

Emanuel-Prov (Ex.1006) Excerpts Chart

Ground 1	
Emanuel	
Ex.1006, 1	“A method and apparatus to provide accurate and precise position and azimuth determination of an object, in which a machine vision image acquisition apparatus acquires an image, processes the acquired image, and computes the position and orientation azimuth of the object.”
Ex.1006, 3	“Position and azimuth are determined by acquiring images of position markers which are placed at known locations in or near the coordinate space, i.e., the region of interest. Subsequent image analysis is performed by commercially available machine vision equipment consisting of one or more cameras and digital processing device(s).”
Ex.1006, 6.	“Machine readable symbols, such as one-dimensional or two dimensional barcodes, encode the identity of each position marker of the coordinate reference, allowing automated devices such as barcode scanners 7 (Figure 1) to read the identities of the symbols.”
Ex.1006, 4.	“Figure 1 shows the overall system of one embodiment in accordance with the present invention and identifies key elements of a coordinate, or position, reference 1, position markers 2, 3 and machine vision system data processing device 5.”
Reasons to Combine Emanuel and Ihara	
Ex.1006, 7-8.	“The position markers 2, 3 on the coordinate reference 1 identify coordinate locations. Each marker is comprised of human readable text, a barcode, and one or more position symbols. Lift truck vehicle, i.e., the object to be located, 6 has affixed to it a machine vision camera 4 and a computational device 5, such as a portable computer. In this example, the lift truck has freedom of motion in two dimensions within the operating area. To store an item, the lift truck acquires a parcel, proceeds to a particular location within the designated area and deposits the item. The position and azimuth determination system is active at all times when the vehicle is within the designated area beneath the position reference 1.” “The images from the camera 4 may be captured continuously, or on command, such as when the vehicle stops, or at a time chosen by the operator.”

	“The preferred embodiment applies a commercial machine vision system such as Model 5100 or Model 5400 from Cognex, Incorporated. "In-Sight Explorer™" software provided with this system offers a wide array of feature extraction, mathematical, geometric, object identification, and barcode symbol decoding subroutines.”
Ex.1006, 9.	“Once the image has passed preprocessing, it is analyzed 24 to locate all position markers.”
[1.0]	
Ex.1006, 1.	“The invention presents a method and apparatus for determining position and azimuth of an object in a three-dimensional space.” “Determining position and/or azimuth of an object within a defined area or volume is an engineering problem that has brought about many solutions, each dedicated toward solving the specific requirements of an application.” “A well known problem exists, for example, where labels or imprinting, especially bar code labels or imprinted bar codes, denote floor positions within a designated storage area. Floor markings can become obscured by stored objects and are subject to physical damage which can reduce or destroy their readability. This invention overcomes such shortcomings by providing position reference near to the designated area, but not on it.”
Ex.1006, 5.	“The method and apparatus of the present invention present a general solution to the problem of object location and may be applied to many fields of use.”
Ex.1006, 3.	“The present invention provides a method and an apparatus for determining position and azimuth within a predefined coordinate system, such as a designated area or volume.”
Ex. 1006, 17.	“A method and apparatus for determining position and azimuth of an object within a predetermined area or volume is disclosed. Position markers, encoded with identity and rotational information are viewed with a camera, images captured and processed, and the position and azimuth of the object are calculated.”
Ex.1006, 8.	“Lift truck vehicle, i.e., the object to be located, 6 has affixed to it a machine vision camera 4 and a computational device 5, such as a portable computer.”

	“The following functional steps analyze the image within the field of view (FOV), decode the position markers' encoded position information, calculate X-Y coordinates in pixel space, and convert the results to actual "real space" positions.” “The preferred embodiment applies a commercial machine vision system such as Model 5100 or Model 5400 from Cognex, Incorporated. "In-Sight Explorer™" software provided with this system offers a wide array of feature extraction, mathematical, geometric, object identification, and barcode symbol decoding subroutines.”
[1.1]	
Ex.1006, 9.	“The camera 4 continuously, or on command, captures analog and/or digital images of the position markers 2,3 of the coordinate reference 1. One or more position markers 2,3 are partially or fully visible within the camera's field of view (FOV) at any given time. Once an image is captured, the software analyzes it as follows:”
Ex.1006, 3.	“Position and azimuth are determined by acquiring images of position markers which are placed at known locations in or near the coordinate space, i.e., the region of interest.”
Ex.1006, 6.	“Machine readable symbols, such as one-dimensional or two dimensional barcodes, encode the identity of each position marker of the coordinate reference, allowing automated devices such as barcode scanners 7 (Figure 1) to read the identities of the symbols.”
Ex.1006, 7.	“The position markers 2, 3 are imprinted or attached to the coordinate reference 1 in a prescribed pattern; for example, in rows and columns corresponding to a desired coordinate plan for the designated area. The position marker 2, shown in Figure 4, comprises three components: text 10 to aid manual identification of each grid location (example: "AA01" = Row "AA", Column "01"), a one-dimensional (i.e., linear) barcode 11 which encodes the marker location "AA01" in any of several common bar code symbologies; and position symbols 9 which serve as position and angular orientation references (i.e., optical targets) for the machine vision system.”
Ex.1006, 10.	“The Position Marker Look-Up Table (LUT) 31 is a database containing actual X, Y, Z coordinate positions and actual azimuth angles that are recorded for all position markers at the time of coordinate reference manufacture. Coordinate values are recorded in

	"real space", such as feet or meters and angles in degrees, such as a compass heading. Decoded marker position data 28 is used 32 to search LUT 31. Actual (i.e., real space) X, Y, Z coordinates for the chosen position marker are returned from LUT 31, and are stored as the approximate X, Y, Z position 33. Pixel coordinates of Key Points B and C, 30, are used to calculate angle CBD, 34, the rotation angle of the position marker relative to the FOV, from which the approximate (uncorrected) azimuth 36 is calculated in step 35."
Ex.1006, 13.	"12. The method of claim 11, wherein an approximate position of the object is determined by retrieving the coordinates of the decoded identity of the position marker from said look-up-table"
[1.2]	
Ex.1006, 10.	"Since the distance AB on the position marker 3 is known and the focal length of the lens of the camera 4 is known, the distance from the camera 4 to the position marker can be determined from the ratio of the length of Line Segment AB in the image to the distance AB on the position marker 3. Since the Z coordinate of the position marker 3 is also known, the Z coordinate of the object may be readily calculated. The Z coordinates are stored in memory 43."
[1.3]	
Ex.1006, 8.	"The following functional steps analyze the image within the field of view (FOV), decode the position markers' encoded position information, calculate X-Y coordinates in pixel space, and convert the results to actual "real space" positions."
Ex.1006, 9.	"The camera 4 continuously, or on command, captures analog and/or digital images of the position markers 2,3 of the coordinate reference 1. One or more position markers 2,3 are partially or fully visible within the camera's field of view (FOV) at any given time. Once an image is captured, the software analyzes it as follows:" "If a single marker is found, selected image data are passed to a decoder 27; if multiple markers are present, image data are passed to a readability test 26, which determines which marker is most readable and passes the selected image data to the decoder 27. Alternatively, the readability test may select the marker closest to the center of the image and pass that image data to the decoder 27. Decoder 27 "reads" the encoded unique identification code of the position marker and returns alphanumeric data which are stored as decoded position marker data 28."

Ex.1006, 3-4.	“The position and azimuth of one or more position markers relative to a camera's view are determined by the machine vision equipment; the position and azimuth in "real" space are then computed from machine vision data using a series of programmed instructions which translate the relative positional and azimuth data to "real" coordinates.”
Ex.1006, 7.	“The position markers 2, 3 are imprinted or attached to the coordinate reference 1 in a prescribed pattern; for example, in rows and columns corresponding to a desired coordinate plan for the designated area. The position marker 2, shown in Figure 4, comprises three components: text 10 to aid manual identification of each grid location (example: "AA01" = Row "AA", Column "01"), a one-dimensional (i.e., linear) barcode 11 which encodes the marker location "AA01" in any of several common bar code symbologies; and position symbols 9 which serve as position and angular orientation references (i.e., optical targets) for the machine vision system. The position marker 3 of Figure 5 provides information equivalent to that of position marker 2, comprising text 10 and a non-concentric code, a two dimensional barcode 12, which serves the dual purpose of encoding the marker identity in any one of several two-dimensional barcode symbologies and serves as a position and angular orientation reference.”
Ex.1006, 10.	“The Position Marker Look-Up Table (LUT) 31 is a database containing actual X, Y, Z coordinate positions and actual azimuth angles that are recorded for all position markers at the time of coordinate reference manufacture. Coordinate values are recorded in "real space", such as feet or meters and angles in degrees, such as a compass heading. Decoded marker position data 28 is used 32 to search LUT 31. Actual (i.e., real space) X, Y, Z coordinates for the chosen position marker are returned from LUT 31, and are stored as the approximate X, Y, Z position 33. Pixel coordinates of Key Points B and C, 30, are used to calculate angle CBD, 34, the rotation angle of the position marker relative to the FOV, from which the approximate (uncorrected) azimuth 36 is calculated in step 35.”
Ex.1006, 12.	“3. The method of claim 2, further comprising the step of translating the information encoded in the selected position marker within the field of view to a coordinate location of the selected marker and then calculating the coordinate location of the object within the predefined coordinate space.”

Ex.1006, 13-14.	“11. The method of claim 7, wherein a look-up-table containing actual X and Y coordinates and azimuth corrections of all position markers within the coordinate reference is maintained.” “12. The method of claim 11, wherein an approximate position of the object is determined by retrieving the coordinates of the decoded identity of the position marker from said look-up-table.” “17. The method of claim 16 wherein the adjusted position of the object is corrected to a true position by applying small variations recorded in the look-up table for the position marker.” “19. The method of claim 18, wherein a correction is made to the approximate azimuth angle by retrieving stored azimuth data for the decoded position marker from the look-up table and adjusting the azimuth accordingly.
[1.4]	
Ex.1006, 10.	“Angle CBD is illustrated in Figure 8 and shown in the context of the FOV in Figure 9. X and Y values of pixel coordinates A and C, 30, are summed and divided by two (37) to establish Point E (Figure 10), the midpoint of line segment AC, and the center of the position marker. Point E coordinates are used to calculate: (a) angle OE, Figure 11, the radial angle between the center of the image and the center of the position marker; and (b) the length of line segment OE, which is equal to the radial distance from the center of the image (center of the camera) 0 to the center of the position marker E. Once these two values have been established, it is possible to calculate 40 a more accurate X, Y position using plane geometry. The results of this calculation are stored in memory 41.” “Adjusted Position in Pixels 41 is converted to real space values by knowing the ratio of pixels to real units of measure (e.g.; 240 pixels per foot).”
[1.5]	
Ex.1006, 8.	“The following functional steps analyze the image within the field of view (FOV), decode the position markers' encoded position information, calculate X-Y coordinates in pixel space, and convert the results to actual "real space" positions.”
Ex.1006, 10.	“To determine the Z coordinate and position, Key Points A and B are used to calculate the length of Line Segment AB of the image. Since the distance AB on the position marker 3 is known and the focal length of the lens of the camera 4 is known, the distance from the

	camera 4 to the position marker can be determined from the ratio of the length of Line Segment AB in the image to the distance AB on the position marker 3. Since the Z coordinate of the position marker 3 is also known, the Z coordinate of the object may be readily calculated. The Z coordinates are stored in memory 43.” “The Position Marker Look-Up Table (LUT) 31 is a database containing actual X, Y, Z coordinate positions and actual azimuth angles that are recorded for all position markers at the time of coordinate reference manufacture. Coordinate values are recorded in "real space", such as feet or meters and angles in degrees, such as a compass heading. Decoded marker position data 28 is used 32 to search LUT 31. Actual (i.e., real space) X, Y, Z coordinates for the chosen position marker are returned from LUT 31, and are stored as the approximate X, Y, Z position 33. Pixel coordinates of Key Points B and C, 30, are used to calculate angle CBD, 34, the rotation angle of the position marker relative to the FOV, from which the approximate (uncorrected) azimuth 36 is calculated in step 35.” “Angle CBD is illustrated in Figure 8 and shown in the context of the FOV in Figure 9. X and Y values of pixel coordinates A and C, 30, are summed and divided by two (37) to establish Point E (Figure 10), the midpoint of line segment AC, and the center of the position marker. Point E coordinates are used to calculate: (a) angle OE, Figure 11, the radial angle between the center of the image and the center of the position marker; and (b) the length of line segment OE, which is equal to the radial distance from the center of the image (center of the camera) 0 to the center of the position marker E. Once these two values have been established, it is possible to calculate 40 a more accurate X, Y position using plane geometry. The results of this calculation are stored in memory 41. To determine the Z coordinate and position, Key Points A and B are used to calculate the length of Line Segment AB of the image. Since the distance AB on the position marker 3 is known and the focal length of the lens of the camera 4 is known, the distance from the camera 4 to the position marker can be determined from the ratio of the length of Line Segment AB in the image to the distance AB on the position marker 3. Since the Z coordinate of the position marker 3 is also known, the Z coordinate of the object may be readily calculated. The Z coordinates are stored in memory 43.”
Ex.1006, 13-14.	“11. The method of claim 7, wherein a look-up-table containing actual X and Y coordinates and azimuth corrections of all position markers within the coordinate reference is maintained.”

	“12. The method of claim 11, wherein an approximate position of the object is determined by retrieving the coordinates of the decoded identity of the position marker from said look-up-table.” “17. The method of claim 16 wherein the adjusted position of the object is corrected to a true position by applying small variations recorded in the look-up table for the position marker.” “19. The method of claim 18, wherein a correction is made to the approximate azimuth angle by retrieving stored azimuth data for the decoded position marker from the look-up table and adjusting the azimuth accordingly.”
[2.0]	
Ex.1006, 10.	“Angle CBD is illustrated in Figure 8 and shown in the context of the FOV in Figure 9. X and Y values of pixel coordinates A and C, 30, are summed and divided by two (37) to establish Point E (Figure 10), the midpoint of line segment AC, and the center of the position marker. Point E coordinates are used to calculate: (a) angle OE, Figure 11, the radial angle between the center of the image and the center of the position marker; and (b) the length of line segment OE, which is equal to the radial distance from the center of the image (center of the camera) 0 to the center of the position marker E.”
[2.1]	
Ex.1006, 6.	3. Machine recognizable symbols are arranged on the position markers of the coordinate reference in a predetermined pattern at predetermined positions, allowing machine vision technology to determine position by analyzing the shapes and symbols on the position markers. Exact position coordinates and azimuth (i.e., the directional orientation of the object) are determined through computer programmed instructions and are based upon geometric analysis of the acquired image data.”
[5.0]	
Ex.1006, 15	“a) a plurality of unique position markers arranged in at predetermined positional locations within the coordinate space such that at least one position marker is within view of the object;”
Ex.1006, 1.	“Determining position and/or azimuth of an object within a defined area or volume is an engineering problem that has brought about many solutions, each dedicated toward solving the specific requirements of an application. The determination of location for items placed in indoor or outdoor storage areas presents practical

	problems. An object's position must be recorded to facilitate returning to that location for later retrieval. Outdoor storage yards, warehouse floors, storerooms, factory floors, ship's holds, railcars, and truck trailers share this need.”
Ex.1006, 7.	“The position markers 2, 3 are imprinted or attached to the coordinate reference 1 in a prescribed pattern; for example, in rows and columns corresponding to a desired coordinate plan for the designated area”
Ex.1006, 3.	“In a preferred embodiment, the processing step c) selects the position marker nearest to the center of the image and uses the selected position marker for the calculation of step d). Alternatively, more than one position marker may be selected, and the position and azimuth orientation of the object may be calculated for each selected position marker to verify the calculation and improve the precision of the position and azimuth determination.”
[5.1]	
Ex.1006, 12.	“The method of claim 1, wherein the processing of the acquired image in step c) comprises the decoding of a one- or two-dimensional barcode, and wherein the decoded data identifies the position marker.”
[7.0]	
Ex.1006, 9.	“In the case of the position marker 2 of Figure 4, having a one-dimensional barcode, the decoder 27 "reads" the encoded unique identification code of the position marker and returns alphanumeric data which are stored as decoded position marker data 28. Selected image data for a single marker are also passed to position marker key point locator 29 which analyzes image data to locate the geometric positional references 9. The key points for this position marker are, for example, a pair of corresponding apexes of the triangular positional references 9.”
Ex.1006, 10.	“The Position Marker Look-Up Table (LUT) 31 is a database containing actual X, Y, Z coordinate positions and actual azimuth angles that are recorded for all position markers at the time of coordinate reference manufacture. Coordinate values are recorded in "real space", such as feet or meters and angles in degrees, such as a compass heading. Decoded marker position data 28 is used 32 to search LUT 31. Actual (i.e., real space) X, Y, Z coordinates for the chosen position marker are returned from LUT 31, and are stored as the approximate X, Y, Z position 33. Pixel coordinates of Key Points B and C, 30, are used to calculate angle CBD, 34, the rotation angle

	of the position marker relative to the FOV, from which the approximate (uncorrected) azimuth 36 is calculated in step 35.”
Ex.1006, 3-4.	“The position and azimuth of one or more position markers relative to a camera's view are determined by the machine vision equipment; the position and azimuth in "real" space are then computed from machine vision data using a series of programmed instructions which translate the relative positional and azimuth data to "real" coordinates.”
Ex.1006, 8.	“The following functional steps analyze the image within the field of view (FOV), decode the position markers' encoded position information, calculate X-Y coordinates in pixel space, and convert the results to actual "real space" positions.”
Ex.1006, 12.	“The method of claim 2, further comprising the step of translating the information encoded in the selected position marker within the field of view to a coordinate location of the selected marker and then calculating the coordinate location of the object within the predefined coordinate space.”
Ex.1006, 13.	“The method of claim 11, wherein an approximate position of the object is determined by retrieving the coordinates of the decoded identity of the position marker from said look-up-table”
Ex.1006, 17.	“A method and apparatus for determining position and azimuth of an object within a predetermined area or volume is disclosed. Position markers, encoded with identity and rotational information are viewed with a camera, images captured and processed, and the position and azimuth of the object are calculated.”
[8.0]	
Ex.1006, 1.	“The invention presents a method and apparatus for determining position and azimuth of an object in a three-dimensional space.” “Determining position and/or azimuth of an object within a defined area or volume is an engineering problem that has brought about many solutions, each dedicated toward solving the specific requirements of an application.” “A well known problem exists, for example, where labels or imprinting, especially bar code labels or imprinted bar codes, denote floor positions within a designated storage area. Floor markings can become obscured by stored objects and are subject to physical damage which can reduce or destroy their readability. This invention

	overcomes such shortcomings by providing position reference near to the designated area, but not on it.”
Ex.1006, 3.	“The present invention provides a method and an apparatus for determining position and azimuth within a predefined coordinate system, such as a designated area or volume.”
[8.1]	
Ex.1006, 9.	“The camera 4 continuously, or on command, captures analog and/or digital images of the position markers 2,3 of the coordinate reference 1. One or more position markers 2,3 are partially or fully visible within the camera's field of view (FOV) at any given time. Once an image is captured, the software analyzes it as follows:”
Ex.1006, 3.	“The present invention provides a method and an apparatus for determining position and azimuth within a predefined coordinate system, such as a designated area or volume.”
Ex.1006, 6.	“Machine readable symbols, such as one-dimensional or two dimensional barcodes, encode the identity of each position marker of the coordinate reference, allowing automated devices such as barcode scanners 7 (Figure 1) to read the identities of the symbols.”
[8.2]	
Ex.1006, 9.	“The camera 4 continuously, or on command, captures analog and/or digital images of the position markers 2,3 of the coordinate reference 1. One or more position markers 2,3 are partially or fully visible within the camera's field of view (FOV) at any given time. Once an image is captured, the software analyzes it as follows:”
Ex.1006, 10.	“Since the distance AB on the position marker 3 is known and the focal length of the lens of the camera 4 is known, the distance from the camera 4 to the position marker can be determined from the ratio of the length of Line Segment AB in the image to the distance AB on the position marker 3. Since the Z coordinate of the position marker 3 is also known, the Z coordinate of the object may be readily calculated. The Z coordinates are stored in memory 43.”
[8.3]	
Ex.1006, 8.	“The following functional steps analyze the image within the field of view (FOV), decode the position markers' encoded position information, calculate X-Y coordinates in pixel space, and convert the results to actual "real space" positions.”

Ex.1006, 9.	“If a single marker is found, selected image data are passed to a decoder 27; if multiple markers are present, image data are passed to a readability test 26, which determines which marker is most readable and passes the selected image data to the decoder 27.
Ex.1006, 10.	“Angle CBD is illustrated in Figure 8 and shown in the context of the FOV in Figure 9. X and Y values of pixel coordinates A and C, 30, are summed and divided by two (37) to establish Point E (Figure 10), the midpoint of line segment AC, and the center of the position marker. Point E coordinates are used to calculate: (a) angle OE, Figure 11, the radial angle between the center of the image and the center of the position marker; and (b) the length of line segment OE, which is equal to the radial distance from the center of the image (center of the camera) 0 to the center of the position marker E. Once these two values have been established, it is possible to calculate 40 a more accurate X, Y position using plane geometry. The results of this calculation are stored in memory 41.”
[8.4]	
Ex.1006, 1.	“A method and apparatus to provide accurate and precise position and azimuth determination of an object, in which a machine vision image acquisition apparatus acquires an image, processes the acquired image, and computes the position and orientation azimuth of the object.” “The invention presents a method and apparatus for determining position and azimuth of an object in a three-dimensional space.” “Determining position and/or azimuth of an object within a defined area or volume is an engineering problem that has brought about many solutions, each dedicated toward solving the specific requirements of an application. The determination of location for items placed in indoor or outdoor storage areas presents practical problems. An object's position must be recorded to facilitate returning to that location for later retrieval. Outdoor storage yards, warehouse floors, storerooms, factory floors, ship's holds, railcars, and truck trailers share this need.”
Ex.1006, 3-4.	“The position and azimuth of one or more position markers relative to a camera's view are determined by the machine vision equipment; the position and azimuth in "real" space are then computed from machine vision data using a series of programmed instructions

	which translate the relative positional and azimuth data to "real" coordinates.”
Ex.1006, 9.	““The camera 4 continuously, or on command, captures analog and/or digital images of the position markers 2,3 of the coordinate reference 1. One or more position markers 2,3 are partially or fully visible within the camera's field of view (FOV) at any given time. Once an image is captured, the software analyzes it as follows:”
[10.0]	
Ex.1006, 10.	“The Position Marker Look-Up Table (LUT) 31 is a database containing actual X, Y, Z coordinate positions and actual azimuth angles that are recorded for all position markers at the time of coordinate reference manufacture. Coordinate values are recorded in "real space", such as feet or meters and angles in degrees, such as a compass heading. Decoded marker position data 28 is used 32 to search LUT 31. Actual (i.e., real space) X, Y, Z coordinates for the chosen position marker are returned from LUT 31, and are stored as the approximate X, Y, Z position 33. Pixel coordinates of Key Points B and C, 30, are used to calculate angle CBD, 34, the rotation angle of the position marker relative to the FOV, from which the approximate (uncorrected) azimuth 36 is calculated in step 35.”
Ex.1006, 13-14.	“11. The method of claim 7, wherein a look-up-table containing actual X and Y coordinates and azimuth corrections of all position markers within the coordinate reference is maintained.” “12. The method of claim 11, wherein an approximate position of the object is determined by retrieving the coordinates of the decoded identity of the position marker from said look-up-table.” “17. The method of claim 16 wherein the adjusted position of the object is corrected to a true position by applying small variations recorded in the look-up table for the position marker.” “19. The method of claim 18, wherein a correction is made to the approximate azimuth angle by retrieving stored azimuth data for the decoded position marker from the look-up table and adjusting the azimuth accordingly.”
Ground 2	
Reasons to Combine Emanuel with Tanaka	

Ex.1006, 1	“A method and apparatus to provide accurate and precise position and azimuth determination of an object, in which a machine vision image acquisition apparatus acquires an image, processes the acquired image, and computes the position and orientation azimuth of the object.” “Determining position and/or azimuth of an object within a defined area or volume is an engineering problem that has brought about many solutions, each dedicated toward solving the specific requirements of an application.” “The determination of location for items placed in indoor or outdoor storage areas presents practical problems. An object's position must be recorded to facilitate returning to that location for later retrieval. Outdoor storage yards, warehouse floors, storerooms, factory floors, ship's holds, railcars, and truck trailers share this need. Many methods are used to record objects' positions, including grids, aisles, or lanes painted on flooring or pavement, vertical stanchions such as light posts labeled to identify storage regions, or markers placed on area boundaries or perimeters. These methods are aimed at providing position identification for human use, and all suffer from deficiencies.”
Ex.1006, 2.	“The present invention provides a reliable and accurate method and apparatus that can be used in many situations. The present invention is believed suitable for stationary or mobile objects, slow or fast motion, incremental or continuous measurement, indoor or outdoor use, and can serve as the sensory apparatus and method for a guidance system, navigation system, or position monitoring system.”
Ex.1006, 16.	“The apparatus of claim 36, wherein the image acquisition system comprises a machine vision system, the machine vision system comprising a camera, a light source, and image capture electronics”
Ex.1006, 9.	“In the case of the position marker 2 of Figure 4, having a one-dimensional barcode, the decoder 27 "reads" the encoded unique identification code of the position marker and returns alphanumeric data which are stored as decoded position marker data 28. Selected image data for a single marker are also passed to position marker key point locator 29 which analyzes image data to locate the geometric positional references 9. The key points for this position marker are, for example, a pair of corresponding apexes of the triangular positional references 9.”

[3.0]	
Ex.1006, 10.	“Since the distance AB on the position marker 3 is known and the focal length of the lens of the camera 4 is known, the distance from the camera 4 to the position marker can be determined from the ratio of the length of Line Segment AB in the image to the distance AB on the position marker 3. Since the Z coordinate of the position marker 3 is also known, the Z coordinate of the object may be readily calculated. The Z coordinates are stored in memory 43.”
Ground 3	
Reasons to combine Emanuel with deVos	
Ex.1006, 1	“A method and apparatus to provide accurate and precise position and azimuth determination of an object, in which a machine vision image acquisition apparatus acquires an image, processes the acquired image, and computes the position and orientation azimuth of the object.”
Ex.1006, 3.	“Alternatively, more than one position marker may be selected, and the position and azimuth orientation of the object may be calculated for each selected position marker to verify the calculation and improve the precision of the position and azimuth determination.”
[6.0]	
Ex.1006, 3.	“In a preferred embodiment, the processing step c) selects the position marker nearest to the center of the image and uses the selected position marker for the calculation of step d). Alternatively, more than one position marker may be selected, and the position and azimuth orientation of the object may be calculated for each selected position marker to verify the calculation and improve the precision of the position and azimuth determination”
[12.0]	
Ex.1006, 9	“The camera 4 continuously, or on command, captures analog and/or digital images of the position markers 2,3 of the coordinate reference 1. One or more position markers 2,3 are partially or fully visible within the camera's field of view (FOV) at any given time. Once an image is captured, the software analyzes it as follows:” “Image data 20 is manipulated by preprocessing routines 21 to enhance image features such as sharpness, contrast, and brightness. The resulting processed image is tested 22 and returned for additional processing 23 if not adequate for interpretation. Once the

	image has passed preprocessing, it is analyzed 24 to locate all position markers. This stage determines whether single or multiple position markers appear within the FOV, and superfluous image data such as position marker printed text, and background objects such as the coordinate reference net are discarded or ignored. Position markers 2,3 found fully visible within the FOV are analyzed for readability 25.”
Ground 4	
Reasons to combine Emanuel and Sheynblat	
Ex.1006, 8	“Contemporary machine vision technology offers sophisticated image processing capabilities which can be applied to a multitude of tasks such as presence or absence detection, dimensional measurement, and object shape identification. Machine vision systems are typically comprised of a video camera, a computing device, and a set of software routines which are provided by the machine vision vendor. The equipment is commercially available and suitable for industrial environments”
Ex.1006, 4.	“In an exemplary embodiment, image processing equipment and data reduction equipment are attached to the object, such as a vehicle. Alternate embodiments may provide local image capture and transmission of the image information for remote processing.”
[11.0]	
Ex.1006, 10.	“The Position Marker Look-Up Table (LUT) 31 is a database containing actual X, Y, Z coordinate positions and actual azimuth angles that are recorded for all position markers at the time of coordinate reference manufacture. Coordinate values are recorded in "real space", such as feet or meters and angles in degrees, such as a compass heading. Decoded marker position data 28 is used 32 to search LUT 31. Actual (i.e., real space) X, Y, Z coordinates for the chosen position marker are returned from LUT 31, and are stored as the approximate X, Y, Z position 33. Pixel coordinates of Key Points B and C, 30, are used to calculate angle CBD, 34, the rotation angle of the position marker relative to the FOV, from which the approximate (uncorrected) azimuth 36 is calculated in step 35.”
Ex.1006, 4.	“In an exemplary embodiment, image processing equipment and data reduction equipment are attached to the object, such as a

	vehicle. Alternate embodiments may provide local image capture and transmission of the image information for remote processing.”
Ex.1006, 13-14.	“11. The method of claim 7, wherein a look-up-table containing actual X and Y coordinates and azimuth corrections of all position markers within the coordinate reference is maintained.” “12. The method of claim 11, wherein an approximate position of the object is determined by retrieving the coordinates of the decoded identity of the position marker from said look-up-table.” “17. The method of claim 16 wherein the adjusted position of the object is corrected to a true position by applying small variations recorded in the look-up table for the position marker.” “19. The method of claim 18, wherein a correction is made to the approximate azimuth angle by retrieving stored azimuth data for the decoded position marker from the look-up table and adjusting the azimuth accordingly.
Ground 5	
[8.1]	
Ex.1006, 9	“The camera 4 continuously, or on command, captures analog and/or digital images of the position markers 2,3 of the coordinate reference 1. One or more position markers 2,3 are partially or fully visible within the camera's field of view (FOV) at any given time. Once an image is captured, the software analyzes it as follows:” “In the case of the position marker 2 of Figure 4, having a one-dimensional barcode, the decoder 27 "reads" the encoded unique identification code of the position marker and returns alphanumeric data which are stored as decoded position marker data 28.” “If a single marker is found, selected image data are passed to a decoder 27; if multiple markers are present, image data are passed to a readability test 26, which determines which marker is most readable and passes the selected image data to the decoder 27. Alternatively, the readability test may select the marker closest to the center of the image and pass that image data to the decoder 27. Decoder 27 "reads" the encoded unique identification code of the position marker and returns alphanumeric data which are stored as decoded position marker data 28. An example of an encoded two dimensional position marker is shown in Figure 6. Selected image data for a single marker are also passed to position marker key point locator 29 which analyzes image data to locate key points A, 8, and

	C of the position marker symbol (Figure 7). Key points are then stored 30 as pixel coordinates.”
Ex.1006, 4.	“Position and azimuth are determined by acquiring images of position markers which are placed at known locations in or near the coordinate space, i.e., the region of interest. Subsequent image analysis is performed by commercially available machine vision equipment consisting of one or more cameras and digital processing device(s). The position and azimuth of one or more position markers relative to a camera's view are determined by the machine vision equipment; the position and azimuth in "real" space are then computed from machine vision data using a series of programmed instructions which translate the relative positional and azimuth data to "real" coordinates. Results are stored, displayed, and/or transmitted to another system, where data may be used to record object location, to direct vehicle guidance, or for other navigation or control purposes.”
Ex.1006, 12	“a) providing a plurality of unique position markers having identifying indicia and positional reference indicia thereupon, the markers being arranged at predetermined positional locations within the coordinate space so that at least one position marker is within view of the object;”
Ex.1006, 8	“The preferred embodiment applies a commercial machine vision system such as Model 5100 or Model 5400 from Cognex, Incorporated. "In-Sight Explorer™" software provided with this system offers a wide array of feature extraction, mathematical, geometric, object identification, and barcode symbol decoding subroutines.”
Ex.1006, 10	“Since the distance AB on the position marker 3 is known and the focal length of the lens of the camera 4 is known, the distance from the camera 4 to the position marker can be determined from the ratio of the length of Line Segment AB in the image to the distance AB on the position marker 3. Since the Z coordinate of the position marker 3 is also known, the Z coordinate of the object may be readily calculated. The Z coordinates are stored in memory 43.”
[8.3]	
Ex.1006, 8	“When the camera 4 captures an image of the overhead position reference 1 the image is transmitted to the machine vision system computational device 5 for analysis. In the case where three dimensional position measurement is needed, the camera would be

	mounted on the lift mechanism, e.g., the movable forks, instead of the cab.”
Ex.1006, 6	“Machine readable symbols, such as one-dimensional or two dimensional barcodes, encode the identity of each position marker of the coordinate reference, allowing automated devices such as barcode scanners 7 (Figure 1) to read the identities of the symbols. Position data in human readable form (such as text) may also be imprinted, attached, or otherwise affixed to the position markers if desired. Printed text allows people to determine approximate locations by simply viewing the coordinate reference and reading the text on the nearest position marker”
Ex.1006, 9	“Decoder 27 "reads" the encoded unique identification code of the position marker and returns alphanumeric data which are stored as decoded position marker data 28. An example of an encoded twodimensional position marker is shown in Figure 6. Selected image data for a single marker are also passed to position marker key point locator 29 which analyzes image data to locate key points A, 8, and C of the position marker symbol (Figure 7). Key points are then stored 30 as pixel coordinates.”
Ex.1006, 10	“The Position Marker Look-Up Table (LUT) 31 is a database containing actual X, Y, Z coordinate positions and actual azimuth angles that are recorded for all position markers at the time of coordinate reference manufacture. Coordinate values are recorded in "real space", such as feet or meters and angles in degrees, such as a compass heading. Decoded marker position data 28 is used 32 to search LUT 31. Actual (i.e., real space) X, Y, Z coordinates for the chosen position marker are returned from LUT 31, and are stored as the approximate X, Y, Z position 33. Pixel coordinates of Key Points B and C, 30, are used to calculate angle CBD, 34, the rotation angle of the position marker relative to the FOV, from which the approximate (uncorrected) azimuth 36 is calculated in step 35.”
Ex.1006, 13-14.	“11. The method of claim 7, wherein a look-up-table containing actual X and Y coordinates and azimuth corrections of all position markers within the coordinate reference is maintained.” “12. The method of claim 11, wherein an approximate position of the object is determined by retrieving the coordinates of the decoded identity of the position marker from said look-up-table.” “17. The method of claim 16 wherein the adjusted position of the object is corrected to a true position by applying small variations recorded in the look-up table for the position marker.”

	“19. The method of claim 18, wherein a correction is made to the approximate azimuth angle by retrieving stored azimuth data for the decoded position marker from the look-up table and adjusting the azimuth accordingly.”
[8.4]	
Ex.1006, 8	“The following functional steps analyze the image within the field of view (FOV), decode the position markers' encoded position information, calculate X-Y coordinates in pixel space, and convert the results to actual "real space" positions.”
Ex.1006, 3-4.	“The position and azimuth of one or more position markers relative to a camera's view are determined by the machine vision equipment; the position and azimuth in "real" space are then computed from machine vision data using a series of programmed instructions which translate the relative positional and azimuth data to "real" coordinates.”
Ex.1006, 6.	“2. Machine readable symbols, such as one-dimensional or two dimensional barcodes, encode the identity of each position marker of the coordinate reference, allowing automated devices such as barcode scanners 7 (Figure 1) to read the identities of the symbols. Position data in human readable form (such as text) may also be imprinted, attached, or otherwise affixed to the position markers if desired. Printed text allows people to determine approximate locations by simply viewing the coordinate reference and reading the text on the nearest position marker.”
Ex.1006, 7.	“The position markers 2, 3 are imprinted or attached to the coordinate reference 1 in a prescribed pattern; for example, in rows and columns corresponding to a desired coordinate plan for the designated area. The position marker 2, shown in Figure 4, comprises three components: text 10 to aid manual identification of each grid location (example: "AA01" = Row "AA", Column "01"), a one-dimensional (i.e., linear) barcode 11 which encodes the marker location "AA01" in any of several common bar code symbologies; and position symbols 9 which serve as position and angular orientation references (i.e., optical targets) for the machine vision system” “The position marker 3 of Figure 5 provides information equivalent to that of position marker 2, comprising text 10 and a non-concentric code, a two dimensional barcode 12, which serves the dual purpose of encoding the marker identity in any one of several two-

	dimensional barcode symbologies and serves as a position and angular orientation reference.”
Ex.1006, 12.	“The method of claim 2, further comprising the step of translating the information encoded in the selected position marker within the field of view to a coordinate location of the selected marker and then calculating the coordinate location of the object within the predefined coordinate space.”
Ex.1006, 13.	“The method according to the apparatus of claim 141, wherein the processing of the acquired image includes the decoding of a one- or two dimensional barcode, and wherein the decoded data identifies position coordinates within the coordinate reference of the position marker.”
Ex.1006, 10.	“To determine the Z coordinate and position, Key Points A and B are used to calculate the length of Line Segment AB of the image. Since the distance AB on the position marker 3 is known and the focal length of the lens of the camera 4 is known, the distance from the camera 4 to the position marker can be determined from the ratio of the length of Line Segment AB in the image to the distance AB on the position marker 3. Since the Z coordinate of the position marker 3 is also known, the Z coordinate of the object may be readily calculated. The Z coordinates are stored in memory 43.”