United States Patent	12383214
Kind Code	B2
Date of Patent	August 12, 2025
Inventor(s)	Garlow; David A. et al.

System and method for mobile imaging

Abstract

An imaging system is disclosed. The imaging system is operable to acquire and/or generate image data at positions relative to a subject. The imaging system includes a drive system configured to move the imaging system.

Inventors: **Garlow; David A. (Lynnfield, MA), Cloutier; Robert P. (Lancaster, MA), Hickey; John T. (Merrimack, NH)**

Applicant: **Medtronic Navigation, Inc.** (Louisville, CO)

Family ID: **65895741**

Assignee: **Medtronic Navigation, Inc. (Lafayette, CO)**

Appl. No.: **18/600129**

Filed: **March 08, 2024**

Prior Publication Data

Document Identifier	Publication Date
US 20240206833 A1	Jun. 27, 2024

Related U.S. Application Data

continuation parent-doc US 17740534 20220510 US 11925494 child-doc US 18600129
continuation parent-doc US 16144058 20180927 US 11344268 20220531 child-doc US 17740534
us-provisional-application US 62565817 20170929

Publication Classification

Int. Cl.: **A61B6/00** (20240101); **A61B5/055** (20060101); **A61B6/03** (20060101); **A61B6/04** (20060101); **A61B6/46** (20240101)

U.S. Cl.:

CPC **A61B6/4405** (20130101); **A61B5/055** (20130101); **A61B6/032** (20130101); **A61B6/035** (20130101); **A61B6/4411** (20130101); **A61B6/4447** (20130101); **A61B6/467** (20130101); **A61B6/547** (20130101); A61B6/04 (20130101); A61B6/4435 (20130101)

Field of Classification Search

CPC: G06T (7/73); G06T (1/0007); G06T (7/0012); G06T (2207/30012); G06T (2207/20084); G06T (7/70); G06T (11/005); G06T (2211/412); G06T (2211/404); G06T (2207/30048); G06T (2207/10081); A61B (6/469); A61B (6/505); A61B (6/0407); A61B (6/5294); A61B (6/4441); A61B (6/5211); A61B (6/032); A61B (6/08); A61B (90/37); A61B (34/20); A61B (6/12); A61B (34/25); A61B (6/547); A61B (2034/2051); A61B (2090/3762); A61B (6/4435); A61B (6/4405); A61B (2034/2055); A61B (5/055); A61B (6/467); A61B (6/4411); A61B (6/035); A61B (6/4447); A61B (6/04); A61B (5/0046); A61B (5/0555); A61B (6/4417); A61B (6/4266); A61B (6/486); A61B (6/481); A61B (6/4476); A61B (6/545); A61B (6/482); A61B (6/507); A61B (6/504); A61B (6/5288); A61B (6/503); A61B (6/02); A61B (6/4085); A61B (2576/023); A61B (8/4209); A61B (6/107); A61B (6/466); A61B (6/462); A61B (6/037); A61B (6/03); A61B (6/5235); A61B (2090/365); A61B (6/487); A61B (6/582); A61B (17/3468); A61B (34/30); A61B (34/32); A61B (34/70); A61B (17/3403); A61B (2017/3411); A61B (2034/305); G06V (10/25); A61M (5/007); G16H (30/40); G01N (2223/419); F16C (25/083); F16C (19/547); F16C (19/364); F16C (33/784); F16C (13/006); F16C (13/022); F16C (13/003); A61N (5/1049); A61N (2005/1063); A61N (5/1007); Y02P (70/10)

USPC: 378/198

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Primary Examiner: Kiknadze; Irakli

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation of U.S. patent application Ser. No. 17/740,534 filed May 10, 2022 which is a continuation of U.S. patent application Ser. No. 16/144,058 filed Sep. 27, 2018, which claims the benefit of U.S. Provisional Application No. 62/565,817, filed on Sep. 29, 2017. This application includes subject matter similar to U.S. patent application Ser. No. 16/144,103 filed Sep. 27, 2018. The entire disclosures of the above applications are incorporated herein by reference.

FIELD

(1) The subject disclosure is related to an imaging system, and particularly a mobile imaging system.

BACKGROUND

(2) This section provides background information related to the present disclosure which is not necessarily prior art.

(3) Imaging systems generally include integrated patient supports that are used during an imaging procedure. Generally known imaging systems include the BodyTom® CT Imaging System sold by Neurologica Corp. and the Airo® CT Imaging System sold by Brain Lab. These imaging systems include patient supports that are custom designed to hold the patient and provide a track for rigid movement of the imaging system relative to patient support. Imaging systems may further include bases that are fixed in place and include a gantry that is able to move a short distance, such as about 12 centimeters to about 18 centimeters relative to the base during imaging. The generally known imaging systems may, therefore, include limited mobility other than relative to the patient support.

SUMMARY

(4) This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

(5) A system for acquiring image data of a subject, also referred to as an imaging system, is disclosed. The imaging system may acquire image data that is used to generate images of various types. The images may include reconstructed three-dimensional images, two-dimensional images, or other appropriate image types. In various embodiments, the imaging system may be an X-ray scanner or a CT scanner. The image data may be two-dimensional (e.g. projection image data) or other appropriate types of image data.

(6) The imaging system may further include a mobility feature that allows it to move relative to a subject. In various embodiments, the subject may be positioned on a support, such as a standard and/or generally known radiolucent surgical table such as the STERIS 4085 SURGICAL TABLE sold by Steris plc, having a place of business in Ohio, that is generally located in selected medical facilities. The imaging system is configured to be positioned relative to the subject to acquire image data of the subject in a selected manner to allow reconstruction of images for display of selected images.

(7) In various embodiments, image data may be acquired while the imaging system is moving relative to the subject. For example, the imaging system may rotate in all or a portion of 360 degrees relative to (e.g. around) the subject. The imaging system may, also or in addition to rotation, move along a longitudinal axis of the subject. In moving along the longitudinal axis of the subject and/or transverse to the longitudinal axis, the imaging system may be driven by a drive system that may include selected wheel supports. The wheel supports may include omni-directional wheels, such as mecanum or omni-wheels. The omni-directional wheels generally include at least a first rolling portion and a second roller or rolling portion. The imaging system may move substantially in one or both of an X-axis and a Y-axis direction. Further, the imaging system may tilt relative to the subject to acquire image data at an angle relative to the longitudinal axis of the subject.

(8) The imaging system may be moved by a manual manipulation of the imaging system. In various embodiments, the imaging system may include a handle that includes one or more sensors that sense a force, such as pressure, from the user to directly move the imaging system relative to the subject. The manual movement of the imaging system may be inclusive or exclusive of other drive or robotic control features of the imaging system. Accordingly, the user may selectively move the imaging system relative to the subject in an efficient and quick manner without pre-planning a

movement of the system.
(9) The imaging system may further include controls, such as automatic or robotic controls, that move the imaging system relative to the subject. The imaging system may move with or according to a pre-planned path relative to the subject for acquiring a selected image data collection of the subject. For example, reconstruction of a selected three-dimensional model of a selected portion of the subject may be selected, and the imaging system may be programmed to automatically move relative to the subject to acquire appropriate amount and type of image data for the three-dimensional reconstruction.
(10) Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

Description

DRAWINGS
(1) The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure.
(2) FIG. **1** is an environmental view of an imaging system;
(3) FIG. **2** is a detail view of a drive system;
(4) FIG. **3** is a detail view of a drive sub-system of the drive system;
(5) FIG. **4**A is a schematic view of the imaging system in a first position;
(6) FIG. **4**B is a schematic view of the imaging system in a second position;
(7) FIG. **5** is a perspective view of a drive system;
(8) FIG. **6** is a first perspective detail view of a drive sub-assembly of the drive system illustrated in FIG. **5**;
(9) FIG. **7** is a second perspective detail view of a drive sub-assembly of the drive system illustrated in FIG. **5**;
(10) FIG. **8** is a detail view of a handle assembly, according to various embodiments;
(11) FIG. **9** is a detail view of a handle assembly, according to various embodiments;
(12) FIG. **10** is a top perspective view of an imaging system cart, according to various embodiments;
(13) FIG. **11** is a bottom plan view of the cart of FIG. **10**;
(14) FIG. **12** is an environmental view of the cart of FIG. **10**;
(15) FIG. **13** is a top perspective view of a cart to hold an imaging system, according to various embodiments;
(16) FIG. **14** is a bottom plan view of the cart of FIG. **13**;
(17) FIG. **15** is a top perspective view of a cart for an imaging system, according to various embodiments;
(18) FIG. **16** is a bottom plan view of the cart of FIG. **15**;
(19) FIG. **17** is a top perspective view of a cart for an imaging system, according to various embodiments; and
(20) FIG. **18** is a bottom plan view of the cart of FIG. **17**.
(21) Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.
DETAILED DESCRIPTION
(22) Example embodiments will now be described more fully with reference to the accompanying drawings.
(23) FIG. **1** is a diagram illustrating an overview of an operating theater system **10** that may include an imaging system **20** and a navigation system **30**, which can be used for various procedures. The

navigation system **30** can be used to track the location of an item, such as an implant or an instrument, relative to a subject, such as a patient **40**. It should further be noted that the navigation system **30** may be used to navigate any type of instrument, implant, or delivery system, including: guide wires, arthroscopic systems, orthopedic implants, spinal implants, deep brain stimulation (DBS) probes, etc. Moreover, the instruments may be used to navigate or map any region of the body. The navigation system **30** and the various tracked or navigated items may be used in any appropriate procedure, such as one that is generally minimally invasive or an open procedure.

(24) The navigation system **30** can interface with the imaging system **20** that is used to acquire pre-operative, intra-operative, or post-operative, or real-time image data of the patient **40**. It will be understood, however, that any appropriate subject can be imaged and any appropriate procedure may be performed relative to the subject. In the example shown, the imaging system **20** comprises or may include portions of an O-Arm® imaging system or device sold by Medtronic Navigation, Inc. having a place of business in Louisville, Colorado, USA. In various embodiments, the imaging system **20** may have a gantry housing **44** that encloses an image data capturing portion **46**. The gantry **44** may include a first portion **48** (which may include a generally fixed portion) and a second portion **50** (which may include a moveable portion relative to the first portion **48**). The image capturing portion **46** may include an x-ray source or emission portion **52** and an x-ray receiving or image receiving portion (also referred to as a detector that may be operable to detect x-rays) **54** located generally or as practically possible 180 degrees from each other and mounted on a moveable rotor (not illustrated) relative to a track **56** of the image capturing portion **46**. The image capturing portion **46** can be operable to rotate 360 degrees around the gantry **44** on or with the rotor during image data acquisition.

(25) The image capturing portion **46** may rotate around a central point or axis **46***a*, allowing image data of the patient **40** to be acquired from multiple directions or in multiple planes. The axis **46***a* of the imaging system **20** may be aligned or positioned relative to an axis, such as a longitudinal axis, of the patient **40**. The imaging system **20** can include all or portions of the systems and methods those disclosed in U.S. Pat. Nos. 7,188,998; 7,108,421; 7,106,825; 7,001,045; and 6,940,941; all of which are incorporated herein by reference. Other possible imaging systems can include C-arm fluoroscopic imaging systems which can also generate three-dimensional views of the patient **40**.

(26) The position of the image capturing portion **46** can be precisely known relative to any other portion of the imaging device **20**. In addition, as discussed herein, the precise knowledge of the position of the image capturing portion **46** can be used in conjunction with the navigation system **30** having a tracking portion (e.g. an optical tracking system including an optical localizer **60** and/or an electromagnetic (EM) tracking system including an EM localizer **62**) to determine the position of the image capturing portion **46** and the image data relative to the tracked subject, such as the patient **40**.

(27) Various tracking devices, including those discussed further herein, can be tracked with the navigation system **30** and the information can be used to allow for displaying on a display **64** of a position of an item, e.g. a tool or instrument **68**. The instrument may be operated, controlled, and/or held by a user **69**. The user **69** may be one or more of a surgeon, nurse, welder, etc. Briefly, tracking devices, such as a patient tracking device **70**, an imaging device tracking device **72**, and an instrument tracking device **74**, allow selected portions of the operating theater to be tracked relative to one another with the appropriate tracking system, including the optical localizer **60** and/or the EM localizer **62**. Generally, tracking occurs within a selected reference frame, such as within a patient reference frame.

(28) It will be understood that any of the tracking devices **70**, **72**, **74** can be optical or EM tracking devices, or both, depending upon the tracking localizer used to track the respective tracking devices. It is understood that the tracking devices **70-74** may all be similar or different, and may all be interchangeable but selected or assigned selected purposes during a navigated procedure. It will be further understood that any appropriate tracking system can be used with the navigation system

30. Alterative tracking systems can include radar tracking systems, acoustic tracking systems, ultrasound tracking systems, and the like.

(29) An exemplarily EM tracking system can include the STEALTHSTATION® AXIEM™ Navigation System, sold by Medtronic Navigation, Inc. having a place of business in Louisville, Colorado. Exemplary tracking systems are also disclosed in U.S. Pat. No. 7,751,865, issued Jul. 6, 2010; U.S. U.S. Pat. No. 5,913,820, issued Jun. 22, 1999; and U.S. Pat. No. 5,592,939, issued Jan. 14, 1997, all herein incorporated by reference.

(30) Further, for EM tracking systems it may be necessary to provide shielding or distortion compensation systems to shield or compensate for distortions in the EM field generated by the EM localizer **62**. Exemplary shielding systems include those in U.S. Pat. No. 7,797,032, issued Sep. 14, 2010 and U.S. Pat. No. 6,747,539, issued Jun. 8, 2004; distortion compensation systems can include those disclosed in U.S. patent application Ser. No. 10/649,214, filed on Jan. 9, 2004, published as U.S. Pat. App. Pub. No. 2004/0116803, all of which are incorporated herein by reference.

(31) With an EM tracking system, the localizer **62** and the various tracking devices can communicate through an EM controller **80**. The EM controller can include various amplifiers, filters, electrical isolation, and other systems. The EM controller **80** can also control the coils of the localizer **62** to either emit or receive an EM field for tracking. A wireless communications channel, however, such as that disclosed in U.S. Pat. No. 6,474,341, issued Nov. 5, 2002, herein incorporated by reference, can be used as opposed to being coupled directly to the EM controller **80**.

(32) It will be understood that the tracking system may also be or include any appropriate tracking system, including a STEALTHSTATION® TRIA®, TREON®, and/or S7™ Navigation System having an optical localizer, similar to the optical localizer **60**, sold by Medtronic Navigation, Inc. having a place of business in Louisville, Colorado. Further alternative tracking systems are disclosed in U.S. Pat. No. 5,983,126, issued Nov. 9, 1999, which is hereby incorporated by reference. Other tracking systems include an acoustic, radiation, radar, etc. tracking or navigation systems.

(33) Briefly, to be discussed in further detail herein, the imaging system **20** can include a support system including a housing or cart **100**. The imaging system **20** can further include a separate image processing unit **102** that can be housed in the cart **100**. The navigation system **30** can include a navigation processing unit **110** that can communicate or include a navigation memory **112**. The navigation processing unit **110** can receive information, including image data, from the imaging system **20** and tracking information from the tracking system, including the respective tracking devices **70**, **72**, and **74** and the localizers **60**, **62**. Image data can be displayed as an image **114** on the display device **64** of a workstation or other computer system **116**. The workstation **116** can include appropriate input devices, such as a keyboard **118**. It will be understood that other appropriate input devices can be included, such as a mouse, a foot pedal or the like.

(34) The image processing unit **102** may be configured, if provided, to process image data from the imaging system **20** and transmit the image data to the navigation processor **110**. It will be further understood, however, that the imaging system **20** need not perform any image processing and the image processing unit **102** can transmit the image data directly to the navigation processing unit **110**. Accordingly, the navigation system **30** may include or operate with a single or multiple processing centers or units that can access single or multiple memory systems based upon system design. It is understood, however, that all of the processing units discussed herein may be generally processors that are executing instructions recalled form a selected memory, have onboard memory, or be application specific processors. Further, each of the processors may be provided or configured to perform all processing tasks discussed herein. Thus, although a specific process may be discussed as an imaging process, the navigation processing unit **110** may also be configured to perform the process.

(35) The imaging system **20**, as discussed herein, may move relative to the patient **40**. The patient **40** may be fixed to an operating table or support table **120**, but is not required to be fixed to the table **120**. The table **120** can include a plurality of straps **124**. The straps **124** can be secured around the patient **40** to fix the patient **40** relative to the table **120**. Various additional or alternative apparatuses may be used to position the patient **40** in a static position on the operating table **120**. Examples of such patient positioning devices are set forth in U.S. Pat. App. Pub. No. 2004/0199072, published Oct. 7, 2004, (U.S. patent application Ser. No. 10/405,068 entitled “An Integrated Electromagnetic Navigation And Patient Positioning Device”, filed Apr. 1, 2003), which is hereby incorporated by reference. Other known apparatuses may include a Mayfield® clamp.
(36) Also, the position of the patient **40** relative to the imaging system **20** can be determined by the navigation system **30** with the patient tracking device **70** and the imaging system tracking device **72**. Accordingly, the position of the patient **40** relative to the imaging system **20** can be determined. An exemplary imaging system, such as the O-Arm® may also be operated to know a first position and can be repositioned to the same first position within a selected tolerance. The tolerance may be about 0.01 millimeters (mm) to about 10 mm, about 0.01 mm to about 2 mm, and about 10 microns. This allows for a substantially precise placement of the imaging system **20** and precise determination of the position of the imaging device **20**. Precise positioning of the imaging portion **22** is further described in U.S. Pat. Nos. 7,188,998; 7,108,421; 7,106,825; 7,001,045; and 6,940,941; all of which are incorporated herein by reference.
(37) Physical space of and/or relative to the subject, such as the patient **40**, may be referred to as subject or patient space. Image space of an image or coordinate system of an image that is generated or reconstructed with the image data from the imaging system **30** may be referred to as image space. The image space can be registered to the patient space by identifying matching points or fiducial points in the patient space and related or identical points in the image space. The imaging device **20** can be used to generate image data at a precise and known position. This can allow image data that is automatically or “inherently registered” to the patient **40** upon acquisition of the image data. Essentially, the position of the patient **40** is known precisely relative to the imaging system **20** due to the accurate positioning of the imaging system **20** in the patient space. This allows points in the image data to be known relative to points of the patient **40** because of the known precise location of the imaging system **20**.
(38) Alternatively, manual or automatic registration can occur by matching fiducial points in image data with fiducial points on the patient **40**. Registration of image space to patient space allows for the generation of a translation map between the patient space and the image space. According to various embodiments, registration can occur by determining points that are substantially identical in the image space and the patient space. The identical points can include anatomical fiducial points or implanted fiducial points. Exemplary registration techniques are disclosed in U.S. Pat. No. 9,737,235, issued Aug. 22, 2017, incorporated herein by reference.
(39) Once registered, the navigation system **30**, with and/or including the imaging system **20**, can be used to perform selected procedures. Selected procedures can use the image data generated or acquired with the imaging system **20**. Further, the imaging system **20** can be used to acquire image data at different times relative to a procedure. As discussed herein, image data can be acquired of the patient **40** subsequent to a selected portion of a procedure for various purposes, including confirmation of the portion of the procedure.
(40) With continuing reference to FIG. **1** and additional reference to FIG. **2**, FIG. **3**, FIG. **4**A, and FIG. **4**B, the imaging system **20** may be configured to acquire image data that is used to generate actual or virtual three dimensional images of the patient **40**. As discussed above, the imaging system processor **102** and/or the navigation system processing unit **110** may be used to generate or reconstruct images for display and/or viewing by a user **69**. The image data is acquired with the patient **40** placed relative to the imaging system **20** to allow the imaging system **20** to obtain image data of the patient **40**. While acquiring the image data, the imaging system **20** may move relative to

the patient **40**.
(41) In various embodiments, to generate a 3D image for display with the display device **64**, image data can be acquired from a plurality of views or positions relative to the patient **40**. The acquired image data may include a plurality of projections through the patient **40**, such as those generated with x-rays, and may include 2D projections. The plurality of projections, or other appropriate image data, of the patient **40** can be used alone or with other information to generate or reconstruct an image to assist in performing a procedure on the patient **40**. It is understood, however, that the patient **40** need not be the subject and other appropriate subjects may be imaged. It will also be understood that any appropriate imaging system can be used, including a magnetic resonance imaging (MRI) system, computed tomography (CT) imaging system, fluoroscopy imaging system, X-ray imaging system, etc.
(42) To acquire the plurality of image data, including the plurality of projections of the patient, the imaging system **20** is moved. In various embodiments, the imaging system **20** includes a drive assembly **140** to move and/or assist in movement of the imaging system **20**. The drive system **140**, as discussed herein, may be a multi-directional drive system, in various embodiments the drive system may be an omni-directional drive system. A multi-directional and/or omni-directional drive system may be configured to move a construct, such as the imaging system **20**, in at least two directions separately and/or simultaneously. When moving, for example, the imaging system **20** may be driven by the multi-directional drive system **140** at an angle relative to 2 perpendicular axes. The multi-directional drive system **140** may be operated to rotate the imaging system **20** around an axis **101** defined within the imaging system **20**. Moreover, the multi-directional drive system **140** may be operable to drive the imaging system **20** in a plurality of axes while acquiring image data of the subject **40**. Further, in various embodiments, the drive system **140** may be operated to move the imaging system in at least two axes of motion simultaneously or separately. It is understood, however, the drive system may move the imaging system **20** in more or less than two axes simultaneously.
(43) The drive system **140** includes wheels or rollers, including at least one (e.g. a first) omni-directional wheel **144**. The omni-directional wheel **144**, which may include rollers, may translate in a plane and rotate around an axis perpendicular to the plane. During translation, the omni-directional wheel **144** may generally move in any direction from a starting point. Further, the translation and rotation of the omni-directional wheel may be substantially precise and controlled. It is understood that the drive assembly **140** may include more than the omni-directional wheel **144** and may include at least three or more omni-directional wheels. Each of the multiple wheels may be positioned at selected locations relative to one another to be driven to achieve a selected movement of the imaging system **20**.
(44) Each of the omni-directional wheels may be substantially similar, however, and include similar or identical portions. The wheels, therefore, may include a second omni-directional wheel **146**, a third omni-directional wheel **148** and a fourth omni-directional wheel **150**. The omni-directional wheels **144**, **146**, **148**, **150** may be any appropriate omni-directional wheels such as the heavy duty Mecanum Wheel (Item number NM254 AL. manufactured by Omni Mechanical Technology, No. 3 Yaxin Alley, Xiao Bian ST, Chang'an Town, Dongguan City, Guang Dong Province, China).
(45) The use of omni-directional wheels may include operation to drive one or more in a selected manner to move the imaging system **20**. For example, two pairs of the wheels could be positioned at corners of a diamond relative to the base **103**. One pair could be driven to move the imaging system in a first direction and the other pair could be driven to move the imaging system **20** substantially orthogonal to the first direction. Alternatively, one of each pair could be driven to rotate the imaging system **20**. Accordingly, one skilled in the art will understand that the imaging system **20** may be moved in a selected manner by selectively driving one or more of the omni-directional wheels. As discussed herein, the driving of the wheels **144-150** may be used to achieve

a selected image data acquisition of the patient **40**.

(46) The omni-directional wheels **144**, **146**, **148**, **150**, with reference to FIG. **2**, including the first omni-directional wheel **144** may include a plurality of components. For example, the omni-directional wheel **144** may include two external plates, including a first external plate **160** and a second external plate **162**. A roller **164** and/or a plurality of rollers may be positioned at an angle relative to a plane of the plate **160** and/or the second plate **162**. The roller **164** may be provided to rotate on an axle **168** that is fixedly or rotatably connected to the two end plates **160**, **162**. In various embodiments, the axles **168** is fixed and the roller **164** rotates around the axles **168**.

(47) With continuing reference to FIG. **2** and FIG. **3**, the drive assembly **140** may be formed or provided as two drive sub-assemblies, including a first drive sub-assembly **174** and a second drive sub-assembly **176**. Each of the drive sub-assemblies **174**, **176** may be substantially identical, but may be controlled substantially or relatively independently, as discussed herein, to move the imaging system **20**. In particular, each of the drive sub-assemblies may include two of the omni-directional wheels **144**, **146**, **148**, **150**. For example, the second drive sub-assembly **176** may include the third omni-directional wheel **148** and the fourth omni-directional wheel **150**.

(48) Each of the omni-directional wheels **144**, **146**, **148**, **150** may be driven by a respective individual motor including a first motor **178** to drive the first omni-directional wheel **144**, a second motor **184** to drive the second omni-directional wheel **146**, a third motor **188** to drive the third omni-directional I wheel **148**, and a fourth motor **192** to drive the fourth omni-directional wheel **150**. The respective motors **178-192** may directly drive their respective omni-directional wheels **144-150**, according to various embodiments. It is understood, however, that each of the respective motors **178-192** may indirectly drive their respective wheels **144-150**. In various embodiments, as illustrated in FIG. **2** and FIG. **3**, a belt drive or chain drive, or other appropriate indirect drive, may interconnect the motors **178-192** with the respective omni-directional wheels **144-150**. It is understood that various other interconnection portions may include tensioners, pulleys, and the like to drive the respective omni-directional wheels **144-150** from the respective motors **178-192**. It is further understood, however, that the wheels may be drive by direct or indirect drive from the respective motors. Further, a disconnect between the wheels **144-150** and the respective motors **178-192** may be provided, as discussed herein.

(49) Each of the omni-directional wheels **144**, as noted above, includes the outer plates **160**, **162**, as illustrated with respect to the first omni-directional wheel **144**. Each of the other wheels **146-150** may include respective outer plates referenced by similar reference numerals augmented by lower case letters.

(50) Each of the drive sub-assemblies **174**, **176** include a framework or frame structure such as a first frame **198** of the first drive sub-assembly **174** and a second frame **200** of the second drive sub-assembly **176**. Each of the frames **198**, **200** may be formed as a single member or multiple members connected together. Further, the frames **198**, **200** may include substantially only internal cross-supports and/or a skeletonized framework with no external boundary members. The frames **198**, **200** hold the respective drive mechanisms, such as the respective motors **178-192** and the various direct and indirect drive members for the respective omni-directional wheels **144-150**.

(51) In various embodiments, a wheel axle **210** extends through the first omni-directional wheel **144** and interconnects with the frame **198**. The axle **210** is connected to the omni-directional wheel **144** to allow rotation of the omni-directional wheel **144** relative to the frames **198**, **200**. For example, the axle **210** may be connected to either or both of the end plates **160**, **162** to rotate the omni-directional wheel **144** when driven by the motor **178**. Rotating the axle **210** rotates the outer plates **160**, **162** to provide motive force to the omni-directional wheel **144**.

(52) Each of the other wheels **146-150** may include respective axles such as a second axle **212** for the second omni-directional wheel, a third axle **214** of the third omni-directional wheel **148** and a fourth axle **216** of the fourth wheel **150**. Each of the respective axles **210-216** may be driven by the respective motors **178-192** with the respective drive or transmission mechanisms, as discussed

above. Driving of the omni-directional wheels **144-150** in a selected manner, as discussed further herein, may move the imaging system **20**.

(53) The drive assembly **140**, including the first drive sub-assembly **174** and the second drive sub-assembly **176** may be interconnected with a linkage **220**. The linkage **220** may be any appropriate linkage, such as a rigid member, including a rigid tubular and/or solid cylindrical member, or other appropriate linkage member. In various embodiments, the linkage **220** includes a substantially cylindrical configuration having an exterior curved surface **222**. The linkage **220** may be movably connected to the respective drive sub-assemblies **174**, **176** at the respective frames **198**, **200**.

(54) For example, the first frame **198** may include a linkage connection **228**. The linkage connection **228** may include a bearing or bushing that allows the linkage **220** to move relative to the framework **198** or the framework **198** relative to the linkage **220**. In various embodiments, the framework **198** may rotate around the linkage **220** generally in the direction of double-headed arrow **230**. Similarly the linkage **220** may be connected to the second drive sub-assembly **176** at a second linkage connection **234** of the frame **200**. Again the linkage **220** and/or the frame assembly **220** may generally move in the direction of double-headed arrow **230** relative to one another via a pushing and/or bearing at the linkage connection **234**.

(55) Accordingly, the drive sub-assembly **174** may move relative to the second drive sub-assembly **176**. In other words, the second drive sub-assembly **176** may move in a first direction, such as in the direction of arrowhead **230***a*, while the first drive sub-assembly **174** moves in the direction of arrowhead **230***b*. The linkage **220**, therefore, and the respective moveable connections **228**, **234** allow for the drive sub-assemblies **174**, **176** to move independently relative to one another generally around the linkage **220** and an axis **236**. As discussed herein, this movement of the drive sub-assemblies **174**, **176** relative to one another allows for a selected movement of the imaging system **20** for acquiring image data of the patient **40**. This may also, as also discussed further herein, eliminate or reduce vibration or motion of the imaging system **20** relative to the patient **40** during the acquisition of the image data.

(56) One or more shock absorbers (also referred to as cushioning or soft mounts) **250** may be provided to connect to the imaging system **20** to the drive assembly **140**. For example, a plurality of the mounts **250** may be provided on the drive assembly **140** either on the frames **198** or projections **250**. The projections may be integral or added with an outer surface of a frame member of the frame **198**, **200**. It is understood that the platforms **252** may be formed with the frames **198**, **200** and need not be a separate member, and are illustrated and discussed herein as separate components merely for illustration. Accordingly, the mounts **250** may be provided at any appropriate location of the drive assembly **140** to connect with the imaging system **20**.

(57) In various embodiments the mounts **250** may be formed of a resilient and/or compliant material, such as a natural or synthetic rubber, metal spring coil, hydraulic shock absorber, or the like. The mounts **250** allow for cushioning and reduction of vibration or elimination of vibration during movement of the drive assembly **140** relative to the imaging system **20**. Accordingly, the drive assembly **140** may move over a surface, such as a floor, pavement, or the like while being non-rigidly connected to the imaging system **20**. The mounts **250** allow for a reduction of a force directed or transferred to the imaging system **252** such as by damping or absorbing a force or motion experienced by the drive assembly **140** during motion of the drive assembly **140**. The motion may be due to an inconsistency or an unevenness over which the surface of the drive assembly **140** moves or may move due to motion of the drive assembly **140**. For example, one or more of the motors **178-192** may cause a shocking or jerking motion during an operation which may be absorbed by the respective mount **250** to thereby eliminate or reduce motion affecting the imaging system **200**. The mounts **250** may move or compress a selected amount to allow for suspension of the imaging system **20** in a substantially flat manner during imaging, such as movement of the imaging system **20** during imaging. In various embodiments, however, it is understood that the drive assembly **140** may be rigidly connected to the cart **100**. Further, the

linkage **220** may not be required between the drive sub-systems **174**, **176**.

(58) Nevertheless, in various embodiments, the mounts **250** provide articulation about the linkage **220**. For example, with discussion relative to the first sub-assembly **174**, only two of the mounts **250**′ and **250**″ are compliant and the other two mounts **250**‴ and **250**⁗ are rigidly attached. In this example, the wheels **144**, **146** float and this creates a three point contact (the left rear, the right rear and the floating front assembly). Since three points define a plane, the base **103** remains relatively stationary relative to the floor **280**. In another example, all of the mounts **250** are compliant and the sub-assembly **174** in total acts similar to an independent suspension to adapt to the terrain and maintain the imaging system **20** relative stationary relative to the floor **280**.

(59) Returning reference to FIG. **1** and continuing reference to FIGS. **2** and **3**, the imaging system **20** may be positioned by the user **69**, or other appropriate individual. In various embodiments, a handle or manipulation assembly **260** is connected with at least a portion, such as a housing or the mobile cart **100** to move the imaging system **20**. The user **69** may engage the handle assembly **260** that includes a grasping portion **262** and a sensing portion **264**. The handle portion **262** may be connected with one or more sensors in the sensing portion **264** to sense a force, such as an amount of force and a direction of force applied to the handle **262**. Other appropriate sensors may be included, such as a flexure, pressure sensor, or the like. In addition, other controls may be provided at the handle assembly **260**. The handle assembly **260** may include portions similar to those included in the O-Arm® imaging system sold by Medtronic, Inc. and/or those disclosed in U.S. Pat. App. Pub. No. 2016/0270748, published Sep. 22, 2016, incorporated herein by reference.

(60) In various embodiments, the handle **262** having a force applied thereto by the user **69** and the sensing unit **264** sensing the force applied by the user **69** to the handle **262** may then move the imaging system **20**. The sensors in the sensing unit **264** may be any appropriate sensor, such as force sensors (e.g. resistance sensors, voltage sensors, load sensors, position sensors, velocity sensors or the like), direction sensors (e.g. gyroscopes), or other appropriate sensors. The sensors in the sensing unit **264** may send a sense signal to a controller, such as included with the image processing unit **102** and/or a separate motion controller **268**. The motion control **268** may receive the sensed signals from the sensors **264** regarding the force applied by the user **69** on the handle **262**. The motion controller **268** may then generate a drive signal to drive one or more of the motors **178-192**. The motion controller **268** may be any appropriate motion controller, such as multi-axis motion controllers including Ethernet or computer card (PCI) controllers including the DMC-18×6 motion controller sold by Galil Motion Control, having a place of business in Rockland, California.

(61) The motion controller **268**, however, may be any appropriate motion controller, and may control the operation of the motors **178-192** to drive the respective wheels **144-150**. By controlling the respective motors **178-192**, the respective omni-directional wheels **144-150** may be rotated around the respective axles **210-216** in an appropriate manner. By driving the omni-directional wheels **144-150** around the respective axles **210-216** in a selected, manner the imaging system **20** may be moved in or along selected and/or appropriate axes.

(62) Movement of the imaging system, such as with the handle assembly **260**, may be fast or course and/or slow or fine. During course movement the imaging system **20** may be moved rapidly, such as about 0.9 miles per hour (MPH) to about 2.0 MPH, including about 1.5 MPH based on a measured or sensed force applied by the user **69**. During fine movement, the imaging system **20** may be moved more slowly, such as about 0.01 MPH to about 0.3 MPH, including about 0.15 MPH based on a measured or sensed force applied by the user **69**. The imaging system **20** may be moved in at least three axes by driving the omni-directional wheels **144-150** according to an appropriate control scheme. Appropriate control schemes include those that drive one or more of the wheels **144-150** to move the imaging system **20** in a selected manner such as along a selected axis of motion and in multiple axes of motion. Driving the wheels **144-150** may also be done in a closed or open loop with or without feedback form the wheels.

(63) Driving the omni-directional wheels at different speeds and/or directions may cause different

total movement of the imaging system **20**. Accordingly, the imaging system **20** may be moved in a first axis **274**. The first axis **274** may be an axis that is generally along a long axis of the subject, such as the patient **40**. Additionally, the motion controller **268** may operate the motors **178-192** to move the imaging assembly **20** in a second axis **276**, which may be substantially perpendicular to the first axis **274**. The two axes **274**, **276** may allow movement of the imaging system **20** generally in a plane.

(64) The movement plane defined by the axes **274**, **276** may be substantially parallel or defined by a surface **280** on which the imaging system **20** is placed. Further the imaging system **20** may rotate around an axis **282**, which may be substantially perpendicular to the first axis **274** and the second axis **276**. Generally the imaging system **20** may rotate in the direction of arrow **284** around the axis **282**. Further the imaging system **20** including the gantry **48** may move in the direction of the axis **282** which is substantially perpendicular to the axes **274**, **276**. Further, the gantry **48** may move in the direction of axis **282** and this movement may not be movement due to the drive assembly **140**, although the motion controller **268** may be used to move the gantry **48** also in the direction of the axis **282**.

(65) Accordingly, the handle assembly **260** may be used to move the imaging system **20**. Movement of the imaging system **20** may be performed during operation of the imaging system **20**, such as gathering image data of the patient **40**. The handle assembly **260** may also be used to move the imaging system **20** to a selected location relative to the patient **40** and then released while gathering image data of the patient **40**. Therefore, it is understood that the handle assembly **260** may be used to move the imaging system **20** at any appropriate time such as prior to, during, or after imaging a patient **40**.

(66) It is further understood that handle assemblies may be positioned at other locations on the imaging system **20**. For example, a second handle assembly **290** may be positioned away from the handle assembly **260**. The second handle assembly **290** may also include a handle **292** and a sensor assembly **294**. The sensor assembly **294** may be similar to the sensor assembly **264** and be in communication with the motion control **268**. The handle assembly **290** may move the imaging system **20** in all of the directions or along the axes **274**, **276**, **282**, and **284**, as discussed above or a limited number thereof. For example, the second handle assembly **290** may be used to move the imaging system **20** from a first gross location (e.g. a storage locker) to a second gross location (e.g. an operating room). Therefore, the second handle assembly **290** may be limited in movement of the imaging system **20** generally along the axes **274**, **276** and in the direction of arrow **284**.

(67) Moreover imaging of the patient **40** may be done substantially automatically, manually, or a combination of both. With continuing reference to FIGS. **1-3** and additional reference to FIGS. **4**A and **4**B, the imaging system **20** is movable relative to the patient **40**. As illustrated in FIGS. **4**A and **4**B the patient **40** is positioned on the support **120**, such as a hospital bed or operating room (e.g. radiolucent) bed. It is understood that patient **40** may be positioned at any appropriate location or room. Nevertheless, the imaging system **20** may move relative to the patient **40** to acquire image data for generation of the image **114** to be displayed on the display device **64**, or any other appropriate display device.

(68) As illustrated in FIG. **4**A, the imaging system **20** may be positioned at an initial or starting position or location **300** relative to the patient **40**. During operation and movement of the imaging system **20**, the patient **40** need not move, according to various embodiments. The imaging system **20** may be moved relative to the subject in any appropriate manner or direction, or combination of direction to movements including those discussed above. For example, the imaging system **20** may move along axis **274** in the direction of arrow **274′**, as illustrated in FIG. **4**A. Accordingly, the imaging system **20** may move from near a head **40***a* of the patient **40** towards a foot **40***b* of the patient **40**, as illustrated in FIG. **4**B.

(69) During movement of the imaging system **20** the gantry **48** may move in the direction of arrow **274′** and/or the entire imaging system assembly may move in the direction of arrow **274′**. During

movement of the entire imaging system **20**, including the gantry **48** and the cart **100**, the motion controller **268** may operate the drive assembly **140**, including the omni-directional wheels **148**, **150** to move the imaging system **20** generally in the direction of arrow **274′**. The imaging system **20** may include various portions, such as those discussed above, which may also rotate around a patient **40**, such as around a long axis of the patient.

(70) As the imaging system **20** moves in the direction of arrow **274′**, including the cart **100**, the omni-directional wheels of the drive system **140** may rotate to move the imaging system **20** in the direction of arrow **274′**. The imaging system **220** moves along the surface **280**, which may also support the patient support **120**. It is understood that the surface **280** may be substantially smooth and planer for movement of the imaging system **20**. It is further understood, however, that surface **280** may include imperfections, such as bumps or projections **280′** that extend above a lower or flat portion **280″** of the surface **280**. Similar low spots or depressions (not illustrated) may be present).

(71) During movement of the imaging system **20** from the starting position **300**, illustrated in FIG. **4**A, to an ending or a second position **302**, illustrated in FIG. **4**B, the imaging system **20** may encounter the bump **280′**. The bump **280′** may move one or more of the omni-directional wheels **144-150** generally in a direction away from the flat surface portion **280″**, such as in the direction of arrow **304**. During movement of the selected omni-directional wheel, such as the omni-directional wheel **150**, the orientation or position of various portions of the imaging system, such as the detector **54** may move relative to the patient **40** from an intended path, such as one generally along a plane and defined by the axes **274**, **276**. The resultant image data may, therefore, not be aligned with all image frames or acquisitions of the image data acquired with the imaging system **20**.

(72) The imaging system **20** may include additional sensors such as those included in a position measurement sensor, which may be referred to as an inertial measurement unit (IMU) **310**. The IMU **310** may include one or more accelerometers and one or more gyroscopes. The IMU **310** may be incorporated into various portions of the imaging system **20**, such as the detector **54**, the gantry **48**, the imaging system support base **103** of the cart **100**, or other appropriate locations.

(73) The IMU **310** may determine an amount of movement of the respective portions such as the detector **54** during movement of the imaging system **20** and or a total motion of the imaging system **20** during movement of the imaging system **20**. The determined motion of the imaging system **20**, such as the detector **54** or including only the detector **54**, may be incorporated into a reconstruction of the image **114** from the image data. For example, a movement of the detector **54** in the direction of arrow **304** of about 1 mm may be determined during acquisition of the image data. The image data acquired during the displacement of the detector **54** may be aligned with the remaining image data based on the measured or determined amount to create a substantially error free or clear image data **144**.

(74) In various embodiments, the IMU **310** may transmit a sensed movement, including a magnitude of movement and a time of movement to the image processing unit **102**, or other appropriate processing unit. The appropriate processing unit, such as the imaging processing unit **102**, may incorporate the amount of movement and time of movement to align all of the image data acquired of the patient **40**.

(75) The IMU **310** may include three accelerometers and three gyroscopes and, therefore, may provide 6 degrees for sensing freedom of movement of the imaging system **20** and/or portions thereof. The IMU **310** may sense the deviations and make a correction to the imaging data in an open loop fashion. In other words, the time and amount of movement may be determined and incorporated into image data acquisition and/or image reconstruction by the imaging processor **102** and/or the navigation processor **110** In various embodiments, the IMU **310** may also or alternatively be operable in a closed looped manner around the IMU **310** to make selected axes of the gantry **44** and/or the imaging system **20** as a whole inertially stable (X, Y, Z, Tilt, wag). In other words, the imaging system **20** as a whole or the gantry **44** and/or the imaging portion **46** may be moved to ensure that the image data is collected in an inertially stabile manner. That is the various

portions of the imaging system **20** may be moved based upon a signal from the IMU **310** to compensate for sensed and/or determined movement. Generally, an axis of rotation of the rotor **56** will not be inertially stabilized since it may rotated 360 degrees around the patient **40** for imaging purposes.

(76) Further, the IMU **310** may be used for navigation. The information from the IMU **310** may be used by the drive controller **268** to insure the imaging system **20** maintains a course in inertial space during image data acquisition. In various embodiments, more than one of the IMU **310** may be present. Because the drive control **268** and the drive system **140**, **340** may use three axes of motion, the IMU for the drive may include only two accelerometers (x/y direction) and one gyroscope for rotation about the vertical axis. This would be used to insure it drives along the table **120** and the patient **40** in a selected manner, such as a straight line, a spline move, or with multipoint guidance. The use of an IMU **310** in either case is optional, however.

(77) In addition to the IMU **310**, or alternatively thereto, the tracking system **30** may also be used to determine movement of the imaging system **20**. As discussed above, the imaging tracking device **72** may be positioned on the imaging system **20**. During movement of the imaging system **20** in the direction of arrow **274′** the tracking system may track movement of the imaging system **20**, including the gantry **48**. The tracked location of the imaging system **20** during acquisition of the image data may also be used to ensure alignment of the image data along a selected axis, such as the axis **274**. Thus, the tracking system **30** may be used to generate or provide position data regarding the location of the imaging system **20** over time, such as while acquiring the image data.

(78) As discussed above, in relation to FIG. **1**, FIG. **2**, and FIG. **3**, the imaging system **20** may include or incorporate a drive system **140**. The drive system **140** may include one or more supports, such as wheel supports, which may include omni-directional wheels. The omni-directional wheels **144-150** may be connected to and/or incorporated into selected structures, such as the frame structures of **198**,**200**. It is understood, however, that the supports, such as the wheels **144-150**, need not be incorporated into the frames **198**,**200** discussed above. Turning reference to FIG. **5**, FIG. **6**, and FIG. **7**, the imaging system **20** may incorporate a drive assembly **340**. The drive assembly **340** may include selected sub-assemblies, such as independent drive sub-assemblies. The drive assembly **340** may include a first independent drive sub-assembly **344**, a second independent drive sub-assembly **346**, a third independent drive sub-assembly **348**, and a fourth independent drive sub-assembly **350**. Each of the drive sub-assemblies **344-350** may include various components, such as those illustrated specifically in FIGS. **6** and **7**. The drive sub-assemblies **344-350** of the drive assembly **340** are mounted or connected to the imaging system **20**, such as to the base or support portion **103**. As illustrated in FIG. **5**, the support base **103** is connected to each of the independent drive sub-assemblies **344-350**. It is understood that the imaging system **20**, including the portions discussed above, may otherwise be associated with the support base **103**. Illustration of only the support base **103** is simply for the present discussion. It is further understood that the imaging system **20** may include all of the features discussed above and the possible movements, as discussed above due to the drive assembly **340**.

(79) Each of the drive sub-assemblies **344-350** may be associated with supports such as the wheels **144-150**, as discussed above. The wheels **144-150**, therefore, are not discussed again in detail, but may include features including those discussed above. In various embodiments, the drive sub-assembly **344** may include or be connected to the wheel **144**. It is understood that each of the drive sub-assemblies may include similar components as the drive sub-assembly **344** and will not be discussed in detail independently. Similar components of the drive sub-assemblies **346-350** include similar reference numbers augmented with a lower case letter.

(80) The wheel **144** of the drive sub-assembly **344** is connected a drive motor, such as the drive motor **178** through the axle **210**. The assembly **344** may include one or more bearing and/or connection components **358**. The drive motor **178** may be connected to the axle **210** by a geared reduction mechanism **360**. The geared reduction mechanism **360** may reduce the motor an

appropriate amount, such as about 50 to 1. Therefore, the motor **178** may drive the wheel **144** in appropriate manner and speed. Further, a drive connection member **362** may interconnect with the axle **210**, as discussed herein.

(81) The motor **178** may be mounted relative to the base **103**, such as fixedly to the base **103**. The drive motor **178** may interconnect with the wheel **144** through a connection or mounting block **364**. The mounting block **364** may be positioned relative to the base **103** and allow for connection of the motor **178** to the wheel **144**, such as through a passage or bore **366**. The mounting block **364** may be movably connected to the base **103** through a pivot mechanism **370**. The pivot mechanism **370** may include a rigid mounting block **372** that is rigidly or fixedly connected to the base **103**. A pivot pin **376** may pass through a bore **378** of the block **372** and through a second bore **380** of the mounting block **364**.

(82) The drive assembly **344** further includes a mounting or pre-tensioning assembly **380**. The pre-tensioning assembly **380** may include a bolt **382** and a nut **384** and various other components, or selective alternatives to these components. The pre-tensioning assembly **380** allows for tensioning of a damping or shock absorption.

(83) The drive assembly **344** may include or allow for a shock absorption or damping of motion of the base **103** due to the floor **280** by allowing the mounting block **364** to pivot and move relative to the fixed block **372** due to the pivot mechanism **370**. A shock absorbing or damping material or assembly, such as a first damping member **390** and a second damping member **392** may be provided between the mounting block **364** and the fixed block **372**. It is understood that more or less of the damping members may be provided and the two are merely exemplary. Further, the materials may be selected to allow for a selected amount of shock absorption or damping of movement of the mounting block **364** relative to the fixed block **372** and may be similar to the mounts **250**, discussed above. Accordingly, the wheel **144** may move relative to the base **103** during movement, as discussed above, of the imaging system **20** without substantially moving the imaging system **20**. The damping assembly **390**, **392** can absorb forces in a selected amount of movement of the wheel **144** relative to the base **103**. Also, each of the sub-assemblies **344-350** may include separate ones of the damping portions. Thus, each of the wheels **144-150** may be moveable independently relative to the base **103** and allow for independent suspension of the wheels **144-150**.

(84) Further the drive assembly **344** may include a lock-out system wherein the axle **210** includes a spline **398** that disengages from the gear mechanism **360** under selected conditions. A spring member **400** may be used to bias or hold the axle **210** away from the gear mechanism **360** when the motor is not being powered or under selected conditions, such as high motor speed or imaging system speed. Accordingly, in an emergency or non-operative condition the wheel **144** would not be driven by the motor **178**.

(85) It is understood that the drive assembly **340** may include a selected number of drive sub-assemblies, such as the four drive sub-assemblies **344**, **348**, **346**, **350**. It is understood that any appropriate number of drive sub-systems may be provided and four is merely exemplary, for example three or five may be provided. Nevertheless, each of the drive sub-assemblies **344-350** may include substantially similar or identical components, which are not repeated here. Each of the drive sub-assemblies **344-350**, or the wheels as discussed above, may be operated substantially and/or completely independently of each other. In other words, each of the wheels may be operated at different speeds or directions. Components that are the same are given like reference numerals augmented with a lower case letter.

(86) Further, it is understood that the drive assembly according various embodiments, including the drive assembly **140** and/or the drive assembly **340**, may be included with other types of wheels or omnidirectional wheels, such as those discussed above. The types of wheels may include mecanum wheels and/or Rotacaster® omnidirectional wheels sold by Rotacaster Wheel Limited having a place of business in Tighes Hill, Australia.

(87) Further, it is understood that an appropriate selected number of wheels, according to various embodiments, may be provided relative to the imaging system **20**. For example, three wheels may be positioned substantially 120 degrees to one another to move the imaging system **20** in the selected axes, as discussed above. Further, it is understood that four or five wheels may also be positioned relative to the imaging system **20** to move the imaging system **20** in a selected manner. It is also understood that the imaging system **20** may be driven in various directions by driving selected wheel(s) in an appropriate manner. For example, two wheels may be positioned opposite one another as a pair a second pair of wheels may be positioned opposite one another. Each of the wheels may be placed on axles that extend along axes such that each pair of wheels extends along the same axis that is perpendicular to the axis of the other wheels. Operation of the wheels, therefore, may move the imaging system in a first or perpendicular axis, rotation around an axis, or diagonal relative to an origin defined by the two pairs of wheels.
(88) Returning reference to FIG. **1** and with additional reference to FIG. **8**, the handle assembly **260** is illustrated in greater detail. As discussed above, the handle assembly **260** includes a graspable member or handle **262**. The handle **262** includes a dimension that allows it to be grasped by a user, such as the user **69** to move the imaging system **20** in a selected manner, such as in 5 degrees of freedom. The handle assembly **260** may be moved to actuate or move only the gantry assembly **44** relative to the cart **100** in a rapid manner. Further, in various embodiments, the handle assembly **260** may also move the cart **100** to move the entire imaging assembly **20**. Thus, the handle assembly may move only the gantry **44**, only the entire imaging system **20**, or both the gantry **44** separate from the entire imaging system **20**.
(89) The sensor assembly **264** may include various sensor portions that are mounted to a ridged base **450** that is rigidly connected to at least a portion of the imaging system **20**, including the cart **100**, the gantry **48**, or other appropriate portions. The sensors may include flexures, pressure sensors, tensions sensors, positions sensors (e.g. joystick), etc. The sensor assembly **264** then includes various portions such as a first sensor sub-assembly **454** that may operate or move the gantry **44** in selected axes, such as a X-axis, Y-axis, or Z-axis relative to the subject **40**. In various embodiments, the axes may be substantially defined by the axes **274**, **276**, **282**, as discussed above. For example, X axis may generally be along the axis **46*a*** of the patient **40**.
(90) The first sensor sub-assembly **454** may be similar to that included in the O-Arm® imaging systems sold by Medtronic, Inc. having a place of business in Minneapolis, Minnesota. The first sensor sub-assembly **454** may include one or more flexure sensors, such as the flexure sensor **456**. Movement of the handle **262** relative to the ridged base **450** causes a force applied to the flexure **456**. The force applied to the flexure **456** may be sensed and a signal generated to cause a selected movement of the gantry **44** and/or the entire imaging system **100**, such as controlled by the motion controller **268**. The signal may be generated based upon a pressure or movement of one end or portion of the flexure relative to another portion. The signal may be based on a distortion of a live wave, resistance, etc.
(91) A second sensor sub-assembly **460** may include a second flexure **464** and a third flexure **466**. It is understood that any appropriate number of flexures may be included in the sensory assembly **264** to sense movement of the handle **262** relative to the base **450**. Further, it is understood, that the sensors may be any appropriate sensors and need not be flexures. Nevertheless, in various embodiments the flexures **464**, **466** extend between a central base or connection **468** and respective arms or projections **474**, **478** connect to second ends of the respective flexures **464**, **466**. Movement of the handle **262**, which is connected to the arms **474**, **478** cause flexion of the flexures **464**, **466**. Flexion of the flexures **464**, **466** is sensed and a signal may be generated to cause movement of the gantry **44**. In various embodiments, the flexures **464**, **466** may operate to cause tilt and/or wag of the gantry **44**. Wag may be rotation of the gantry **44** generally in the direction of double headed arrow **284**. Tilt may be tilting the gantry **44** such that the plain of the gantry is moved to a non-perpendicular angle relative to the axis **46*a*** of the patient **40**. Accordingly, the respective flexures

464, **466** may generate signals either alone or in combination to cause tilt and wag of the gantry **44**.
(92) The handle assembly **260** may be operated to move the gantry **44** in a rapid or quick manner. This may allow for positioning of the gantry **44** relative to the subject **40** for imaging of the subject **40**, as discussed above. Further the handle assembly **260** may be used to move the imaging system **20** by controlling the drive assembly, such that the drive assembly **140**, **340** to move the imaging system **20** including the cart **100**. Accordingly, it is understood that the handle assembly **260** may be used to move the gantry **44** alone or in combination with the cart **100**, and also to move the cart **100** alone or in combination with the gantry **44**.
(93) With continuing reference to FIG. **1** and additional reference to FIG. **9** the second handle assembly **290** is illustrated and discussed in greater detail. The handle assembly **290**, as discussed above includes the handle assembly **292** and sensor assembly **294**. The sensor assembly **294** may include two sensor assemblies **490** and **492**. The two sensor assemblies may be positioned at opposite ends or opposed ends of the handle **292** to sense forces or movement at the respective ends **292***a* and **292***b* of the handle **292**. Each of these sensor assemblies **490**, **492** may be substantially identical, and therefore items will not be repeated, but reference numerals for similar portions are included in the figures augmented by a lowercase letter.
(94) The sensor sub-assembly **490** includes a base **498** that may be rigidly attached to the cart **100**. The sensor sub-assembly **490** may include a second base **500** that is also rigidly connected to a structure of the cart **100**. A connection member **502** may extend and also connect to the cart **100** and allow for selected movement of the handle **292** to be sensed by the sensor sub-assembly **490**. The sensor sub-assembly **490** includes at least a first flexure **504** and may include a second flexure **506** to sense motion generally in the direction of arrow **510**, which may be generally in the direction towards the cart **100** such as by pushing on the handle **292**. The sensor sub-assembly **490** may also include at least a third flexures **514** and may include a fourth flexure **516** to sense movement of the handle **292**, such as laterally relative to the cart **100** generally in the direction of arrow **520**. As noted above the second sensor sub-assembly **492** may include similar portions to sense like movement relative to the cart **100**.
(95) The sensor sub-assemblies **490**, **492** may include or send differential signals to the motion control **268** to cause movement of the drive assemblies **140**, **340**. Accordingly, force or movement applied to the handle **292** may cause the sensor assembly **294** to send signals to the motion control **268** to drive the cart **100** and, therefore, the imaging system **20** via the drive assemblies **340**, **140**.
(96) The handle **292** may include a selected number of members, such as a first member **540** that is connected to the first sensor sub-assembly **490** and a second handle member **542** that is connected to the second sensor sub-assembly **492**. A third handle member **546** may be movably coupled to the handle members **540**, **542** at respective ends or portions of the third handle portion **546**. In various embodiments, the third handle portion **546** may be movably coupled to the first handle member **540** by a pin **550** to allow for a selected amount of movement of the third handle member **546** relative to the first handle member **540**. A second pin **554** may be provided to connect the third handle member **546** to the second handle member **542** to also allow a selective amount of movement of the third handle member **546** relative to the second handle member **542**. Accordingly, the handle assembly **292** may be provided in a plurality of members for connection to the sensor assembly **294**. The movement of the third handle member **546** relative to the first and second handle members **540**, **542** may allow for a decoupling of the sensor sub-assemblies **549**, **542** relative to one another. Accordingly, appropriate or selected signals from the sensor sub-assemblies **490**, **492** regarding a selected motion or desired or selected motion of the handle **292** relative to the cart **100** may be sensed inappropriate signals sent to the motion control **286** to move the cart **100**.
(97) The imaging system **20** may be moved according to various appropriate techniques. In moving the imaging system **20**, image data may be acquired of the patient **40** for various purposes. Regarding imaging, the image data could be acquired for use as a 3D mode or a 2D mode. In the 2D mode images may be stitched together create a long 2D image of the patient **40**. In 3D mode, an

image may be recreated in 3D space. In either case, moving the imaging system **20** relative to the patient **40** may allow for a large field of view of the patient with the final image created with the acquired image data. Further, determining a position of the imaging system **20** during the image data acquisition may assist in assuring a clear and error free final image based r created on the image data.

(98) As discussed above the imaging system may be moved substantially manually by the operator **64** engaging one or more of the handle systems, such as the first handle system **260**, to move the imaging system **20**. Alternatively, or in addition thereto, the user **69** may input a selected imaging analysis, such as a three-dimensional reconstruction, and the imaging processing unit **102** may execute instructions to determine an appropriate movement of the imaging system **20** from the first location **300** to the second location **302** to acquire image data to perform the appropriate or selected reconstruction. It is understood that the user **69** may also select imaging of a selected portion of the patient **40**, rather than an entire three-dimensional reconstruction. Also the imaging system **20**, including the image processing unit **102**, may then determine a movement of the imaging system including a rotation of the detector **54** and/or the emitter **52**, movement of the gantry **48**, or movement of the imaging system **20** using the drive system **140**. All motions of the imaging system **20** may be used to move the imaging system **20** relative to the patient **40** to acquire the image data. The movement of the imaging system **20**, therefore, may be substantially automatic based upon (including only upon) the input by the user **69** of the type of image data to be acquired and/or a desired resultant image or reconstruction of an image based on the image data.

(99) Further, a combination of manual movement and automatic movement may be performed. For example, the user **69** may move the imaging system to move to a selected location, such as near a thoracic region of the patient **40**. The user **69** may then identify a selected number of images and spacing of images and/or image data. The imaging system **20**, at this selected location and/or a limited image acquisition region or volume, may then move, such as only rotating the detector and/or emitter **54**, **52** and/or moving the gantry **48**. Accordingly, it is understood by one skilled in the art, that the imaging system **20** may be moved manually or automatically, or a combination thereof to acquire image data of the subject **40**.

(100) In various embodiments, the various handle assemblies, such as the handle assembly **260**, may be used by the user **69** to grossly or coarsely move the imaging system **20**. Gross movement may include moving the imaging system **20** into a selected operating theater or near the patient **40**. Fine movement may follow the gross movement, such as to acquire the image data. The fine movement may be substantially automatic, such as being driven by the imaging system controller **102** and/or the motion controller **268**. Accordingly, the imaging system **20** may be moved relative to the subject **40** with the drive system **140** to acquire image data in either or both of a gross or course manner and/or a fine manner.

(101) As discussed above, the imaging system **20** may include an appropriate drive system to assist in moving at the imaging system **20** from location to location, such as relative to the subject **40** and/or into an operating room or moving the imaging system from one operating room or location to another operating room. Further, the drive system may assist in moving the imaging system **20** for access to the subject **40** by the user **69** during a selected procedure, such as following or prior to imaging of the subject **40**. The drive system may be oriented relative to the imaging system **20**, such as the cart **100**, the gantry **48**, or other portions of the imaging system **20** to assist in moving the imaging system **20** and/or allowing access to the subject **40**.

(102) According to various embodiments, therefore, the imaging system **20** may include various drive systems, such as those discussed above and further herein. Within initial reference to FIG. **10** and FIG. **11**, a drive system **640** may be incorporated or attached to the cart **100** of the imaging system **20**. The drive system **640** may be similar to the drive system **340** illustrated in FIG. **5** discussed above.

(103) The drive system **640** includes a plurality of multi-directional or omni-directional wheels,

such as wheels similar or identical to mecanum wheels including a first hub member **644** and the second hub member **648** with one or a plurality of rollers **652** rotatably mounted between the hubs **644**, **648**. The roller **652** may be rotatably fixed to the hubs **644**, **648** via axles **654** through the roller **642**. The roller **652** may be rotatably positioned or mounted to the axle **654** while the axle is mounted to the hubs **644**, **648** in a fixed manner. Alternatively thereto, however, the roller **652** may be fixed to the axle **654** and the axle **654** may rotate relative to the hubs **644**, **648**. It is understood, however, that the roller **652** may rotate independently relative to each of the other rollers on the wheel **642**. The roller **652** generally rotates on a roller axis **664** relative to the hubs **644**, **648** and an axis of the wheel, as discussed herein.
(104) It is further understood that a selected number of wheels, such as four wheels designated herein as **642***a*, **642***b*, **642***c*, and **642***d*. Each of the wheels may be substantially identical to one another, save for their position relative to the base **103** of the cart **100**. Further, the gantry **48** is not illustrated relative to the cart **100** in FIG. **10** and FIG. **11**, but a gantry mount **48***m* is illustrated for reference. The gantry **48** may be mounted and moveable relative to the base **103** and due to the drive system **640**.
(105) The base **103** may extend from a power and control portion **100***c* (i.e. near a rear of the cart **100**) of the cart **100** toward a front **100***f* of the cart **100**. The base **103** may also extend between a first side **100***s***1** and a second side **100***s***2**. In various embodiments, as illustrated in FIG. **10** and FIG. **11**, the base **103** may be substantially rectangular. Each of the wheels **642** may be positioned at or near a corner of the base **103**. Generally, one of the hubs, such as the hub **648**, may be positioned nearer the base **103** than the second hub **644**. In various embodiments, the clearance between the hub **648** and the sidewall of the base may be only enough to allow for free-rotation of the wheel **642**, but it is understood that the additional spacing may be provided.
(106) Further, the hubs **644**, **648** generally rotate around a wheel axis **660**. Generally, the wheels **642** on opposite sides of the cart rotate around substantially the same axis **660**, thus there may be a rear axis **660***r* and a front axis **660***f*. The rollers **652** are positioned on the respective wheel **642**, however, are generally positioned to rotate around an axis **664** that is at an angle **668** relative to the rotational axis **660** of the wheel **642**. In various embodiments, the angle **668** may be about 10 degrees (°) to about 90 degrees, including about 35 degrees to about 55 degrees, and further including about 45 degrees. It Is understood, however, that the angle **668** of the rollers **652** relative to the wheel axis **660**, may also exist if the rollers were mounted at a center of the roller relative to one or more of a hub that is closer to a center of the wheel assembly **642**.
(107) Accordingly, if the base **103** is generally moving in the direction of the arrow **672** along a long axis **670** of the cart **103** the rollers **652** will have a force angle that is not aligned or parallel with the direction of travel of the base **103**. Accordingly, an inefficiency of driving at the cart **100** in any direction may be greater than only having a wheel that rotates generally in the direction of travel and around the axis **660**.
(108) Similar to the system illustrated above, the respective wheel **642** may be each individually powered, and therefore controlled, via independent or individual drive systems that include motors. Each of the individual drive systems may include a motor assembly **672** and a gearing, such as a gear reducing, assembly **676**. The motor **672** may drive the gear reducing assembly **676** to drive or rotate an axle mounted within a mounting block **678**. The mounting block **678** may capture an axle **682** within the mounting block **678**. The axle **682** may allow the wheel **642** to rotate around the axis **660**.
(109) The mounting block **678** may be fixedly connected to the base **103**. Accordingly each of the four wheels **642***a*-**642***d* may have its respective mounting block **678** and axle **682** fixed relative to the base **103** at the respective corners, as illustrated in FIG. **10** and FIG. **11**. The mounting block **678** may be generally rigidly fixed to the base **103**. The cart **100**, including the base **103**, may, however, include a selected amount of flexibility. For example, when the wheels **642** are mounted to the base **103** and positioned on a flat surface, as illustrated in FIG. **12**, the front wheel **642***b* may

be raised or lowered a selected amount or distance **684**, such as about 1 mm to about 5 cm, by a surface projection or depression **685**. It is understood, however, that the base **103** may be formed with an appropriate flexibility to allow for movement of the cart **100** over a selected obstruction, such as an obstruction that would raise the wheel **642***b* about 1 mm to about 5 cm while maintaining all four of the wheels **642** in contact with the floor surface **683**, including the surface projection or depression **685**. Accordingly, the wheel **642**, such as at the mounting block **678**, may be rigidly fixed to the base **103** while still allowing for all four wheels to be maintained substantially in contact with the floor surface **683**, even if an obstruction is encountered.

(110) As discussed above, the respective axle **682** may be driven by the respective motor **672** to rotate the respective wheels **642**. Upon driving the wheel **642**, by powering the motor **672**, the respective wheels will rotate based upon the input from the motor **672**. The rotation around the axis **660** may generally be in a plane that is parallel with the sides **103***s***1**, **103***s***2** of the base. The axis **660** is generally or substantially, such as within about 3 degrees of perpendicular to the long axis **673** of the cart **103**.

(111) Each of the four wheels may be powered substantially independently to move the cart **100** in any appropriate direction. For example, the wheel **642** may allow for movement of the cart **100** generally in the direction of double headed arrow **690**, such as generally forward toward the forward portion **100***f* or rearward toward the control center portion **100***c*. Further, driving the wheel **642** in the respective manner allows for rotational movement, such as generally in the direction of curved double headed arrow **694** or in a lateral motion, such as generally in the direction of double headed arrow **696**. The lateral motion in the direction of the double headed arrow **696** may be generally perpendicular to the double headed arrow **690**. Therefore, according to various embodiments, the cart **100** may be moved in a direction that may be generally along the z-axis of the gantry **48**, such as the axis **274** illustrated in FIG. **4**A and discussed above.

(112) The positioning of the four wheels **642** is generally at the corners of the base **103** and generally along the sides **103***s***1**, **103***s***2** and allow for a substantial stability of the imaging system **100**. As discussed above, the gantry **48** may move relative to the control portion **100***c* and relative to the base **103**. As illustrated in FIG. **1**, the gantry **48** may move generally along the directions of the various axes **274**, **276**, **282** and may also wag relative to the cart **100** such as generally along the curved line **284**. Accordingly, positioning of the wheels **642** relative to the base **103** may allow for stability of the imaging system **20** during positioning of the gantry **48**. Also, the center of gravity of the imaging system **20** may be substantially maintained within the four corners of the base **103** during any position of the gantry **48**. Accordingly, the imaging system **20** with the wheels illustrated in FIG. **10** and FIG. **11**, may be substantially stable even at a selected lean, such as on a ramp or angle of about 15 degrees or less, including about 10 degrees or less.

(113) Therefore, during movement of the imaging system **20** including the wheels **642** substantially at the corners of the base **103**, the imaging system **20** may remain substantially stable. Movement of the imaging system may require power to move the imaging system **20**, such as by powering the motor **672**. Powering the motor **672**, however, would be required to overcome the forces of the rollers **652** mounted to the respective wheels **642** during movement along a surface, such as a floor. Accordingly, the drag or inefficiency relative to a single solid wheel rotating generally in the direction of the movement of the double headed arrow **690**, may be about a cosine of the angle **668**.

(114) Turning reference to FIGS. **13** and FIG. **14**, a drive assembly **740** is illustrated. The drive assembly **740** may be mounted to the base **103** of the imaging system **20**, similar to the drive system **640** discussed above and illustrated in FIG. **10** and FIG. **11**. Further, the imaging system **20** is substantially identical to the imaging system **20**, discussed above, including the cart **100** that will now be described in detail here. However, the drive system **740** may include a plurality of wheels **742**, herein designated as four wheels **742***a*, **742***b*, **742***c*, and **742***d*. Each of the wheels **742** may include a first hub **744** and a second hub **748**. The wheel **742**, however, may differ from the wheel **642**, by including a plurality of roller **752** that are generally mounted rotatably on the hubs **748**,

744 respectively, rather than between the hubs **748**, **744**. As illustrated in FIG. **14**, the wheel assemblies may include portions that are substantially similar to those discussed above, including the motor **672**, the gearing or gear reducer **676**, and mounting block **678**. The wheel **742** may be rotatably mounted via the mounting block **678** by an axle **682**.

(115) With reference to FIG. **14**, and with exemplary discussion of the wheel **742***a*, the wheel **742***a* may rotate on the axle **682** around an axis **756**. The axis **756** which may be defined by the axle **682** and may be around which the respective hubs **744**, **748** rotate. The roller **752** can only rotate around an axis **758** that is substantially perpendicular to the axis **756**. Accordingly, the wheel **742***a* may generally move in the direction along the axis **756** without a contrary force vector relative thereto.

(116) The base **103** may include the sides **100***s***1** and **100***s***2** and the long axis **673**. The cart **100** may generally move in the direction of the double headed arrow **690**, **694**, and **696** as discussed above. The axis **756** of the axle **682** may generally be at an angle **764** relative to the axis **673** of the cart **103**. Each of the independent wheel assemblies **742** may have the respective axes **756** at the angle **764** relative to the central axis **696**. As illustrated in FIG. **14**, the wheel axes **756** may be within a range of perpendicular to the central axis **696**, such as about 10 degrees to about 20 degrees. The angle may be toward the front **100***f* or toward the rear or control console **100***c*. As illustrated in FIG. **14**, therefore, the angle **764** may be about 70° to about 90°, further including about 70° to about 88°, and further including about 70° to about 80°.

(117) The angle **764** may allow the efficiency of driving the cart **100** generally in the direction of the double headed arrow **696** along the axis **673** to be similar to the cosine of the angle **764**. Similarly, the angle of the axis **756** relative to the movement direction shown by the double headed arrow **696** may also be based upon an angle of the axis **756** to the axis. As illustrated in FIG. **13** and FIG. **14**, the axis of rotation **756** of the wheels **742** is generally at the angle **764** relative to the long axis **673** of the base **103**. The rollers **752**, however, generally rotate on the axis **758** that is about 90° relative to the axis **756** of the wheel **742**.

(118) Each wheel assembly **742** may be driven independently by powering the motor **672**, similar to the processes discussed above, to move the cart **100**. As discussed above, the cart **100** may also be moved generally along the z-axis, such as in the direction of the arrows **696** including the axis **274**, as illustrated in FIG. **4**A, by driving the wheels **742**. It is further understood that the gantry **48** may also move relative to the cart **100**.

(119) The wheel assemblies may be mounted to the base **103** with the mounting blocks **678** in a manner similar to that discussed above. For example the mounting blocks **678** may be fixed rigidly to the base **103**. The base **103**, however, may have a selected flexibility such that one or more of the wheels may go over a projection or depression, as discussed above, relative to a substantially flat portion of the support surface while allowing all of the four wheel assemblies **742** to remain in contact with the support surface. Accordingly, the cart **100** may be moved from a first location to another second location while maintaining the stability of the imaging system **20** and/or allowing the imaging system **20** to be transported over imperfections in a support surface.

(120) Further the positioning of the wheel assemblies **742** at the corners of the base **103**, is illustrated in FIG. **13** and FIG. **14**, allows the imaging system **20** to be maintained substantially stable even on an incline. For example, the imaging system **20** may be positioned on an incline, such as a ramp, and be stable at any position of the gantry **48** relative to the cart **100** when the incline is 15 degrees or less, including about 10 degrees or less. Generally, the center of gravity of the imaging system **20** remains within the geometry defined by the wheels **742** to assist in maintaining stability of the imaging system **20** during positioning and transportation of the imaging system **20**.

(121) Also the positioning of the wheel assembly **742** to rotate around the respective axis **756** at an angle relative to the central axis **673** of the base **103** may allow for an efficient movement of the imaging device **20**. As discussed above, the movement of the imaging device **20** in substantially

any direction may cause for a force vector of the rollers **752** to be at an angle relative to the direction of travel. However, the angle of the axis **756** relative to the central axis **673** of the base **103** may cause the resistance to be the cosine of the angle **764** which is generally about 22% less efficient than if the wheels were solid wheels that rotate about an axis perpendicular to the long axis **673** and in the direction of travel of the cart **100**.

(122) With reference to FIG. **15** and FIG. **16**, a drive system **840** is illustrated for the imaging assembly **20**. Similar to FIG. **13** and FIG. **14**, however, the gantry **48** is not illustrated relative to the cart **100**, however, the control portion **100***c* is illustrated as is a forward or front portion **100***f*. The drive system **840** includes a selected number of wheels **842**, including four wheels referred to herein **842***a*, **842***b*, **842***c*, and **842***d*. The wheels **842** may be substantially similar to the wheels **742**, illustrated in FIG. **14**, save for their positioning relative to the base **103**. The wheels, therefore, have hubs **744**, **748** and rollers **752**. The rollers **752** generally rotate in the same geometry relative to the hubs **744**, **748** and manner as discussed above as to the wheels **842** rotate like the wheels **742**.

(123) The wheels **842** are connected to the base **103** with mounting block **678** and may be driven by motors **672**. Further, each of the wheels may rotate around selected axes extending through the respective mounting blocks **678** including respective axis **852** for wheel assembly **842***a*, axis **856** for the wheel assembly **842***b*, axis **860** for the wheel assembly **842***c*, and axis **864** for the wheel assembly **842***d*.

(124) The wheel assemblies **842** operate in a similar manner as the wheel assemblies **742** discussed above. However, as illustrated in FIG. **16**, the central axis or axis of rotation **852** and **860** are substantially identical such that the wheel **842***a* and the wheel **842***c* rotate around the same axis that is generally perpendicular to the long axis **673** of the base **103**. The two wheels **842***a*, **842***c*, however, may drive the cart **100** generally in the direction of the double-headed arrow **690** with only the two wheels **842***a* and **842***c* while the rollers **890** on the wheel **842***b* and rollers **894** on the wheel **842***d* rotate freely on the respective wheels **842***b*, **842***d*.

(125) In a similar manner, when moving the cart **100** in the direction along the axis of the double headed arrow **696** the two wheels **842***d* and **842***b* may be powered and rollers **896** and **900** of the wheels **842***a*, **842***c* respectively, may rotate freely. The axes **856**, **864** may generally be aligned or parallel with the long axis **673** of the base **103**. The wheels **842***b*, **842***d*, therefore, may rotate around the respective axes to the move the base **103** in a direction generally orthogonal to the long axis **673**.

(126) Accordingly, the wheel drive assembly **840** may generally move the cart **100** along the two orthogonal axes by driving only two of the wheel assemblies at a time, alternatively. Further, the wheel assemblies may be powered to rotate to the cart **100** generally in the direction of the double headed arrow **694**. Thus, less than all of the wheels may be powered to move the cart **100** in selected directions, such as along a line aligned with the long axis **673** or one orthogonal to the long axis **673**.

(127) As discussed above, the mounting structure **678** may be fixed to the base **103** in a substantially rigid manner. However, contact of all four of the wheels may be maintained with a support surface, such as a floor, even over bumps or depressions therein, due to flexibility of the base **103**, as discussed above.

(128) The base **103** may not be a single uniform size, however, as illustrated in FIG. **15** and FIG. **16**. For example, as illustrated in FIG. **15** the base **103** may include a first portion **910** that has a first dimension, such as a width **914**. The base **103** may further include a second portion **916** that has a second dimension, such as a width **918**. The second width **918** may be less than the first width **914** or the respective dimension, of the respective portion **916**, **914** of the base **103**. The second portion of the base **916** nearer the front portion **100***f* may have a smaller width that may be great enough to hold or allow mounting of the gantry mount **48***m*, but need not be as wide as the first portion **910** of the base **103**. Accordingly, a user, such as the surgeon **69**, may move closer to

the subject **40** and the gantry **48** when not obstructed by a portion of the base **103**.
(129) Further, the orientation and configuration of the drive assembly **40**, as illustrated in FIG. **16**, may define a plane having substantially three points defined by the first wheel **842***a*, the second wheel **842***b*, and the third wheel **842***c*. The fourth wheel **842***d* is generally along the line between the first wheel **842***a* and the third wheel **842***c*. The generally triangular configuration of the drive assembly **840**, included in contact of the wheel assemblies **842** with a support surface, such as a floor, may allow for maneuvering of the cart **100** in small or tight spaces, such as around corners and/or doorways. Further the generally triangular configuration allows for the user **69** to place feet or legs near the gantry and the cart **100** when the second portion **916** of the base **103** is formed as narrowly as possible. By aligning the wheel assembly **842***b* to rotate around the axis **856** that is generally along a long axis defined by the double headed arrow **690** of the cart **100**. The configuration of the drive assembly **840**, however, may still maintain stability of the imaging system **20** in selected configurations of the gantry **48** relative to the base **103** even when on inclines of 15 degrees, including about 10 degrees or less.
(130) Turning, reference to FIG. **17** and FIG. **18**, a drive assembly **940** is illustrated. The drive assembly **940** may be mounted on the base **103** of the cart **100** that extends from near the portion with the control **100***c* to the front **100***f* in between to side **100***s***1** and **100***s***2**. The drive assembly may include wheel assemblies **942**, such as three wheel assemblies **942***a*, **942***b*, and **942***c*.
(131) Each of the wheel assemblies may include two hub members **944** and **948** similar to the wheel assembly **742** and hubs **744**, **748** discussed above. Further, each of the hubs may have a plurality of rollers **952** rotatably mounted thereon. The wheel assemblies **942** are similar to the wheel assemblies **742**, discussed above, including the individual configuration and geometries and will not be discussed in detail here. Each of the wheel assemblies are rigidly mounted to the base **103** with a mounting block **978** and may be driven by a motor **972**. If selected, a gearing or transmission mechanism may also be provided between the motor **972** and the respective wheels **942**. Further, each of the wheels **942** may rotate on an axle **982**. The axle **982** may define an axis **990** around which the hubs **944**, **948** rotate, causing the wheel assembly **942** to rotate around the axis **990** when driven by the motor **972**. As discussed above, the rollers **952** may rotate around an axis **991** that is about 90 degrees relative to the wheel axis **990**.
(132) Each of the wheel assemblies of the drive assembly **940** rotate around a respective axis, therefore the wheel assembly **942***a* rotates around the axis **990**, the wheel assembly **942***b* rotates around the axis **994**, and the wheel assembly **942***c* rotates around the axis **998**. The axes **990**, **994**, **998** may be positioned at an angle relative to one another that may substantially equal, such as about 120 degrees apart, or at any appropriate selected angle. Thus, an angle **1002** is formed between each of the axes. The cart base **103** may have the longitudinal axis **673** which may generally be in line with the double headed arrow **690** generally the direction from the front to the back of the cart **100**. The wheel assemblies may have one axis, such as the axis **994** of the wheel assembly **942***b* that is substantially aligned or in line with the long axis **673**. The other two axes **990**, **998** may be formed at an angle relative to the long axis **673** such as that the angle **1006** may be about 40 degrees to about 80 degrees, including about 60 degrees. Thus, when the cart **100** moves in any direction, such as in the direction of the double headed arrow **690**, none of the wheel assemblies roll freely. When the cart **100** moves in the direction of the double headed arrow **696** only the wheel assembly **942***b* rotates in a direction of rotation. Thus, the drive assembly **940** may have a force vector at the roller that is not in line with the direction of movement for movement of the cart **100**, in most directions. Nevertheless, only three wheel assemblies of the drive assembly **940** are provided thus reducing contact and friction with the surface during movement of the cart **100**.
(133) Further the base **103** may be formed of a flexible material to allow for maintaining contact of all of the wheel assemblies **942** with a support surface, even when the support surface includes irregularities or projections or depressions, as discussed above. The wheels **942** may be spaced a

distance apart, such as an appropriate distance, to maintain a stability of the cart **100**.

(134) In various embodiments, however, as illustrated in FIG. **18**, the wheel assemblies **942** may only project partially from or past the sides **100***s***1**, **100***s***2** to allow for driving of the cart **100**. Moreover, the base **103** may include the two sections **910** and **916** that have the differing widths **914**, **918**, similar to the cart **100***a* and base **103***a*, discussed above. Thus, the second section **916** that is positioned to accept the mount **48***m* of the gantry may be narrower in the width **918** than the width **914** of the first section **910**. As discussed above, this allows the surgeon **69** to move closer to the gantry and/or the patient **40** during a selected procedure. Again this also may be provided by positioning the axis of rotation **994** of the wheel assembly **942***b* to be in line with the long axis **673** of the cart **100**. Also, the cart **100** may still remain stable in various configurations of the gantry **48** relative to the cart **100***a*. Further, the drive assembly **940** may be operated to move the gantry **48** in selected axis or axes for imaging, such as the Z-axis and the gantry **48** may not move relative to the cart **100***a* in the Z-axis.

(135) As discussed above, the drive assemblies, such as the drive assembly **340**, **640**, **740**, **840**, and **940** may all be provided to include wheel assemblies that allow for multidirectional movement of the cart **100** without rotating the wheel assemblies relative to the cart. Selected types or configurations of wheels may include mecanum and/or omni-directional wheels, as discussed above. The wheel designs may also be selected to achieve the selected movement of the cart based upon movement control of the wheels. Further, an appropriate number of wheels may include more than 4 wheel assemblies or less than 3 wheel assemblies, according to various embodiments.

(136) These wheels allow for movement of the cart **100** in substantially orthogonal and directions and rotation around a point without twisting or rotating the wheels relative to the cart **100**. Thus the cart **100** may move in orthogonal axes without rotating wheel assemblies, such as rotating caster wheels. Thus, as discussed above and illustrated in FIGS. **4**A and **4**B, the cart **100** may be used to move the gantry **48** in a Z-axis for acquiring image data of the subject **40**. The gantry **48** may move relative to the cart in a Z-axis, according to various embodiments. According to various embodiments, however, the cart **100** may move in a Z-axis in addition to the gantry **48** also moving relative to the cart **100** in the Z-axis. Further it is understood, however, that the gantry **48** may be fixed to the cart **100** and the cart **100** moves in the Z-axis rather than the gantry **48**. This allows the imaging system **20** to include a Z-axis movement or movement along the axis **274**, as illustrated in FIG. **1**, that is due to movement of the gantry **48** relative to the cart **100** alone, movement of the gantry **48** relative to the cart in combination with movement of the cart, or only movement of the cart **100** to move the gantry **48** while the gantry **48** remains fixed relative to the cart.

(137) Example embodiments are provided so that this disclosure will be thorough, and will fully convey the scope to those who are skilled in the art. Numerous specific details are set forth such as examples of specific components, devices, and methods, to provide a thorough understanding of embodiments of the present disclosure. It will be apparent to those skilled in the art that specific details need not be employed, that example embodiments may be embodied in many different forms and that neither should be construed to limit the scope of the disclosure. In some example embodiments, well-known processes, well-known device structures, and well-known technologies are not described in detail.

(138) The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

Claims

1. A system to acquire image data of a subject, comprising: a detector configured to detect an emitted energy, wherein the detection of the emitted energy is operable to be image data; a gantry having an interior space to moveably enclose the detector, wherein the detector is configured to move within the gantry; a cart having a support structure and a base that extends along a longitudinal axis, wherein the support structure is configured to support the gantry away from a surface; and a multi-directional drive system mounted to the base; wherein the multi-directional drive system is operable to receive an input to move the cart within a plane; wherein the multi-directional drive system includes at least one moveable support having at least one omni-directional wheel; wherein the multi-directional drive system includes at least one motor to drive the at least one omni-directional wheel; wherein the at least one omni-directional wheel rotates about an axle having an axle axis; wherein the axle axis extends at a non-perpendicular angle relative to the longitudinal axis.
2. The system of claim 1, wherein the at least one omni-directional wheel includes a plurality of rollers configured to allow the at least one omni-directional wheel to translate in a plane or rotate around an axis.
3. The system of claim 1, wherein the multi-directional drive system includes a first multi-directional drive sub-system and a second multi-directional drive sub-system.
4. The system of claim 3, wherein the at least one omni-directional wheel includes a plurality of omni-directional wheels; wherein the first multi-directional drive sub-system includes at least a first omni-directional wheel and a second omni-directional wheel of the plurality of omni-directional wheels; wherein the second multi-directional drive sub-system includes a third omni-directional wheel and a fourth omni-directional wheel of the plurality of omni-directional wheels.
5. The system of claim 4, wherein each of the a first omni-directional wheel, the second omni-directional wheel, the third omni-directional wheel, and the fourth omni-directional wheel is positioned near a corner of a support base defined by the multi-directional drive system.
6. The system of claim 4, further comprising: a first motor coupled to the first omni-directional wheel to drive the first omni-directional wheel; a second motor coupled to the second omni-directional wheel to drive the second omni-directional wheel; a third motor coupled to the third omni-directional wheel to drive the third omni-directional wheel; and a fourth motor coupled to the fourth omni-directional wheel to drive the fourth omni-directional wheel.
7. The system of claim 1, wherein the at least one omni-directional wheel includes a first omni-directional wheel, a second omni-directional wheel, a third omni-directional wheel, and a fourth omni-directional wheel; wherein each of the first omni-directional wheel, the second omni-directional wheel, the third omni-directional wheel, and the fourth omni-directional wheel are operable to be driven independently of each other omni-directional wheel to rotate the cart and translate the cart in a plane.
8. The system of claim 1, further comprising a movement control assembly, including: a handle configured to be engaged by a user; a sensor to sense a force applied by the user and a direction of the force; and a movement control configured to receive a signal from the sensor based on the sensed force and generate a drive signal to drive the multi-directional drive system to all of (i) rotate the cart and (ii) translate the cart in a plane.
9. The system of claim 1, further comprising: a sensor configured to sense a change in location of at least one of the detector, the gantry, the cart, or combinations thereof during movement of the cart due to the multi-directional drive system; wherein the sensor is configured to generate a location signal regarding the change in location.
10. The system of claim 9, further comprising: an imaging processor configured to generate an image based on the image data and the location signal from the sensor.

11. The system of claim 1, wherein the at least one directional wheel includes a first omni-directional wheel that rotates about the axle axis, a second omni-directional wheel that rotates about a second axle axis, and a third omni-directional wheel that rotates about a third axle axis, wherein the second axle axis extends at a non-perpendicular angle relative to the longitudinal axis and the third axle axis is on the longitudinal axis.
12. A system to acquire image data of a subject, comprising: an image data collection system; a gantry having an interior space to moveably enclose the image data collection system; a cart having a support structure and a base that extends along a longitudinal axis, wherein the support structure is configured to support the gantry away from a surface; and a multi-directional drive system mounted to the base including a plurality of omni-directional wheels and at least one motor to drive the plurality of omni-directional wheels; and a movement control system having an input system to receive an input from a user to control the multi-directional drive system; wherein the multi-directional drive system is operable to receive an input to move the cart within a plane; wherein at least one omni-directional wheel of the plurality of omni-directional wheels rotates about an axle having an axle axis; wherein the axle axis extends at a non-perpendicular angle relative to the longitudinal axis.
13. The system of claim 12, wherein each of the omni-directional wheels includes a plurality of rollers configured to allow each of the omni-directional wheels to translate in a plane or rotate around an axis.
14. The system of claim 13, wherein the multi-directional drive system is non-rigidly mounted to the base.
15. The system of claim 14, wherein the multi-directional drive system includes a first frame member and a second frame member; wherein the first frame member is moveable relative to the second frame member; wherein both the first frame member and the second frame member are moveable relative to the base.
16. The system of claim 15, wherein the multi-directional drive system further includes a linkage moveable connected to both the first frame member and the second frame member.
17. The system of claim 12, wherein the movement control assembly includes: a handle configured to be engaged by the user; a sensor to sense a force applied by the user and a direction of the force; and a movement control configured to receive a signal from the sensor based on the sensed force and generate a drive signal to drive the multi-directional drive system to all of (i) rotate the cart and (ii) translate the cart in a plane.
18. The system of claim 12, wherein the at least one omni-directional wheel includes a first rotatable hub and a second rotatable hub configured to rotate about the axle axis, wherein the first rotatable hub and the second rotatable hub each include a plurality of rollers positioned on each hub and configured to rotate about the axle axis.
19. A method of moving an imaging system to acquire image data of a subject, comprising: providing an image data collection system within a gantry; providing the gantry supported by a cart having a support structure and a base that extends along a longitudinal axis, wherein the support structure is configured to hold the gantry away from a surface; and operating a movement control system having an input system to receive an input from a user to control a multi-directional drive system; controlling the multi-directional drive system with a signal from the movement control system mounted to the base; wherein the multi-directional drive system includes a plurality of omni-directional wheels and at least one motor to drive the plurality of omni-directional wheels; wherein at least one omni-directional wheel of the plurality of omni-directional wheels rotates about an axle having an axle axis; wherein the axle axis extends at a non-perpendicular angle relative to the longitudinal axis.
20. The method of claim 19, further comprising: applying a force to a handle assembly; operating a sensor to sense the force; and receiving a sense signal from the sensor to move the imaging system in at least one of six-degrees of freedom.