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(54) **METHOD AND SYSTEM FOR CARDIAC SCAN PLANE PRESCRIPTION**

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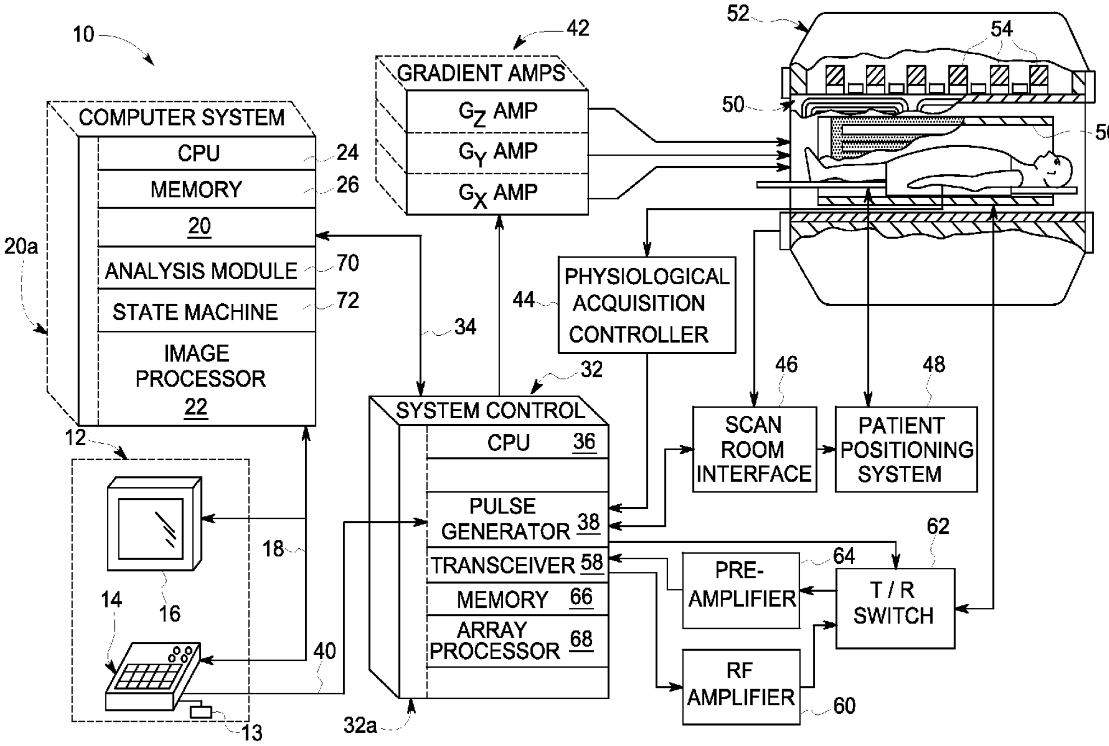
(57) **ABSTRACT**

The present application discloses a method of prescribing a scan plane during Magnetic Resonance Imaging (MRI) of an anatomy. The method comprises acquiring a volume image of the anatomy at a first resolution and simultaneously displaying three planar images representing cross-sections through the anatomy. The three images are orthogonal to each other and intersecting at a common point in the volume. The method also comprises further displaying a pair of axes on each image showing a correspondence of the image with each of the other two images, and receiving a manipulation of one at least one of the axes on at least one of the images and automatically updating the other images to maintain the correspondences. The method also comprises acquiring a volume of the anatomy at a second resolution that is higher than the first resolution.



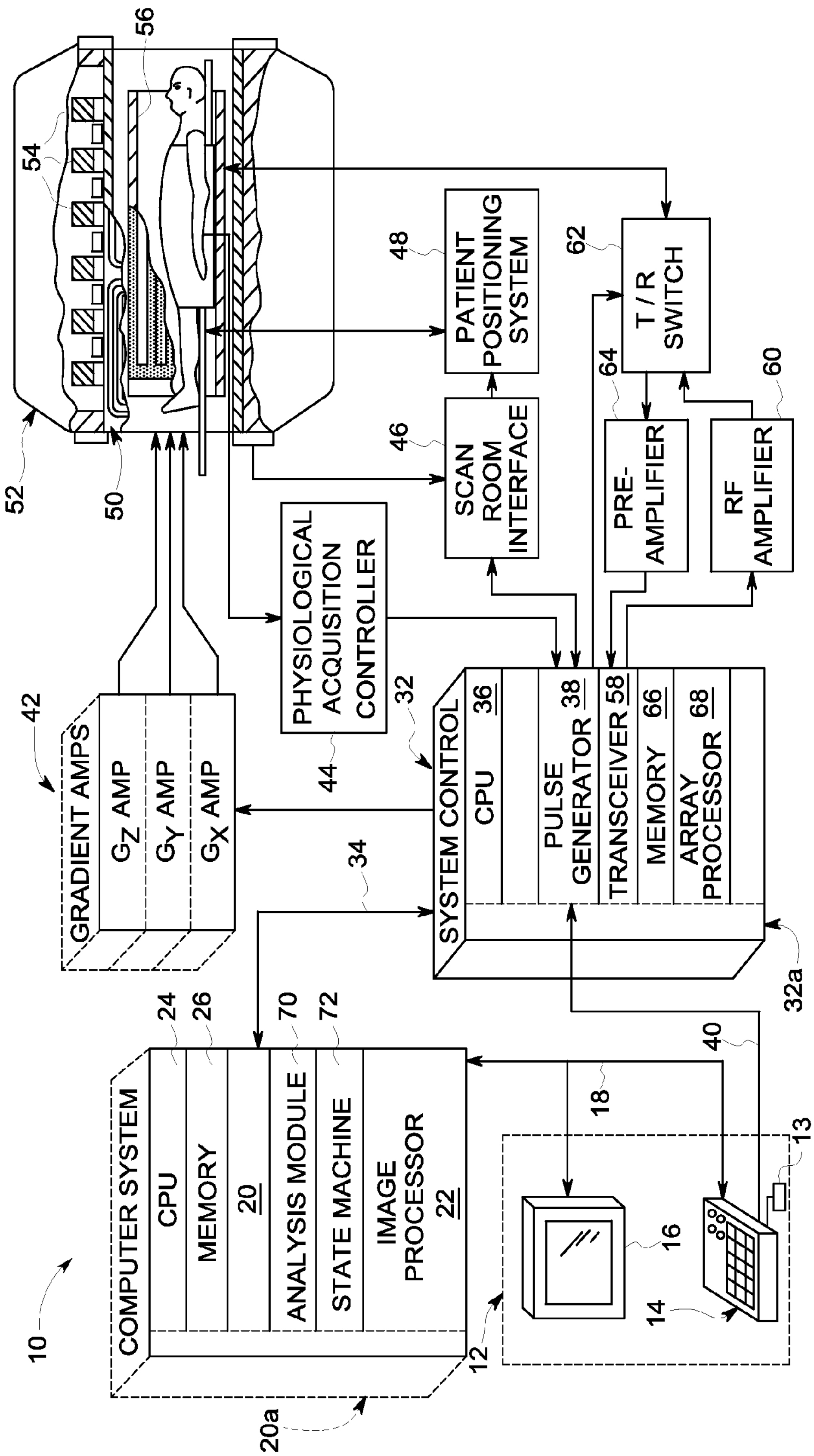

56
54
52
50
48
PATIENT POSITIONING SYSTEM
46
SCAN ROOM INTERFACE
62
T / R SWITCH
64
PRE-AMPLIFIER
60
RF AMPLIFIER
42
GRADIENT AMPS
G_Z AMP
G_Y AMP
G_X AMP
PHYSIOLOGICAL ACQUISITION CONTROLLER
44
32
SYSTEM CONTROL
CPU 36
PULSE GENERATOR 38
TRANSCEIVER 58
MEMORY 66
ARRAY PROCESSOR 68
34
32a
40
10
COMPUTER SYSTEM
CPU
MEMORY
20
ANALYSIS MODULE
STATE MACHINE
IMAGE PROCESSOR 22
24
26
70
72
20a
18
12
13
14
16

FIG. 1

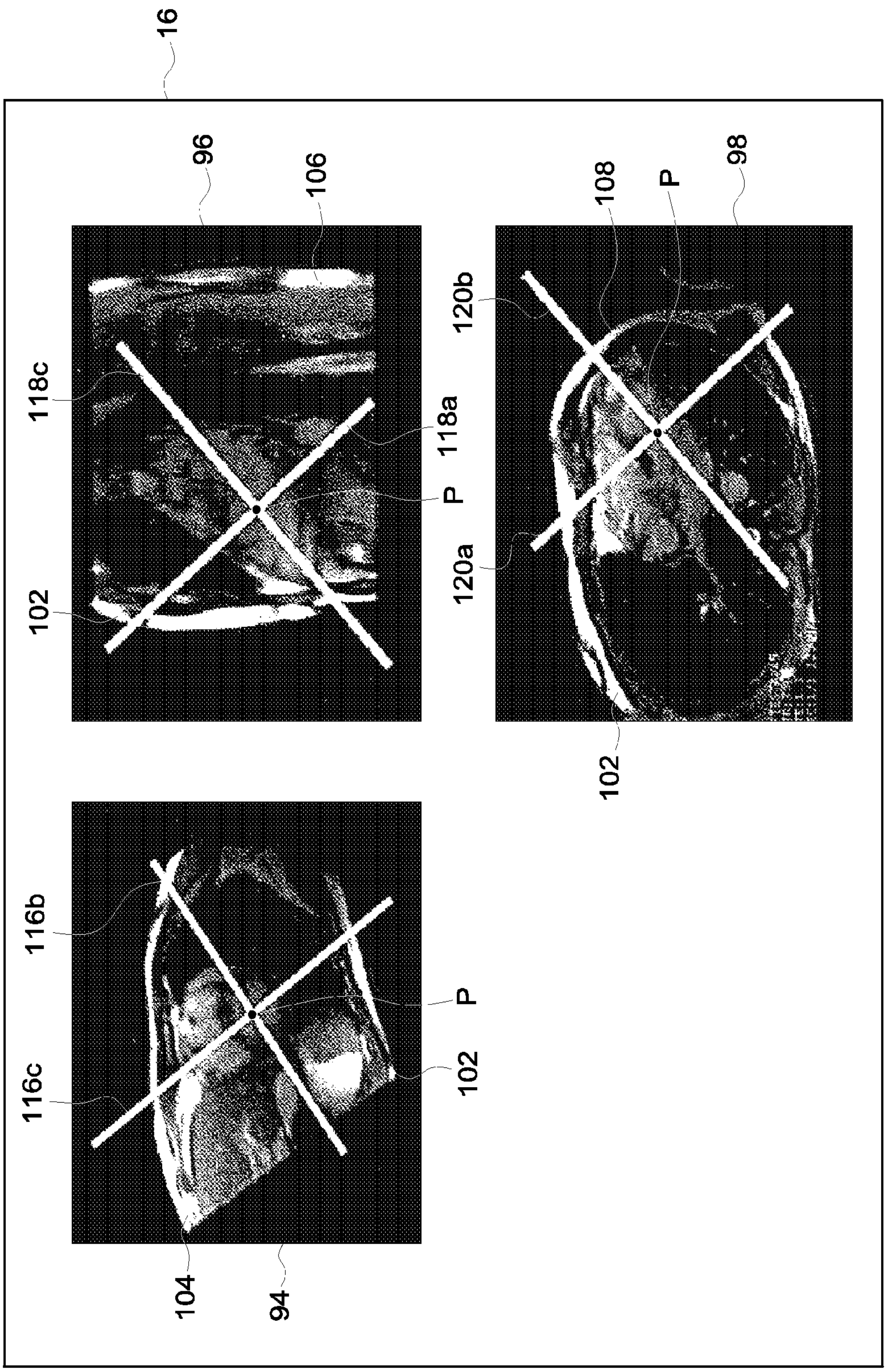

16
96
106
118c
118a
P
102
98
108
P
120b
120a
102
116b
116c
P
102
104
94

FIG. 2

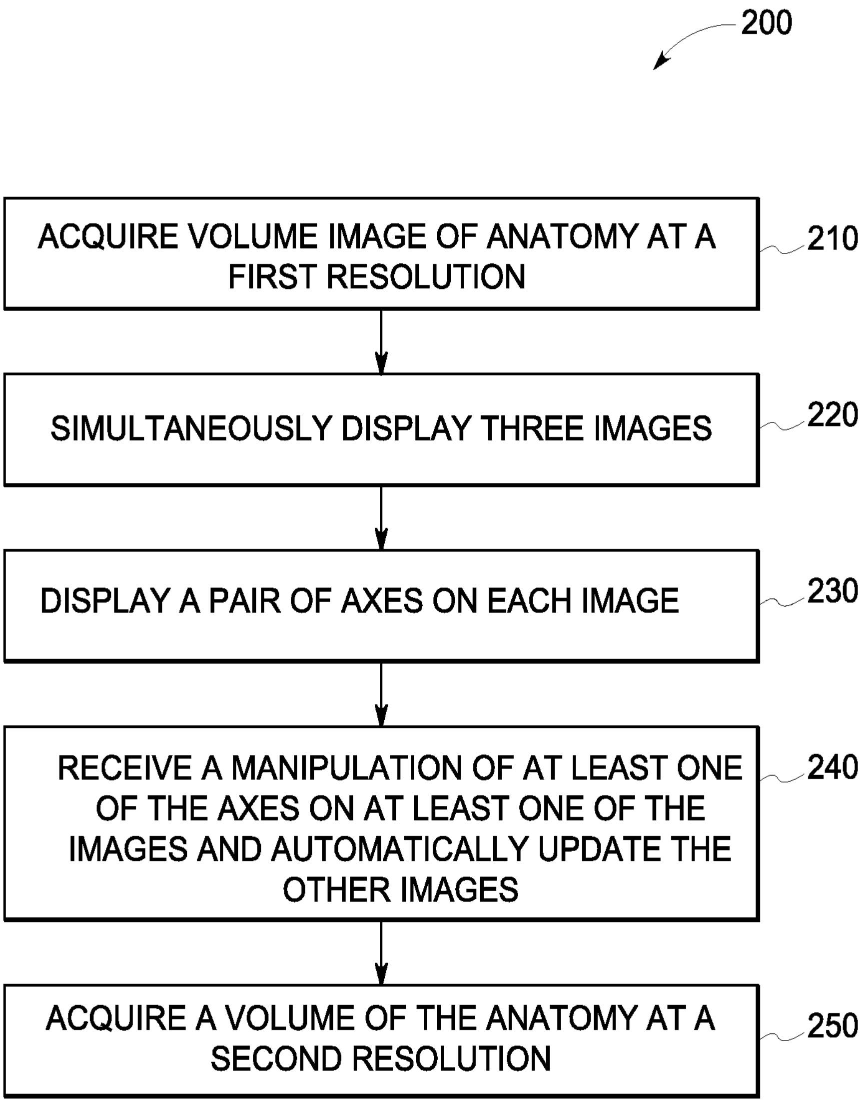

200
ACQUIRE VOLUME IMAGE OF ANATOMY AT A FIRST RESOLUTION
210
SIMULTANEOUSLY DISPLAY THREE IMAGES
220
DISPLAY A PAIR OF AXES ON EACH IMAGE
230
RECEIVE A MANIPULATION OF AT LEAST ONE OF THE AXES ON AT LEAST ONE OF THE IMAGES AND AUTOMATICALLY UPDATE THE OTHER IMAGES
240
ACQUIRE A VOLUME OF THE ANATOMY AT A SECOND RESOLUTION
250

FIG. 3

METHOD AND SYSTEM FOR CARDIAC SCAN PLANE PRESCRIPTION

BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates to Magnetic Resonance Imaging (MRI), and more particularly, to a method of scan plane prescription for cardiac MRI.

[0002] For cardiac MRI scanning, a user typically acquires oblique plane images such as short-axis images, four-chamber images, and two-chamber images. Because the planes are oblique, neither normal nor parallel to any axis of mechanical coordinate system or patient coordinate system, a complex procedure is performed to determine each plane location and orientation. The procedure is time-consuming, typically taking more than several minutes. Additionally, the plane prescription procedure is difficult for a novice user to perform. It requires training and experience to do so competently and efficiently. Therefore, automation of scan plane orientation and location has been desired.

[0003] To address this problem, automatic scan plane computation techniques have been explored. These techniques typically start acquiring low resolution "localizer" images. In the case of cardiac imaging, the localizer image contains the whole heart volume in its field of view. The software then processes the input localizer image and computes scan plane location and orientation based on image processing techniques and machine learning.

[0004] However, there are known problems with this technology and method. For example, the success rate of automatically computing the correct plane prescription is not as high as desired. Achieving correct scan plane prescription at a success rate of 95% or higher is quite difficult. Additionally, the user is not aware of the failure of the scan plane prescription until after the higher resolution images are acquired, and manual manipulation of the higher resolution images is required. This can be very time consuming and difficult for novice users. Therefore, there is a need for a method and system to determine whether computed scan plane prescription is successful or not, and to correct plane prescription quickly and effectively when automatic scan plane prescription fails.

BRIEF DESCRIPTION OF THE INVENTION

[0005] The above-mentioned shortcomings, disadvantages and problems are addressed herein which will be understood by reading and understanding the following specification.

[0006] In an embodiment a method of prescribing a scan plane during Magnetic Resonance Imaging (MRI) of an anatomy comprises acquiring a volume image of the anatomy at a first resolution and simultaneously displaying three planar images representing cross-sections through the anatomy. The three images are orthogonal to each other and intersecting at a common point in the volume. The method also comprises further displaying a pair of axes on each image showing a correspondence of the image with each of the other two images, and receiving a manipulation of one at least one of the axes on at least one of the images and automatically updating the other images to maintain the correspondences. The method also comprises acquiring a volume of the anatomy at a second resolution that is higher than the first resolution.

[0007] In another embodiment, a MRI system comprises an apparatus configured to acquire an MRI volume image of an anatomy and a processing unit configured to prescribe a scan plane. The system also comprises an operator console comprising a display and an input device. The display is configured to display the prescribed scan plane comprising three planar images representing cross-sections through the anatomy, the three images being orthogonal to each other and intersecting at a common point in the volume, and a pair of axes on each image showing a correspondence of the image with each of the other two images. The processing unit is configured to receive manipulation of at least one of the axes on at least one of the images by the input device in order to modify the prescribed scan plane.

[0008] Various other features, objects, and advantages of the invention will be made apparent to those skilled in the art from the accompanying drawings and detailed description thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a schematic block diagram of an exemplary magnetic resonance imaging (MRI) system in accordance with an embodiment of the disclosure;

[0010] FIG. **2** is a schematic representation of a screen shot in accordance with an embodiment of the disclosure; and

[0011] FIG. **3** is a flowchart of a method of prescribing a scan plane during MRI of an anatomy in accordance with an embodiment of the disclosure.

DETAILED DESCRIPTION OF THE INVENTION

[0012] In the following detailed description, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific embodiments that may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the embodiments, and it is to be understood that other embodiments may be utilized and that logical, mechanical, electrical and other changes may be made without departing from the scope of the embodiments. The following detailed description is, therefore, not to be taken as limiting the scope of the invention.

[0013] FIG. **1** is a schematic block diagram of an exemplary magnetic resonance imaging (MRI) system in accordance with an embodiment. The operation of MRI system **10** is controlled from an operator console **12** that includes a keyboard or other input device **13**, a control panel **14**, and a display **16**. The console **12** communicates through a link **18** with a computer system **20** and provides an interface for an operator to prescribe MRI scans, display resultant images, perform image processing on the images, and archive data and images. The computer system **20** includes a number of modules that communicate with each other through electrical and/or data connections, for example, such as are provided by using a backplane **20***a*. Data connections may be direct wired links or may be fiber optic connections or wireless communication links or the like. The modules of the computer system **20** include an image processor module **22**, a CPU module **24** and a memory module **26** which may include a frame buffer for storing image data arrays. In an alternative embodiment, the image processor module **22** may be replaced by image processing functionality on the CPU module **24**. The computer system **20** is linked to archival media devices, permanent or back-up memory storage or a network. Computer system **20** may also communicate with a separate system control computer **32** through a link **34**. The input device **13** can include a mouse, joystick, keyboard, track ball, touch activated screen, light wand, voice control, or any similar or equivalent input device, and may be used for interactive geometry prescription.

[0014] The system control computer **32** includes a set of modules in communication with each other via electrical and/or data connections **32***a*. Data connections **32***a* may be direct wired links, or may be fiber optic connections or wireless communication links or the like. In alternative embodiments, the modules of computer system **20** and system control computer **32** may be implemented on the same computer system or a plurality of computer systems. The modules of system control computer **32** include a CPU module **36** and a pulse generator module **38** that connects to the operator console **12** through a communications link **40**. The pulse generator module **38** may alternatively be integrated into the scanner equipment (e.g., resonance assembly **52**). It is through link **40** that the system control computer **32** receives commands from the operator to indicate the scan sequence that is to be performed. The pulse generator module **38** operates the system components that play out (i.e., perform) the desired pulse sequence by sending instructions, commands and/or requests describing the timing, strength and shape of the RF pulses and pulse sequences to be produced and the timing and length of the data acquisition window. The pulse generator module **38** connects to a gradient amplifier system **42** and produces data called gradient waveforms that control the timing and shape of the gradient pulses that are to be used during the scan. The pulse generator module **38** may also receive patient data from a physiological acquisition controller **44** that receives signals from a number of different sensors connected to the patient, such as ECG signals from electrodes attached to the patient. The pulse generator module **38** connects to a scan room interface circuit **46** that receives signals from various sensors associated with the condition of the patient and the magnet system. It is also through the scan room interface circuit **46** that a patient positioning system **48** receives commands to move the patient table to the desired position for the scan.

[0015] The gradient waveforms produced by the pulse generator module **38** are applied to gradient amplifier system **42** which is comprised of G_x, G_y and G_z amplifiers. Each gradient amplifier excites a corresponding physical gradient coil in a gradient coil assembly generally designated **50** to produce the magnetic field gradient pulses used for spatially encoding acquired signals. The gradient coil assembly **50** forms part of a resonance assembly **52** that includes a polarizing superconducting magnet with superconducting main coils **54**. Resonance assembly **52** may include a whole-body RF coil **56**, surface or parallel imaging coils **76** or both. The coils **56**, **76** of the RF coil assembly may be configured for both transmitting and receiving or for transmit-only or receive-only. A patient or imaging subject **70** may be positioned within a cylindrical patient imaging volume **72** of the resonance assembly **52**. A transceiver module **58** in the system control computer **32** produces pulses that are amplified by an RF amplifier **60** and coupled to the RF coils **56**, **76** by a transmit/receive switch **62**. The resulting signals emitted by the excited nuclei in the patient may be sensed by the same RF coil **56** and coupled through the transmit/receive switch **62** to a preamplifier **64**. Alternatively, the signals emitted by the excited nuclei may be sensed by separate receive coils such as parallel coils or surface coils **76**. The amplified MR signals are demodulated, filtered and digitized in the receiver section of the transceiver **58**. The transmit/receive switch **62** is controlled by a signal from the pulse generator module **38** to electrically connect the RF amplifier **60** to the RF coil **56** during the transmit mode and to connect the preamplifier **64** to the RF coil **56** during the receive mode. The transmit/receive switch **62** can also enable a separate RF coil (for example, a parallel or surface coil **76**) to be used in either the transmit or receive mode.

[0016] The MR signals sensed by the RF coil **56** or parallel or surface coil **76** are digitized by the transceiver module **58** and transferred to a memory module **66** in the system control computer **32**. Typically, frames of data corresponding to MR signals are stored temporarily in the memory module **66** until they are subsequently transformed to create images. An array processor **68** uses a known transformation method, most commonly a Fourier transform, to create images from the MR signals. These images are communicated through the link **34** to the computer system **20** where it is stored in memory. In response to commands received from the operator console **12**, this image data may be archived in long-term storage or it may be further processed by the image processor **22** and conveyed to the operator console **12** and presented on display **16**.

[0017] Referring to FIG. **2**, the display **16** is depicted in accordance with embodiment. The display **16** comprises three planar images **104**, **106**, **108** of an anatomy **102**. The anatomy **102** will hereinafter be described as a heart. It should be appreciated, however, that other anatomies may be envisioned. For example, the anatomy **102** may be a liver, a brain or a joint.

[0018] In the depicted embodiment, each image **104**, **106**, **108** is comprised in a viewport **94**, **96**, **98**, respectively. It should be appreciated that the distinct viewports **94**, **96**, **98** for each image **104**, **106**, **108** could be eliminated while also operating within the scope of the present disclosure. For example, all three images **104**, **106**, **108** may be comprised in a single viewport.

[0019] Each planar image **104**, **106**, **108** represents a cross-section through the heart **102**. For example, image **104** represents a short-axis view of the heart **102**. The short-axis view depicts the left ventricle and the right ventricle. In another example, image **106** represents a 2-chamber view of the heart **102**. The 2-chamber view depicts the left ventricle and the left atrium. In yet another example, image **108** represents the 4-chamber view of the heart **102** and it depicts the left ventricle, left atrium, right ventricle and the right atrium.

[0020] Each of the three images **104**, **106**, **108**, are orthogonal to each other and intersect at a common point P in the volume of the anatomy **102**. For the purpose herein, the term orthogonal may be defined as perpendicular. For example, three planes that are orthogonal to one another may be the axial, sagittal and coronal planes, wherein the axial plane divides the superior and inferior parts of the body, the sagittal plane divides the right side of the body from the left, and the coronal plane divides the anterior (front) of the body from the posterior (back) of the body.

[0021] A pair of axes **116**, **118**, **120**, may be superimposed on each image **104**, **106**, **108**, respectively. The pair of axes **116** comprises axis **116***b* and axis **116***c*. The pair of axes **118** comprises axis **118***a* and axis **118***c*. The pair of axes **120** comprises axis **120***a* and axis **120***b*. The pairs of axes **116**, **118**, **120** show a correspondence of the image with each of the other two images. For example, image **104** has axis **116***b* which represents the intersection of the plane of image **104** with the plane of image **106**. Axis **116***c* represents the intersection of the plane of image **104** with the plane of image **108**. In another example, image **106** has axis **118***a* which represents the intersection of the plane of image **106** with the plane of image **104**. Axis **118***c* represents the intersection of the plane of image **106** with the plane of image **108**. In yet another example, image **108** has axis **120***a* which represents the intersection of the plane of image **108** with the plane of image **104**. Axis **120***b* represents the intersection of the plane of image **108** with the plane of image **106**.

[0022] It may be desirable to use a color-coding scheme to quickly and efficiently aid the user to identify the corresponding axes with image or viewport. In one embodiment, the viewports **94**, **96**, **98** and/or images **104**, **106**, **108** are color coded and the axes **116***b*, **116***c*, **118***a*, **118***c*, **120***a*, **120***b* are colored to correspond to the intersecting image. The viewports **94**, **96**, **98** and/or images **104**, **106**, **108** may be color coded in a variety of ways. For example, in one embodiment, the viewport **94** may be outlined in a color such as red, for example, and axes **118***a* and **120***a* would also be colored red to show a correspondence to viewport **94**. In another embodiment, there is a blue-colored symbol, for example, in viewport **96** and axes **116***b* and **120***b* would also be colored blue. In yet another embodiment, text appearing in viewport **98** may be in a green-colored font and axes **116***c* and **118***c* would be in green. It should be appreciated that other embodiments of the color-coding of viewports **94**, **96**, **98** and/or images **104**, **106**, **108** with axes **116***b*, **116***c*, **118***a*, **118***c*, **120***a*, **120***b* may be envisioned.

[0023] Each axis **116***b*, **116***c*, **118***a*, **118***c*, **120***a*, **120***b* may be manipulated via the input device **13**. The manipulation may include rotating, shifting or a combination thereof. Rotating may comprise the movement of one axis about the intersection point P. Shifting may comprise movement of one axis such that the intersection point P is modified.

[0024] Having described exemplary components of the MRI system **10**, a method **200** of prescribing a scan plane will now be described in accordance with an embodiment. Referring to FIG. **3**, the method **200** may include a step **210** comprising acquiring a volume image of the anatomy **102** at a first resolution. As stated above with respect to FIG. **2**, the anatomy **102** may be a heart. It should be appreciated, however, that other anatomies may be envisioned. For example, the anatomy **102** may be a liver, a brain or a joint. The volume image may be a "localizer" image as is commonly known in the art. At step **210**, the first resolution may be a low resolution. For example, in one embodiment, the first resolution may be between 1.5 mm and 8 mm.

[0025] The method **200** may include a step **220** comprising simultaneously displaying the three planar images **104**, **106**, **108** on the display **16**. For purposes herein, simultaneously may be defined as concurrent. As described above with respect to FIG. **2**, the three images **104**, **106**, **108** are orthogonal to each other and intersect at an intersection point P in the volume of the anatomy **102**. In one embodiment, the three planar images **104**, **106**, **108** may be a short-axis image, a 2-chamber image and a 4-chamber image, respectively. The three images **104**, **106**, **108** may be displayed in viewports **94**, **96**, **98**, respectively, or, alternatively, the images **104**, **106**, **108** may be displayed in another configuration or manner.

[0026] The method **200** may include a step **230** comprising displaying the pair of axes **116**, **118**, **120** on each image **104**, **106**, **108**. The pairs of axes **116**, **118**, **120** may be superimposed on each image **104**, **106**, **108**. The pair of axes **116** comprises axis **116***b* and axis **116***c*. The pair of axes **118** comprises axis **118***a* and axis **118***c*. The pair of axes **120** comprises axis **120***a* and axis **120***b*.

[0027] Each pair of axes **116**, **118**, **120** represents a correspondence of the image with the other two images. For example, image **104** has axis **116***b* which represents the intersection of the plane of image **104** with the plane of image **106**. Axis **116***c* represents the intersection of the plane of image **104** with the plane of image **108**. In another example, image **106** has axis **118***a* which represents the intersection of the plane of image **106** with the plane of image **104**. Axis **118***c* represents the intersection of the plane of image **106** with the plane of image **108**. In yet another example, image **108** has axis **120***a* which represents the intersection of the plane of image **108** with the plane of image **104**. Axis **120***b* represents the intersection of the plane of image **108** with the plane of image **106**.

[0028] In one embodiment, the images and/or viewports may be color coded with the axes **116***b*, **116***c*, **118***a*, **118***c*, **120***a*, **120***b* may be color-coded in order to show the correspondences between axes and images.

[0029] The method **200** may include a step **240** comprising receiving manipulation of at least one of the axes **116***b*, **116***c*, **118***a*, **118***c*, **120***a*, **120***b* on at least one of the images **104**, **106**, **108**, and automatically updating the other images to maintain correspondences. Each axis **116***b*, **116***c*, **118***a*, **118***c*, **120***a*, **120***b* may be manipulated via the input device **13**. The manipulation may include rotating, shifting or a combination thereof. Rotating may comprise the movement of one axis about the intersection point P. Shifting may comprise the movement of one axis such that the intersection point P is altered.

[0030] In one embodiment, the step **240** may be performed substantially in real time. For the purpose herein, substantially in real time may be defined as without intentional delay. For example, the images may be updated within one to two seconds of receipt of the manipulation.

[0031] The method **200** may include a step **250** comprising acquiring a volume of the anatomy **102** at a second resolution that is higher than the first resolution. In one embodiment, the second resolution may be between 1 mm and 2 mm.

[0032] The method **200** and apparatus **10** provide numerous benefits. For example, the refinement and adjustment of an automatically calculated scan plane allows for more efficient, faster, scan plane prescription, especially where the automatically calculated prescription fails. It also makes scan plane prescription more accessible for novice users as it eliminates the need for entirely manual prescription.

[0033] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

We claim:

1. A method of prescribing a scan plane during Magnetic Resonance Imaging (MRI) of an anatomy comprising:

acquiring a volume image of the anatomy at a first resolution;

simultaneously displaying three planar images representing cross-sections through the anatomy, the three images being orthogonal to each other and intersecting at a common point in the volume,

further displaying a pair of axes on each image showing a correspondence of the image with each of the other two images,

receiving a manipulation of one at least one of the axes on at least one of the images, and automatically updating the other images to maintain the correspondences, and

acquiring a volume of the anatomy at a second resolution that is higher than the first resolution.

2. The method of claim **1**, wherein the anatomy is a heart.

3. The method of claim **2**, wherein the three planar images comprise a 4-chamber image, a 2-chamber image and a short-axis image.

4. The method of claim **1**, wherein each planar image is displayed in a viewport.

5. The method of claim **1**, wherein the manipulation is rotating.

6. The method of claim **1**, wherein the manipulation is shifting.

7. The method of claim **1**, wherein the receiving a manipulation and updating the other images step occurs substantially in real time.

8. The method of claim **1**, further comprising acquiring a calibration scan at a scan location in order to align the scan location with the anatomy.

9. The method of claim **1**, wherein each image is color coded and the axis corresponding to that image is similarly colored.

10. The method of claim **1**, wherein the anatomy is a liver.

11. The method of claim **1**, wherein the anatomy is a brain.

12. The method of claim **1**, wherein the anatomy is a joint.

13. A Magnetic Resonance Imaging (MRI) system comprising:

an apparatus configured to acquire an MRI volume image of an anatomy;

a processing unit configured to prescribe a scan plane; and

an operator console comprising a display and an input device,

wherein the display is configured to display the prescribed scan plane comprising three planar images representing cross-sections through the anatomy, the three images being orthogonal to each other and intersecting at a common point in the volume, and a pair of axes on each image showing a correspondence of the image with each of the other two images; and

wherein the processing unit is configured to receive manipulation of at least one of the axes on at least one of the images by the input device in order to modify the prescribed scan plane.

14. The MRI system of claim **13**, wherein the processing unit is further configured to update all three planar images substantially in real time based on the manipulation in order to maintain correspondences.

15. The MRI system of claim **13**, wherein the anatomy is a heart.

16. The MRI system of claim **15**, wherein the three planar images comprises a 4-chamber image, a 2-chamber image and a short-axis image.

17. The MRI system of claim **13**, wherein the manipulation is rotating.

18. The MRI system of claim **13**, wherein the manipulation is shifting.

19. The MRI system of claim **13**, wherein each image is color coded and the axis corresponding to that image is similarly colored.

20. The MRI system of claim **13**, wherein the anatomy is at least one of a liver, brain, and joint.

* * * * *

专利名称(译)	心脏扫描平面处方的方法和系统		
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申请号	US14/571767	申请日	2014-12-16
[标]申请(专利权)人(译)	通用电气公司		
申请(专利权)人(译)	通用电气公司		
当前申请(专利权)人(译)	通用电气公司		
[标]发明人	OKUDA HIROHITO ODA YOSHIHIRO TAKAYAMA OSAMU VAIDYA VIVEK		
发明人	OKUDA, HIROHITO ODA, YOSHIHIRO TAKAYAMA, OSAMU VAIDYA, VIVEK		
IPC分类号	G01R33/54 A61B5/00 A61B5/055		
CPC分类号	G01R33/543 A61B5/055 A61B5/0044 A61B5/7425 A61B2576/026 A61B5/4244 A61B5/4528 A61B2576/023 A61B2560/0223 A61B5/0042 A61B5/0037 A61B5/7475 G01R33/4833 G16H30/40		
外部链接	Espacenet USPTO		

摘要(译)

本申请公开了一种在解剖结构的磁共振成像（MRI）期间规定扫描平面的方法。该方法包括以第一分辨率获取解剖结构的体积图像并同时显示表示穿过解剖结构的横截面的三个平面图像。三个图像彼此正交并且在体积中的公共点处相交。该方法还包括在每个图像上进一步显示一对轴，示出图像与其他两个图像中的每一个的对应关系，并且在至少一个图像上接收对至少一个轴的操纵并自动更新其他图像来维护对应关系。该方法还包括以高于第一分辨率的第二分辨率获取一定体积的解剖结构。