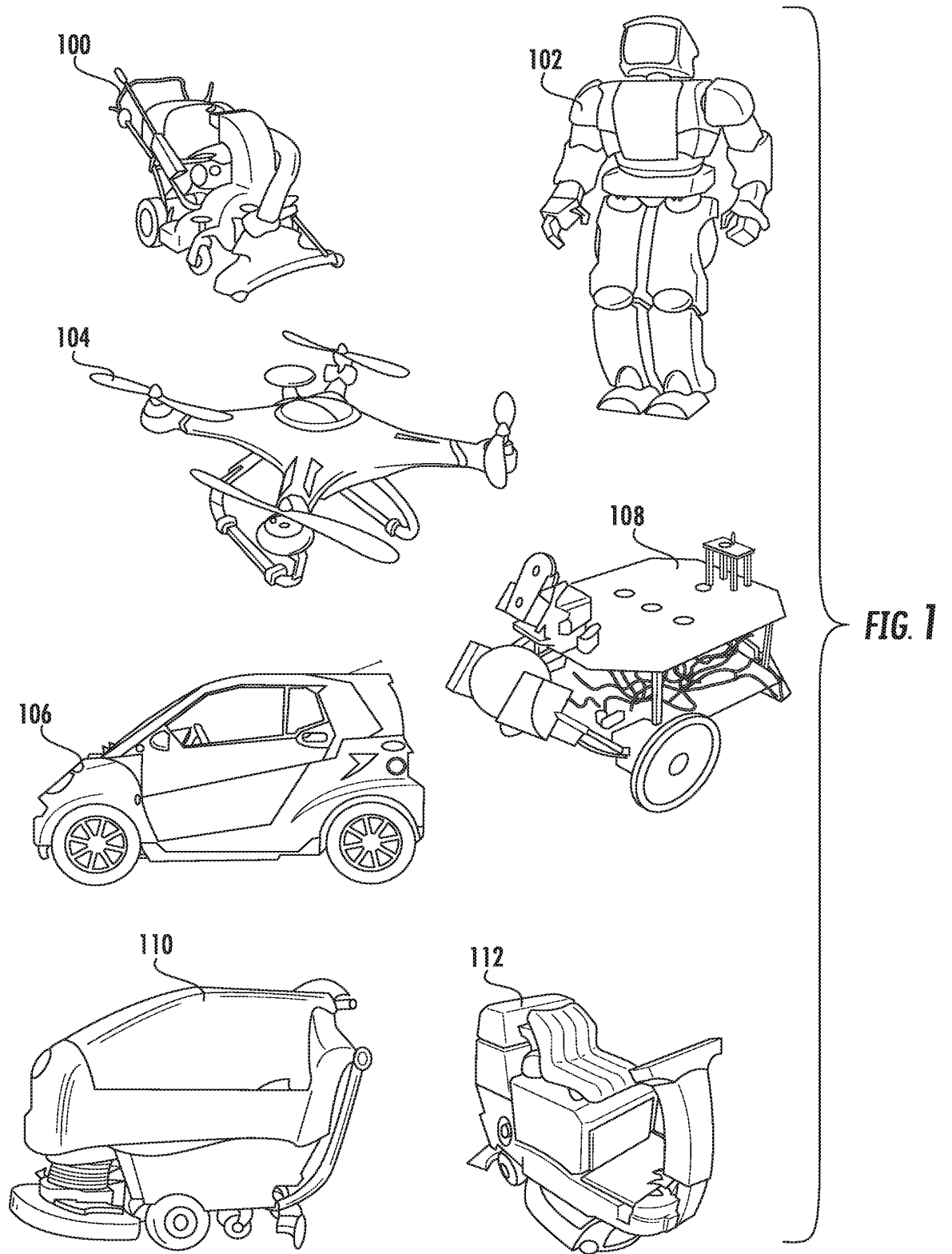
If the Office has any questions or comments which may be resolved over the telephone, he/she is requested to call the undersigned at (858) 675-1670.

Respectfully submitted,

GAZDZINSKI & ASSOCIATES, PC

Dated: April 16, 2018

By: /Peter J. Gutierrez, III/
Peter J. Gutierrez, III
Registration No. 56,732
Attorney of Record
16644 West Bernardo Dr., Suite 201
San Diego, CA 92127
Telephone No.: (858) 675-1670
Facsimile No.: (858) 675-1674



Electronic Acknowledgement Receipt	
EFS ID:	32354419
Application Number:	15341612
International Application Number:	
Confirmation Number:	3389
Title of Invention:	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION
First Named Inventor/Applicant Name:	Borja Ibarz Gabardos
Customer Number:	132059
Filer:	Peter John Gutierrez III/Christine McGaw
Filer Authorized By:	Peter John Gutierrez III
Attorney Docket Number:	BRAIN.134A/BC201609A
Receipt Date:	16-APR-2018
Filing Date:	02-NOV-2016
Time Stamp:	19:54:37
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	Applicant Response to Pre-Exam Formalities Notice	Notice.pdf	150244	no	4
			6c96f1d17cf364d2130b8682c9d52c596d4840f7		
Warnings:					

Information:					
2	Amendment after Notice of Allowance (Rule 312)	312Amend.pdf	110577	no	9
			02f83d512113ffe24690e0bd754376f77dd103f		
Warnings:					
Information:					
3	Drawings-only black and white line drawings	ReplacementFig1.pdf	1051201	no	1
			bb08afcf63488a213b6b65413aa17911b6d5714		
Warnings:					
Information:					
Total Files Size (in bytes):			1312022		
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. <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.					



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/341,612	11/02/2016	Borja Ibarz Gabardos	BRAIN.134A/BC201609A	3389
132059	7590	02/14/2018		
Gazdzinski & Associates, PC 16644 West Bernardo Drive Suite 201 San Diego, CA 92127			EXAMINER FREJD, RUSSELL WARREN	
			ART UNIT	PAPER NUMBER
			3661	
			MAIL DATE	DELIVERY MODE
			02/14/2018	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.



UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

Application No. : 15341612
Applicant : Gabardos
Filing Date : 11/02/2016
Date Mailed : 02/14/2018

NOTICE TO FILE CORRECTED APPLICATION PAPERS

Notice of Allowance Mailed

This application has been accorded an Allowance Date and is being prepared for issuance. The application, however, is incomplete for the reasons below.

Applicant is given two (2) months from the mail date of this Notice within which to respond. This time period for reply is extendable under 37 CFR 1.136(a) for only TWO additional MONTHS.

The informalities requiring correction are indicated in the attachment(s). If the informality pertains to the abstract, specification (including claims) or drawings, the informality must be corrected with an amendment in compliance with 37 CFR 1.121 (or, if the application is a reissue application, 37 CFR 1.173). Such an amendment may be filed after payment of the issue fee if limited to correction of informalities noted herein. See Waiver of 37 CFR 1.312 for Documents Required by the Office of Patent Publication, 1280 Off. Gaz. Patent Office 918 (March 23, 2004). In addition, if the informality is not corrected until after payment of the issue fee, for purposes of 35 U.S.C. 154(b)(1)(iv), "all outstanding requirements" will be considered to have been satisfied when the informality has been corrected. A failure to respond within the above-identified time period will result in the application being ABANDONED.

See attachment(s).

*A copy of this notice **MUST** be returned with the reply. Please address response to
"Mail Stop Issue Fee, Commissioner for Patents,
P.O. Box 1450, Alexandria, VA 22313-1450".*

/Marsha Palmer/
Publication Branch
Office of Data Management
(571) 272-4200

IDENTIFICATION OF DRAWING DEFICIENCIES

- ☐ There is a hole or the image thereof within the illustration. FIG(s)
- ☐ The illustration is penetrated or traversed by a solid or broken line that is not intended to be part of the drawing, such as a dark line caused by a flaw in the copying process. FIG(s)
- ☐ An ink stamp or the image thereof obscures part of the illustration. FIG(s)
- ☐ The drawing is marred by black smudges, obliterations, or fax/copier marks (for example, speckles or dots in a substantial portion of the drawing). FIG(s)
- ☐ Figure numbers are duplicated or missing. FIG(s)
- ☐ Drawing sheet or figure is missing. FIG(s)
- ☐ Numbers, letters, or reference characters in the drawing have been crossed out or are illegibly handwritten. FIG(s)
- ☐ The character of the lines, numbers, and letters is poor. FIG(s)
- ☐ The drawing's background shows that the original drawing was made on graph paper or other paper with a pattern or decoration. FIG(s)
- ☐ The FIG. number label is placed in a location that causes the drawing to be read upside down. FIG(s)
- ☐ Data, a reference number, or part of the drawing is truncated or missing, or a lead line has no reference number. FIG(s)
- ☐ The drawing and/or the FIG. label contain(s) foreign language. FIG(s)
- ☒ This utility application contains a photograph of a view that is capable of being illustrated as a line drawing. FIG(s) 1
- ☐ A petition under 37 CFR 1.84(a)(2) to accept color drawings has been granted, but the brief description of the drawings in the specification does not contain (or has not been amended to contain) the paragraph required by 37 CFR 1.84(a)(2)(iii).
- ☐ This reissue application contains added and/or amended drawings that are not labeled as "New" or "Amended" or "Canceled" as required by 37 CFR 1.173(b)(3). FIG(s)
- ☐ This Design reissue application contains a drawing that is labeled as "Canceled" but is not surrounded by brackets, or a drawing that is surrounded by brackets but is not labeled as "Canceled." See 37 CFR 1.173(b)(3). FIG(s)
- ☐ OTHER:
- ☐ COMMENTS:

Application No. 15341612

IDENTIFICATION OF SPECIFICATION/DRAWING INCONSISTENCIES

- ☐ On Page of the specification there is a brief description of FIG. , but the drawings filed do not include a drawing with that designation. Applicant must respond either by supplying the omitted drawing or by amending the specification to remove all references to that drawing.
- ☒ The drawings filed 11/02/2016 include FIG. 4f, but the specification's brief description of the drawings does not describe a drawing with that designation. Applicant must respond either by amending the specification to add a brief description of that drawing or by correcting the drawings to remove the drawing in question.
- ☐ In the utility application, drawings are present in the application and are referred to in the detailed description of the invention, but the specification does not contain a brief description of the several views as required by 37 CFR 1.74 and 37 CFR 1.77(b)(9).
- ☐ The design application does not contain a description of the figure or figures of the drawing as required by 37 CFR 1.153(a) and 37 CFR 1.154(b)(4).
- ☐ In the plant application, the specification does not contain a brief description of the drawing as required by 37 CFR 1.163(c)(8).
- ☐ Page of the specification refers to FIG. , but no drawing with that designation is described in the brief description of the drawings and no drawing with that designation is present in the application. Applicant must respond either by amending the specification to remove all references to that drawing, or by supplying that drawing and amending the specification to add a brief description of it.
- ☐ In the reissue application, FIG. , is labeled as "New" but is not described in the reissue specification's brief description of the drawings. Applicant must respond by amending the reissue specification's brief description of the drawings to add a brief description of the new drawing.
- ☐ OTHER:
- ☐ COMMENTS:



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United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/341,612	11/02/2016	Borja Ibarz Gabardos	BRAIN.134A/BC201609A	3389
132059	7590	04/23/2018	EXAMINER	
Gazdzinski & Associates, PC 16644 West Bernardo Drive Suite 201 San Diego, CALIFORNIA 92127 UNITED STATES OF AMERICA			FREJD, RUSSELL WARREN	
			ART UNIT	PAPER NUMBER
			3661	
			MAIL DATE	DELIVERY MODE
			04/23/2018	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.

Corrected Notice of Allowability	Application No. 15/341,612	Applicant(s) Gabardos et al.	
	Examiner RUSSELL W FREJD	Art Unit 3661	AIA Status Yes

-- 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 the 1.312 amendment received on 4/16/18.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are 1-20. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

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

Certified copies:

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.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
☐ 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. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____ 3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____ 4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____	5. ☐ Examiner's Amendment/Comment 6. ☐ Examiner's Statement of Reasons for Allowance 7. ☒ Other <u>1.312 Amendment</u> .
--	--

/Russell Frejd/ Primary Examiner, Art Unit 3661	
--	--

OK TO ENTER: /RF/ 4/20/18

BRAIN.134A/BC201609A

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant : Borja Ibarz Gabardos et al.

App. No. : 15/341,612

Filed : November 2, 2016

For : **SYSTEMS AND METHODS FOR
DYNAMIC ROUTE PLANNING
IN AUTONOMOUS
NAVIGATION**

Examiner : Frejd, Russell Warren

Group Art Unit: 3661

CUSTOMER NO. 132059

**CERTIFICATE OF ELECTRONIC
(EFS-WEB) TRANSMISSION**

I hereby certify that this correspondence is being transmitted via the Office electronic filing system in accordance with 37 C.F.R. § 1.8(a)(1)(i)(C) from the Pacific Time Zone of the United States on the local date shown below.

April 16, 2018
(Date)

/Peter J. Gutierrez, III/
Peter J. Gutierrez, III, Reg. No. 56,732

**AMENDMENT AND RESPONSE TO NOTICE OF ALLOWANCE
PURSUANT TO 37 C.F.R. § 1.312**

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

Dear Sir:

Pursuant to 37 C.F.R. § 1.312, and in response to the Notice of Allowance and Fee(s) Due dated February 7, 2018 ("Notice of Allowance") and the Notice to File Corrected Application Papers dated February 14, 2018 ("Notice to Correct"), the following is provided:



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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

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/341,612	11/02/2016	Borja Ibarz Gabardos	BRAIN.134A/BC201609A

CONFIRMATION NO. 3389

PUBLICATION NOTICE



OC000000099274709

132059
Gazdzinski & Associates, PC
16644 West Bernardo Drive
Suite 201
San Diego, CA 92127

Title:SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION

Publication No.US-2018-0120856-A1

Publication Date:05/03/2018

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publicly available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently <http://www.uspto.gov/patft/>.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently <https://portal.uspto.gov/pair/PublicPair>. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known		
				Application Number		15/341,612
				Filing Date		11-02-2016
				First Named Inventor		Borja Ibarz Gabardos
				Art Unit		3661
				Examiner Name		Frejd, Russell Warren
Sheet	1	of	3	Attorney Docket Number		BRAIN.134A/BC201609A

U. S. PATENT DOCUMENTS					
Examiner Initials*	Cite No. ¹	Document Number	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		Number-Kind Code ² (if known)			
	001	US-7212651	05-01-2007	VIOLA; Paul A. et al.	
	002	US-7576639	08-18-2009	BOYLES; Tonnie Michael et al.	
	003	US-8514236	08-20-2013	WANG; Feng-Feng et al.	
	004	US-9746339	08-29-2017	MATTILA; Ville-Veikko et al.	
	005	US-20020107649	08-08-2002	TAKIGUCHI; Kiyoaki et al.	
	006	US-20120072166	03-22-2012	KEAL; William Kerry et al.	
	007	US-20140002843	01-02-2014	MIYAMOTO; Naruyuki et al.	
	008	US-20160182502	06-23-2016	SMITH; Ned M. et al.	

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	Cite No. ¹	Foreign Patent Document	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T ⁶
		Country Code ³ Number ⁴ Kind Code ⁵ (if known)				
		None				

Examiner Signature		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. ¹ Applicant's unique citation designation number (optional). ² See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. ³ Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). ⁴ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁵ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁶ Applicant is to place a check mark here if English language Translation is attached. 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 2 hours 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, 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 (1-800-786-9199) and select option 2.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	15/341,612
				Filing Date	11-02-2016
				First Named Inventor	Borja Ibarz Gabardos
				Art Unit	3661
				Examiner Name	Frejd, Russell Warren
Sheet	2	of	3	Attorney Docket Number	BRAIN.134A/BC201609A

NON-PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No. ¹	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,page(s),volume-issue number(s),publisher, city and/or country where published.	T ²
		None	

Examiner Signature		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. 1 Applicant's unique citation designation number (optional). 2 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 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 2 hours 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, 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 (1-800-786-9199) and select option 2.

Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	15/341,612
				Filing Date	11-02-2016
				First Named Inventor	Borja Ibarz Gabardos
				Art Unit	3661
				Examiner Name	Frejd, Russell Warren
				Attorney Docket Number	BRAIN.134A/BC201609A
Sheet	3	of	3		

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.

- ☐ A certification statement is not submitted herewith.

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	/Peter J. Gutierrez, III/	Date (YYYY-MM-DD)	2018-05-03
Name/Print	Peter J. Gutierrez, III	Registration Number	56,732

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.**

Electronic Patent Application Fee Transmittal				
Application Number:		15341612		
Filing Date:		02-Nov-2016		
Title of Invention:		SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION		
First Named Inventor/Applicant Name:		Borja Ibarz Gabardos		
Filer:		Peter John Gutierrez III/Christine McGaw		
Attorney Docket Number:		BRAIN.134A/BC201609A		
Filed as Small Entity				
Filing Fees for Utility under 35 USC 111(a)				
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	2806	1	120	120
Total in USD (\$)				120

Electronic Acknowledgement Receipt	
EFS ID:	32529210
Application Number:	15341612
International Application Number:	
Confirmation Number:	3389
Title of Invention:	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION
First Named Inventor/Applicant Name:	Borja Ibarz Gabardos
Customer Number:	132059
Filer:	Peter John Gutierrez III/Christine McGaw
Filer Authorized By:	Peter John Gutierrez III
Attorney Docket Number:	BRAIN.134A/BC201609A
Receipt Date:	03-MAY-2018
Filing Date:	02-NOV-2016
Time Stamp:	19:44:54
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$ 120
RAM confirmation Number	050418INTEFSW00005542501423
Deposit Account	501423
Authorized User	Chrissie McGaw
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)					
37 CFR 1.21 (Miscellaneous fees and charges)					
File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal Letter	Transmittal_US.pdf	70886	no	2
			bfd0d8108c005237884a2782c30ae69bc8868dbad		
Warnings:					
Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	IDS_US.pdf	110283	no	3
			05f9e47a385642a5b777d5d7449e2182b2f83804		
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
3	Fee Worksheet (SB06)	fee-info.pdf	30840	no	2
			c6dd38316e69e9ea532f6b1b9fb572ccd68757f9		
Warnings:					
Information:					
Total Files Size (in bytes):			212009		
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. <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.					

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Borja Ibarz Gabardos, et al.	)	<u>CUSTOMER NO. 132059</u>
			)	
Appl. No.	:	15/341,612	)	I hereby certify that this correspondence is
			)	being transmitted via the Office electronic
Filed	:	November 2, 2016	)	filing system in accordance with 37
			)	C.F.R. § 1.8(a)(1)(i)(C) from the Pacific
			)	Time Zone of the United States on the
			)	local date shown below.
For	:	SYSTEMS AND METHODS	)	<u>May 3, 2018</u>
		FOR DYNAMIC ROUTE	)	(Date)
		PLANNING IN AUTONOMOUS	)	
		NAVIGATION	)	<u>/Peter J. Gutierrez, III/</u>
			)	Peter J. Gutierrez, III, Reg. No. 56,732
Examiner	:	Frejd, Russell Warren	)	
			)	
Group Art Unit:		3661	)	
			)	
			)	
			)	

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

Dear Examiner:

Applicant submits herewith an IDS citing eight (8) references for consideration by the Office.

Pursuant to 37 CFR § 1.97(d), this Information Disclosure Statement is being filed after the mailing date of either a Final Action under 37 C.F.R. § 1.113, or a Notice of Allowance under 37 C.F.R. § 1.311, and is accompanied by the statement specified in 37 C.F.R. § 1.97(e), and the fee set forth in 37 C.F.R. § 1.17(p).

Pursuant to 37 C.F.R. § 1.97(e)(2), 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 § 1.56(c) more than three months prior to the filing of the Information Disclosure Statement.

App. No. : 15/341,612
Filed : November 2, 2016

Pursuant to 37 C.F.R. § 1.97(g) and (h), Applicant makes no representation that a search has been made or that the information cited is considered to be material to patentability. Additionally, inclusion on this list is not an admission that any of the cited documents are prior art in this application. Further, Applicant makes no representation regarding the completeness of this list or that better art does not exist.

Respectfully submitted,

GAZDZINSKI & ASSOCIATES, PC

Dated: May 3, 2018

By: /Peter J. Gutierrez, III/
Peter J. Gutierrez, III
Registration No. 56,732
16644 West Bernardo Drive, Suite 201
San Diego, CA 92127
Telephone: (858) 675-1670
Facsimile: (858) 675-1674

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	15/341,612
				Filing Date	11-02-2016
				First Named Inventor	Borja Ibarz Gabardos
				Art Unit	3661
				Examiner Name	Frejd, Russell Warren
				Attorney Docket Number	BRAIN.134A/BC201609A
Sheet	1	of	3		

U. S. PATENT DOCUMENTS					
Examiner Initials*	Cite No. ¹	Document Number	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		Number-Kind Code ² (if known)			
	001	US-20120109150	05-03-2012	QUAID; Arthur et al.	
	002	US-20150199458	07-16-2015	BACON; James A. et al.	
	003	US-20150283703	10-08-2015	IZHIKEVICH; Eugene M. et al.	
	004	US-20160282862	09-29-2016	DUFFLEY; Samuel et al.	
	005	US-20160309973	10-27-2016	SHEIKH; Faizan et al.	

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	Cite No. ¹	Foreign Patent Document	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T ⁶
		Country Code ³ Number ⁴ Kind Code ⁵ (if known)				
		None				

Examiner Signature		Date Considered	
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*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. ¹ Applicant's unique citation designation number (optional). ² See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. ³ Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). ⁴ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁵ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁶ Applicant is to place a check mark here if English language Translation is attached. 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 2 hours 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, 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 (1-800-786-9199) and select option 2.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	15/341,612
				Filing Date	11-02-2016
				First Named Inventor	Borja Ibarz Gabardos
				Art Unit	3661
				Examiner Name	Frejd, Russell Warren
Sheet	2	of	3	Attorney Docket Number	BRAIN.134A/BC201609A

NON-PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No. ¹	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,page(s),volume-issue number(s),publisher, city and/or country where published.	T ²
		None	

Examiner Signature		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. 1 Applicant's unique citation designation number (optional). 2 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 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 2 hours 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, 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 (1-800-786-9199) and select option 2.

Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	15/341,612
				Filing Date	11-02-2016
				First Named Inventor	Borja Ibarz Gabardos
				Art Unit	3661
				Examiner Name	Frejd, Russell Warren
				Attorney Docket Number	BRAIN.134A/BC201609A
Sheet	3	of	3		

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.

- ☐ A certification statement is not submitted herewith.

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	/Peter J. Gutierrez, III/	Date (YYYY-MM-DD)	2018-05-03
Name/Print	Peter J. Gutierrez, III	Registration Number	56,732

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.**

Electronic Patent Application Fee Transmittal				
Application Number:		15341612		
Filing Date:		02-Nov-2016		
Title of Invention:		SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION		
First Named Inventor/Applicant Name:		Borja Ibarz Gabardos		
Filer:		Peter John Gutierrez III/Chrissie McGaw		
Attorney Docket Number:		BRAIN.134A/BC201609A		
Filed as Small Entity				
Filing Fees for Utility under 35 USC 111(a)				
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	2806	1	120	120
Total in USD (\$)				120

Electronic Acknowledgement Receipt	
EFS ID:	32529240
Application Number:	15341612
International Application Number:	
Confirmation Number:	3389
Title of Invention:	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION
First Named Inventor/Applicant Name:	Borja Ibarz Gabardos
Customer Number:	132059
Filer:	Peter John Gutierrez III/Chrissie McGaw
Filer Authorized By:	Peter John Gutierrez III
Attorney Docket Number:	BRAIN.134A/BC201609A
Receipt Date:	03-MAY-2018
Filing Date:	02-NOV-2016
Time Stamp:	19:49:44
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	Transmittal Letter	Transmittal_foreign.pdf	70282 a20cf3f23e74573c6628a3553a8f3c76687ee684	no	2
Warnings:					

Information:					
2	Information Disclosure Statement (IDS) Form (SB08)	IDS_foreign.pdf	110353	no	3
			05b879451a2a5217c321f126d207042a8b295751		
Warnings:					
Information:					
This is not an USPTO supplied IDS fillable form					
3	Fee Worksheet (SB06)	fee-info.pdf	30838	no	2
			fd11f863d6d1eb7175c09edf715af92a4d3e7a04		
Warnings:					
Information:					
Total Files Size (in bytes):			211473		
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. <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.					

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	Borja Ibarz Gabardos, et al.	)	<u>CUSTOMER NO. 132059</u>
			)	
Appl. No.	:	15/341,612	)	I hereby certify that this correspondence is
			)	being transmitted via the Office electronic
Filed	:	November 2, 2016	)	filing system in accordance with 37
			)	C.F.R. § 1.8(a)(1)(i)(C) from the Pacific
			)	Time Zone of the United States on the
			)	local date shown below.
For	:	SYSTEMS AND METHODS	)	<u>May 3, 2018</u>
		FOR DYNAMIC ROUTE	)	(Date)
		PLANNING IN AUTONOMOUS	)	
		NAVIGATION	)	<u>/Peter J. Gutierrez, III/</u>
			)	Peter J. Gutierrez, III, Reg. No. 56,732
Examiner	:	Frejd, Russell Warren	)	
			)	
Group Art Unit:	:	3661	)	
			)	
			)	
			)	

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

Dear Examiner:

Applicant submits herewith an IDS citing five (5) references for consideration by the Office.

Pursuant to 37 CFR § 1.97(d), this Information Disclosure Statement is being filed after the mailing date of either a Final Action under 37 C.F.R. § 1.113, or a Notice of Allowance under 37 C.F.R. § 1.311, and is accompanied by the statement specified in 37 C.F.R. § 1.97(e), and the fee set forth in 37 C.F.R. § 1.17(p).

Pursuant to 37 C.F.R. § 1.97(e)(1), each item of information contained in the Information Disclosure Statement was first cited in a 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.

Pursuant to 37 C.F.R. § 1.97(g) and (h), Applicant makes no representation that a search has been made or that the information cited is considered to be material to patentability.

App. No. : 15/341,612
Filed : November 2, 2016

Additionally, inclusion on this list is not an admission that any of the cited documents are prior art in this application. Further, Applicant makes no representation regarding the completeness of this list or that better art does not exist.

Respectfully submitted,

GAZDZINSKI & ASSOCIATES, PC

Dated: May 3, 2018

By: /Peter J. Gutierrez, III/
Peter J. Gutierrez, III
Registration No. 56,732
16644 West Bernardo Drive, Suite 201
San Diego, CA 92127
Telephone: (858) 675-1670
Facsimile: (858) 675-1674

Electronic Patent Application Fee Transmittal				
Application Number:		15341612		
Filing Date:		02-Nov-2016		
Title of Invention:		SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION		
First Named Inventor/Applicant Name:		Borja Ibarz Gabardos		
Filer:		Peter John Gutierrez III/Christine McGaw		
Attorney Docket Number:		BRAIN.134A/BC201609A		
Filed as Small Entity				
Filing Fees for Utility under 35 USC 111(a)				
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	2806	1	120	120
Total in USD (\$)				120

Electronic Acknowledgement Receipt	
EFS ID:	32534090
Application Number:	15341612
International Application Number:	
Confirmation Number:	3389
Title of Invention:	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION
First Named Inventor/Applicant Name:	Borja Ibarz Gabardos
Customer Number:	132059
Filer:	Peter John Gutierrez III/Christine McGaw
Filer Authorized By:	Peter John Gutierrez III
Attorney Docket Number:	BRAIN.134A/BC201609A
Receipt Date:	04-MAY-2018
Filing Date:	02-NOV-2016
Time Stamp:	13:06:09
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$ 120
RAM confirmation Number	050418INTEFSW00010815501423
Deposit Account	501423
Authorized User	Chrissie McGaw
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)					
37 CFR 1.20 (Post Issuance fees)					
37 CFR 1.21 (Miscellaneous fees and charges)					
File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Fee Worksheet (SB06)	fee-info.pdf	30841	no	2
			ae76259a827e40b6ce2508f10890e48be2c5e1b7		
Warnings:					
Information:					
Total Files Size (in bytes):			30841		
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. <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.					

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: **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)

132059 7590 02/07/2018
 Gazdzinski & Associates, PC
 16644 West Bernardo Drive
 Suite 201
 San Diego, CALIFORNIA 92127

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.
15/341,612	11/02/2016	Borja Ibarz Gabardos	BRAIN 134A/BC201609A	3389

TITLE OF INVENTION: SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
REGULAR	SMALL	\$500	\$0.00	\$0.00	\$500	05/07/2018

EXAMINER	ART UNIT	CLASS-SUBCLASS
FREJD, RUSSELL WARREN	3661	701-625000

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. <u>GAZDZINSKI &</u> 2. <u>ASSOCIATES, PC</u> 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: Brain Corporation
 (B) RESIDENCE (CITY and STATE OR COUNTRY): San Diego, CA

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 credits any overpayment, to Deposit Account Number 501423 (enclose an extra copy of this form).

5. Change in Entity Status (from status indicated above)

- ☐ Applicant certifying micro entity status. See 37 CFR 1.29
☐ Applicant asserting small entity status. See 37 CFR 1.27
☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
 NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
 NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature: Peter J. Gutierrez, III Date: May 4, 2018
 Typed or printed name: Peter J. Gutierrez, III Registration No. 56,732

Electronic Patent Application Fee Transmittal				
Application Number:		15341612		
Filing Date:		02-Nov-2016		
Title of Invention:		SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION		
First Named Inventor/Applicant Name:		Borja Ibarz Gabardos		
Filer:		Peter John Gutierrez III/Christine McGaw		
Attorney Docket Number:		BRAIN.134A/BC201609A		
Filed as Small Entity				
Filing Fees for Utility under 35 USC 111(a)				
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:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL	1504	1	0	0
UTILITY APPL ISSUE FEE	2501	1	500	500
Extension-of-Time:				
Miscellaneous:				
PRINTED COPY OF PATENT - NO COLOR	8001	3	3	9
Total in USD (\$)				509

Electronic Acknowledgement Receipt	
EFS ID:	32539879
Application Number:	15341612
International Application Number:	
Confirmation Number:	3389
Title of Invention:	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION
First Named Inventor/Applicant Name:	Borja Ibarz Gabardos
Customer Number:	132059
Filer:	Peter John Gutierrez III/Christine McGaw
Filer Authorized By:	Peter John Gutierrez III
Attorney Docket Number:	BRAIN.134A/BC201609A
Receipt Date:	04-MAY-2018
Filing Date:	02-NOV-2016
Time Stamp:	17:44:44
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$509
RAM confirmation Number	050718INTEFSW00015865501423
Deposit Account	501423
Authorized User	Chrissie McGaw
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees) 37 CFR 1.20 (Post Issuance fees) 37 CFR 1.21 (Miscellaneous fees and charges)					
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)	Transmittal_.pdf	449408	no	1
			1eb1dfaf6b0a952ab1f753fd7d39792b352e1f3		
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	33999	no	2
			58a53fe8742d10d81a80edf6009e78c0c09727b7		
Warnings:					
Information:					
Total Files Size (in bytes):			483407		
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. <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.					



UNITED STATES PATENT AND TRADEMARK OFFICE

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United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/341,612	11/02/2016	Borja Ibarz Gabardos	BRAIN.134A/BC201609A	3389
132059	7590	05/16/2018	EXAMINER	
Gazdzinski & Associates, PC			FREJD, RUSSELL WARREN	
16644 West Bernardo Drive				
Suite 201				
San Diego, CALIFORNIA 92127				
UNITED STATES OF AMERICA				
ART UNIT		PAPER NUMBER		
3661				
MAIL DATE		DELIVERY MODE		
05/16/2018		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.

Corrected Notice of Allowability	Application No. 15/341,612	Applicant(s) Gabardos et al.	
	Examiner RUSSELL FREJD	Art Unit 3661	AIA Status Yes

-- 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 the IDSs received on 5/3/18.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are 1-20. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

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

Certified copies:

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.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
☐ 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)	5. ☐ Examiner's Amendment/Comment
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date <u>5/3/18 (2)</u> .	6. ☐ Examiner's Statement of Reasons for Allowance
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.	7. ☐ Other _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____.	

/RUSSELL WARREN FREJD/ Primary Examiner, Art Unit 3661	
---	--

<i>Search Notes</i> 	Application/Control No. 15/341,612	Applicant(s)/Patent Under Reexamination Gabardos et al.
	Examiner RUSSELL FREJD	Art Unit 3661

CPC - Searched*		
Symbol	Date	Examiner
G05D: 1/0214, 1/0276, 1/0088, 2201/3415	1/24/18	RF
G01C: 21/343, 21/3415	"	"
A47L: 11/4011	"	"

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
G05D: 1/0214, 1/0276, 1/0088, 2201/3415	1/24/18	RF
G01C: 21/343, 21/3415	"	"
A47L: 11/4011	"	"
WEST	"	"
UPDATE SEARCH: WEST	5/14/18	RF

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<i>Search Notes</i> 	Application/Control No. 15/341,612	Applicant(s)/Patent Under Reexamination Gabardos et al.
	Examiner RUSSELL FREJD	Art Unit 3661

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
G05D	1/0214, 1/0276, 1/0088, 2201/3415	1/24/18	RF
G01C	21/343, 21/3415	"	"
A47L	11/4011	"	"
PGPUBS TEXT SEARCH		"	"

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Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	15/341,612
				Filing Date	11-02-2016
				First Named Inventor	Borja Ibarz Gabardos
				Art Unit	3661
				Examiner Name	Frejd, Russell Warren
Sheet	1	of	3	Attorney Docket Number	BRAIN.134A/BC201609A

U. S. PATENT DOCUMENTS					
Examiner Initials*	Cite No. ¹	Document Number	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		Number-Kind Code ² (if known)			
	001	US-7212651	05-01-2007	VIOLA; Paul A. et al.	
	002	US-7576639	08-18-2009	BOYLES; Tonnie Michael et al.	
	003	US-8514236	08-20-2013	WANG; Feng-Feng et al.	
	004	US-9746339	08-29-2017	MATTILA; Ville-Veikko et al.	
	005	US-20020107649	08-08-2002	TAKIGUCHI; Kiyooki et al.	
	006	US-20120072166	03-22-2012	KEAL; William Kerry et al.	
	007	US-20140002843	01-02-2014	MIYAMOTO; Naruyuki et al.	
	008	US-20160182502	06-23-2016	SMITH; Ned M. et al.	

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	Cite No. ¹	Foreign Patent Document	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T ⁶
		Country Code ³ Number ⁴ Kind Code ⁵ (if known)				
		None				

Examiner Signature		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. ¹ Applicant's unique citation designation number (optional). ² See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. ³ Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). ⁴ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁵ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁶ Applicant is to place a check mark here if English language Translation is attached. 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 2 hours 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, 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 (1-800-786-9199) and select option 2.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /RF/

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Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	15/341,612
				Filing Date	11-02-2016
				First Named Inventor	Borja Ibarz Gabardos
				Art Unit	3661
				Examiner Name	Frejd, Russell Warren
Sheet	2	of	3	Attorney Docket Number	BRAIN.134A/BC201609A

NON-PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No. ¹	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, page(s), volume-issue number(s), publisher, city and/or country where published.	T ²
		None	

Examiner Signature	/RUSSELL FREJD/	Date Considered	05/14/2018
-----------------------	-----------------	--------------------	------------

*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. 1 Applicant's unique citation designation number (optional). 2 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 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 2 hours 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, 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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Substitute for form 1449/PTO		Complete if Known			
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)		Application Number	15/341,612		
		Filing Date	11-02-2016		
		First Named Inventor	Borja Ibarz Gabardos		
		Art Unit	3661		
		Examiner Name	Frejd, Russell Warren		
Sheet	3	of	3	Attorney Docket Number	BRAIN.134A/BC201609A

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.

- ☐ A certification statement is not submitted herewith.

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	/Peter J. Gutierrez, III/	Date (YYYY-MM-DD)	2018-05-03
Name/Print	Peter J. Gutierrez, III	Registration Number	56,732

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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Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	15/341,612
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				Art Unit	3661
				Examiner Name	Frejd, Russell Warren
Sheet	1	of	3	Attorney Docket Number	BRAIN.134A/BC201609A

U. S. PATENT DOCUMENTS					
Examiner Initials*	Cite No. ¹	Document Number	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		Number-Kind Code ² (if known)			
	001	US-20120109150	05-03-2012	QUAID; Arthur et al.	
	002	US-20150199458	07-16-2015	BACON; James A. et al.	
	003	US-20150283703	10-08-2015	IZHIKEVICH; Eugene M. et al.	
	004	US-20160282862	09-29-2016	DUFFLEY; Samuel et al.	
	005	US-20160309973	10-27-2016	SHEIKH; Faizan et al.	

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	Cite No. ¹	Foreign Patent Document	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T ⁶
		Country Code ³ Number ⁴ Kind Code ⁵ (if known)				
		None				

Examiner Signature		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. ¹ Applicant's unique citation designation number (optional). ² See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. ³ Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). ⁴ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁵ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁶ Applicant is to place a check mark here if English language Translation is attached. 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 2 hours 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, 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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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /RF/

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Substitute for form 1449/PTO INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	15/341,612
				Filing Date	11-02-2016
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				Art Unit	3661
				Examiner Name	Frejd, Russell Warren
Sheet	2	of	3	Attorney Docket Number	BRAIN.134A/BC201609A

NON-PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No. ¹	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,page(s), volume-issue number(s), publisher, city and/or country where published.	T ²
		None	

Examiner Signature	/RUSSELL FREJD/	Date Considered	05/14/2018
-----------------------	-----------------	--------------------	------------

*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. 1 Applicant's unique citation designation number (optional). 2 Applicant is to place a check mark here if English language Translation is attached. This collection of information is required by 37 CFR 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 2 hours 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, 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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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)		Application Number	15/341,612		
		Filing Date	11-02-2016		
		First Named Inventor	Borja Ibarz Gabardos		
		Art Unit	3661		
		Examiner Name	Frejd, Russell Warren		
Sheet	3	of	3	Attorney Docket Number	BRAIN.134A/BC201609A

CERTIFICATION STATEMENT

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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.

- ☐ A certification statement is not submitted herewith.

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	/Peter J. Gutierrez, III/	Date (YYYY-MM-DD)	2018-05-03
Name/Print	Peter J. Gutierrez, III	Registration Number	56,732

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.**

WEST Search History

DATE: Monday, May 14, 2018

<u>Hide?</u>	<u>Set Name</u>	<u>Query</u>	<u>Hit Count</u>
<i>Prior Art</i>			
<i>DB=PGPB,USPT; THES=ASSIGNEE; PLUR=YES; OP=ADJ</i>			
☐	L65	L55 and (interpolation same route same poses same (collision with free) same path)	0
☐	L64	L55 and (route same map same robot same travel)	0
☐	L63	L62 and (route same map same robot same travel)	0
☐	L62	L55 and (robot same sensor? same environment same object?)	2
☐	L61	L60 and (route same footprint same points)	0
☐	L60	L55 and (route same (pose or poses))	2
☐	L59	L55 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	0
☐	L58	L55 and ((autonomous guided vehicle? or AGV?) and (navigat\$ same map same environment))	0
☐	L57	L55 and (autonomous with navigation) and (dynamic with route with planning)	0
☐	L56	L55 and (autonomous with navigation) and (robot same map same environment)	0
☐	L55	L54 OR 153	18
☐	L54	(7212651 OR 7576639 OR 8514236 OR 9746339).PN. OR 20020107649 OR 20120072166 OR 20140002843 OR 20160182502	11
☐	L53	20120109150 OR 20150199458 OR 20150283703 OR 20160282862 OR 20160309973	7
☐	L37	L18 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	1
☐	L36	L18 and (route same footprint same points)	1
☐	L35	L24 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	1
☐	L34	L24 and (route same footprint same points)	1
☐	L33	L24 and (route with ((attractive near5 forces) or (repulsive near5 forces)))	1
☐	L32	L24 and (route with footprint with points)	1
☐	L31	L29 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	1
☐	L30	L29 and (route same footprint same points)	1
☐	L29	L24 and (route same (pose or poses))	16
☐	L28	L25 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	1
☐	L27	L25 and (route with ((attractive near5 forces) or (repulsive near5 forces)))	1
☐	L26	L25 and (route with footprint with points)	1

☐	L25	L24 and (route with (pose or poses))	6
☐	L24	(autonomous with navigation) and (robot same map same environment)	574
☐	L23	L19 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	1
☐	L22	L19 and (route with ((attractive near5 forces) or (repulsive near5 forces)))	1
☐	L21	L19 and (route same footprint same points)	1
☐	L20	L19 and (route with footprint with points)	1
☐	L19	L18 and (route with (pose or poses))	2
☐	L18	L5 and (autonomous with navigation) and (robot same map same environment)	145
☐	L17	L6 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	1
☐	L16	L6 and (route with ((attractive near5 forces) or (repulsive near5 forces)))	1
☐	L15	L6 and (route same footprint same points)	1
☐	L14	L6 and (route with footprint with points)	1
☐	L13	L1 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	1
☐	L12	L1 and (route with ((attractive near5 forces) or (repulsive near5 forces)))	1
☐	L11	L1 and (route same footprint same points)	1
☐	L10	L1 and (route with footprint with points)	1
☐	L9	L6 and (route same (pose or poses))	1
☐	L8	L6 and (route with (pose or poses))	1
☐	L7	Gabardos.in. and (autonomous with navigation) and (dynamic with route with planning)	1
☐	L6	L5 and (autonomous with navigation) and (dynamic with route with planning)	7
☐	L5	(((((G05D1/0214))) (((G05D1/0276))) (((G05D2201/0203)))) or (((G01C21/343))) (((G01C21/3679))) (((G01C21/3415))))).cpc.	5021
☐	L4	L1 and (interpolat\$ same route same pose?)	1
☐	L3	L1 and (route same pose?)	2
☐	L2	L1 and (route with pose?)	1
☐	L1	(autonomous with navigation) and (dynamic with route with planning)	29

*Interference**DB=PGPB,USPT; THES=ASSIGNEE; PLUR=YES; OP=ADJ*

☐	L52	L49 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	0
☐	L51	L49 and (route same footprint same points)	0
☐	L50	L49 and (route same (pose or poses))	0
☐	L49	((autonomous guided vehicle ? or AGV ?) and (navigat \$ same map same environment))	39
☐	L48	L43 and (route with ((attractive near5 forces) or (repulsive near5 forces))).clm.	1
☐	L47	L43 and (route with footprint with points).clm.	1
☐	L46	L40 and (route same ((attractive near5 forces) or (repulsive near5 forces))).clm.	1

☐	L45	L40 and (route same footprint same points).clm.	1
☐	L44	L43 and (route same (pose or poses)).clm.	1
☐	L43	(autonomous with navigation) and (robot same map same environment).clm.	69
☐	L42	L40 and (route same ((attractive near5 forces) or (repulsive near5 forces)))	1
☐	L41	L40 and (route same footprint same points)	1
☐	L40	L39 and (route same (pose or poses))	4
☐	L39	L38 and (autonomous with navigation) and (robot same map same environment)	197
☐	L38	((G05D1/0214) (G05D1/0276) (G05D2201/0203) (G05D1/0088)) or ((G01C21/343) (G01C21/3679) (G01C21/3415))).cpc.	7146

END OF SEARCH HISTORY



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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/341,612	06/19/2018	10001780	BRAIN.134A/BC201609A	3389

132059 7590 05/30/2018
Gazdzinski & Associates, PC
16644 West Bernardo Drive
Suite 201
San Diego, CA 92127

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 14 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):

Borja Ibarz Gabardos, La Jolla, CA;
BRAIN CORPORATION, San Diego, CA
Jean-Baptiste Passot, Solana Beach, CA;

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Doc Code: PA..

Document Description: Power of Attorney

PTO/AIA/82A (07-13)

Approved for use through 09/30/2025. OMB 0651-0035

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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REGISTERED PRACTITIONERS**

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Application Number	15/341,612
Filing Date	11/02/2016
First Named Inventor	Borja Ibarz Gabardos
Title	SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION
Art Unit	3661
Examiner Name	RUSSELL WARREN FREJD
Attorney Docket Number	035471.076US1

SIGNATURE of Applicant or Patent Practitioner

Signature	/Sidharth Kapoor/	Date (Optional)	
Name	Sidharth Kapoor	Registration Number	68,159
Title (if Applicant is a juristic entity)			
Applicant Name (if Applicant is a juristic entity)			
NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.			
☒ *Total of <u>1</u> forms are submitted.			

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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)



I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above:

197519

OR



I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:



The address associated with the above-mentioned Customer Number

OR



The address associated with Customer Number:

OR



Firm or
Individual Name

Address

City

State

Zip

Country

Telephone

Email

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

Brain Corporation



Inventor or Joint Inventor (title not required below)



Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)



Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)



Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature

Andy Ng

Date (Optional)

Name

Andy Ng

Title

General Counsel

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.



Total of 1 forms are submitted.

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION # 15/341,612	RECEIPT DATE / TIME 01/08/2025 02:16:40 AM Z ET	ATTORNEY DOCKET # BRAIN.134A/BC201609A
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Title of Invention

SYSTEMS AND METHODS FOR DYNAMIC ROUTE PLANNING IN AUTONOMOUS NAVIGATION

Application Information

APPLICATION TYPE	Utility - Nonprovisional Application under 35 USC 111(a)	PATENT #	10001780
CONFIRMATION #	3389	FILED BY	Sidharth Kapoor
PATENT CENTER #	68642680	FILING DATE	11/02/2016
CUSTOMER #	132059	FIRST NAMED INVENTOR	Borja Ibarz Gabardos
CORRESPONDENCE ADDRESS	-	AUTHORIZED BY	-

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
15-341612- POA.pdf	2	Power of Attorney	415 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
15-341612- POA.pdf	ABD2B7DA73489CE58B5D94C23D4DD3725D418B47F6678794 47D25FDF8FBC4D4126E748737BA2EB08C93B52341041D2C54 8FDBFF278B0624BE5A39992316161A8

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 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 NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/341,612	11/02/2016	Borja Ibarz Gabardos	035471.076US1

CONFIRMATION NO. 3389

POA ACCEPTANCE LETTER



OC000000083692689

197519
Pierson Ferdinand, LLP
1101 Pennsylvania Avenue N.W.
Suite 300
Washington, DC 20005

Date Mailed: 01/30/2025

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 01/08/2025.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at (571) 272-4000 or (571) 272-4200 or 1-888-786-0101.

/ggasgedom/



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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
15/341,612	11/02/2016	Borja Ibarz Gabardos	BRAIN.134A/BC201609A

CONFIRMATION NO. 3389

POWER OF ATTORNEY NOTICE



OC000000083692633

132059
Gazdzinski & Associates, PC
16644 West Bernardo Drive
Suite 300
San Diego, CA 92127

Date Mailed: 01/30/2025

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 01/08/2025.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at (571) 272-4000 or (571) 272-4200 or 1-888-786-0101.

/ggasgedom/