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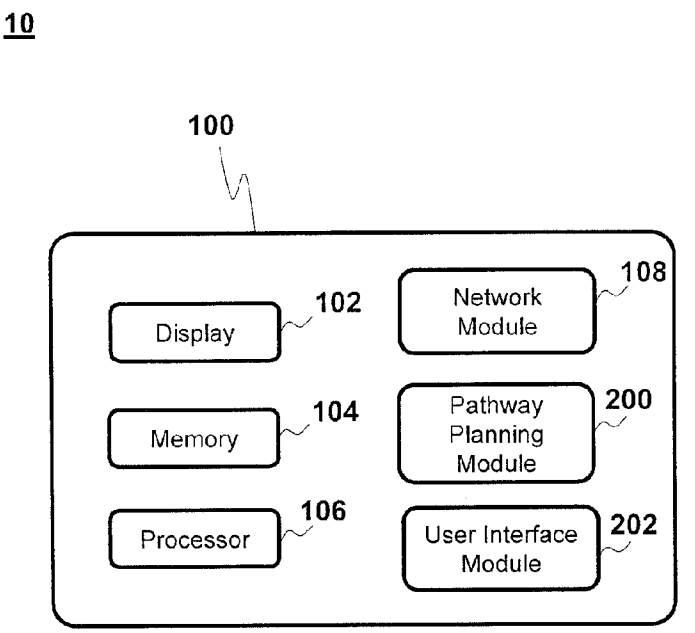

(57) Abrégé/Abstract:
A system and method for planning a pathway through an anatomical luminal network of a patient including memory storing a computer program configured to analyze and manipulate CT images, a processor configured to execute the computer program, and a display device configured to display a user interface of the computer program. The user interface includes a CT image window configured to display a slice of CT image data, a localizer window configured to display an image of at least one lung, the localizer window including a localizer configured to identify a location of the displayed slice relative to the at least one lung, and a target selection element configured to select a target from a displayed slice of CT image data in response to a user input.

Abstract

A system and method for planning a pathway through an anatomical luminal network of a patient including memory storing a computer program configured to analyze and manipulate CT images, a processor configured to execute the computer program, and a display device configured to display a user interface of the computer program. The user interface includes a CT image window configured to display a slice of CT image data, a localizer window configured to display an image of at least one lung, the localizer window including a localizer configured to identify a location of the displayed slice relative to the at least one lung, and a target selection element configured to select a target from a displayed slice of CT image data in response to a user input.

PATHWAY PLANNING SYSTEM AND METHOD

BACKGROUND

1. Technical Field

[0001] The present disclosure relates to a system and method for planning a pathway through an anatomical luminal network of a patient.

2. Discussion of Related Art

[0002] During a surgical procedure clinicians often use CT images for determining a plan or pathway for navigating through the luminal network of a patient. It is often difficult, however, for the clinician to effectively plan a pathway based on CT images alone, especially in the smaller branches of the bronchial tree where CT images typically do not provide sufficient resolution for accurate navigation.

[0003] To assist a clinician in planning a pathway through a luminal network, automated pathway planning systems and methods have been implemented that automatically generate a pathway from a target designated on a CT image to an entry point of a patient, e.g., a patient's mouth, nose, other natural entry points or an artificial entry point such, for example, as an incision. One example of an automated pathway planning system and method can be found in U.S. Patent No. 8,218,846.

[0004] When using a fully automated pathway planning system, however, the medical device may reach the end of the pathway in an orientation where the working end of the medical device is not oriented toward the target. In this example, a side of the medical device may be oriented towards the target instead of the working end and it may be difficult or impossible for the clinician to gain access to the target with the working end. In particular, when navigating through the small airways of the bronchial tree it may be difficult or even impossible to flex or turn the working end of

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the medical device towards a target when the target is located perpendicular to the path of travel of the medical device through the small airways.

SUMMARY

[0005] Systems and methods for planning a pathway through an anatomical luminal network of a patient are provided.

[0006] In an aspect of the present disclosure, a system for planning a pathway through an anatomical luminal network of a patient is disclosed including memory storing a computer program configured to analyze and manipulate CT images, a processor configured to execute the computer program, and a display device configured to display a user interface of the computer program. The user interface includes a CT image window configured to display a slice of CT image data, a localizer window configured to display an image of at least one lung, the localizer window including a localizer configured to identify a location of the displayed slice relative to the at least one lung, and a target selection element configured to select a target from a displayed slice of CT image data in response to a user input.

[0007] In an aspect of the present disclosure, the CT image window is configured to display at least one other slice of the CT image data in response to a user input and the localizer is configured to move relative to the image of the at least one lung to identify a location of the displayed at least one other slice relative to the at least one lung.

[0008] In an aspect of the present disclosure, the CT image window is configured to sequentially display slices of the CT image data in response to the user input.

[0009] In an aspect of the present disclosure, the CT image window is configured to display the slice of the CT image data from one of the axial, coronal and sagittal directions.

[00010] In an aspect of the present disclosure, the localizer window is configured to display an image of the at least one lung from one of the axial, coronal and sagittal directions.

[00011] In an aspect of the present disclosure, the image of the at least one lung is a fluoroscopy-like image.

[00012] In an aspect of the present disclosure, the user interface is further configured to display an edit target window including an CT slice from each of the Axial, Coronal and Sagittal directions, each CT slice configured to display a target sizing element positioned over the target and resizable in response to a user input.

[00013] In an aspect of the present disclosure, a method for planning a pathway through an anatomical luminal network of a patient is disclosed including the steps of: displaying a first slice of CT image data in a CT image window; displaying an image of at least one lung in a localizer window; setting a location element of the localizer window on the image of at least one lung at a first location corresponding to the location of the first slice relative to the at least one lung; receiving a user input; displaying a second slice of CT image data in the CT image window in response to the user input; and setting the location element of the localizer window on the image of the at least one lung at a second location corresponding to the location of the second slice relative to the at least one lung.

[00014] In an aspect of the present disclosure, the CT image window sequentially displays slices of the CT image data in response to the user input.

[00015] In an aspect of the present disclosure, the method further includes the steps of: receiving a user input identifying a target on at least one of the first slice or the second slice; and setting the target as a target for pathway planning in response to the user input.

[00016] In an aspect of the present disclosure, setting the target includes positioning a target selection element over the target.

[00017] In an aspect of the present disclosure, the method further includes the step of displaying a slice of the CT image data from each of the Axial, Coronal and Sagittal directions, each slice including the target thereon and a resizable target sizing element disposed over the target.

[00018] In an aspect of the present disclosure, the method further includes the step of resizing the target sizing element in one or more of the displayed Axial, Coronal and Sagittal slices in response to a user input.

[00019] In an aspect of the present disclosure, the user input is selected from the group consisting of manipulating a portion of the target sizing element in at least one of the displayed Axial, Coronal, and Sagittal slices and inputting dimension variables.

[00020] In an aspect of the present disclosure, a non-transitory computer-readable storage medium encoded with a program is disclosed, that, when executed by a processor causes a user interface to perform the steps of: displaying a first slice of CT image data in a CT image window; displaying an image of at least one lung in a localizer window; setting a location element of the localizer window on the image of at least one lung at a first location corresponding to the location of the first slice relative to the at least one lung; receiving a user input; displaying a second slice of CT image data in the CT image window in response to the user input; and setting the location element of the localizer window on the image of the at least one lung at a second location corresponding to the location of the second slice relative to the at least one lung.

[00021] In an aspect of the present disclosure, the CT image window sequentially displays slices of the CT image data in response to the user input.

[00022] In an aspect of the present disclosure, the program further causes the user interface to perform the steps of: receiving a user input identifying a target on at least one of the first slice or the second slice; and setting the target as a target for pathway planning in response to the user input.

[00023] In an aspect of the present disclosure, setting the target includes positioning a target selection element over the target.

[00024] In an aspect of the present disclosure, the program further causes the user interface to perform the step of displaying a slice of the CT image data from each of the Axial, Coronal and Sagittal directions, each slice including the target thereon and a resizable target sizing element disposed over the target.

[00025] In an aspect of the present disclosure, the program further causes the user interface to perform the step resizing the target sizing element in one or more of the displayed Axial, Coronal and Sagittal slices in response to the user input.

[00026] Any of the above aspects and embodiments of the present disclosure may be combined without departing from the scope of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[00027] Objects and features of the presently disclosed system and method will become apparent to those of ordinary skill in the art when descriptions of various embodiments thereof are read with reference to the accompanying drawings, of which:

[0010] FIG. 1 is a schematic diagram of a computing device for pathway planning in accordance with an embodiment of the present disclosure;

[0011] FIG. 2A is a view of a CT scan image of a patient's lungs taken from the Axial direction in accordance with an embodiment of the present disclosure;

[0012] FIG. 2B is perspective view a patient's body illustrating the Axial direction in accordance with an embodiment of the present disclosure;

[0013] FIG. 2C is a view of a CT scan image of a patient's lungs taken from the Coronal direction in accordance with an embodiment of the present disclosure;

[0014] FIG. 2D is perspective view of a patient's body illustrating the Coronal direction in accordance with an embodiment of the present disclosure;

[0015] FIG. 2E is a view of a CT scan image of a patient's lungs taken from the Sagittal direction in accordance with an embodiment of the present disclosure;

[0016] FIG. 2F is perspective view of a patient's body illustrating the Sagittal direction in accordance with an embodiment of the present disclosure;

[0017] FIG. 3 is a flow chart illustrating the four phases of pathway planning in accordance with an embodiment of the present disclosure;

[0018] FIG. 4 is an illustration of a user interface for the selection of patient data in accordance with an embodiment of the present disclosure;

[0019] FIG. 5 is a flow chart of a method of selecting patient data in accordance with an embodiment of the present disclosure;

[0020] FIG. 6 is an illustration of a user interface for adding a target to a pathway plan in accordance with an embodiment of the present disclosure;

[0021] FIG. 7 is a flow chart of a method of adding a target to a pathway plan in accordance with an embodiment of the present disclosure;

[0022] FIG. 8 is an illustration of a user interface for editing target details of an added target in accordance with an embodiment of the present disclosure;

[0023] FIG. 9 is an illustration of a user interface for reviewing a 3D map in accordance with an embodiment of the present disclosure;

[0024] FIG. 10 is a flow chart of a method of reviewing a 3D map in accordance with an embodiment of the present disclosure;

[0025] FIG. 11A is an illustration of a user interface for finding a pathway from a target to an entry point of a patient;

[0026] FIG. 11B is an illustration of the user interface of FIG. 11A after a CT image of the user interface has been rotated about an initial axis;

[0027] FIG. 11C is a perspective view of a 3D model of a patient's bronchial tree, illustrating an initial axis of rotation in accordance with an embodiment of the present disclosure;

[0028] FIG. 11D is an illustration of the user interface of FIG. 11B after a waypoint has been added and a pathway between the target and the waypoint has been created with the CT image rotated about the axis of the pathway;

[0029] FIG. 11E is an illustration of the user interface of FIG. 11D after a second waypoint has been added and a second pathway between the waypoint and the second waypoint has been created;

[0030] FIG. 11F is an illustration of the user interface of FIG. 11E after the CT image has been rotated about the axis of the second pathway to display a known airway;

[0031] FIG. 11G is an illustration of the user interface of FIG. 11F after a third waypoint has been added within the known airway and the pathway has been automatically completed;

[0032] FIG. 12 is a flow chart of a method of finding a known airway and creating a pathway in accordance with an embodiment of the present disclosure;

[0033] FIG. 13 is an illustration of a user interface for the reviewing a pathway accordance with an embodiment of the present disclosure;

[0034] FIG. 14 is a flow chart of a method of reviewing a pathway in accordance with an embodiment of the present disclosure;

[0035] FIG. 15 is an illustration of a user interface for the reviewing a target and pathway and for creating additional targets and pathways in accordance with an embodiment of the present disclosure;

[0036] FIG. 16 is an illustration of a user interface for the reviewing and exporting a pathway plan in accordance with an embodiment of the present disclosure; and

[0037] FIG. 17 is a flow chart of a method of reviewing and exporting targets, pathways, and pathway plans in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0038] Although the present disclosure will be described in terms of a specific embodiment, it will be readily apparent to those skilled in this art that various modifications, rearrangements and substitutions may be made without departing from the spirit of the present disclosure. The scope of the present disclosure is defined by the claims appended hereto.

[0039] Referring now to FIG. 1, the present disclosure is generally directed to a pathway planning system 10 and method for planning a pathway through an

anatomical luminal network of a patient for use during an operation. The pathway planning system 10 may include a computing device 100 such as, for example, a laptop, desktop, tablet, or other similar device, having a display 102, memory 104, one or more processors 106 and/or other components of the type typically found in a computing device. Display 102 may be touch sensitive and/or voice activated, enabling display 102 to serve as both an input and output device. Alternatively, a keyboard (not shown), mouse (not shown), or other data input devices may be employed.

[0040] Memory 104 includes any non-transitory, computer-readable storage media for storing data and/or software that is executable by processor 106 and which controls the operation of the computing device 100. In an embodiment, the memory 104 may include one or more solid-state storage devices such as flash memory chips. In an alternative embodiment, the memory 104 may be mass storage connected to the processor 106 through a mass storage controller (not shown) and a communications bus (not shown). Although the description of computer-readable media contained herein refers to a solid-state storage, it should be appreciated by those skilled in the art that computer-readable storage media can be any available media that can be accessed by the processor 106. That is, computer readable storage media includes non-transitory, volatile and non-volatile, removable and non-removable media implemented in any method or technology for storage of information such as computer-readable instructions, data structures, program modules or other data. For example, computer-readable storage media includes RAM, ROM, EPROM, EEPROM, flash memory or other solid state memory technology, CD-ROM, DVD, or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by the computing device 100.

[0041] Computing device 100 may also include a network module 108 connected to a distributed network or the internet via a wired or wireless connection for the transmission and reception of data to and from other sources. For example,

computing device 100 may receive computed tomographic (CT) images of a patient from a server, for example, a hospital server, internet server, or other similar servers, for use during pathway planning. Patient CT images may also be provided to computing device 100 via a removable memory 104.

[0042] A pathway planning module 200 includes a software program stored in memory 104 and executed by processor 106 of the computing device 100. As will be described in more detail below, pathway planning module 200 guides a clinician through a series of steps to develop a pathway plan for later use during a medical procedure. Pathway planning module 200 communicates with a user interface module 202 for displaying visual interactive features to a clinician on the display 102 and for receiving clinician input.

[0043] As used herein, the term "clinician" refers to any medical professional (i.e., doctor, surgeon, nurse, or the like) or other user of the pathway planning system 10 involved in planning, performing, monitoring and/or supervising a medical procedure involving the use of the embodiments described herein.

[0044] Referring temporarily to FIGS. 2A-2F, as a practical matter the most effective method of identifying targets involves the use of a computed tomographic (CT) image. By way of introduction, the use of CT images as diagnostic tools has become routine and CT results are frequently the primary source of information available to a clinician regarding the size and location of a lesion, tumor or other similar target of interest. This information is used by the clinician for planning an operative procedure such as a biopsy, but is only available as "offline" information which must typically be memorized to the best of the practitioner's ability prior to beginning a procedure. CT images are typically obtained by digitally imaging a patient in slices in each of the Axial, Coronal and Sagittal directions. For example, FIG. 2A illustrates a slice of a CT image taken from the Axial direction, i.e., as though looking parallel to the spine of the patient as illustrated in FIG. 2B. FIG. 2C illustrates a slice of a CT image taken from the Coronal direction, i.e., from a birds eye view of the patient as illustrated in FIG. 2D. FIG. 2E illustrates a slice of a CT image taken from the Sagittal direction, i.e., from a side of the patient as illustrated in FIG. 2F. A

clinician may review the CT image data slice by slice from each direction when attempting to identify or locate a target.

[0045] Referring now to FIG. 3, in an embodiment, pathway planning using the pathway planning module 200 may be performed in four separate phases. In a first phase S1, a clinician selects a patient for pathway planning. In a second phase S2, the clinician adds a target. In a third phase S3, the clinician creates the pathway to the target. Finally, in the fourth phase S4, the clinician reviews and accepts the plan and may export the plan for use in a medical procedure. The clinician may repeat either or both of the second and third phases S2 and S3 as needed to select additional targets and/or create additional pathways for a particular patient. For example, the clinician may select additional targets and may create a pathway to each target. The clinician may also or alternatively create multiple pathways the same target. With reference to FIGS. 4-16, each of stages S1-S4 will now be described in more detail below.

[0046] As used herein, the term "window" refers to any screen, image, overlay, user interface or combination thereof, projected or provided on the display 102 by user interface 202.

[0047] Referring now to FIGS. 4 and 5, in phase S1, user interface 202 presents a clinician with a window 210 for selecting patient data 212 on which to perform pathway planning. FIG. 4 illustrates user interface 202 including window 210 while FIG. 5 illustrates a method of selecting patient data according to an embodiment of the present disclosure. User interface 202 initially starts the method of selecting patient data at step S500 by opening window 210 for the clinician's review. Window 210 includes a selectable source location menu 214 that provides the clinician with the ability to select a source from which patient data 212 is received for use in pathway planning. In step S510 the clinician selects from a number of storage or memory devices including, for example, cd, dvd, blue-ray, other insertable optical media, universal serial bus (USB) memory devices, external or internal hard drives, solid state storage devices, or any other type of memory or storage 104 connected to or in data communication with computing device 100, as described above. The

window 210 may also provide access to patient data 212 stored in a remote location such as, for example, a server on a network or the internet. Source location menu 214 may allow the clinician to select a single source of patient data or may allow the clinician to select multiple sources of patient data at the same time. Source location menu 214 may also include an option to list patients from all sources. In step S504, the clinician may search through the list of patients or may input a search term in a search box 216 to narrow down the list of patients to those meeting a selected criteria such as, for example, a patient's first or last name, ID number, date of birth or other similar criteria. Once the clinician has selected the desired patient, the clinician proceeds to step S506.

[0048] In step 506, once a patient is selected by the clinician, a drop down menu 218 is displayed for the patient including a list of the patient's available CT images 220 and any pathway plans 222 for the selected patient that have been previously created for each CT image 220. The clinician may choose to create a new plan based on the CT image 220 by selecting the create new plan option 224 and proceeding to step S510 or may open a previously created plan by selecting an open plan option 226 and proceeding to step S514, if a previously created plan is present for the selected CT image 220. When the create new plan option 224 is selected, the CT images 220 are imported, preferably in a DICOM format, into the pathway planning module 200. The computing device 100 processes the CT images 220 and assembles them into a three-dimensional CT volume by arranging the CT images 220 in the order they were taken and spacing them apart according a distance between slices set on the CT scanning device when they were taken. Pathway planning module 200 may perform a data fill function to create a seamless three-dimensional (3D) model or CT volume of the patient's bronchial tree. The pathway planning module 200 uses the newly-constructed CT volume to generate a three-dimensional map of the airways in the bronchial tree. The three dimensional map can either be skeletonized, such that each airway is represented as a line, or it may include airways having dimensions representative of their respective diameters. Preferably, when the three dimensional map is being generated, the airways are

marked with an airflow direction (inhalation, exhalation, or separate arrows for each) for later use. Technologies for generating three-dimensional CT volumes and models are described in commonly assigned U.S. Pat. Nos. 6,246,784 and 6,345,112 both to Summers et al., as well as the references cited therein.

[0049] Window 210 also includes a capture screen option 228 that allows the clinician to capture an image of the current screen shown on the display 102, for example, window 210, and save the captured image to memory. The capture screen option 228 may also be configured to remove patient specific data from the captured image to protect patient privacy. The removal of patient specific data may be an option selectable by the clinician and may be set to "on" by default.

[0050] Referring now to FIGS. 6-8, if the clinician has selected the create new plan option 224 from window 210, the method proceeds to step S512 and phase S2, adding a target. FIGS. 6 and 8 illustrate user interface 202 including windows 230 and 244 while FIG. 7 illustrates a method of adding a target according to an embodiment of the present disclosure. When phase S2 is initiated the method proceeds to step S700 and user interface 202 opens a window 230 for identification and selection of a target 232 on which to perform pathway planning. In window 230, the clinician is provided with a slice 234 of the CT image data in a main window 236. The slice 234 may be taken from the CT image data in any one of the Axial, Coronal and Sagittal directions. The clinician may freely switch the slice 234 shown in the main window 236 between slices 234 from the Axial, Coronal and Sagittal directions at any time. In the illustrated example, a slice 234 from the Axial CT image data is provided. It is important to note that by only showing a single slice and direction at a time, for example, only a slice 234 from the Axial CT image data, the clinician is provided with a simple and clean interface from which to select a target. The clinician may manipulate and relocate the image of the selected slice 234 in the main window 236 and may zoom in or out on the selected slice 234 to obtain an enlarged or reduced view of a particular portion of the selected slice 234.

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[0051] Window 230 also includes a localizer 238 which provides a general overview of the patient's CT image data for use by the clinician. In the illustrated example, localizer 238 provides a localizer window 240 including generic view of a patient's lungs from the Coronal direction. The localizer window 240 may, for example, display a CT image from the Coronal direction, a fluoroscopy-like image, or other similar images that provide a clinician with a view of the patient's lungs. Localizer 238 includes a location element 242, for example, a line or bar, extending across localizer window 240 which provides a clinician with a location of the selected slice 234 displayed in main window 236 relative to the patient's lungs as displayed by the localizer 238. Location element 242 is selectable by the clinician and moveable or slidable relative to the localizer window 240 to allow the clinician to scroll through the CT image slices of the patient's lungs displayed on the main window 236. For example, the CT image slices may be scrolled through or displayed in a sequential order defined by the CT image data. The clinician may also or alternatively click on or select a portion of the localizer window 240 to move localizer 238 to the selected location in the patient's lungs. The clinician may also or alternatively scroll through the CT image slices of the patient's lungs displayed in the main window 236 via an input device such as, for example, a mouse wheel or other device without interacting directly with user interface 202. When another direction is selected for display on main window 236, for example, the Coronal direction, localizer 238 may display a generic view of one of the other directions, for example, the Axial or Sagittal direction. Localizer 238 provides the clinician with a general reference for where a particular lesion or other target 232 is located in the patient's lungs. Localizer 238 may also display one or more previously selected targets for the clinician's reference.

[0052] In step S702, the clinician scrolls through the CT image slices 234 to identify a target 232 on the CT image. In step S704, once a target 232 has been identified in the current CT slice 234, the clinician may click on or otherwise select the target 232 from the main window 236 using a target selection element 243, for example, a crosshair, mouse pointer, hand, or other similar selection element. The clinician may, for example, drag the CT image displayed on the main window 236 so

that the target selection element 243 is positioned over the target 232, or alternatively, may directly select target 232 by clicking on the target 232 using a mouse (not shown) or other input device. If display 102 is touch-sensitive, the clinician may touch the target 232 on display 102 to select the target 232. The target 232 may then be added to the plan in step S706 by selecting the add a target option 245.

[0053] Referring now to FIG. 8, once a target 232 has been added, a target details window 244 is displayed by user interface 202. Target details window 244 may overlay window 230 or may replace window 230. Target details window 244 provides the clinician with the selected target 232 as shown in enlarged or zoomed versions of the Axial view 246, Coronal view 248 and Sagittal view 250. In step S708, the clinician may input width, height, and depth dimensions for the target 232, name the target 232, and add additional comments relating to the target 232. In addition, a target sizing element 252, e.g., a crosshair or other similar element, is positioned over the target 232 in each of views 246, 248, 250 and is manipulatable or movable by the clinician to center the target 232 in the target sizing element 252 in each view 246, 248, 250. Target sizing element 252 also includes an adjustable boundary ring 254 that is manipulatable by the clinician to resize the dimensions of the target 232. For example, the clinician may resize the boundary ring 254 on each of the Axial view 246, Coronal view 248 and Sagittal view 250 to accurately define the dimensions of the target 232. Boundary ring 254 may be circular, oval or other similar geometric shapes and the shape of the boundary ring 254 may be adjusted to substantially match the general dimensions of the target 232. In an embodiment, boundary ring 254 may be adjusted in a non-geometric manner by the clinician, for example, a free-form manipulation of boundary ring 254, to conform to non-geometric dimensions of the target 232. It is important to note that because the target 232 is a three dimensional object such as, for example, a lesion, tumor, or the like, and each view 246, 248, 250 is taken from a different direction, manipulation and adjustment of the boundary ring 254 on one of the views 246, 248, 250 by the clinician may result in a change or adjustment of the boundary ring 254 in one or both of the remaining views 246, 248, 250. In this manner the clinician may accurately select the target

dimensions and the location of the target 232 in all three views, effectively mapping the target to specific coordinates and dimensions in a 3-D coordinate space. In step S710, once the dimensions and location of target 232 have been selected by the clinician the clinician selects the save target option 256 and proceeds to a review of the generated three dimensional map of the patient's bronchial tree in step S712.

[0054] Referring now to FIGS. 9 and 10, after the clinician has selected the save target option 256 of window 230, the method proceeds to step S1000, reviewing the 3D map of the bronchial tree. In step S1000, user interface 202 opens a window 260 for review of the three dimensional map generated by the pathway planning module 200. Window 260 includes a three dimensional map window 262 displaying a three dimensional model 264 of the patient's bronchial tree and a scan window 266 displaying a CT image from one of the Axial, Coronal and Sagittal directions for the clinician's reference. In the illustrated embodiment, the CT image from the Coronal direction is displayed. The CT image from the Coronal direction is displayed because the Coronal direction provides images of the patient's bronchial tree from the bird's eye or frontal view and is more likely to display to the clinician major recognizable features of the bronchial tree, for example, trunks and branches of the major airways. By comparing the CT image to the three dimensional model 264, the clinician is able to determine or verify that the three dimensional model 264 includes the major recognizable features of the patient's bronchial tree and also that there are no gross abnormalities in the three dimensional model 264 when compared to the CT image. In step S1002, the clinician rotates the three dimensional model as needed by manipulating a rotation slider 268 of three dimensional map window 262 to determine if the 3D map is acceptable. In step S1004, if the clinician is satisfied that the three dimensional model 264 is substantially accurate, for example, the major or central airways are sufficiently illustrated, the clinician selects the approve map option 270 and proceeds to the phase S3 and the airway finder. If the 3D map is not acceptable, the clinician proceeds to step S1006 and returns to step S500 to select new patient data, for example, a new patient or a new CT scan for the same patient.

[0055] Referring now to FIGS. 11A-11G and 12, after the clinician has selected the approve map option 270 of window 260, the method proceeds to phase S3 and step S1200 to start the airway finder. FIGS. 11A-11B and 11D-11G illustrate user interface 202 including window 272, FIG. 11C illustrates an initial axis "A" for use by the airway finder, and FIG. 12 illustrates a method of finding an airway and completing a pathway according to an embodiment of the present disclosure. In step S1200, referring initially to FIGS. 11A-11C, user interface 202 opens a window 272 for creating a pathway from the target 232 to the an entry point of the patient, for example, a natural orifice such as the mouth or nose, or an artificial entry point such as an incision. Window 272 includes an airway finder 274 displaying a CT image 276 including the target 232 and a rotation interface 278 describing the rotation of the CT image 276 about a specified axis. In an embodiment, upon initial opening of window 272, only the target 232 is shown on the CT image 276 of the airway finder window 274 and rotation indicators 280, e.g., arrows 280a and rotation bar 280b, on a rotation interface 278 are aligned. Rotation interface 278 provides rotational information regarding a relative rotation of CT image 276 about the specified axis. Referring now to FIG. 11B, a target marker 232A is displayed on the CT image 276 and is positioned over the target 232 to illustrate the location of target 232 to the clinician. A lead line 232B extends from a center of target marker 232A and is moveable by the clinician through movement of a pointer, mouse or other input devices. For example, the movement of an input device by the clinician moves an end 232C of lead line 232B that extends away from the target 232. The clinician uses lead line 232B to select an appropriate airway as will be described in more detail below with respect to step S1208.

[0056] In an embodiment, referring briefly to FIG. 11C, an initial axis "A" is set in step S1202 upon the initial opening of window 272 and is defined along an axis taken from the target 232 to a central portion of the tracheal lumen of the patient. By defining the initial axis "A" along axis from the target 232 to the trachea, the likelihood that a clinician can find an airway near the target 232 that will connect the target 232 to the entry point is increased. This is due to the tree like or branching nature of the

bronchial tree. In other embodiments, the initial axis "A" may be defined along an axis taken from the target 232 to any other portion of the patient's bronchial tree, for example, to a central portion of the closest main branch of bronchial tree or to the closest known airway of the 3D map of the patient's bronchial tree.

[0057] In step S1204, the clinician rotates the CT image 276 about the initial axis by, for example, rolling a mouse wheel, manipulating another input device, and/or by manipulating a portion of user interface 202, for example, rotation interface 278. As the clinician rotates the CT image 276 about the initial axis, indicators 280 on the rotation interface 278 move relative to one another, for example, the rotation bar 280b moves relative to the arrows 280a, in a corresponding direction along rotation interface 278 to indicate the amount of rotation relative to the initial view. When the rotation bar 280b reaches the end of rotation interface 278 after continued rotation in the same direction by the clinician, rotation bar 280b will disappear from the end of the rotation interface 278, reappear on an opposite end of rotation interface 278, and continue to slide along rotation interface 278 in the same direction. When the clinician has rotated the CT image 276 a full rotation about the initial axis, indicators 280, e.g., arrows 280a and rotation bar 280b, will once again be aligned at the center of rotation interface 278.

[0058] Referring now to FIGS. 11B and 11D, when rotating the CT image 276 about the initial axis, the clinician assesses the CT image 276 in step S1206 to determine whether an airway 282 near the target 232 is present. For example, an area of darkness in the CT image 276 that extends away from the target 232 or extends near the target 232 may be an indication that an airway 282 is present. If the clinician determines that an airway 282 is present, the method proceeds to step S1208 and the clinician positions end 232C of lead line 232B at the determined location within the airway 282 on the CT image 276 to create a pathway waypoint 282a on the CT image 276. The pathway planning module 200 draws a pathway line 284 between the target 232 and the pathway waypoint 282a on the CT image 276 and proceeds to step S1210. In this way, the clinician defines the portion of the airway 282 closest to the target 232. If no airway 282 is present, the clinician returns

to step S1204 and continues to rotate the CT image about the specified axis. If the pathway waypoint 282a is not positioned correctly or the clinician desires to look for another airway, the clinician may remove the pathway waypoint 282a and return to either of steps S1204 or S1208.

[0059] In step S1210, pathway planning module 200 determines whether the pathway waypoint 282a selected by the clinician is located within a known airway of the three dimensional map generated by the pathway planning module 200. If the pathway waypoint 282a is located within a known airway of the three dimensional map, the method proceeds to step S1214 and the pathway is automatically completed by the pathway planning module 200 from the pathway waypoint 282a through the known airways of the three dimensional map to the trachea and the entry point of the patient, as further illustrated below for waypoint 282a in FIG. 11G.

[0060] If the pathway waypoint 282 is not located within a known airway of the three dimensional map, the method proceeds to step S1212. Referring now to FIGS. 11D and 11E, airway finder 274 displays a CT image 286 including the target 232, target marker 232a, pathway waypoint 282a, pathway line 284, and rotation interface 278, as described above. As illustrated in FIG. 11D, a lead line 282b having an end 282c now extends from pathway waypoint 282a.

[0061] In step S1212, the specified axis is set to an axis defined by pathway line 284. CT image 286 is rotatable about pathway line 284 instead of the initial axis "A" and rotation interface 278 displays the relative rotation of the CT image 286 about the axis defined by pathway line 284. By defining the axis of rotation about pathway line 284, the likelihood of the clinician finding airways on CT image 286 that connect to the airway 282 including the pathway waypoint 282a is increased. After the specified axis has been set to the axis of pathway line 284, the method returns to step S1204. When rotating the CT image 286 about the axis defined by pathway line 284, the clinician assesses the CT image 286 to determine whether an airway 288 connected to the pathway including pathway waypoint 282a is present as described above. If the clinician determines that an airway 288 is present in step S1206, the method proceeds to step S1208 and the clinician positions end 282C of lead line

282B at the determined location within the airway 288 on the CT image 286 to create a pathway waypoint 288a on the CT image 286. The pathway planning module 200 draws a pathway line 290 from pathway waypoint 282a to pathway waypoint 288a on the CT image 286, as illustrated in FIG. 11E. If the pathway waypoint 288a is not positioned correctly or the clinician desires to look for another airway, the clinician may remove the pathway waypoint 288a and return to either of steps S1204 or S1208.

[0062] In step S1210, referring now to FIGS. 11F, the pathway planning module 200 determines whether the pathway waypoint 288a selected by the clinician is located within a known airway, e.g., airway 291, of the three dimensional map generated by the pathway planning module 200. If the pathway waypoint 288a is not located within a known airway of the three dimensional map, the method proceeds to step S1212 and the clinician continues to set additional pathway waypoints as described above until a pathway waypoint is located within a known airway of the three dimensional map.

[0063] Referring now to FIG. 11G, a pathway waypoint 291a has been added in the manner described above in airway 291. In this illustration, airway 291 is a known airway of the three dimensional map. The method proceeds to step S1214 and the pathway 291b is automatically completed by the pathway planning module 200 from the pathway waypoint 291a through the airway 291 and the known branches of the three dimensional map of the bronchial tree to the entry point of the patient. Once a pathway is automatically completed, the method proceeds to step S1216 and a pathway completed window 292 is displayed by the user interface 202 providing the clinician with a proceed to pathway review option 293a and an undo automatic completion option 293a. The clinician may select the proceed to pathway review option 293a to proceed to step S1218 and start review of the pathway. Alternatively, if the clinician would like to continue mapping waypoints using airway finder 274, the clinician may select the undo automatic completion option 293b and return to step S1212 for the creation of further pathway waypoints as described above.

[0064] In this manner a pathway plan is created for later use by a clinician during a procedure or operation. Because the clinician can manually select and create the pathway and pathway waypoints that are closest to the target 232 prior to automatic completion, the clinician is able create a pathway plan that directly controls the final orientation of a medical device at the end of the pathway plan relative to the target 232. This allows the clinician to create a pathway plan for the medical device that will allow the medical device to travel along the small airways of the patient in a direction that will allow the working end of the medical device to be oriented generally toward the target 232, where generally toward the target 232 includes any orientation from which the clinician may effectively gain access to the target 232 within the limits of the medical device used.

[0065] Referring now to FIGS. 13 and 14, after the clinician has completed a pathway, the method proceeds step S1400 and user interface 202 opens a window 294 for reviewing the pathway from the target 232 to the entry point of the patient. FIG. 13 illustrates user interface 202 including window 294 while FIG. 14 illustrates a method of reviewing a pathway according to an embodiment of the present disclosure. Window 294 includes a virtual window 295 and a three dimensional map window 296. Three dimensional map window 296 displays a three dimensional model 298 of the patient's bronchial tree similar to three dimensional map window 262. Virtual window 295 displays a CT-based "virtual bronchoscopy" which depicts simulated views similar to those of actual bronchoscope views and includes a view selection tab 295a for selecting between a virtual bronchoscopy view, a local view, and radial view. During the virtual bronchoscopy, the clinician may switch between the virtual, local and radial views as needed to review the pathway. The virtual bronchoscopy view displays a virtual visualization of the airways, derived from the CT data, that is an approximation of the video image from a bronchoscope, the local view displays an elevated perspective view of a cross-section of the CT volume through the current navigation location, and the radial view displays a cross-section of the CT volume that is perpendicular to the navigation location and local pathway segment. The technology of virtual bronchoscopy is described in commonly assigned U.S. Pat.

Nos. 6,246,784 and 6,345,112 both to Summers et al., as well as the references cited therein.

[0066] In step S1402, once the pathway has been created by the clinician, the user reviews the plan, targets and pathways by following a fly-through virtual bronchoscopy on virtual window 295. The user interface 202 generates a line 300 in virtual window 295 which represents the created pathway. The clinician follows the line 300 from the entry point through the trachea and through the airways of the patient's bronchial tree until the line 300 reaches the target 232. As can be appreciated, as the clinician follows the line 300 through the increasingly smaller airways of the patient's bronchial tree, the ability of the pathway planning module 200 to resolve the smaller airways is increasingly difficult due to a lack of resolution in the imported CT images. Because of this lack of resolution, the simulated views of the virtual bronchoscopy displayed in virtual window 295 may eventually fail to depict a clear airway lumen. Regardless, the target 232 and line 300 will be displayed in the virtual window 295 to allow the clinician to utilize the system for pathway planning purposes.

[0067] As the clinician follows the line 300 through the patient's bronchial tree to the target 232, a corresponding marker 298a travels along the three dimensional model 298 to the target 232 indicating a location of the simulated view of the virtual window 295 relative to the three dimensional model 298. In step S1404, after reviewing the virtual bronchoscopy the clinician determines whether the pathway is acceptable. If the pathway is acceptable the clinician may select the approve option 299a and the method proceeds to steps S1408. If the pathway is not acceptable, the method proceeds to steps S1406 and the clinician may select the discard pathway and start over option 299b to return to the airway finder window 272 to edit the pathway or create a new pathway.

[0068] Referring now to FIGS. 15-17, once the clinician has reviewed and accepted the pathway, the method proceeds to phase S4 and step S1700. FIGS. 15 and 16 illustrate user interface 202 including windows 302 and 316, respectively, while FIG. 17 illustrates a method of reviewing a plan according to an embodiment of

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the present disclosure. In step S1700, user interface 202 opens a window 302 including a three dimensional map window 304 and views of each of the Axial 306, Coronal 308 and Sagittal 310 directions displaying the selected pathway. Window 302 includes target tabs 312 and a pathway list 314. Target tabs 312 allow the clinician to add additional targets and select already identified targets for further review. Pathway list 312 allows the clinician to review the pathways associated with a selected target tab 312 and to add a pathway for the selected target tab 312. In step S1704, the clinician determines if the targets are acceptable. If the targets are not acceptable, the method proceeds to step S1706 and the pathway planning module 200 returns the clinician to the add a target window 230 to add a new target, as described above. If the targets are acceptable, the method proceeds to step S1708 and the clinician determines if the pathways are acceptable. If the pathways are not acceptable the method proceeds to step S1710 and the pathway planning module 200 returns the clinician to the airway finder window 272 for creation of additional pathways, as described above. If both the targets and the pathways are acceptable, the clinician selects the finish and export option 315 and proceeds to plan review in step S1716.

[0069] Referring now to FIG. 16, in step S1716 user interface 202 opens a window 316 including a three dimensional map window 318 and a list of the targets 320 identified for the selected plan. Each target 320 is selectable by the clinician to display the associated pathways 322 and each pathway 322 is reviewable by the clinician through the selection of a review option 324. Window 316 also provides an indication of whether the three dimensional map has been reviewed and approved and whether the current plan has been exported. In step S1712, if the 3D map has not been approved, the clinician may re-review the three dimensional map by selecting the review 3D map option 326. If the review 3D map option 326 has been selected, the method proceeds to step S1714 and the pathway planning module 200 returns the clinician to the review 3D map window 260 described above. If the 3D map has been approved, the method proceeds to step S1716 and the clinician determines whether the overall plan is acceptable. If the plan is not acceptable, the

method proceeds to step S1718 and the pathway planning module 200 returns the clinician to the patient selection window 210 described above. If the clinician is satisfied with the plan, the method proceeds to step S1720 and the clinician may export the plan for use during a surgical procedure by selecting the export option 328. The plan may be exported to any form of non-transitory computer readable medium, memory or storage device as described above for memory 104 including, for example, a memory or storage on the device 100, a removable storage device, exported by transmission across a wired or wireless connection to a remote or server memory, etc.

[0070] With reference to FIGS. 4, 6, 15 and 16 the user interface 202 may include one or more navigation bars that are manipulatable by the clinician to return to or repeat any of the above phases and/or steps. For example, as illustrated in FIG. 4, the clinician may manipulate a navigation bar 330 to switch between the phases. The clinician may also be provided with the option to return to a previous step or window in any of the user interface 202 windows.

[0071] As noted above, the present disclosure employs CT images for the pathway planning. CT images are also typically used by the clinician during a medical procedure for the navigational purposes. The CT images are preferable to other imaging modalities because they have their own system of coordinates. Matching two systems of coordinates, e.g., that of the CT images and that of the patient, is commonly known as registration. Registration is generally performed by identifying locations in both the CT images and on or inside the body, and measuring their coordinates in both systems.

[0072] Methods of manual and semi-automated registration of CT data and patient data are described in detail in for example U.S. Patent No. 7,233,820 assigned to Covidien LP. Because manual registration is somewhat time consuming and requires multiple steps, many practitioners rely on the automatic registration techniques described below. However, in some instances, particularly if the CT image data is not of sufficient quality it may still be necessary or desirable to conduct manual registration.

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[0073] Automatic registration has become the norm for most procedures because while the manual fiducial point designation of the above referenced registration techniques is highly effective, the choice of number of points sampled necessarily represents a tradeoff between accuracy and efficiency. Similarly, while the semi-automated technique is a viable option it requires an image sensor at the distal end of the catheter assembly which adds increased complexity to the system.

[0074] Automatic registration techniques are described in detail in commonly assigned U.S. Patent Application Publication No. 2011/0085720. Automatic registration between a digital image of a branched structure and a real-time indicator representing a location of a sensor inside the branched structure is achieved by using a sensor to "paint" a digital picture of the inside of the structure. Once enough location data has been collected, registration is achieved. The registration is "automatic" in the sense that navigation through the branched structure necessarily results in the collection of additional location data and, as a result, registration is continually refined.

[0075] Although embodiments have been described in detail with reference to the accompanying drawings for the purpose of illustration and description, it is to be understood that the inventive processes and apparatus are not to be construed as limited thereby. It will be apparent to those of ordinary skill in the art that various modifications to the foregoing embodiments may be made without departing from the scope of the disclosure.

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CLAIMS:

1. Use of a system, the system configured for planning a pathway through an anatomical luminal network of a patient, the system comprising:

a processor;

a memory storing instructions that, when executed by the processor, cause the system to analyze and manipulate CT images; and

a display configured to present a user interface, the user interface comprising:

a CT image window configured to:

display a slice of CT image data; and

display at least one other slice of CT image data in response to a display input received at the user interface;

a localizer window configured to:

display an image of at least one lung, wherein the localizer window includes a localizer configured to:

identify a cross-sectional location of the displayed slice of CT image data relative to the at least one lung; and

slidably move in response to a localizermovement input received at the user interface, relative to the image of the at least one lung, causing the processor to sequentially update a displayed slice of CT image data in the CT image window; and

a target selector configured to display a target selection element at a location in response to a target selection input received at the user interface within the displayed slice of the CT image data, and select a target located at the displayed target selection element within the displayed slice of CT image data, the target selection element being resizable in response to a resize input received at the user interface,

wherein the use of the system is to control a final orientation of a medical device, in the pathway, relative to the target.

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2. The use according to claim 1, wherein the CT image window is further configured to display the slice of the CT image data from one of an axial, coronal, and sagittal directions.

3. The use according to claim 1, wherein the localizer window is configured to display an image of the at least one lung from one of an axial, coronal and sagittal direction.

4. The use according to claim 1, wherein the image of the at least one lung is a fluoroscopy-like image.

5. The use according to claim 1, wherein the user interface is further configured to display an edit target window including a CT slice from each of an axial, coronal and sagittal direction, each CT slice configured to display a target sizing element positioned over the target and resizable in response to the resize input received at the user interface.

6. A method for planning a pathway through an anatomical luminal network of a patient, the method comprising:

digitally imaging a patient in slices to obtain slices of CT image data;

displaying one of the slices of CT image data in a CT image window to obtain a displayed slice of CT image data;

displaying an image of at least one lung in a localizer window;

setting a location element of the localizer window on the image of at least one lung at a first location corresponding to a cross-sectional location of the slice relative to the at least one lung, wherein the location element is slidably moveable in response to a location element movement input received at the location element and sequentially updating the displayed slice of CT image data;

receiving the location element movement input at the location element;

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sequentially displaying the slice of CT image data or a subsequent slice of CT image data in the CT image window in response to the location element movement input;

setting the location element of the localizer window on the image of the at least one lung at the subsequent location corresponding to the cross-sectional location of the subsequent slice relative to the at least one lung;

displaying a target selection element at a location in response to a target selection input within the displayed slice of CT image data, the target selection element being resizable in response to a resize input received at the target selection element;

selecting a target located at the displayed target selection element within the displayed slice of CT image data; and

using the pathway to control a final orientation of a medical device, in the pathway, relative to the target.

7. The method according to claim 6, further comprising:

receiving the target selection input identifying the target on at least one of the slice or the subsequent slice; and

setting the target as a target for pathway planning in response to the target selection input.

8. The method according to claim 7, wherein setting the target includes positioning a target selection element over the target.

9. The method according to claim 7, the method further comprising the step of:

displaying a slice of CT image data from each of an axial, coronal and sagittal direction, each slice including the target thereon and a resizable target sizing element disposed over the target.

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10. The method according to claim 9, the method further comprising:

resizing the target sizing element in one or more of the displayed axial, coronal and sagittal slices in response to the resize input.

11. The method according to claim 10, wherein the resize input is selected from the group consisting of manipulating a portion of the target sizing element in at least one of the displayed axial, coronal, and sagittal slices and inputting dimension variables.

12. A non-transitory computer-readable storage medium storing instructions that, when executed by a processor, cause the processor to carry out the method according to any one of claims 6 to 11.

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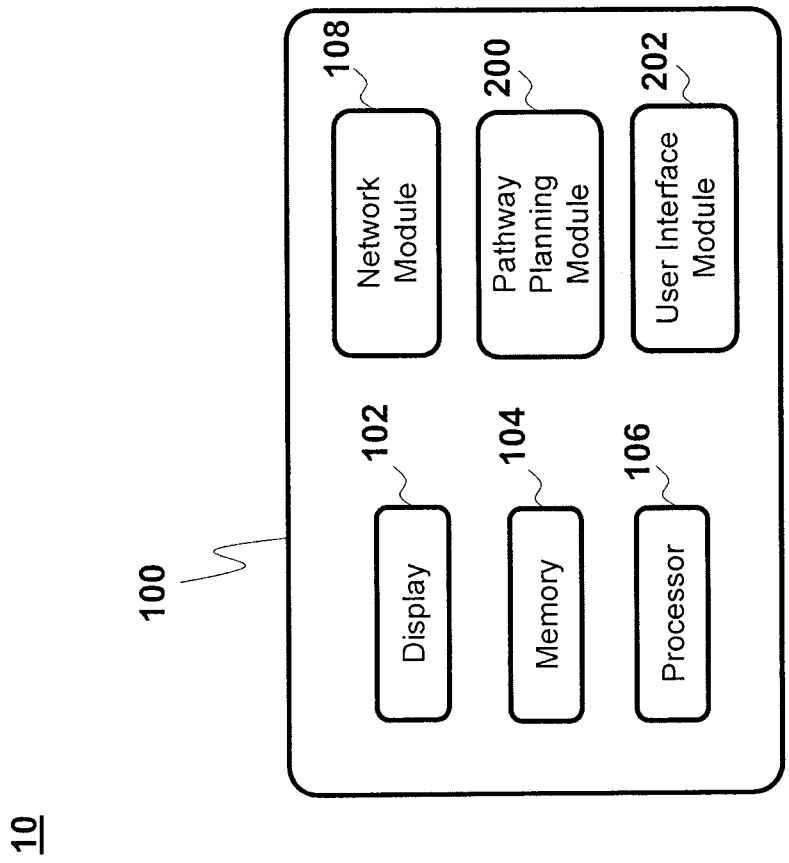

10
100
102
Display
104
Memory
106
Processor
108
Network Module
200
Pathway Planning Module
202
User Interface Module

FIG. 1

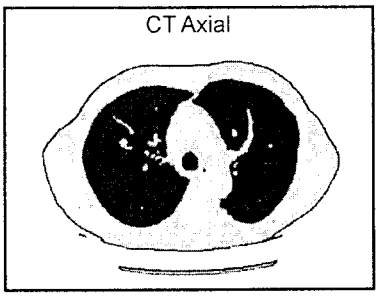


FIG. 2A

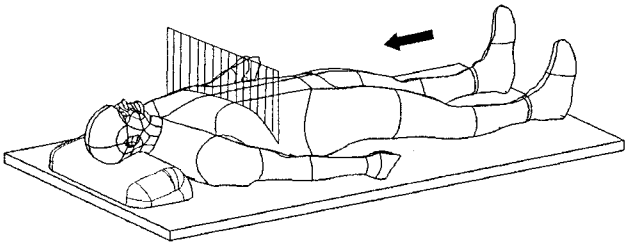


Fig. 2B

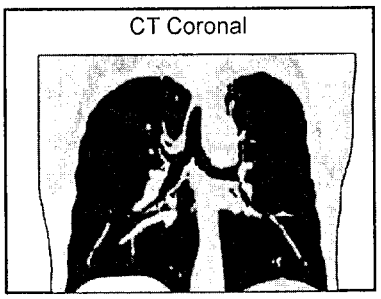


FIG. 2C

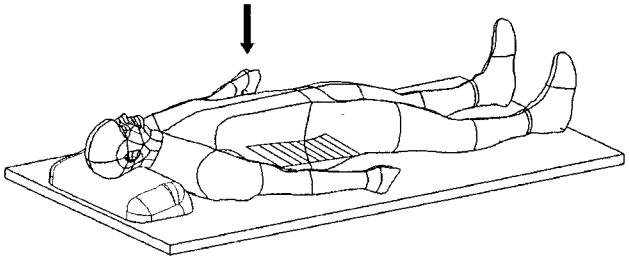


Fig. 2D

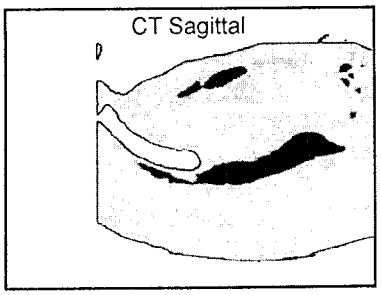


FIG. 2E

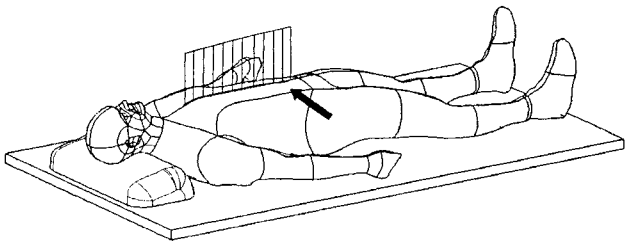


Fig. 2F

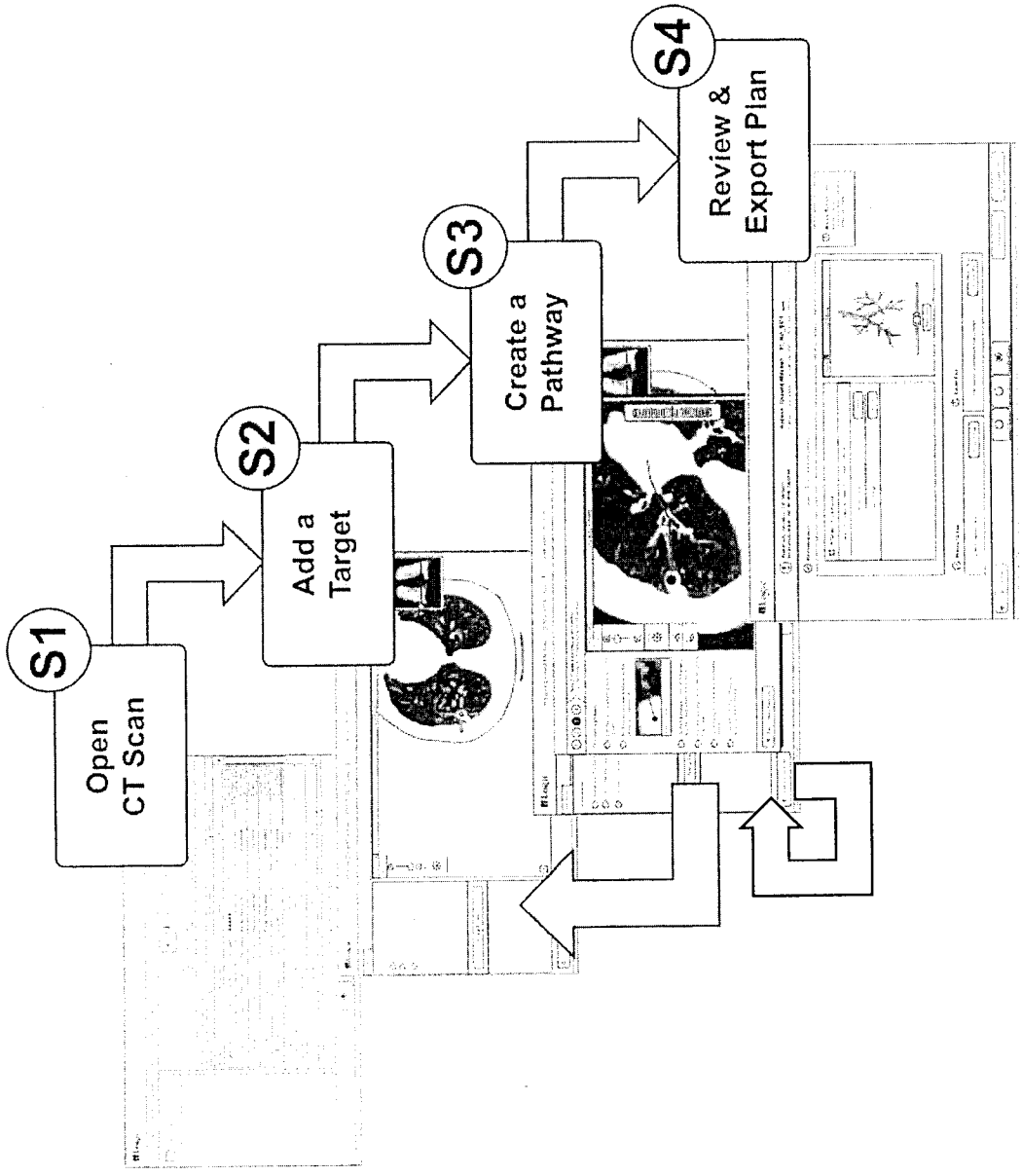

S1
Open
CT Scan
S2
Add a
Target
S3
Create a
Pathway
S4
Review &
Export Plan

FIG. 3

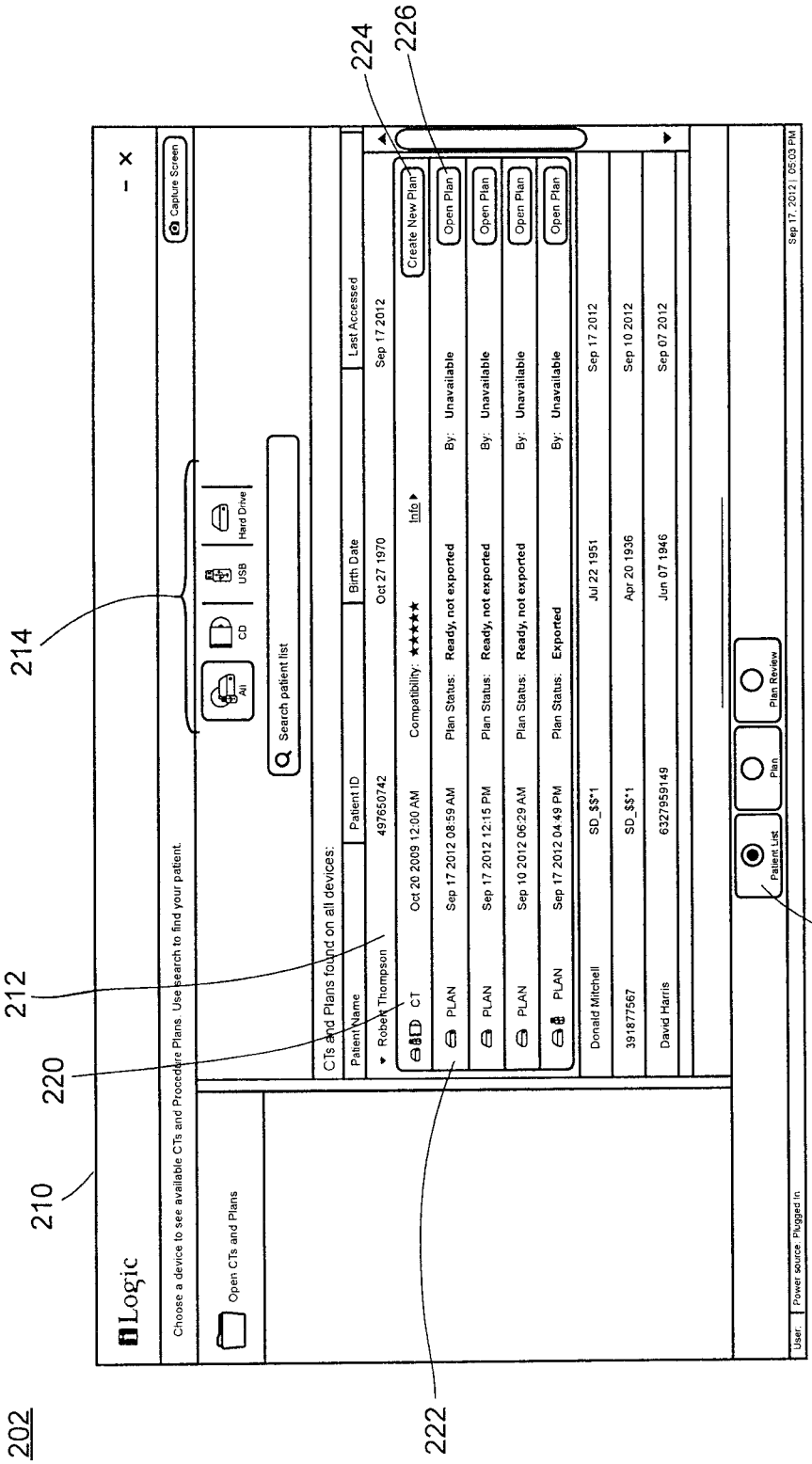

202
210
212
214
220
222
224
226
330
iLogic
Choose a device to see available CTs and Procedure Plans. Use search to find your patient.
Capture Screen
Open CTs and Plans
All
CD
USB
Hard Drive
Search patient list
CTs and Plans found on all devices:
Patient Name
Patient ID
Birth Date
Last Accessed
Robert Thompson
4976500742
Oct 27 1970
Sep 17 2012
CT
Oct 20 2009 12:00 AM
Compatibility: ★★★★★
Info
Create New Plan
PLAN
Sep 17 2012 08:59 AM
Plan Status: Ready, not exported
By: Unavailable
Open Plan
PLAN
Sep 17 2012 12:15 PM
Plan Status: Ready, not exported
By: Unavailable
Open Plan
PLAN
Sep 10 2012 06:29 AM
Plan Status: Ready, not exported
By: Unavailable
Open Plan
PLAN
Sep 17 2012 04:49 PM
Plan Status: Exported
By: Unavailable
Open Plan
Donald Mitchell
SD_$$*1
Jul 22 1951
Sep 17 2012
391877567
SD_$$*1
Apr 20 1936
Sep 10 2012
David Harris
6327959149
Jun 07 1946
Sep 07 2012
Patient List
Plan
Plan Review
User:
Power source: Plugged in
Sep 17, 2012 | 05:03 PM

FIG. 4

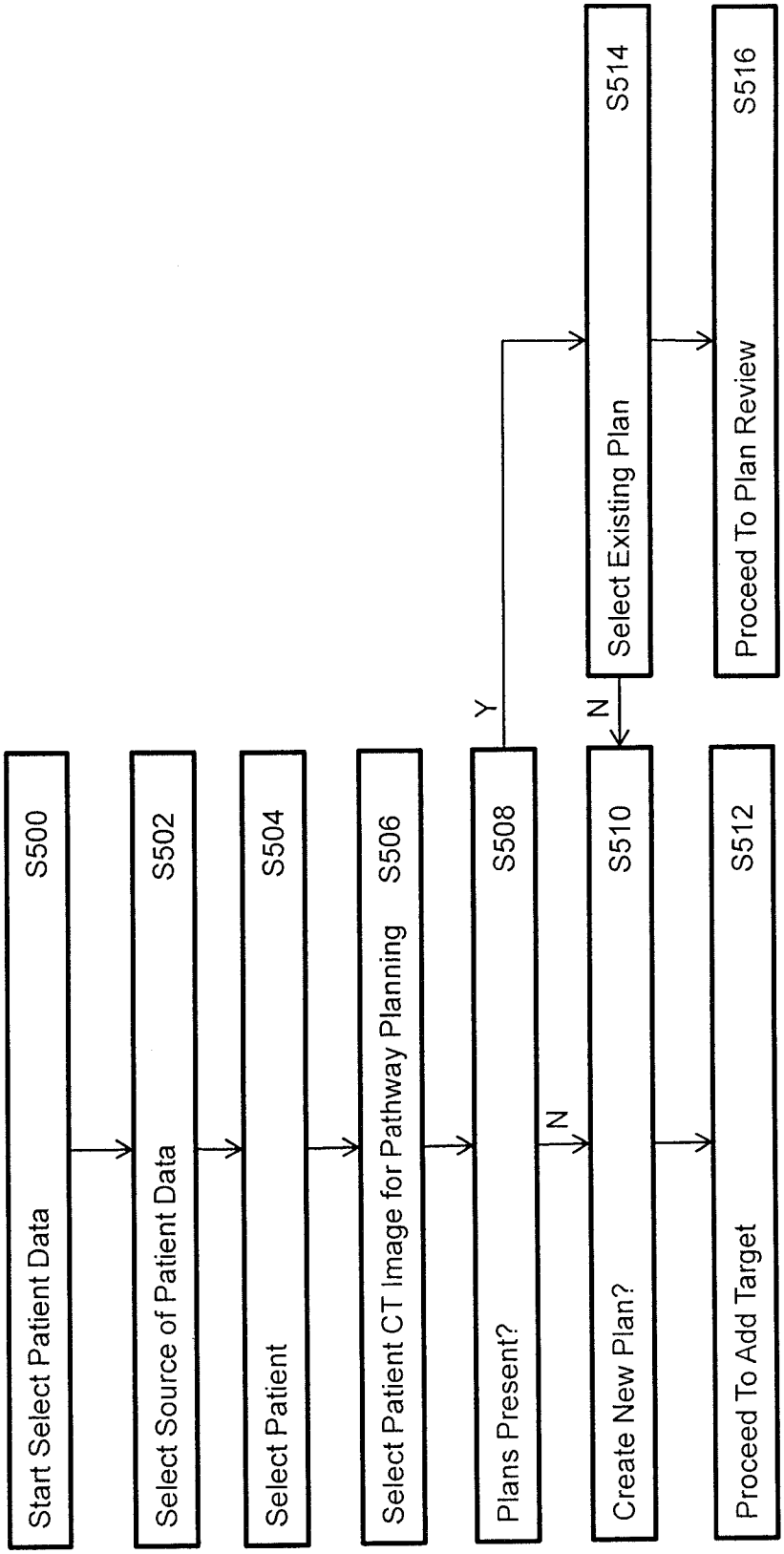

Start Select Patient Data
S500
Select Source of Patient Data
S502
Select Patient
S504
Select Patient CT Image for Pathway Planning
S506
Plans Present?
S508
Y
N
Select Existing Plan
S514
Create New Plan?
S510
N
Proceed To Plan Review
S516
Proceed To Add Target
S512

FIG. 5

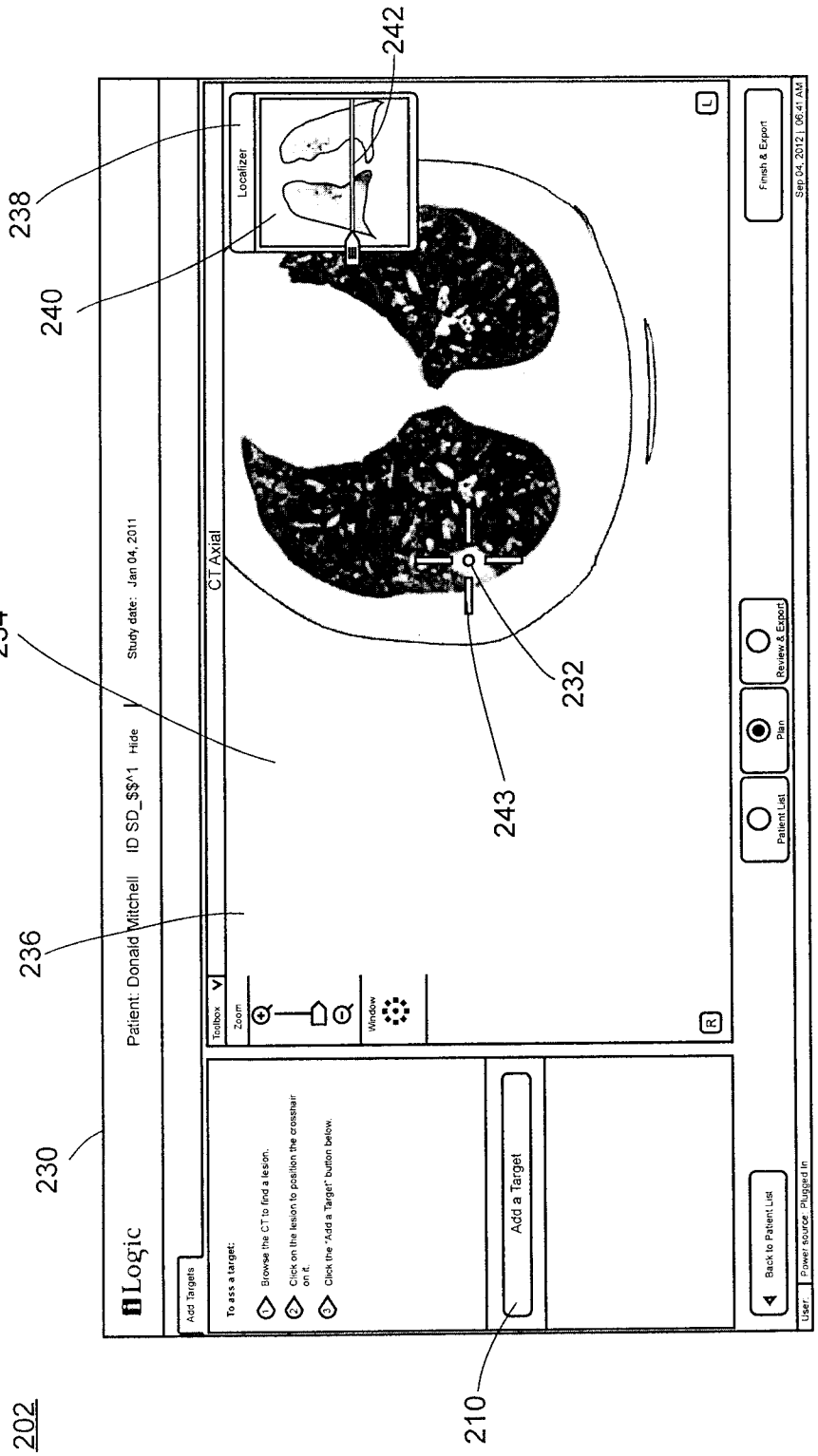

202
210
230
232
234
236
238
240
242
243
iLogic
Patient: Donald Mitchell
ID SD_$$^1
Hide
Study date: Jan 04, 2011
Add Targets
To ass a target:
1. Browse the CT to find a lesion.
2. Click on the lesion to position the crosshair on it.
3. Click the "Add a Target" button below.
Add a Target
Toolbox
Zoom
Window
CT Axial
Localizer
R
L
Back to Patient List
Patient List
Plan
Review & Export
Finish & Export
User:
Power source: Plugged in
Sep 04, 2012 | 06:41 AM

FIG. 6

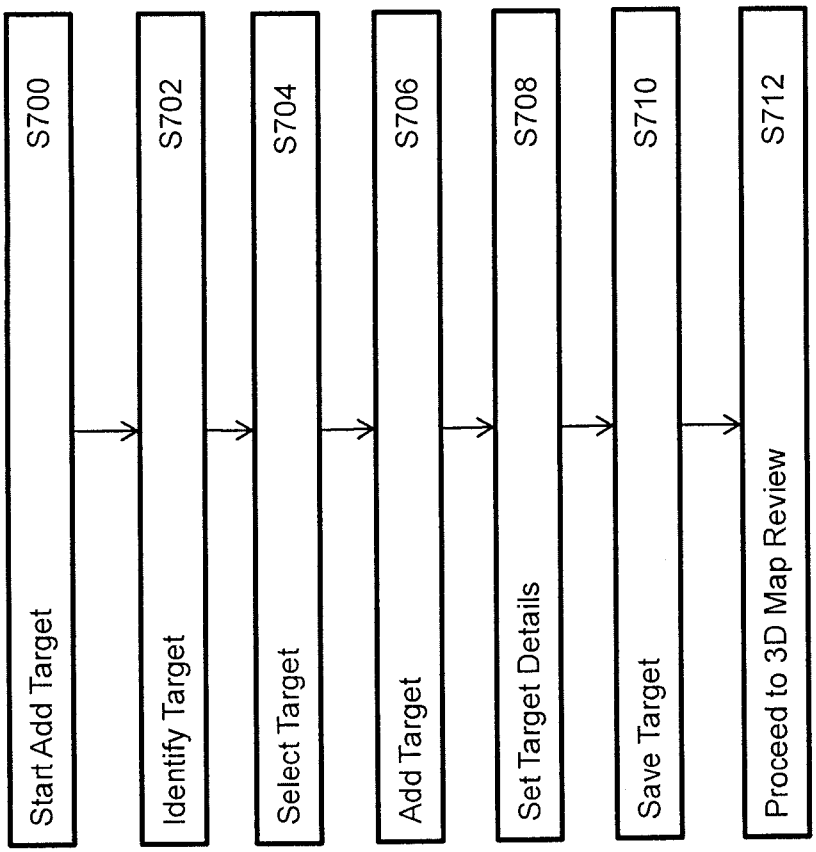

Start Add Target
S700
Identify Target
S702
Select Target
S704
Add Target
S706
Set Target Details
S708
Save Target
S710
Proceed to 3D Map Review
S712

FIG. 7

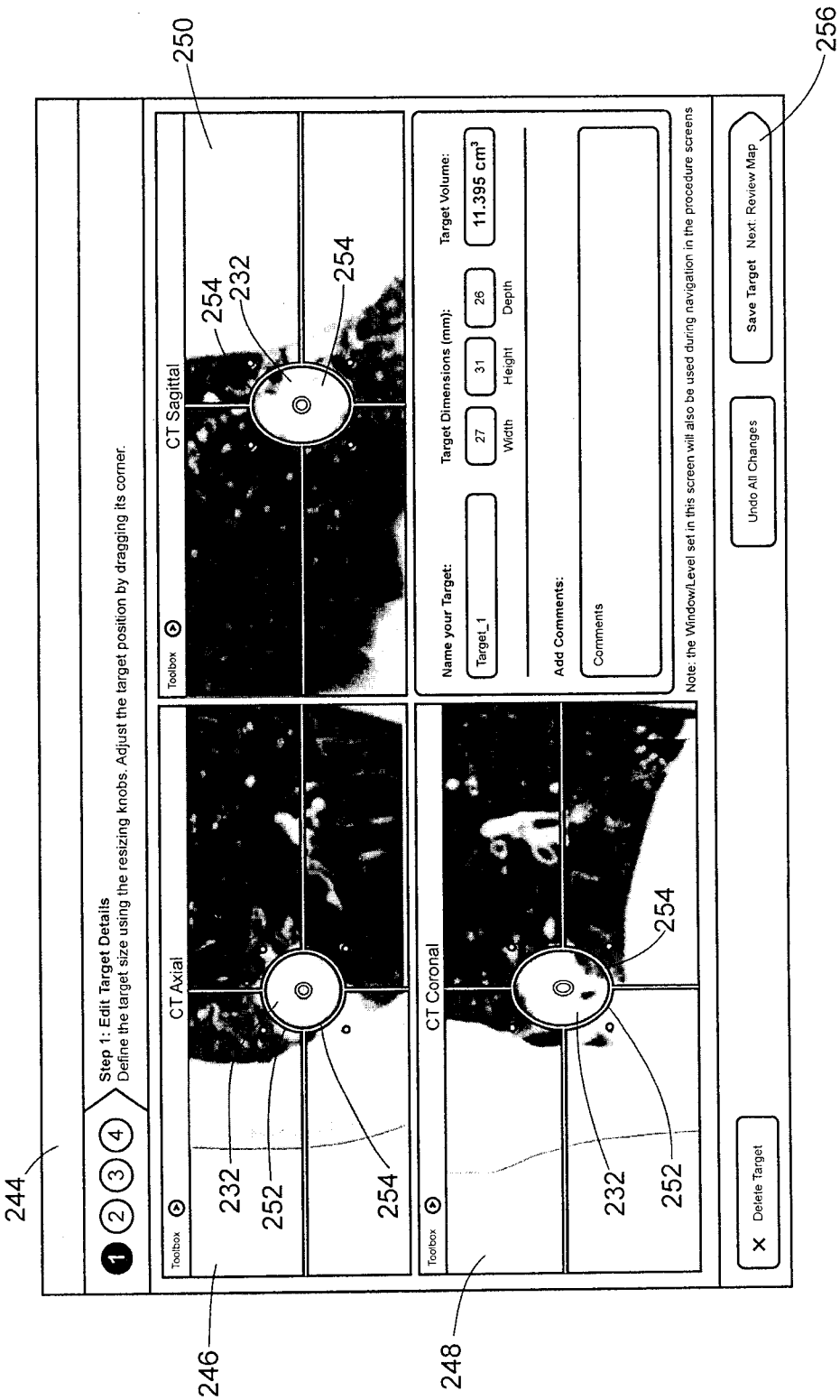

202
244
1 2 3 4
Step 1: Edit Target Details
Define the target size using the resizing knobs. Adjust the target position by dragging its corner.
Toolbox
CT Axial
232
252
254
246
Toolbox
CT Sagittal
254
232
254
250
Toolbox
CT Coronal
254
232
252
248
Name your Target:
Target_1
Target Dimensions (mm):
27
Width
31
Height
26
Depth
Target Volume:
11.395 cm³
Add Comments:
Comments
Note: the Window/Level set in this screen will also be used during navigation in the procedure screens
Undo All Changes
Save Target
Next: Review Map
256
Delete Target

FIG. 8

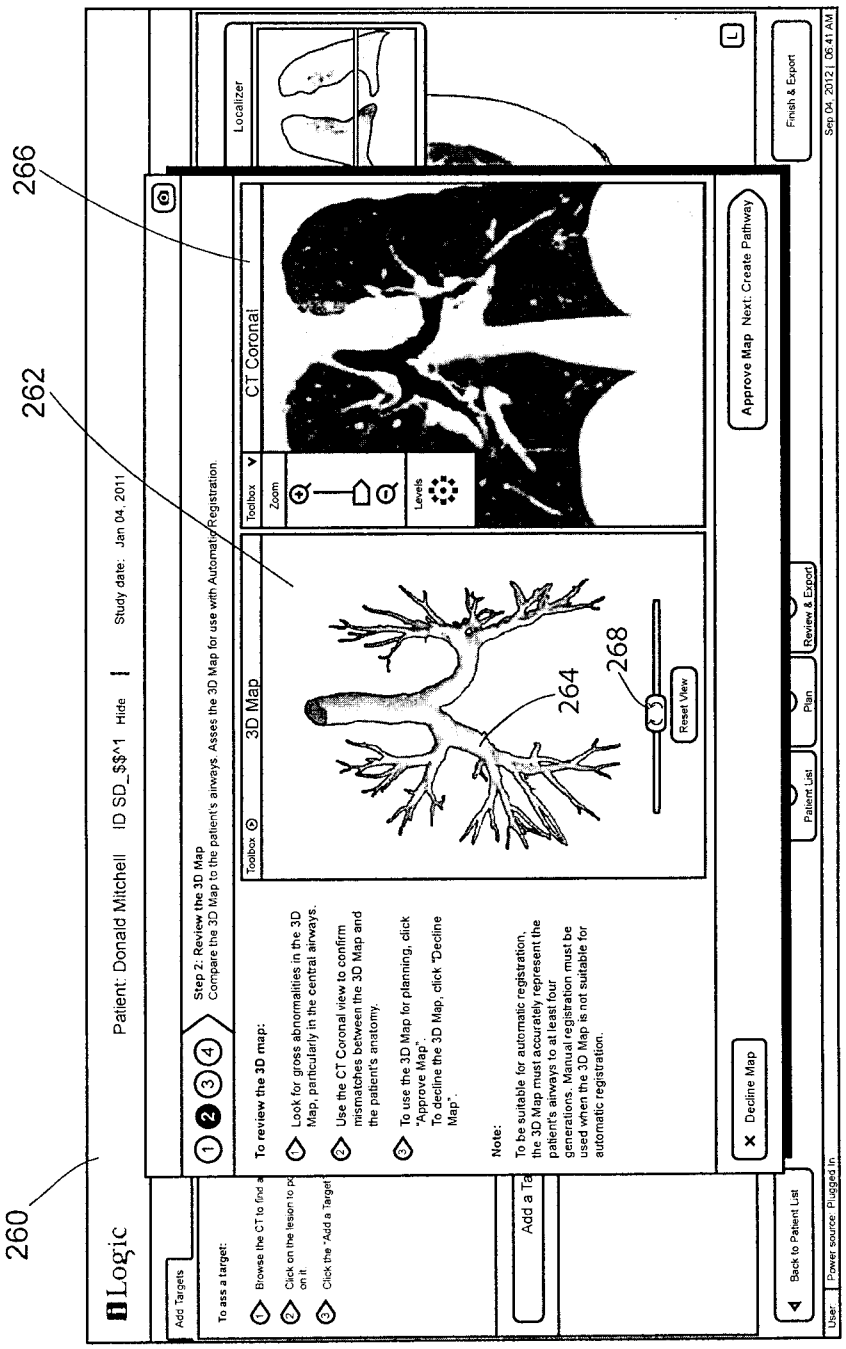

202
260
262
266
Logic
Patient: Donald Mitchell
ID SD_$$^1
Hide
Study date: Jan 04, 2011
Add Targets
To ass a target:
Step 2: Review the 3D Map
Compare the 3D Map to the patient's airways. Asses the 3D Map for use with Automatic Registration.
To review the 3D map:
Look for gross abnormalities in the 3D Map, particularly in the central airways.
Use the CT Coronal view to confirm mismatches between the 3D Map and the patient's anatomy.
To use the 3D Map for planning, click "Approve Map".
To decline the 3D Map, click "Decline Map".
Note:
To be suitable for automatic registration, the 3D Map must accurately represent the patient's airways to at least four generations. Manual registration must be used when the 3D Map is not suitable for automatic registration.
Toolbox
3D Map
Zoom
Levels
264
268
Reset View
Toolbox
CT Coronal
Localizer
Add a Ta
Decline Map
Approve Map Next: Create Pathway
Back to Patient List
Patient List
Plan
Review & Export
Finish & Export
User:
Power source: Plugged in
Sep 04, 2012 | 06:41 AM

FIG. 9

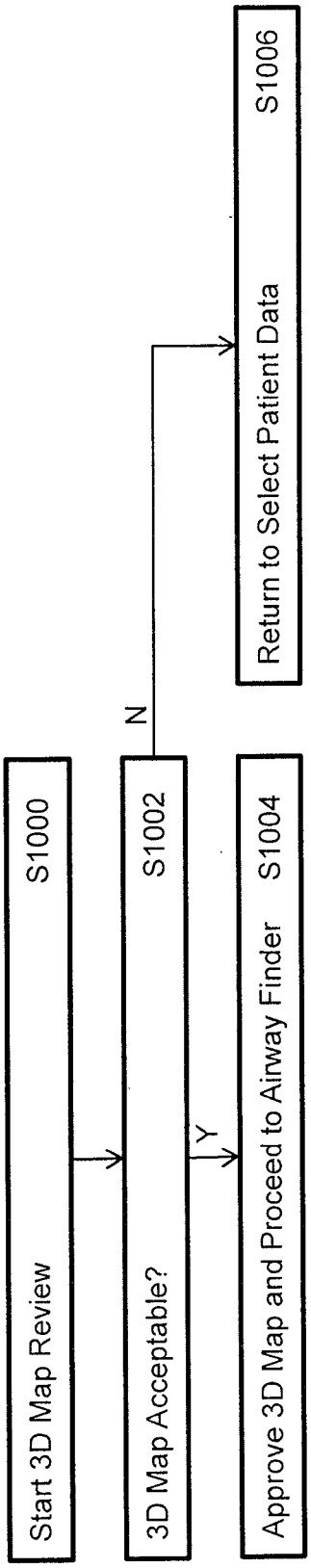

Start 3D Map Review
S1000
3D Map Acceptable?
S1002
N
Y
Return to Select Patient Data
S1006
Approve 3D Map and Proceed to Airway Finder
S1004

FIG. 10

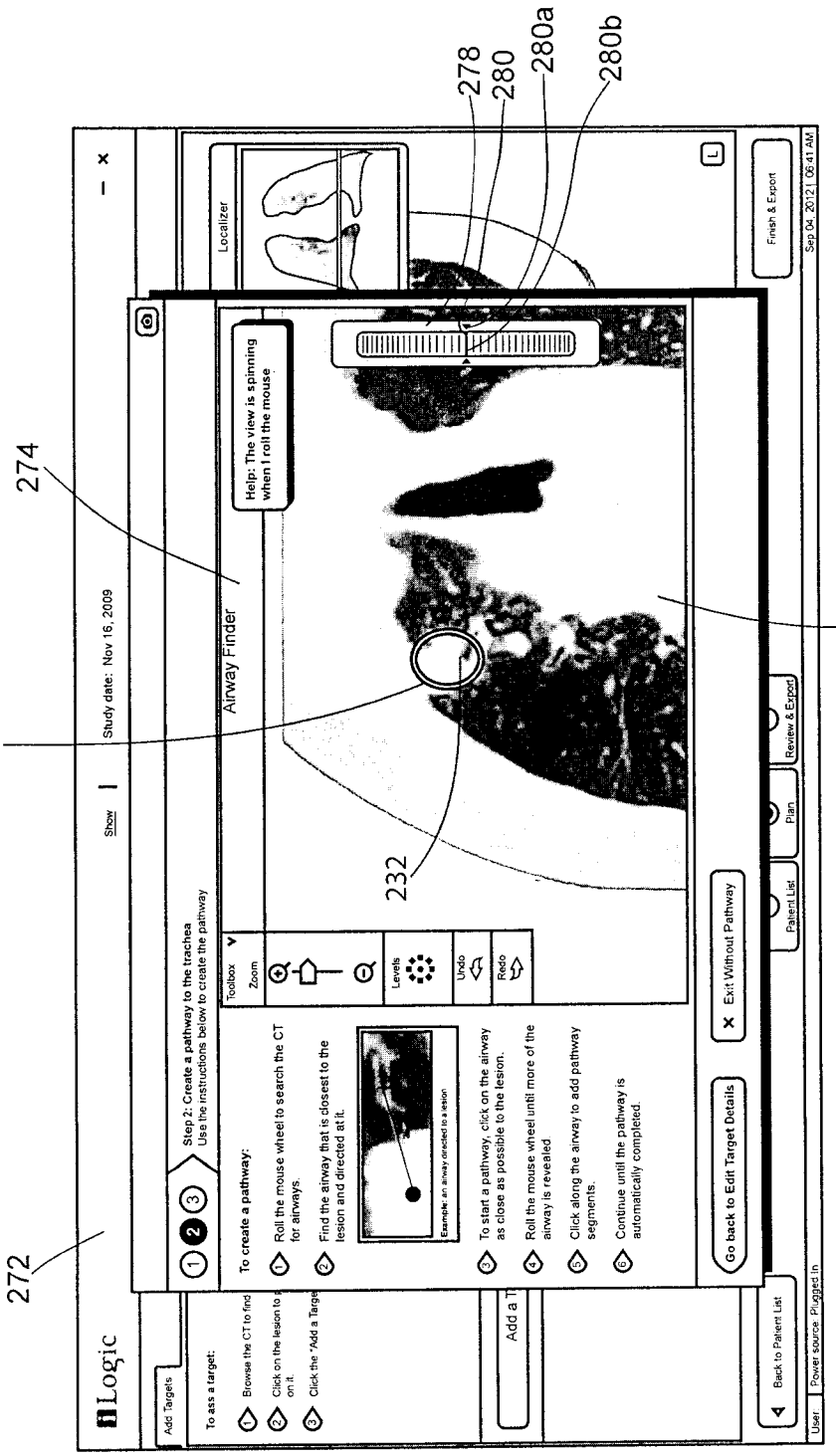

202
272
274
232A
276
278
280
280a
280b
232
Logic
Show
Study date: Nov 16, 2009
Airway Finder
Localizer
Step 2: Create a pathway to the trachea
Use the instructions below to create the pathway
Help: The view is spinning when I roll the mouse
Toolbox
Zoom
Levels
Undo
Redo
To create a pathway:
1. Roll the mouse wheel to search the CT for airways.
2. Find the airway that is closest to the lesion and directed at it.
Example: an airway directed to a lesion
3. To start a pathway, click on the airway as close as possible to the lesion.
4. Roll the mouse wheel until more of the airway is revealed
5. Click along the airway to add pathway segments.
6. Continue until the pathway is automatically completed.
Go back to Edit Target Details
Exit Without Pathway
Patient List
Plan
Review & Export
Finish & Export
Add Targets
To ass a target:
Add a T
Back to Patient List
User
Power source: Plugged in
Sep 04, 2012 | 06:41 AM

FIG. 11A

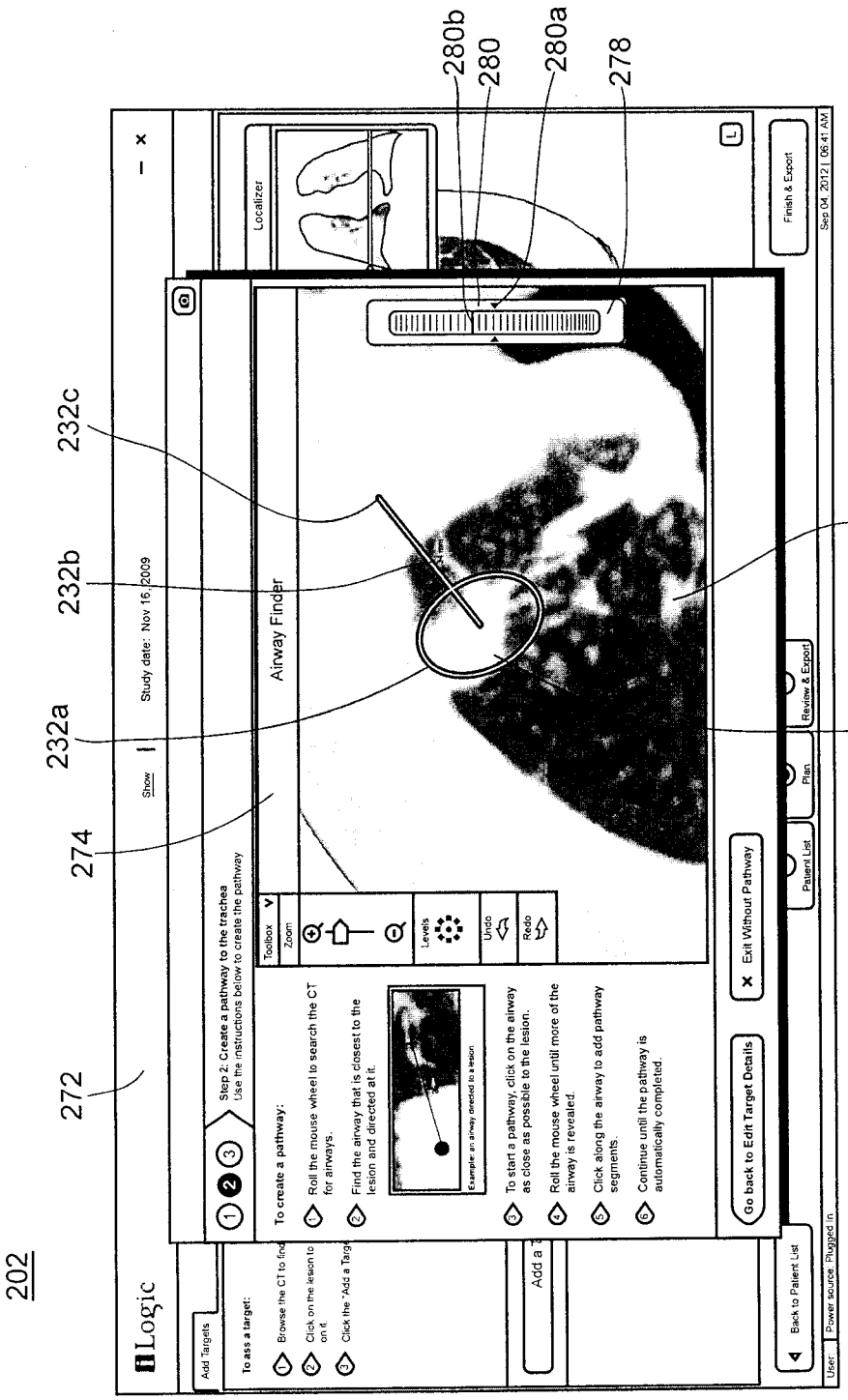

202
272
274
232a
232b
232c
280b
280
280a
278
276
232
Airway Finder
Localizer
Step 2: Create a pathway to the trachea
Use the instructions below to create the pathway
To create a pathway:
Roll the mouse wheel to search the CT for airways.
Find the airway that is closest to the lesion and directed at it.
To start a pathway, click on the airway as close as possible to the lesion.
Roll the mouse wheel until more of the airway is revealed.
Click along the airway to add pathway segments.
Continue until the pathway is automatically completed.
Go back to Edit Target Details
Exit Without Pathway
Back to Patient List
Patient List
Plan
Review & Export
Finish & Export

FIG. 11B

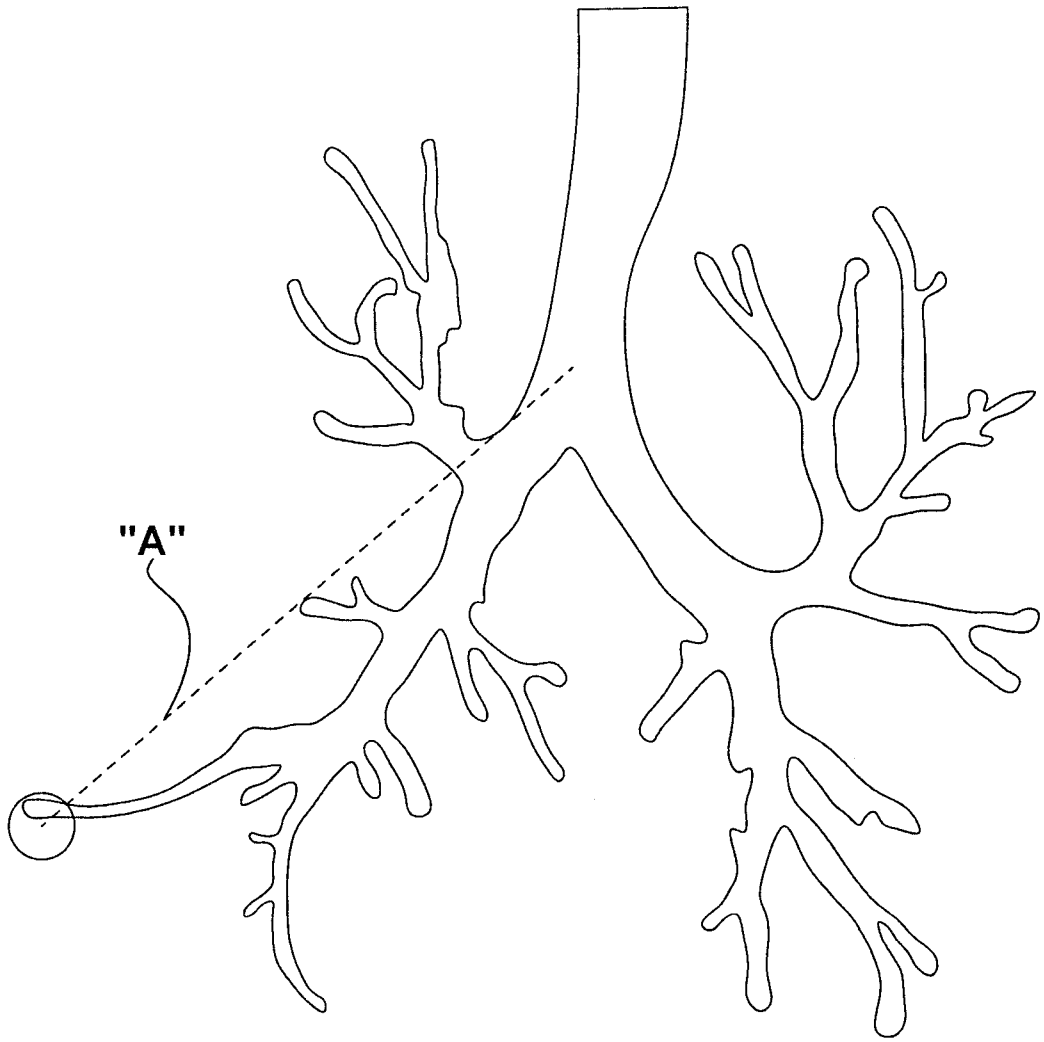


FIG.11C

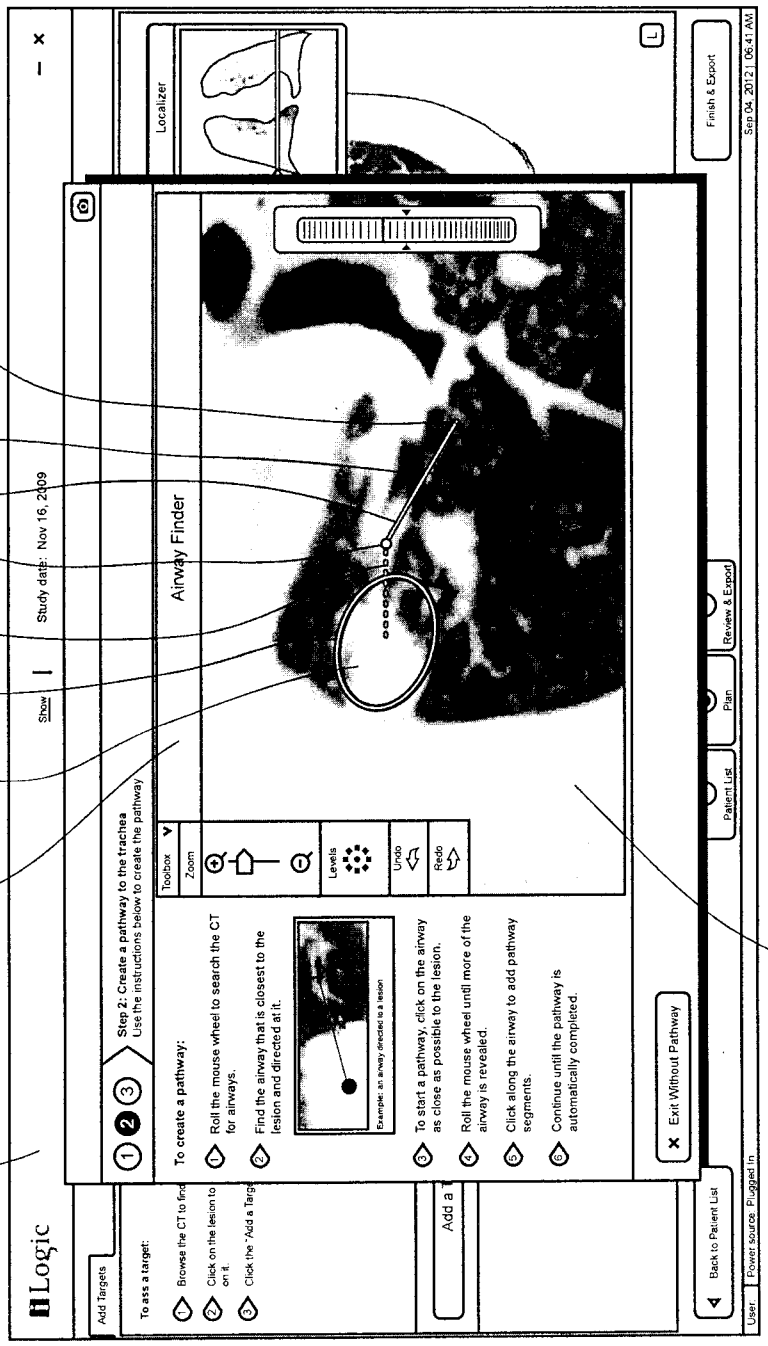

202
272
274
232
232a
284
282
282a
282b
282c
276
Logic
Study date: Nov 16, 2009
Airway Finder
Localizer
Step 2: Create a pathway to the trachea
Use the instructions below to create the pathway
To create a pathway:
Roll the mouse wheel to search the CT for airways.
Find the airway that is closest to the lesion and directed at it.
To start a pathway, click on the airway as close as possible to the lesion.
Roll the mouse wheel until more of the airway is revealed.
Click along the airway to add pathway segments.
Continue until the pathway is automatically completed.
Toolbox
Zoom
Levels
Undo
Redo
Exit Without Pathway
Back to Patient List
Patient List
Plan
Review & Export
Finish & Export

FIG. 11D

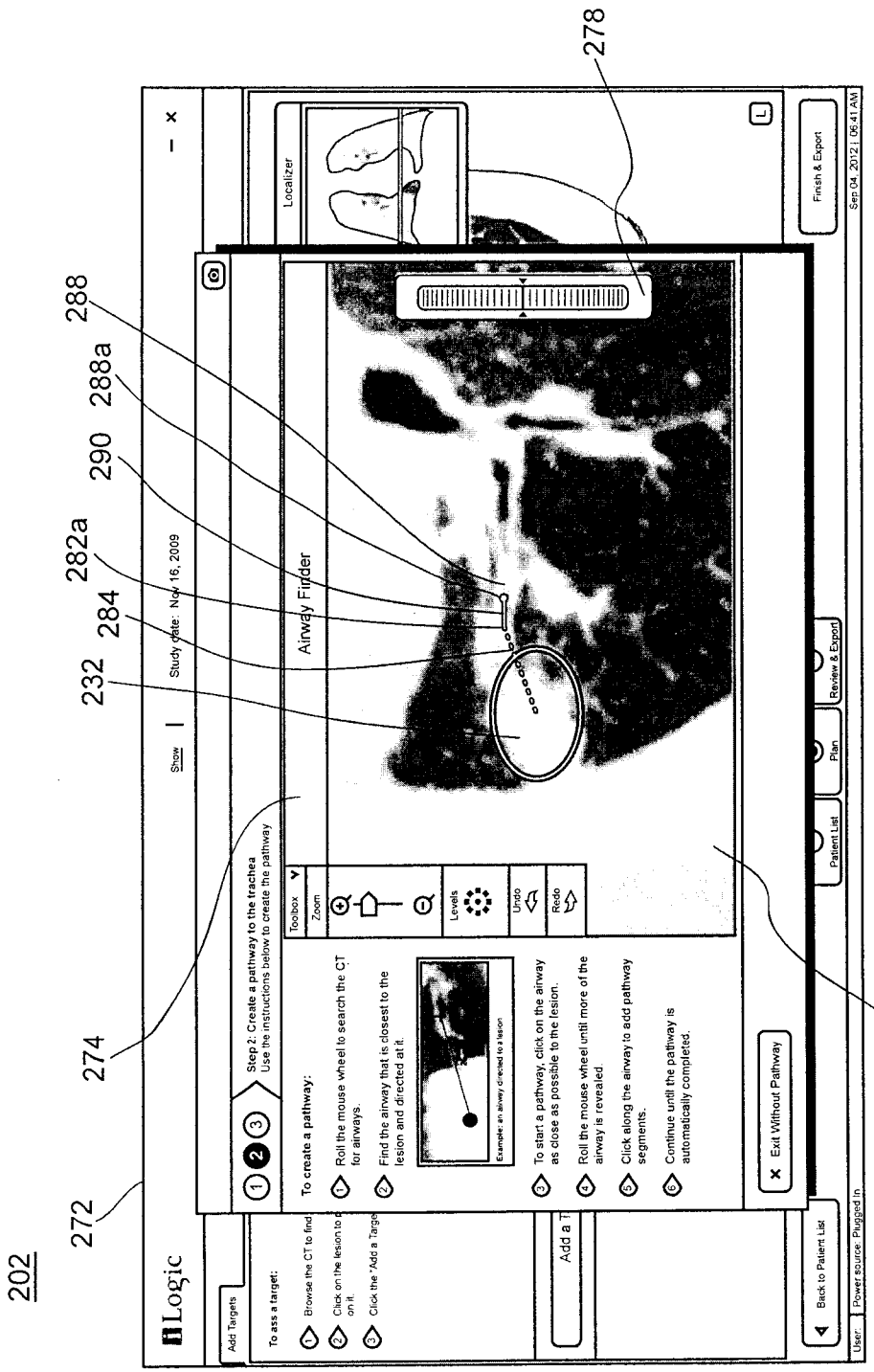

202
272
274
232
284
282a
290
288a
288
278
286
Logic
Show
Study date: Nov 16, 2009
Airway Finder
Localizer
Add Targets
To ass a target:
Step 2: Create a pathway to the trachea
Use the instructions below to create the pathway
To create a pathway:
Roll the mouse wheel to search the CT for airways.
Find the airway that is closest to the lesion and directed at it.
To start a pathway, click on the airway as close as possible to the lesion.
Roll the mouse wheel until more of the airway is revealed.
Click along the airway to add pathway segments.
Continue until the pathway is automatically completed.
Toolbox
Zoom
Levels
Undo
Redo
Exit Without Pathway
Back to Patient List
Patient List
Plan
Review & Export
Finish & Export
User:
Power source: Plugged In
Sep 04, 2012 | 06:41 AM

FIG. 11E

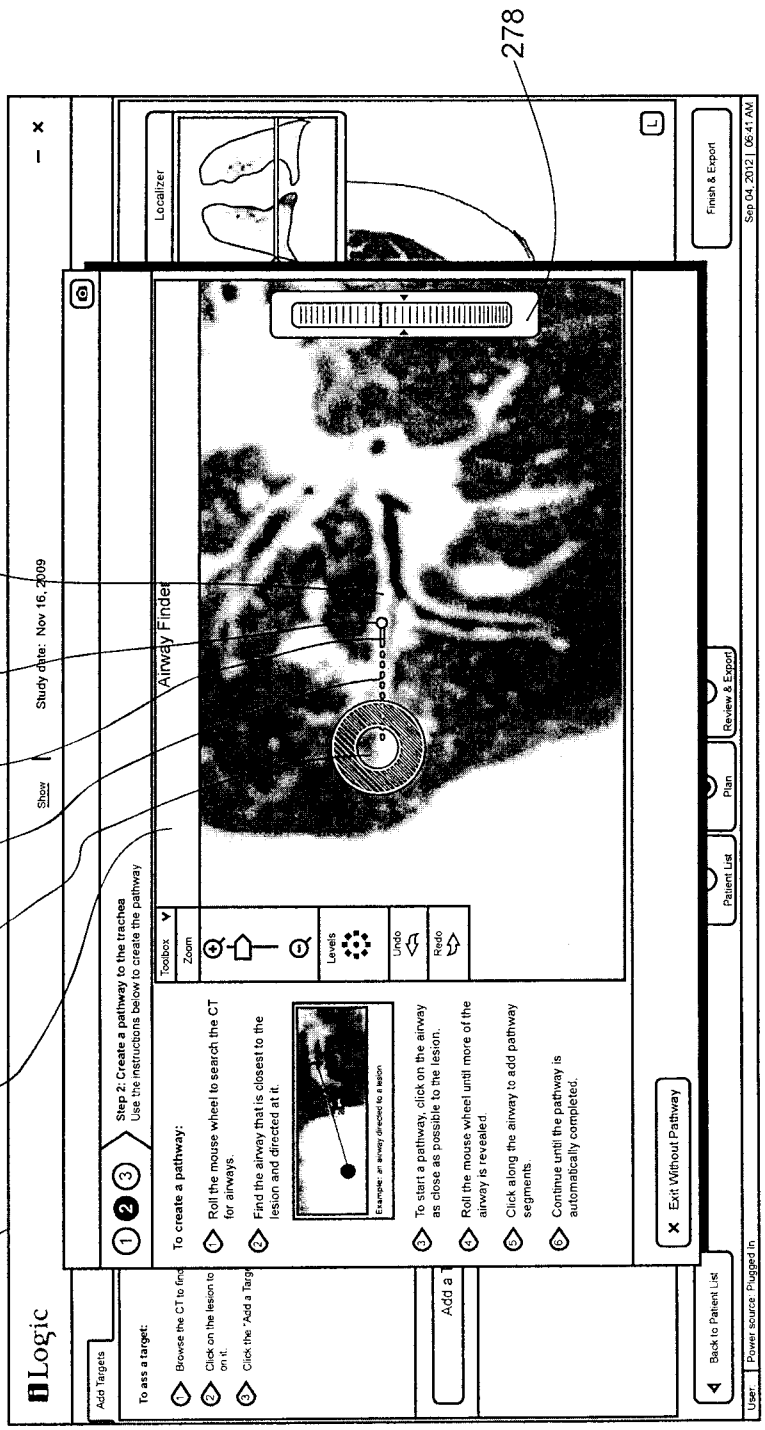

202
272
274
232
284
290
288a
291
278
Logic
Study date: Nov 16, 2009
Show
Airway Finder
Localizer
Step 2: Create a pathway to the trachea
Use the instructions below to create the pathway
To create a pathway:
1. Roll the mouse wheel to search the CT for airways.
2. Find the airway that is closest to the lesion and directed at it.
3. To start a pathway, click on the airway as close as possible to the lesion.
4. Roll the mouse wheel until more of the airway is revealed.
5. Click along the airway to add pathway segments.
6. Continue until the pathway is automatically completed.
Example: an airway directed to a lesion
Toolbox
Zoom
Levels
Undo
Redo
Add Targets
To ass a target:
Exit Without Pathway
Back to Patient List
Patient List
Plan
Review & Export
Finish & Export
User
Power source: Plugged In
Sep 04, 2012 | 06:41 AM

FIG. 11F

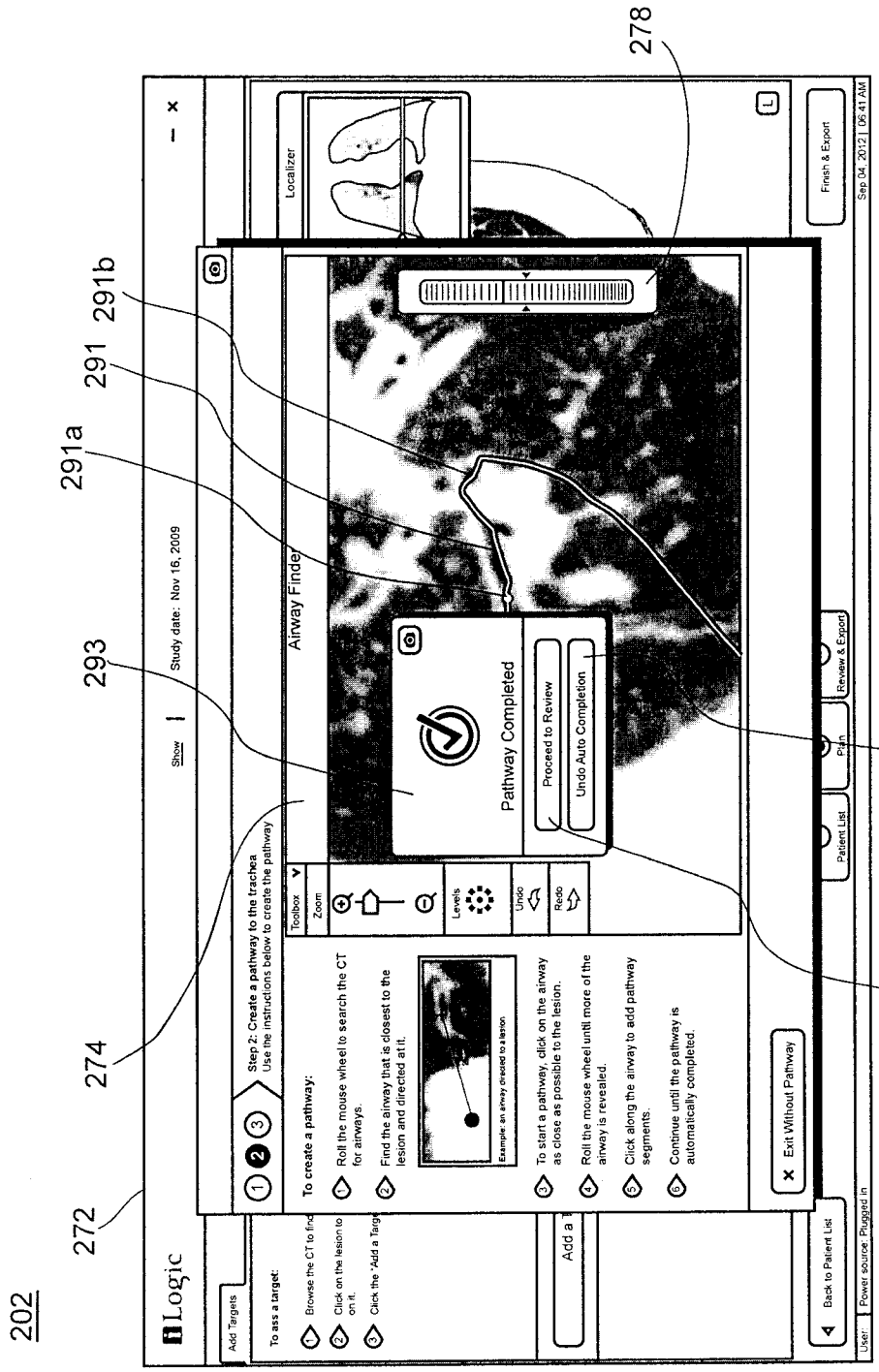

202
272
274
293
291a
291
291b
278
293b
293a
Logic
Show
Study date: Nov 16, 2009
Step 2: Create a pathway to the trachea
Use the instructions below to create the pathway
Airway Finder
Localizer
Toolbox
Zoom
Levels
Undo
Redo
To create a pathway:
Roll the mouse wheel to search the CT for airways.
Find the airway that is closest to the lesion and directed at it.
Example: an airway directed to a lesion
To start a pathway, click on the airway as close as possible to the lesion.
Roll the mouse wheel until more of the airway is revealed.
Click along the airway to add pathway segments.
Continue until the pathway is automatically completed.
Pathway Completed
Proceed to Review
Undo Auto Completion
Exit Without Pathway
Back to Patient List
Patient List
Review & Export
Finish & Export
Sep 04, 2012 | 06:41 AM

FIG. 11G

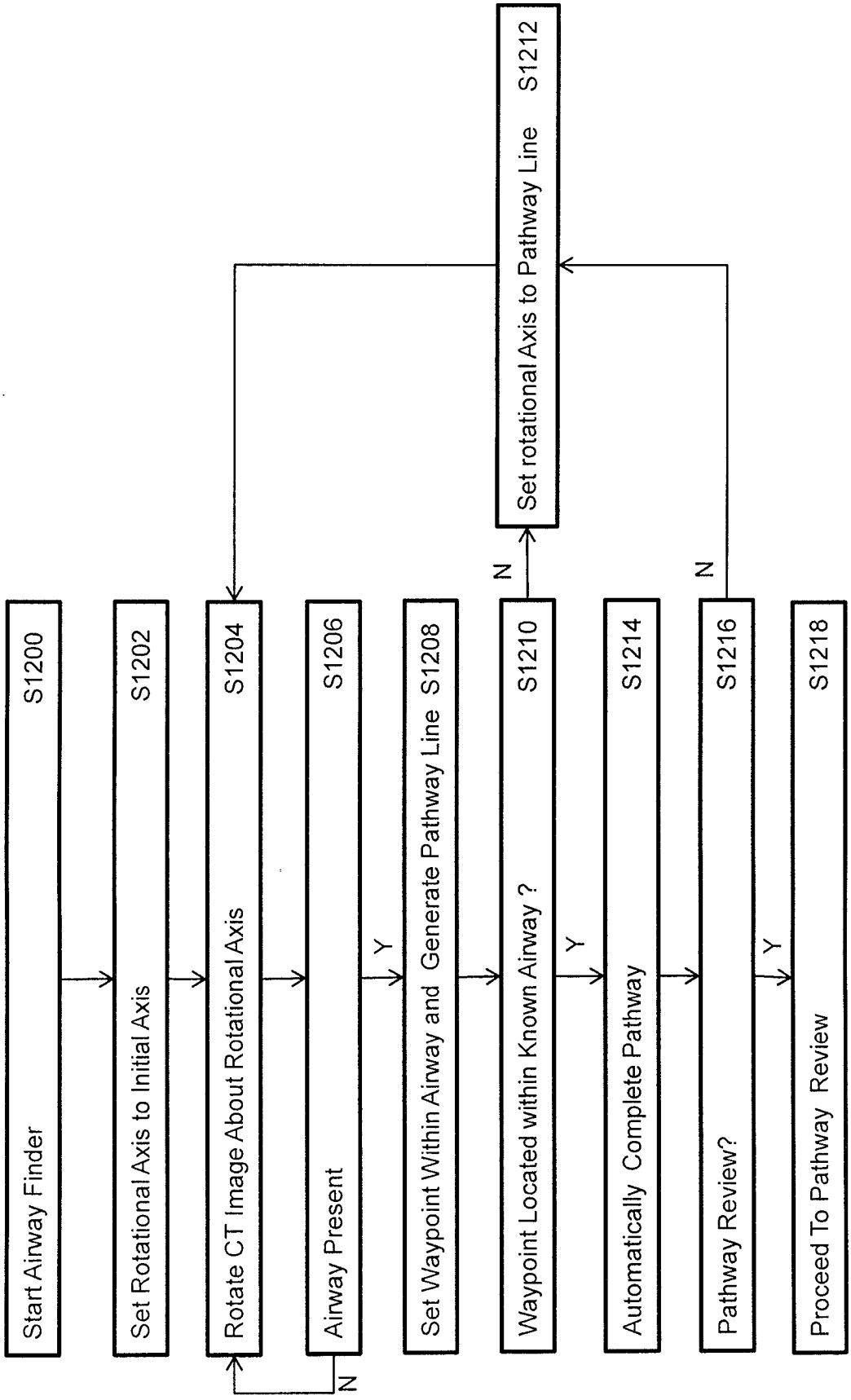

Start Airway Finder S1200
Set Rotational Axis to Initial Axis S1202
Rotate CT Image About Rotational Axis S1204
Airway Present S1206
Y
N
Set Waypoint Within Airway and Generate Pathway Line S1208
Waypoint Located within Known Airway ? S1210
Y
N
Set rotational Axis to Pathway Line S1212
Automatically Complete Pathway S1214
Pathway Review? S1216
Y
N
Proceed To Pathway Review S1218

FIG. 12

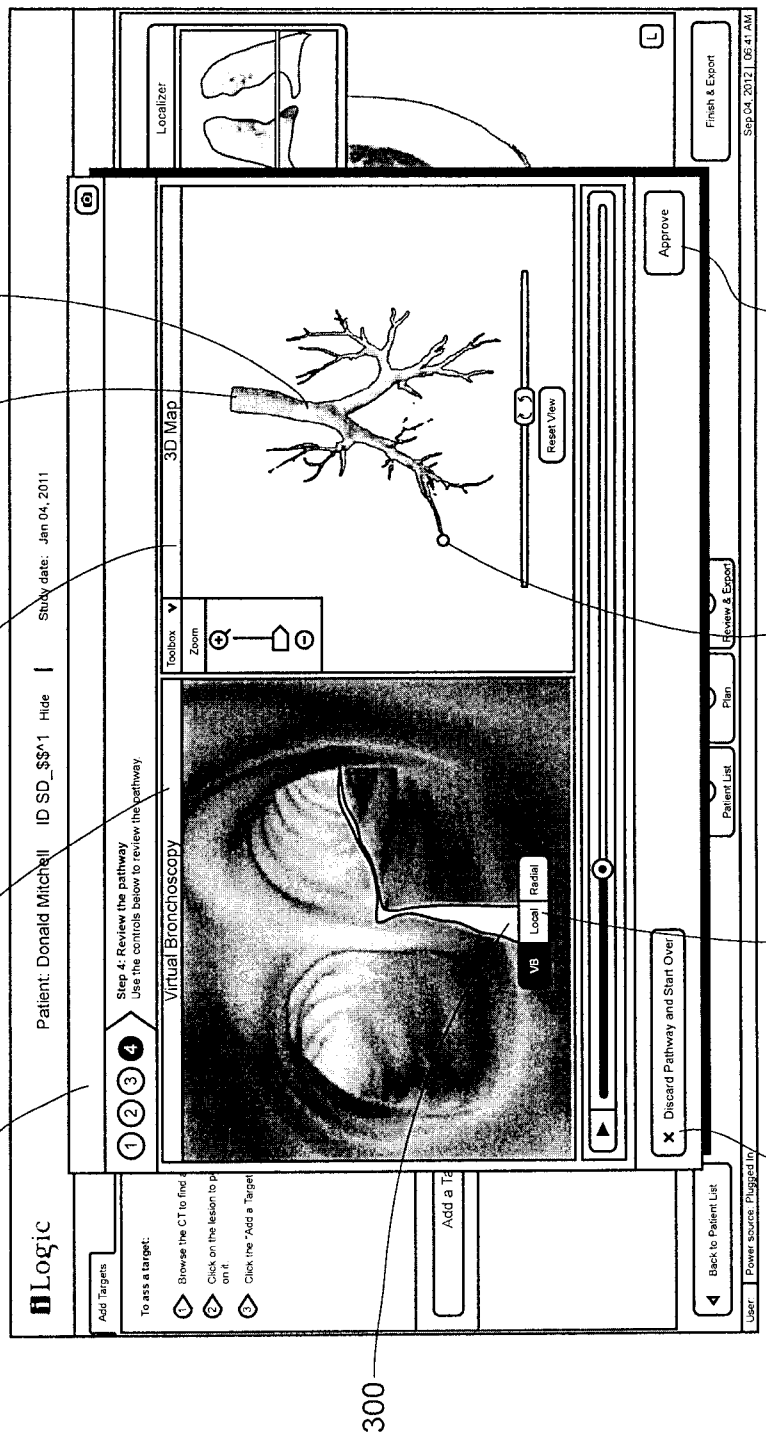

202
Logic
Patient: Donald Mitchell ID SD_$$^1 Hide Study date: Jan 04, 2011
Step 4: Review the pathway
Use the controls below to review the pathway
Virtual Bronchoscopy
3D Map
Localizer
Toolbox
Zoom
Reset View
VB
Local
Radial
Approve
Discard Pathway and Start Over
Back to Patient List
Patient List
Plan
Review & Export
Finish & Export
Add Targets
Add a Ta
User
Power source: Plugged In
Sep 04, 2012 | 06:41 AM
294
295
296
298
298a
300
232
295a
299a
299b

FIG. 13

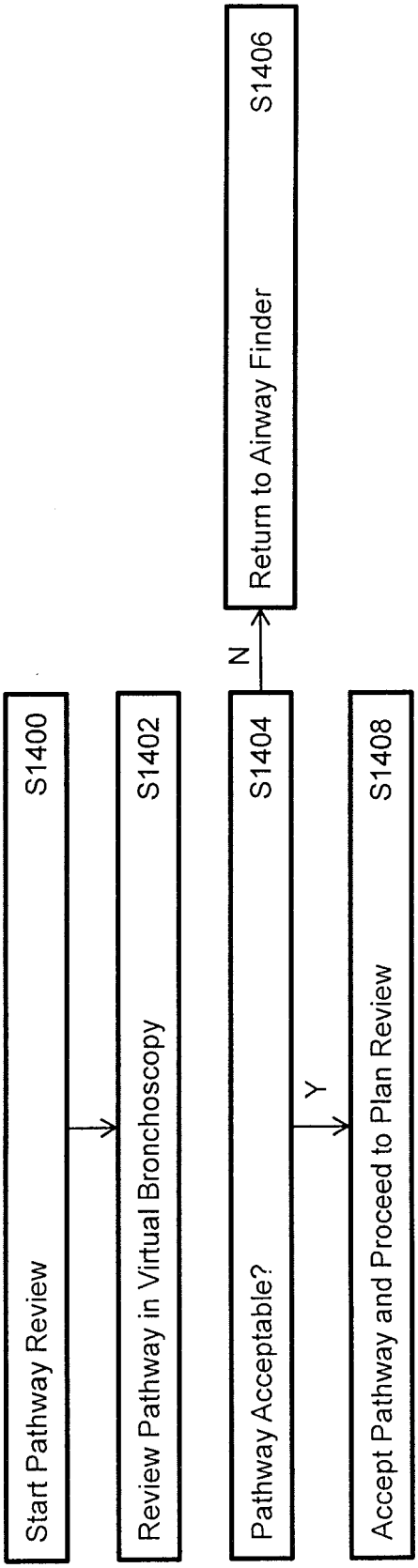

Start Pathway Review
S1400
Review Pathway in Virtual Bronchoscopy
S1402
Pathway Acceptable?
S1404
N
Return to Airway Finder
S1406
Y
Accept Pathway and Proceed to Plan Review
S1408

FIG. 14

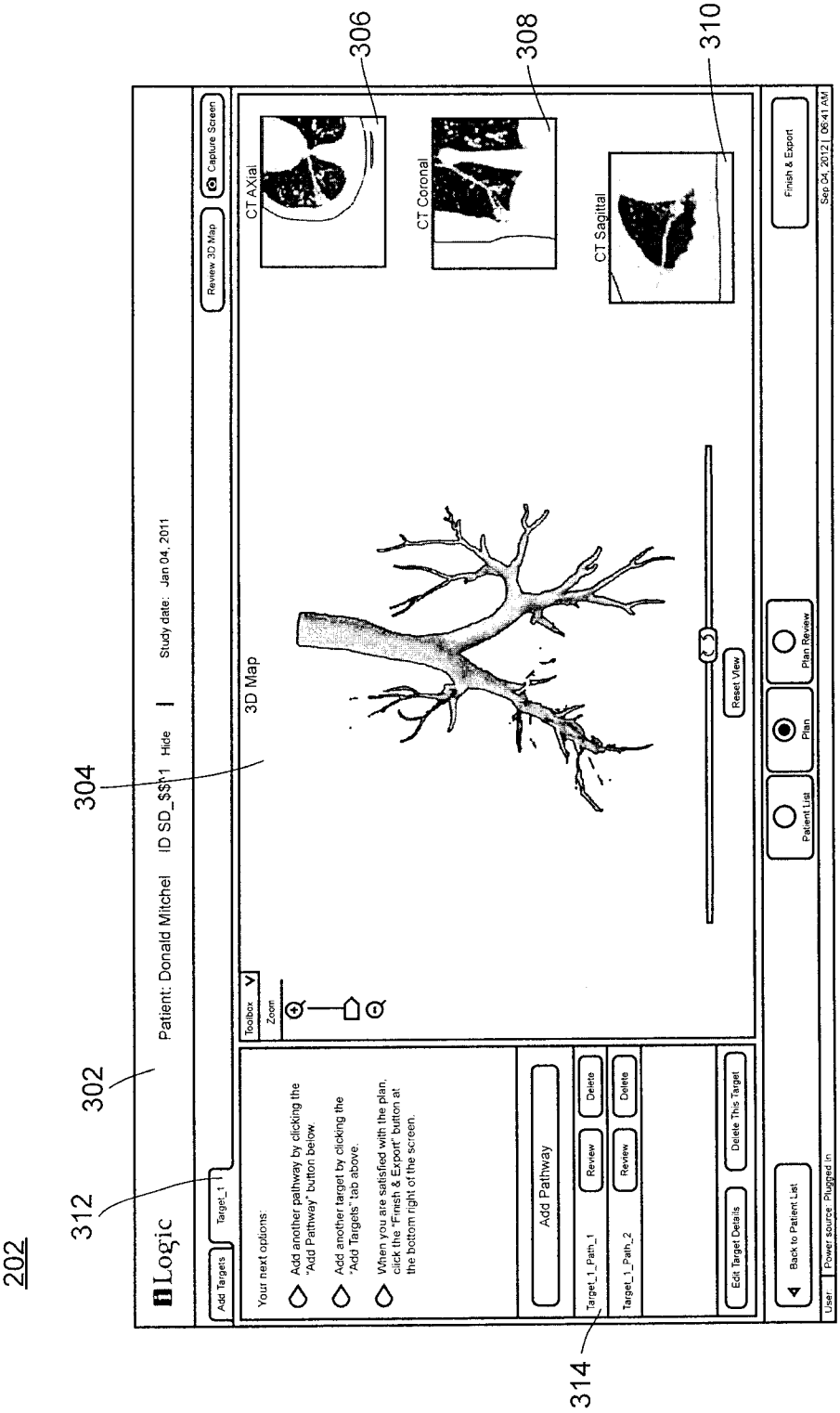

202
312
302
304
306
308
310
314
Logic
Patient: Donald Mitchel
ID SD_$$\1
Hide
Study date: Jan 04, 2011
Capture Screen
Review 3D Map
Add Targets
Target_1
Your next options:
Add another pathway by clicking the "Add Pathway" button below.
Add another target by clicking the "Add Targets" tab above.
When you are satisfied with the plan, click the "Finish & Export" button at the bottom right of the screen.
Add Pathway
Target_1_Path_1
Review
Delete
Target_1_Path_2
Review
Delete
Edit Target Details
Delete This Target
3D Map
Toolbox
Zoom
CT AXial
CT Coronal
CT Sagittal
Reset View
Back to Patient List
Patient List
Plan
Plan Review
Finish & Export
User
Power source: Plugged in
Sep 04, 2012 | 06:41 AM

FIG. 15

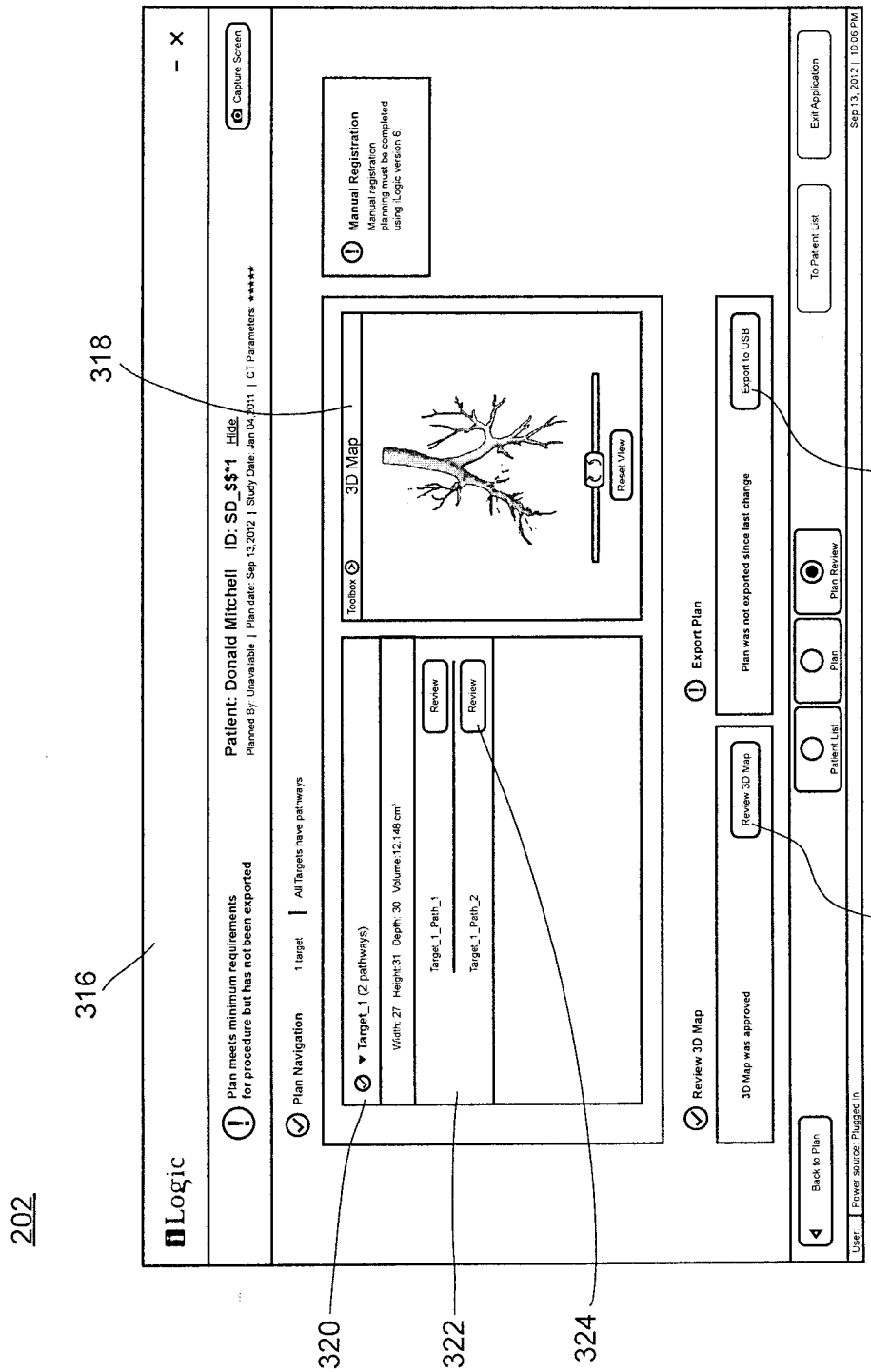

202
316
318
320
322
324
326
328
Logic
Plan meets minimum requirements for procedure but has not been exported
Patient: Donald Mitchell ID: SD_$$*1 Hide
Planned By: Unavailable | Plan date: Sep.13,2012 | Study Date: Jan.04,2011 | CT Parameters: *****
Capture Screen
Manual Registration
Manual registration planning must be completed using Logic version 6.
Plan Navigation
1 target
All Targets have pathways
Target_1 (2 pathways)
Width: 27 Height:31 Depth: 30 Volume:12.148 cm³
Target_1_Path_1
Target_1_Path_2
Review
Review
Toolbox
3D Map
Reset View
Export Plan
Plan was not exported since last change
Export to USB
Review 3D Map
3D Map was approved
Review 3D Map
To Patient List
Exit Application
Back to Plan
Patient List
Plan
Plan Review
User:
Power source: Plugged In
Sep.13, 2012 | 10:06 PM

FIG. 16

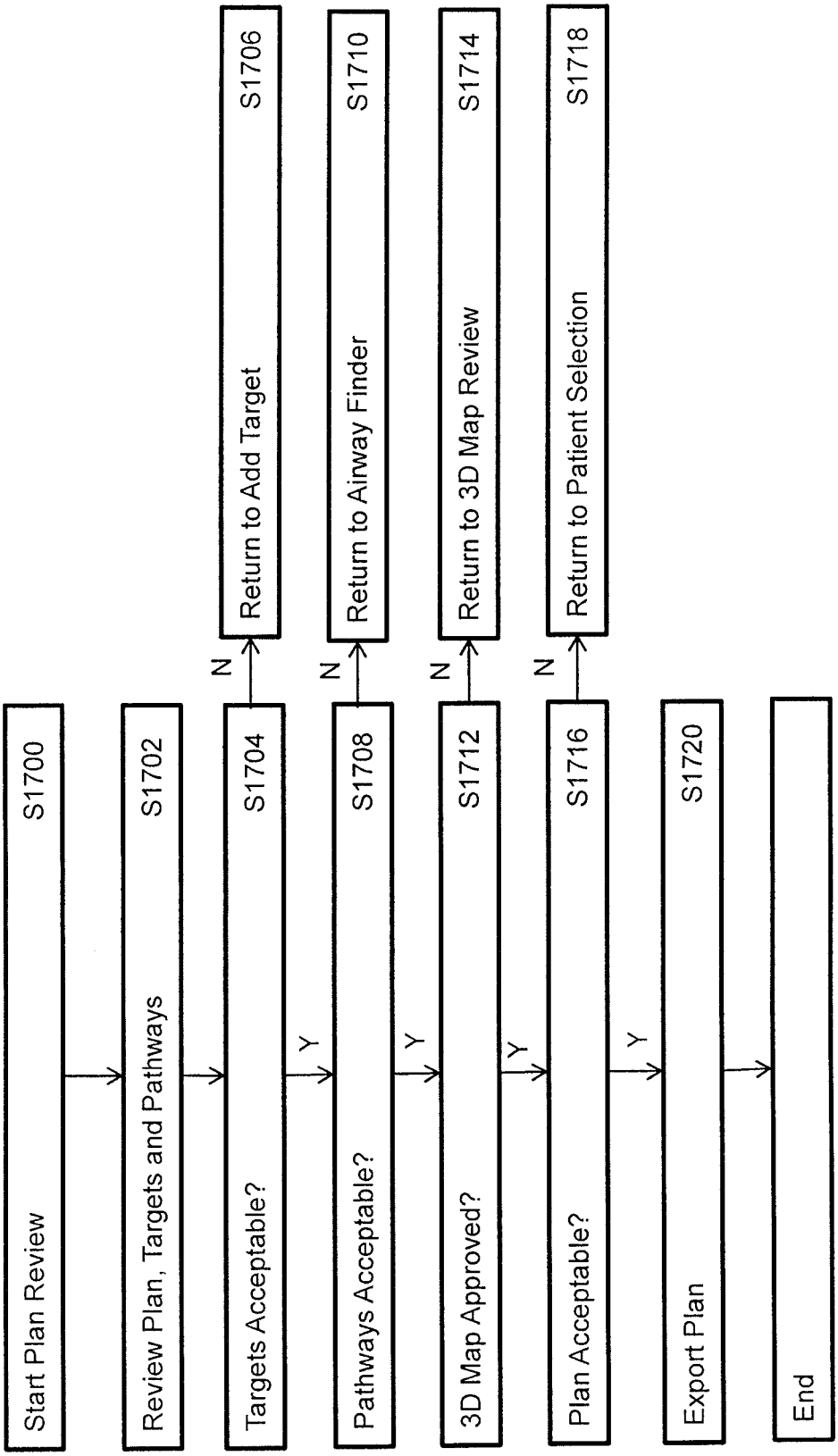
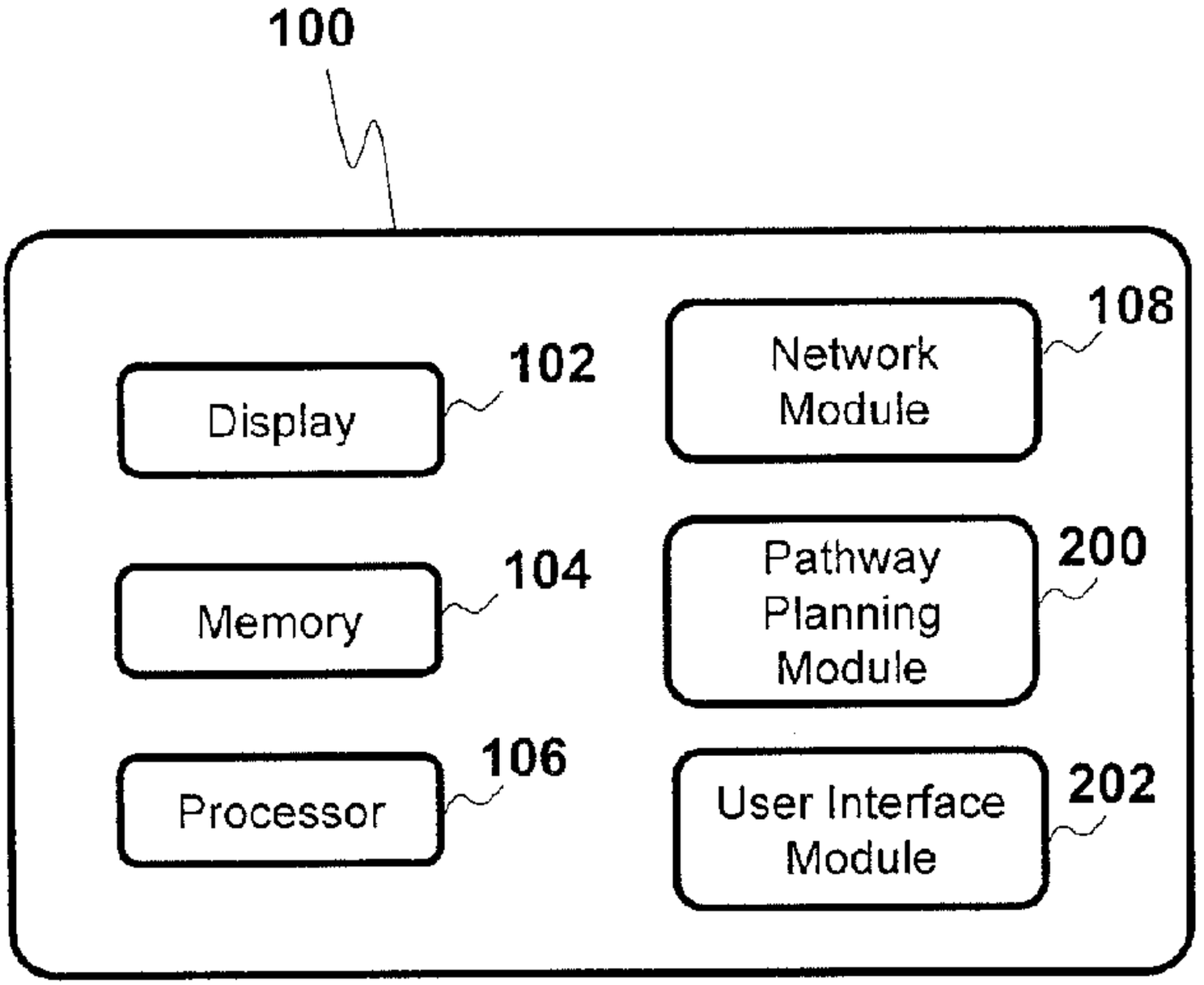

Start Plan Review
S1700
Review Plan, Targets and Pathways
S1702
Targets Acceptable?
S1704
N
Return to Add Target
S1706
Y
Pathways Acceptable?
S1708
N
Return to Airway Finder
S1710
Y
3D Map Approved?
S1712
N
Return to 3D Map Review
S1714
Y
Plan Acceptable?
S1716
N
Return to Patient Selection
S1718
Y
Export Plan
S1720
End

FIG. 17

10


100
Display
102
Memory
104
Processor
106
Network Module
108
Pathway Planning Module
200
User Interface Module
202