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Patent Handling System for a Medical Imaging System

Abstract

A patient handling system (PHS) for a medical imaging system having a tunnel that extends through at least one scanning portion of the system. The PHS includes a first moveable pedestal that supports a detachable first pallet that includes a first patient. The first pedestal moves the first pallet through the tunnel to enable scanning of the first patient. The PHS also includes a second moveable pedestal located at a tunnel exit. The second pedestal attaches to the first pallet as the first pallet moves through the tunnel and the first pedestal subsequently detaches from the first pallet. The second pedestal then moves away from the tunnel exit to remove the first pallet from the tunnel. A second patient to be scanned is simultaneously prepared for scanning on a second pallet as the first pallet is moved through the tunnel in order to increase patient throughput through system.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation under 35 U.S.C. § 120 of copending U.S. application Ser. No. 18/004,183, filed Jan. 4, 2023, which is a U.S. National Stage Application under 35 U.S.C. § 371 of International Application No. PCT/US2020/070783, filed Nov. 13, 2020, both of which are incorporated by reference herein in their entirety.

TECHNICAL FIELD

[0002] Aspects of the present invention relate to a patient handling system (PHS) for a medical imaging system having a tunnel that extends through at least one scanning portion of the imaging system, and more particularly, to a PHS that includes a first moveable pedestal that supports a detachable first pallet that moves through the tunnel to enable scanning of a first patient and a second moveable pedestal located at a tunnel exit that attaches to the first pallet as the first pallet moves through the tunnel wherein the first pedestal subsequently detaches from the first pallet and the second pedestal then moves away from the tunnel exit to remove the first pallet from the tunnel.

BACKGROUND

[0003] Positron emission tomography (PET) is a nuclear medicine imaging technique that produces a three-dimensional image or map of functional processes in a patient's body. The sensitivity performance of PET systems has been improved by improving time of flight (ToF) performance and by elongating the axial field of view (FoV) of the PET system to provide greater solid angle coverage of PET detectors. Such long axial FoV systems are expensive and thus there are cost benefits to scanning as many patients per day as possible. The improved sensitivity and ToF performances of long axial FoV systems allow the patient scan time to be reduced. However, the number of additional patients that can be scanned in a given time period is limited by the amount of time needed to prepare a patient for the scan along with loading and unloading the patient on a patient bed of the system before and after the scan.

[0004] For example, hybrid PET/computed tomography (CT) imaging systems are frequently used to generate PET and CT images, respectively, that are co-registered to provide a combined image that gives medical personnel both anatomic and metabolic information about the patient's body. Referring to FIG. **1**, an exemplary PET/CT imaging system **10** having a CT portion **12** and a PET portion **14** is shown. The CT portion **12** includes a gantry **15** having a recording unit that includes an X-ray source **16** and an X-ray detector **18**. The recording unit rotates about a longitudinal axis **20** during the recording of a tomographic image, and the X-ray source **16** emits X-rays **22** during a recording.

[0005] The PET portion **16** of the system **10** includes at least one PET detector ring each including a plurality of known PET detectors arranged in a ring shape configuration on a backplane. The PET detectors define an FoV that extends in the same direction as the longitudinal axis **20**. During a known operation of the PET portion of system, annihilation events occur in the FoV wherein an electron interacts with a positron to cause the generation of gamma radiation that is then detected by the PET detectors. The detection of gamma radiation is used to generate PET images which are then used in conjunction with CT images generated by the CT portion **14** of system **16** to provide images as previously described.

[0006] The system **10** includes a gantry and a tunnel **24** that extends through the CT **12** and PET **14**

portions and a table base **26** having a moveable patient bed **28** that supports a patient **30**. In an initial position, the bed **28** is located outside the tunnel **24** to enable loading of the patient **30**. In use, the bed **28** moves from the initial position and then through the tunnel **24** to translate the patient along the longitudinal axis **20** and through CT **12** and PET **14** portions in order to generate the PET and CT images, respectively. After scanning, the bed **28** then returns to the initial position to unload the patient **30**. The table base **26** includes a control unit **32** connected to a computer **34** that controls operation of the system **10**. The system **10** may be configured by a determination unit **36** utilizing a stored computer program that can be executed on the computer **34**. The computer **34** is connected to an output device **38** such as a computer monitor and an input device **40**. An output **42** on the output device **38** comprises, for example, a graphical user interface for actuating individual units of the system **10** and control unit **32**. Further, different views of recorded data can be displayed on the output device **38**. The input device **42** may include a keyboard and mouse, for example.

SUMMARY OF THE INVENTION

[0007] A patient handling system (PHS) for a medical imaging system is disclosed wherein the imaging system includes a tunnel that extends through at least one scanning portion of the imaging system. The PHS includes a first moveable pedestal that supports a detachable first pallet that includes a first patient. The first pedestal moves the first pallet through the tunnel to enable scanning of the first patient. The PHS also includes a second moveable pedestal located at a tunnel exit. The second pedestal attaches to the first pallet as the first pallet moves through the tunnel and the first pedestal subsequently detaches from the first pallet. The second pedestal then moves away from the tunnel exit to remove the first pallet from the tunnel. A second patient to be scanned is simultaneously prepared for scanning on a second pallet as the first pallet is moved through the tunnel in order to increase patient throughput through system.

[0008] In another embodiment, a patient handling system (PHS) for a medical imaging system is disclosed having a tunnel that extends through at least one scanning portion of the imaging system. The PHS includes a first moveable pedestal that supports a first pallet that includes a first patient wherein the first pedestal moves the first pallet through the tunnel to enable scanning of the patient. The PHS also includes a second moveable pedestal that supports a second pallet that includes a second patient wherein the first and second pallets are oriented at an angle relative to each other. Further, the PHS includes a table that rotates the imaging system to align the imaging system with either the first or second pallets wherein when the scan of the first patient is complete, the table rotates to align the imaging system with the second pallet and the second pedestal moves the second pallet through the tunnel to enable scanning of the second patient.

[0009] Those skilled in the art may apply the respective features of the present invention jointly or severally in any combination or sub-combination.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The exemplary embodiments of the invention are further described in the following detailed description in conjunction with the accompanying drawings, in which:

[0011] FIG. **1** depicts an exemplary PET/CT imaging system having a CT portion and a PET portion.

[0012] FIGS. **2**A-**2**C depict a patient handling system (PHS) in accordance with an aspect of the invention.

[0013] FIG. **3** depicts a PHS in accordance with an alternate embodiment of the invention.

[0014] FIG. **4** depicts a PHS in accordance with a further alternate embodiment of the invention.

[0015] FIG. **5** shows a flowchart for an acquisition and motion control system for the alternate

embodiments shown in FIGS. **3** and **4**.

DETAILED DESCRIPTION

[0016] Although various embodiments that incorporate the teachings of the present disclosure have been shown and described in detail herein, those skilled in the art can readily devise many other varied embodiments that still incorporate these teachings. The scope of the disclosure is not limited in its application to the exemplary embodiment details of construction and the arrangement of components set forth in the description or illustrated in the drawings. The disclosure encompasses other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless specified or limited otherwise, the terms "mounted," "connected," "supported," and "coupled" and variations thereof are used broadly and encompass direct and indirect mountings, connections, supports, and couplings. Further, "connected" and "coupled" are not restricted to physical or mechanical connections or couplings.

[0017] Referring to FIGS. **2**A-**2**C, a patient handling system (PHS) **50** in accordance with an aspect of the invention is shown. The PHS **50** may be used in conjunction with a medical imaging system having a patient tunnel for receiving a patient such as a magnetic resonance imaging (MRI) system, a positron emission tomography (PET) system, a single-photon emission computed tomography (SPECT) system, a PET/MRI system, an X-ray computed tomography (CT) system, a PET/CT system, a SPECT/CT system and others. For purposes of illustration, the invention will be described in connection with the PET/CT imaging system **10** including the CT **12** and PET **14** portions having PET detectors **16**. Further, the system **10** may include an elongated axial field of view that forms a long axial view system. For example, the length of a long axial field of view may be approximately 1 meter or longer. Alternatively, the invention may be used in conjunction with PET scanners having standard or shorter fields of view.

[0018] The tunnel **24** extends through the CT **12** and PET **14** portions and includes a tunnel entrance **52** and a tunnel exit **54**. The PHS **50** and system **10** are shown located in a radiation shielded scan room **56** of a medical facility, for example, having an entrance **58** and exit **60** and an operator room **62** that is shielded by radiation glass **64**. The PHS **50** includes first **66** and second **68** pedestals and a first patient pallet **70** that supports a first patient **72**. The first **66** and second **68** pedestals are each independently moveable toward and away from the system **10**. In an aspect of the invention, the first **66** and second **68** pedestals are moveably mounted to first **74** and second **76** tracks or rails, respectively, to guide movement of the first **66** and second **68** pedestals. The first **74** and second **76** tracks each include a linear actuator such as a linear motor to independently move either or both the first **66** and second **68** pedestals in a horizontal direction **78** either toward or away from the system **10**. The linear motors are controlled using a motion controller in communication with a computer associated with the system **10** such as computer **34**. First **80** and second **82** ends of the first pallet **70** include first **84** and second **86** attachment devices, respectively, that removably attach to the first **66** and second **68** pedestals, respectively.

[0019] In FIG. **2**A, the first pedestal **66** is shown spaced apart from the tunnel entrance **52** in a loaded position **88** and the second pedestal **68** is located adjacent the tunnel exit **54** in a pallet retrieval position **90**. In the loaded position **88**, the first end **80** of the first pallet **70** is attached to the first pedestal **66** by the first attachment device **84** such that only the first pedestal **66** supports the first pallet **70**. In addition, the first patient **72** on the first pallet **70** has been prepared for scanning by the CT **12** and PET **14** portions and is ready for scanning. The first pedestal **66** is actuated to move toward the system **10** which moves the first pallet **70** such that the second end **82** is inserted into the tunnel **24** via the tunnel entrance **52**. The first pallet **70** is advanced through the tunnel **24** by the first pedestal **66** to enable successive CT and PET scans of the first patient **72** and continues advancing until the second end **82** extends from the tunnel exit **54**. In FIG. **2**A, a

previously scanned patient **92** positioned on another pallet **94** that has been removed from the tunnel **24** and unloaded from the system **10**. The pallet **94** is located on a stretcher **96** having wheels **98** to enable transport of the previously scanned patient **92** out of the room **56** via the exit **60**.

[0020] Referring to FIG. **2**B, the second end **82** of the first pallet **70** is shown attached to the second pedestal **68** in the pallet retrieval position **90** by the second attachment device **86**. The second end **82** is attached to the second pedestal **68** when the second end **82** extends from the tunnel exit **54**. The first end **80** of the first pallet **70** is then detached from the first pedestal **66** such that only the second pedestal **68** supports the first pallet **70**. FIG. **2**B also depicts a new or second patient **100** positioned on a second pallet **102** located on a second stretcher **104** having wheels **106** to enable transport of the second patient **100** into the room **56** via the entry **58**. As the first pallet **70** is advanced through the tunnel **24** for successive CT and PET scans, the second patient **100** on the second pallet **102** is simultaneously prepared for CT and PET scanning by medical personnel. For example, preparing a patient for CT and PET scanning may include the attachment of leads from an electrocardiogram device on the patient and/or connections for respiratory devices and setup of the devices.

[0021] Referring to FIG. **2**C, the second pedestal **68** moves away from the pallet retrieval position **90** to a retracted position **108** wherein the second pedestal **68** is spaced apart from the system **10** and the first pallet **70** is removed from the tunnel **24**. The first pallet **70** is then detached from the second pedestal **68** to enable unloading of the first pallet **70** from the second pedestal **68**. The first pallet **70** is then positioned on a stretcher **96** (as shown in FIG. **2**A). As the first pallet **70** is being removed from the tunnel **24** by the second pedestal **68**, the first pedestal **66** simultaneously returns to the loaded position **88** (as shown in FIG. **2**A) wherein the first end **80** of the second pallet **102** is attached to the first pedestal **66** by the first attachment device **84** as previously described. When the first pallet **70** is removed from the tunnel **24**, the first pedestal **66** then moves toward the system **10** such that the second end **82** of the second pallet **102** enters the tunnel **24** to enable successive CT and PET scans of the previously prepared second patient **100** and the process repeats.

[0022] Thus, patient throughput through the system **10** is optimized due to time savings which in turn reduces the total cost of ownership of the system **10**. In particular, while a first patient is being scanned, a second patient is simultaneously prepared for scanning. In addition, as a first pallet including the first patient is being removed from the tunnel by the second pedestal, a second pallet including the previously prepared second patient, is simultaneously loaded on the first pedestal and is ready to be inserted into the tunnel **24** for scanning of the second patient. Further, standard production PET/CT systems and software may be used in conjunction with the PHS of the current embodiment thus minimizing costs.

[0023] The room **56** is defined by radiation shielded walls **110** and may be configured as a single long room that includes the first **66** and second **68** pedestals, pallets **70**, **94**, **102** stretchers **96**, **104** and the system **10**. Radiation shielding glass or a radiation shielded accordion room separator **112** may be used to separate the room **56**. This reduces exposure of medical personnel and/or patients being prepared for scanning to X-ray radiation from another patient being scanned and/or radioactivity from a radioisotope that is injected into a patient in connection with a PET scan, for example. Alternatively, the room **56** may be separated by a wall to form adjacent rooms wherein the system **10** extends through an opening in the wall. In another configuration, two rooms and a utility room located between the two rooms may be used wherein a portion of the system **10** is located in the utility room and a remaining part of the system **10** extends through a wall of the utility room into the scan room **56**.

[0024] Referring to FIG. **3**, a PHS **120** in accordance with an alternate embodiment of the invention is shown. In this embodiment, the first pallet **70** is oriented at an approximately 90 degree angle relative to the second pallet **102** (shown as a top view in FIG. **3**). The first **70** and second **102** pallets are attached to the first **66** and second **68** pedestals. In addition, the system **10** is

located on a rotatable table **122** that enables 90 degree rotation of the system **10** to enable alignment of the system **10** with either the first **70** or second **102** pallet. It is understood that the first **70** and second **102** pallets may be oriented relative to each other at angles greater or less than 90 degrees and that the table **122** rotates in a rotation angle corresponding to the orientation of the first **70** and second **102** pallets.

[0025] The table **122** is shown oriented such that a system axis **124** is aligned with a first axis **126** of the first pallet **70** and a second axis **128** of the second pallet **102** is oriented at 90 degrees relative to the system axis **124**. The first pedestal **66** is shown spaced apart from the tunnel entrance **52** in a first initial position **130** wherein a patient may be loaded or unloaded. First **72** and second **100** patients are located on the first **70** and second **102** pallets, respectively.

[0026] The first pedestal **66** is actuated to move toward the system **10** which moves the first pallet **70** such that the second end **82** is inserted into the tunnel **24** via the tunnel entrance **52**. The first pallet **70** is advanced through the tunnel **24** by the first pedestal **66** to enable successive CT and PET scans of the first patient **72**. As the first pallet **70** is advanced through the tunnel **24** for CT and PET scanning, the second patient **100** on the second pallet **102** is simultaneously prepared for CT and PET scanning by medical personnel. For example, preparing a patient for CT and PET scanning may include the attachment of leads from an electrocardiogram device on the patient and/or connections for respiratory devices and setup of the devices.

[0027] Once the scan of the first patient **72** is completed, the first pedestal **66** and first pallet **70** move back to the first initial position **130**. The table **122** is then rotated approximately 90 degrees until the system axis **124** is aligned with the second axis **128** of the second pallet **102**. In this position, the second pedestal **68** is spaced apart from the tunnel entrance **52** in a second initial position **132** in which a patient may be loaded and unloaded. The second pallet **102** is then advanced through the tunnel **24** by the second pedestal **68** to enable successive CT and PET scans of the second patient **100**. As the second pallet **102** is advanced through the tunnel for CT and PET scanning, the first patient **72** is unloaded from the first pallet **70** and a third patient is loaded and simultaneously prepared for CT and PET scanning by medical personnel while on the first pallet **70**. Once the scan of the second patient **100** is completed, the second pedestal **68** and second pallet **102** move back to the second initial position **132** and the process repeats as previously described. In another aspect of the invention, the first **66** and second **68** pedestals may each include a collision avoidance system in order to move either of the pedestals **66**, **68** and thus the associated pallets **70**, **102** toward or away from the CT portion **12** to prevent a collision between the system **10** and the pallets **70**, **102**. For example, the collision avoidance system may be activated if bed extensions are used.

[0028] Thus, patient throughput through the system **10** is optimized due to time savings which in turn reduces the total cost of ownership of the system. In particular, while a patient is being scanned on a first pallet **70**, a previously scanned patient is unloaded from a second pallet **102** and a next patient is loaded and simultaneously prepared for scanning. Further, standard production PET/CT systems and software may be used in conjunction with the PHS **120** of the current embodiment thus minimizing costs. The room **56** may have a square or rectangular shape. In addition, the operator room **62** may be located in a corner of the room **56** such that an operator has a constant view of both sides of the system **10** so that patients and the scan room **56** may be monitored.

[0029] Referring to FIG. **4**, a PHS **134** in accordance with a further alternate embodiment of the invention is shown. In this embodiment, the first pallet **70** is oriented at an approximately 180 degree angle relative to the second pallet **102**. The first **70** and second **102** pallets are attached to the first **66** and second **68** pedestals, respectively, as previously described. In addition, the system **10** is located on a rotatable table **136** that enables 180 degree rotation of the system **10** to enable alignment of the system **10** with either the first **70** or second **102** pallet.

[0030] The table **136** is shown oriented such that the system axis **124** is aligned with the first **126**

and second **128** axes of the first **70** and second **102** pallets, respectively. The first pedestal **66** is shown spaced apart from the tunnel entrance **52** in the first initial position **130** wherein a patient may be loaded or unloaded. First **72** and second **100** patients are located on the first **70** and second **102** pallets, respectively.

[0031] Operation of the alternate embodiment shown in FIG. **4** is similar to the embodiment shown in FIG. **3**. The first pallet **70** is advanced through the tunnel **24** by the first pedestal **66** to enable successive CT and PET scans of the first patient **72**. As the first pallet **70** is advanced through the tunnel **24** for CT and PET scanning, the second patient **100** on the second pallet **102** is simultaneously prepared for CT and PET scanning by medical personnel.

[0032] Once the scan of the first patient **72** is completed, the first pedestal **66** and first pallet **70** move back to the first initial position **130**. The table **136** is then rotated 180 degrees until the system axis **124** is aligned with the second axis **128** of the second pallet **102**. In this position, the second pedestal is spaced apart from the tunnel entrance **52** in the second initial position **132** wherein a patient may be loaded and unloaded. The second pallet **102** is then advanced through the tunnel **24** by the second pedestal **66** to enable successive CT and PET scans of the second patient **100**. As the second pallet **102** is advanced through the tunnel **24** for CT and PET scanning, the first patient **72** is unloaded from the first pallet **70** and a third patient is loaded and simultaneously prepared for CT and PET scanning by medical personnel while on the first pallet **70**. Once the scan of the second patient **100** is completed, the second pedestal **68** and second pallet **102** move back to the second initial position **132** and the process repeats as previously described.

[0033] FIG. **5** shows a flowchart **140** for an acquisition and motion control system for the embodiments shown in FIGS. **3** and **4**. A console computer is the interface between the system and the operator and includes a display or multiple displays that display the status of each scan. The operator enters patient information, scan protocol, dosage, the pedestal used to scan the patient and other information into the computer at Step **150**. The scan protocol is then passed to an acquisition system that manages data acquisition from the system as Step **160**. A pedestal used to scan the patient is switched at Step **170**. A selected pedestal is controlled at Step **180** by a motion control system. In addition, table rotation is controlled at Step **190** by the motion control system.

[0034] While particular embodiments of the present disclosure have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the disclosure. It is therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this disclosure.

Claims

1. A method of increasing a patient throughput of a medical imaging system selected from a medical imaging system group consisting of positron emission tomography (PET) system or magnetic resonance imaging (MRI) system or combined PET/MRI system, PET system or X-ray computed tomography (CT) system or combined PET/CT system or single-photon emission computed tomography (SPECT) system or combined SPECT/CT system, wherein the medical imaging system includes a tunnel that extends through at least one scanning portion of the medical imaging system, comprising: providing a first moveable pedestal comprising a first pallet that includes a first patient, wherein the first moveable pedestal moves the first pallet through the tunnel to enable scanning of the first patient; providing a second moveable pedestal comprising a second pallet that includes a second patient, wherein the first pallet and the second pallet are oriented at an angle relative to each other; and providing a table that rotates the medical imaging system to align the medical imaging system with either the first pallet or the second pallet, wherein when a scan of the first patient is complete, the table rotates to align the medical imaging system with the second pallet, and the second moveable pedestal moves the second pallet through the tunnel to enable

scanning of the second patient.

2. The method according to claim 1, further including simultaneously preparing the second patient on the second pallet for scanning as the first pallet is moved through the tunnel during scanning in order to increase a patient throughput through the medical imaging system.

3. The method according to claim 2, further including preparing the second patient for scanning by attaching leads of a medical device on the second patient or connecting and setting up medical devices.

4. The method according to claim 1, further including moving the first moveable pedestal and the first pallet to a first initial position after scanning, wherein the first moveable pedestal is spaced apart from a tunnel entrance to enable loading or unloading of a patient.

5. The method according to claim 1, further including orienting the first moveable pedestal and the second moveable pedestal at an angle of either 90 degrees or 180 degrees relative to each other.

6. The method according to claim 1, further including removably attaching first and second ends of the first pallet to the first and second pedestals, respectively.

7. The method according to claim 1, wherein the PET/CT medical imaging system includes a long axial field of view.

8. The method according to claim 1, further including unloading the first patient from the first pallet, loading a third patient on the first pallet and simultaneously preparing the third patient as the second pallet is advanced through the tunnel.