United States of America

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The Director

of the United States Patent and Trademark Office has received an application for a patent for a new and useful invention. The title and description of the invention are enclosed. The requirements of law have been complied with, and it has been determined that a patent on the invention shall be granted under the law.

Therefore, this United States

Patent

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John A. Squires

Director of the United States Patent and Trademark Office

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(12) **United States Patent**
Yang

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(45) **Date of Patent: Dec. 16, 2025**

(54) **PUNCTURE GUIDING SYSTEM AND METHOD**

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(73) Assignee: **NATIONAL TAIWAN UNIVERSITY**, Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 389 days.

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§ 371 (c)(1),
(2) Date: **Jul. 27, 2023**

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PCT Pub. Date: **Dec. 15, 2022**

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A61B 90/50 (2016.01)

(52) **U.S. Cl.**
CPC ***A61B 34/32*** (2016.02); ***A61B 90/50*** (2016.02)

(58) **Field of Classification Search**
CPC A61B 34/30; A61B 34/32; A61B 90/11; A61B 90/50
USPC 606/130
See application file for complete search history.

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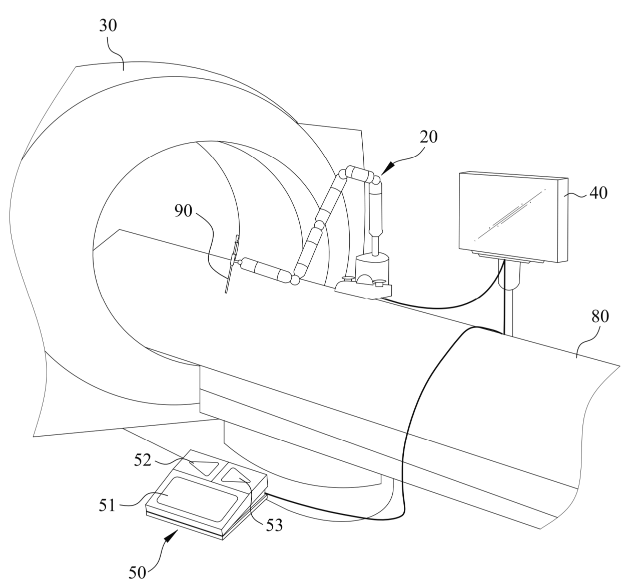
(57) **ABSTRACT**

A puncture guiding system and method are provided. The system includes a control device, a robotic arm, a diagnostic detection device, a screen, and a foot pedal. The method includes: installing the cannula on the robotic arm and placing the cannula on the patient's body; the diagnostic detection device scanning the patient to obtain a plurality of two-dimensional images; constructing a three-dimensional image; displaying the image on the screen; providing the foot pedal; according to the action of a switching button, the robotic arm switches between manual mode and fixed mode; setting a moving path of the cannula, and the screen displaying the movement trajectories; according to the activation of a first or a second moving button, the cannula moving to a first or a second position, and the screen displaying the movement trajectories. The invention enables the cannula to move more stably, slowly and safely.

20 Claims, 15 Drawing Sheets



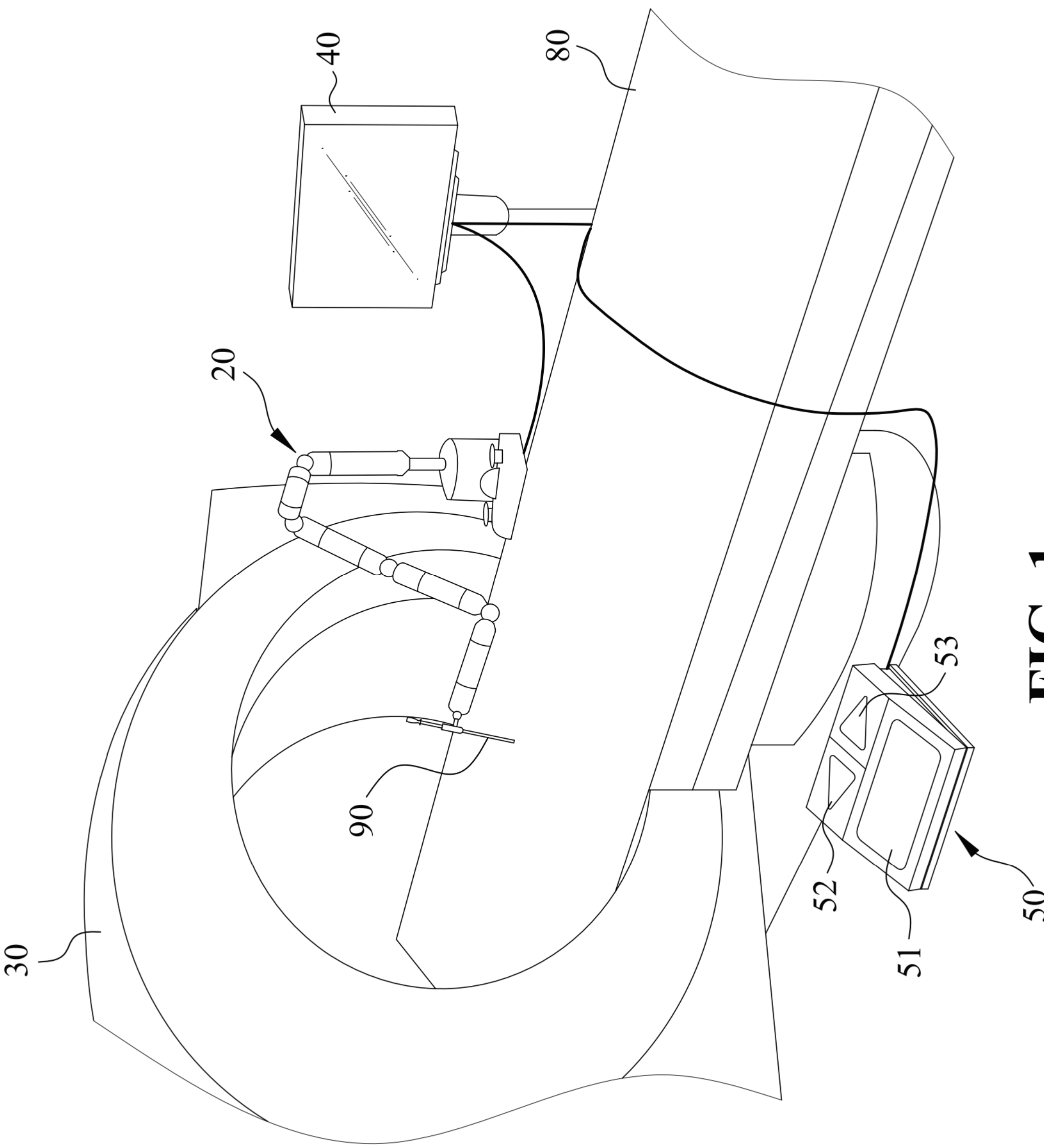
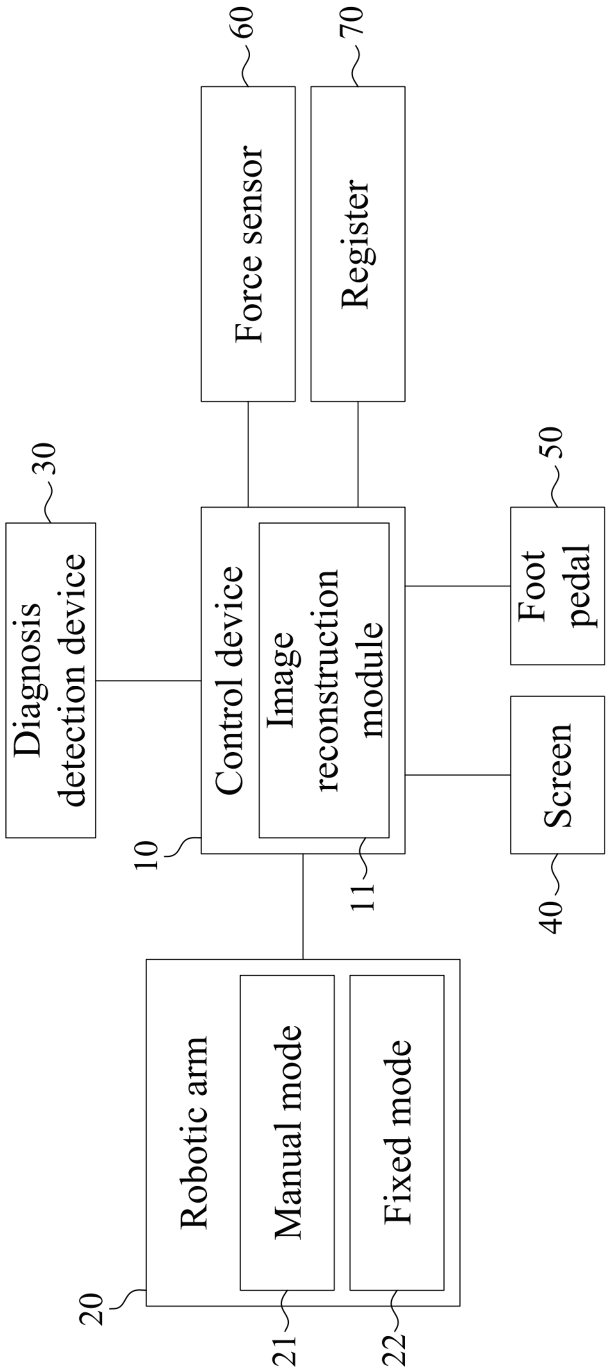


FIG. 1



60
70
Force sensor
Register
30
50
Diagnosis detection device
Control device
Image reconstruction module
Foot pedal
Screen
10
11
40
Robotic arm
Manual mode
Fixed mode
20
21
22

FIG. 2

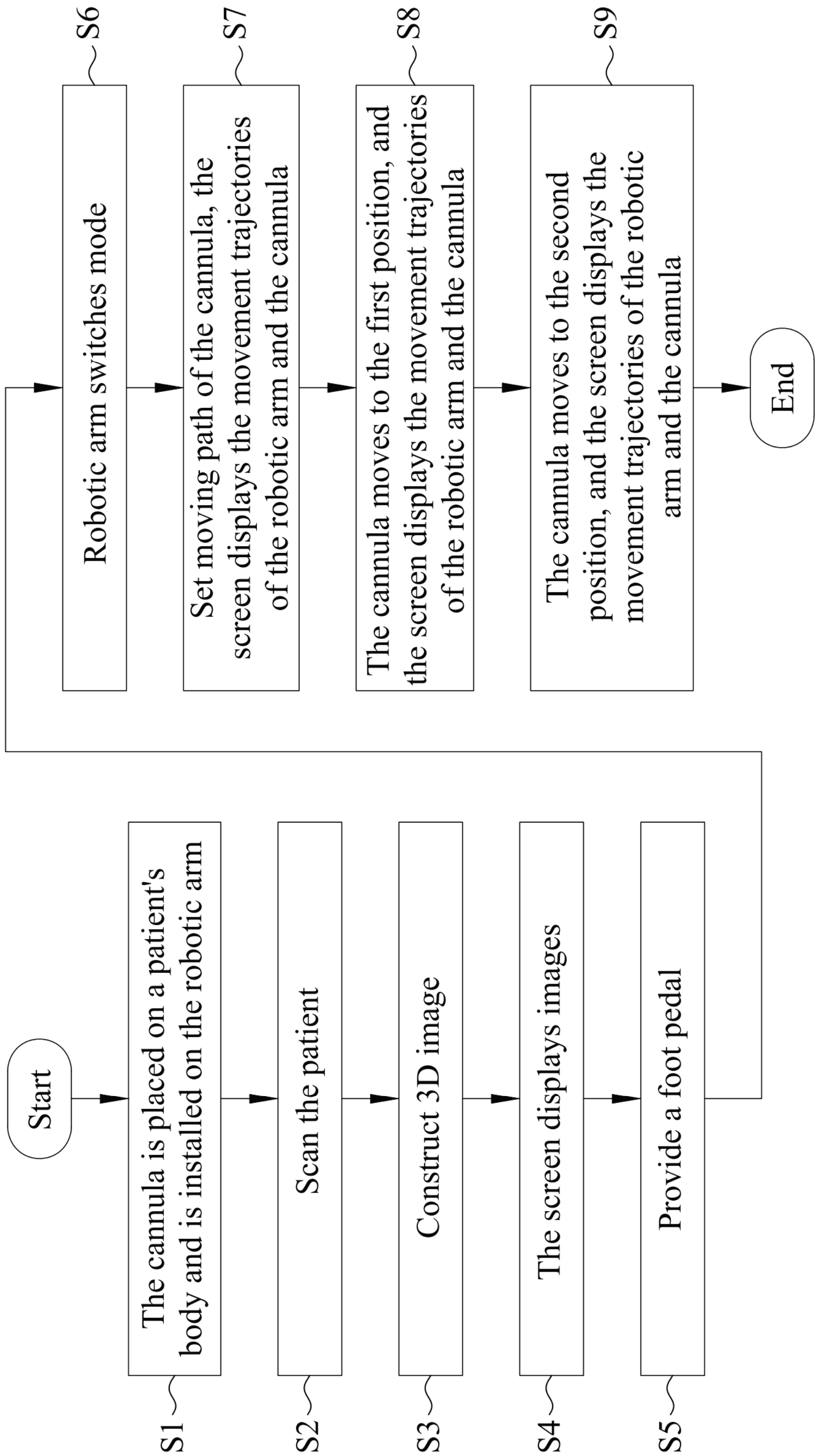

Start
The cannula is placed on a patient's body and is installed on the robotic arm
S1
Scan the patient
S2
Construct 3D image
S3
The screen displays images
S4
Provide a foot pedal
S5
Robotic arm switches mode
S6
Set moving path of the cannula, the screen displays the movement trajectories of the robotic arm and the cannula
S7
The cannula moves to the first position, and the screen displays the movement trajectories of the robotic arm and the cannula
S8
The cannula moves to the second position, and the screen displays the movement trajectories of the robotic arm and the cannula
S9
End

FIG. 3

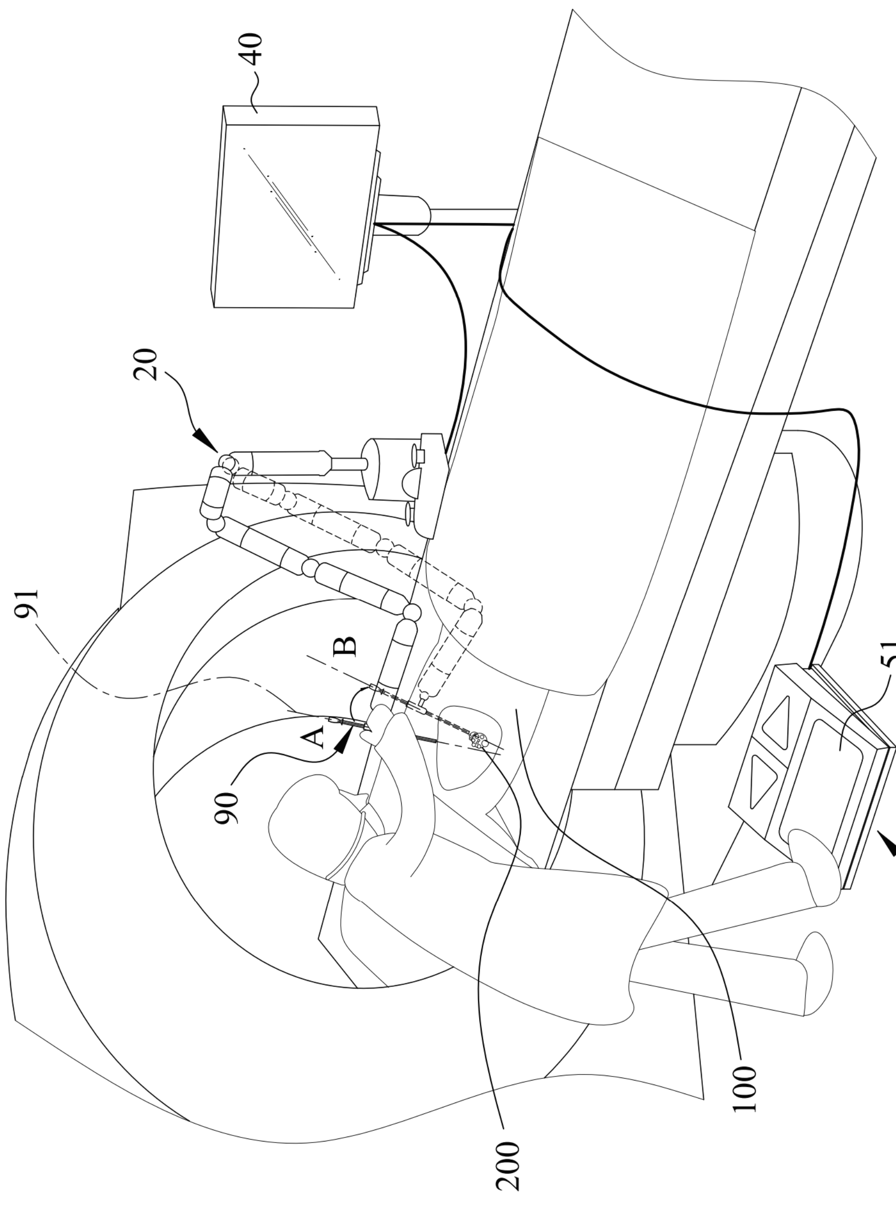


FIG. 4

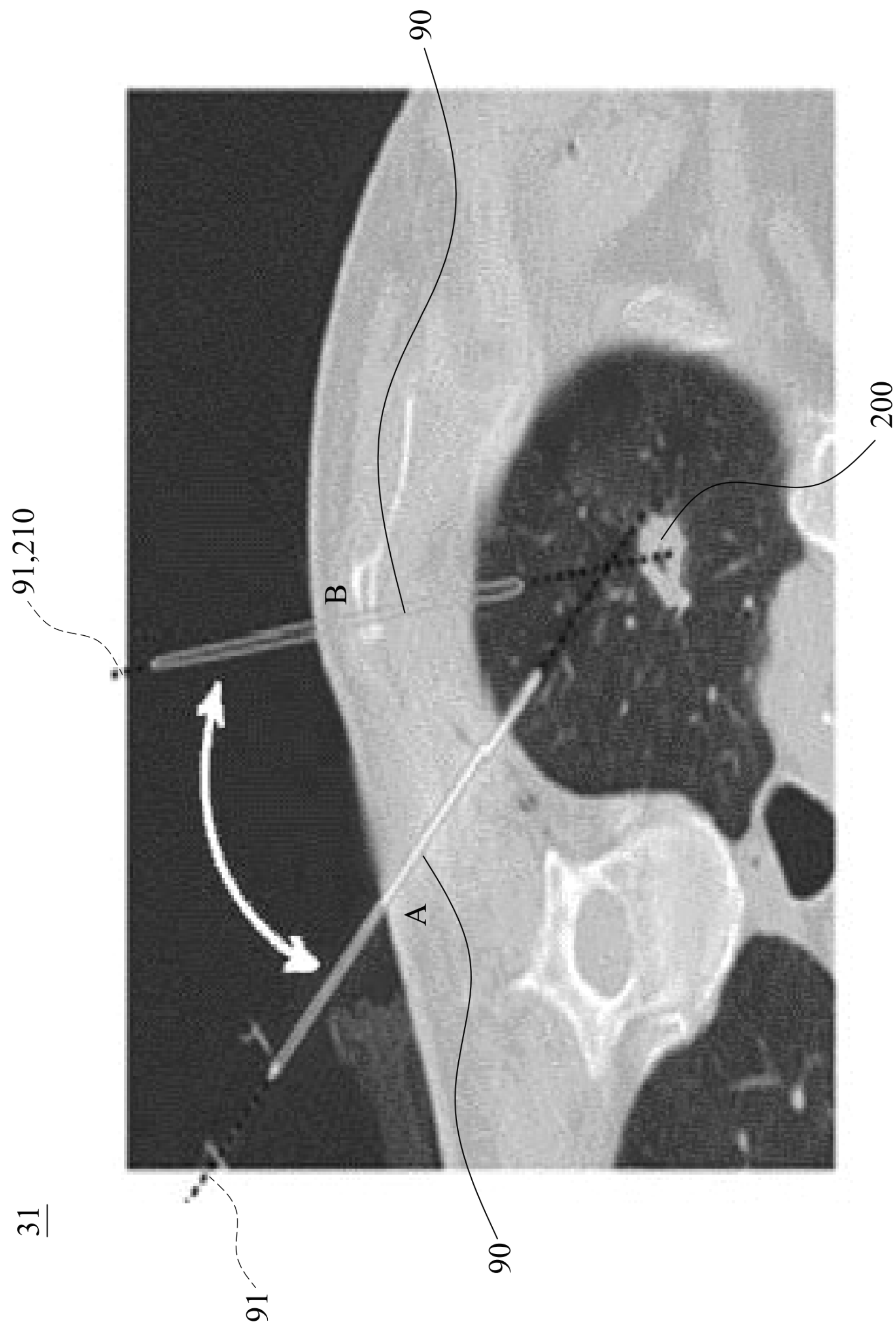


FIG. 5

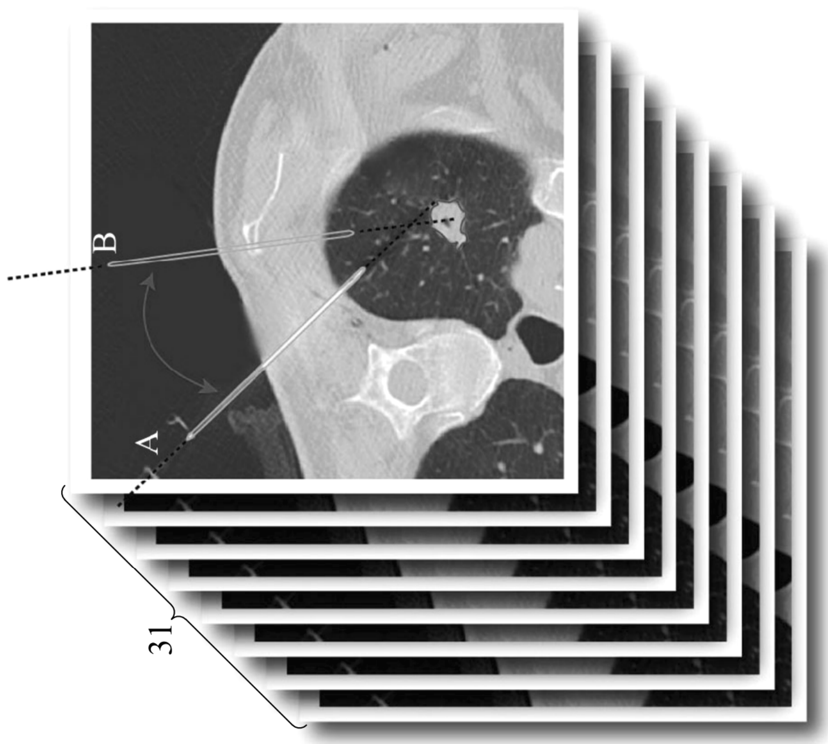


FIG. 6

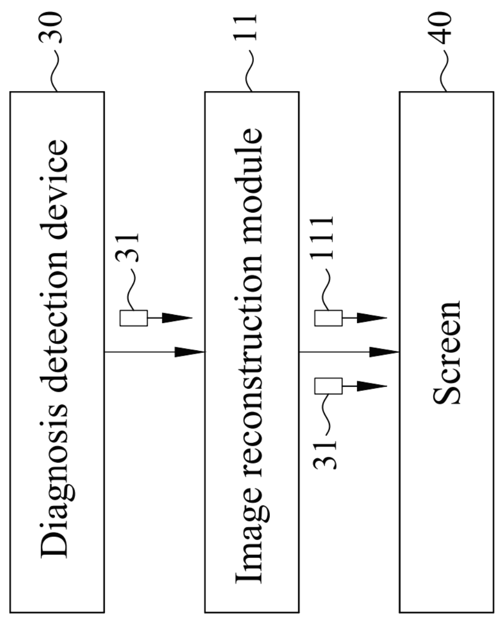

30
Diagnosis detection device
31
11
Image reconstruction module
111
31
40
Screen

FIG. 7

31 111

40 31 31

FIG. 8

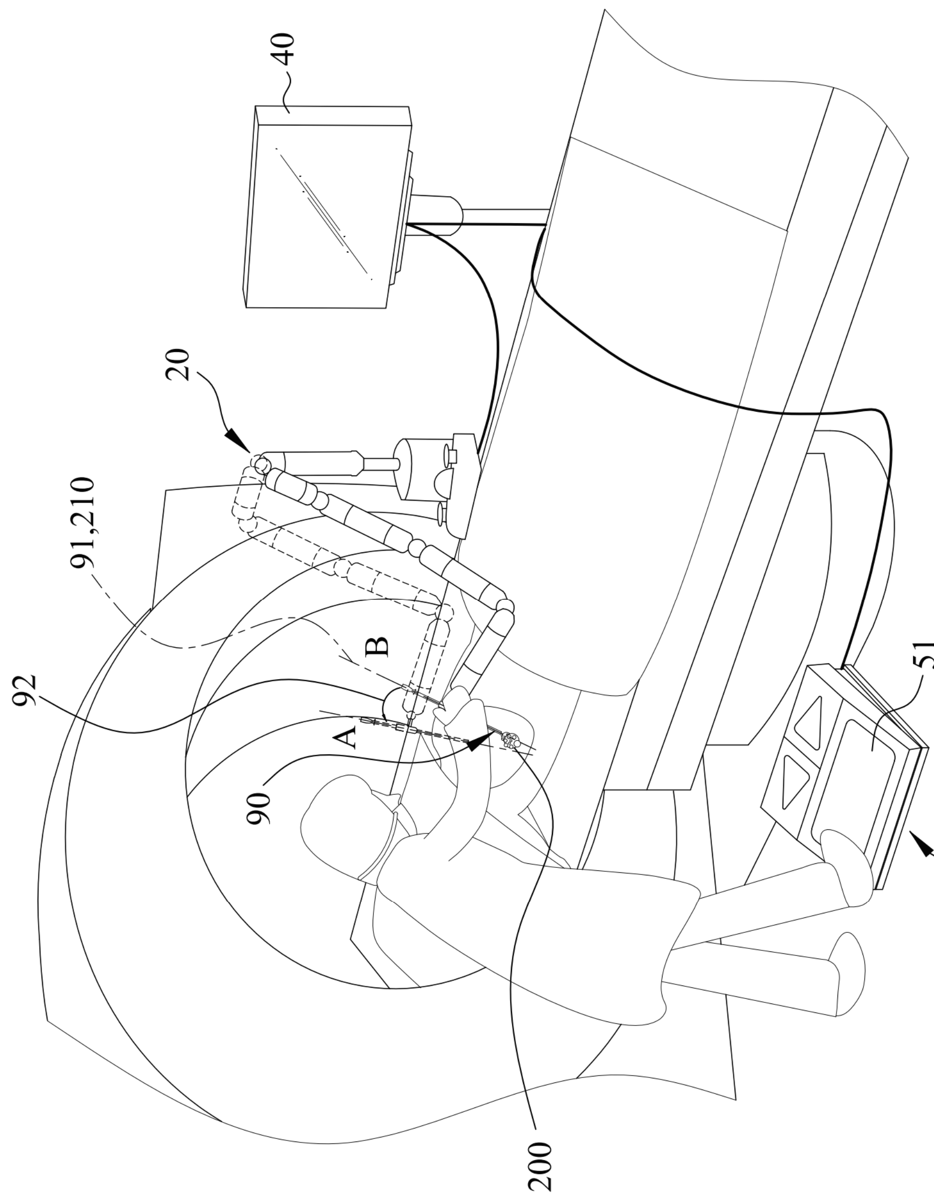
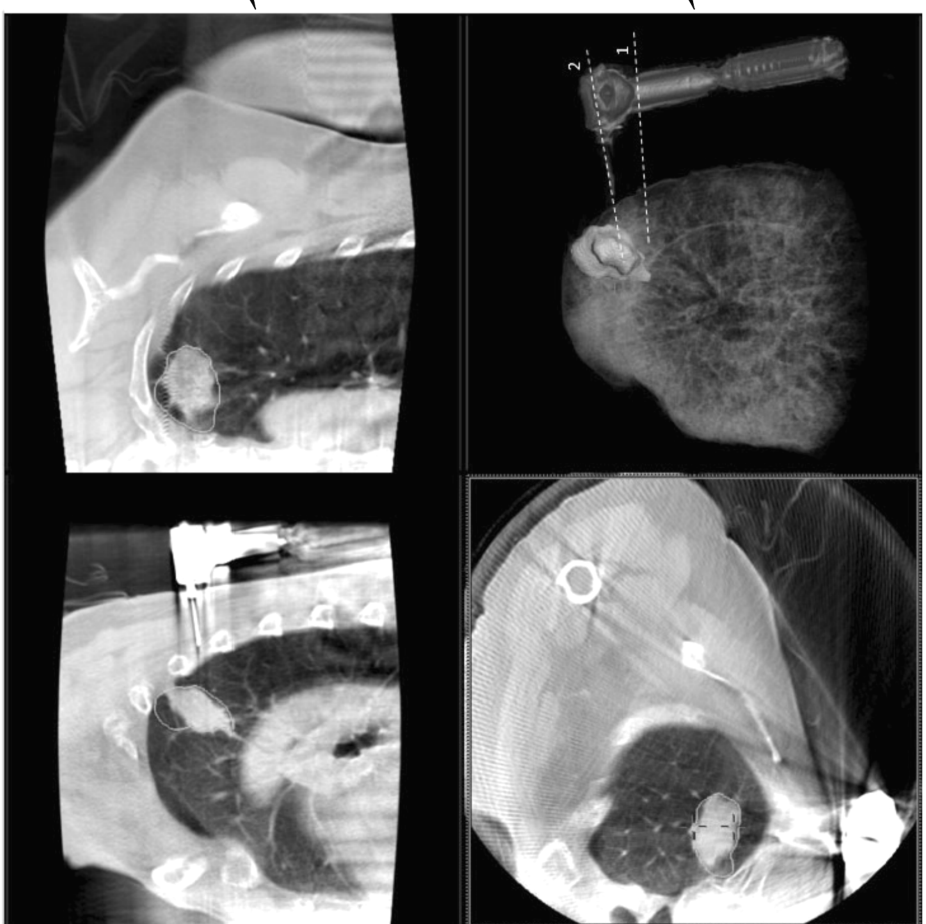


FIG. 9

31

111



31

31

40

FIG. 10

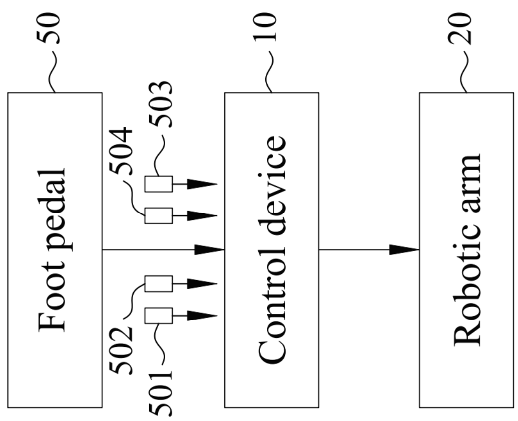

50
Foot pedal
504
503
502
501
10
Control device
20
Robotic arm

FIG. 11

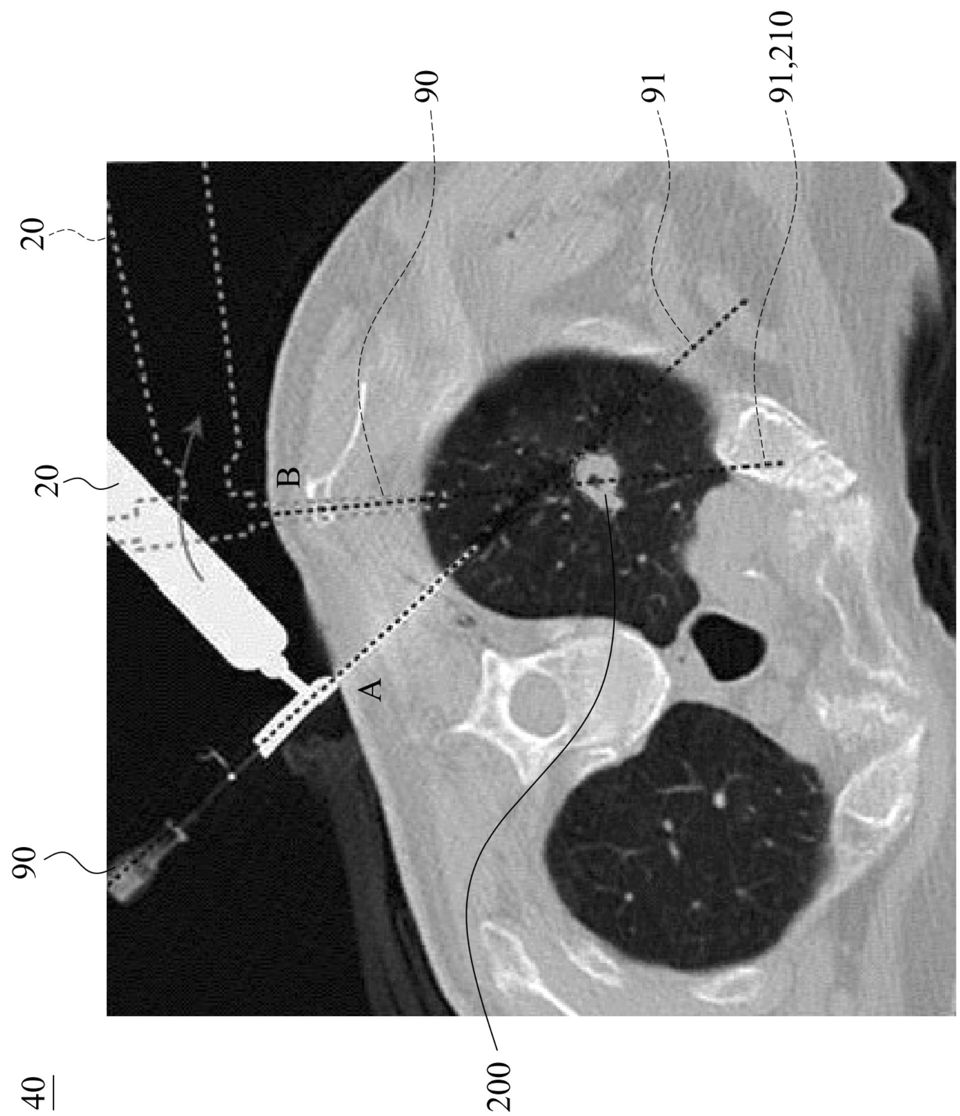


FIG. 12

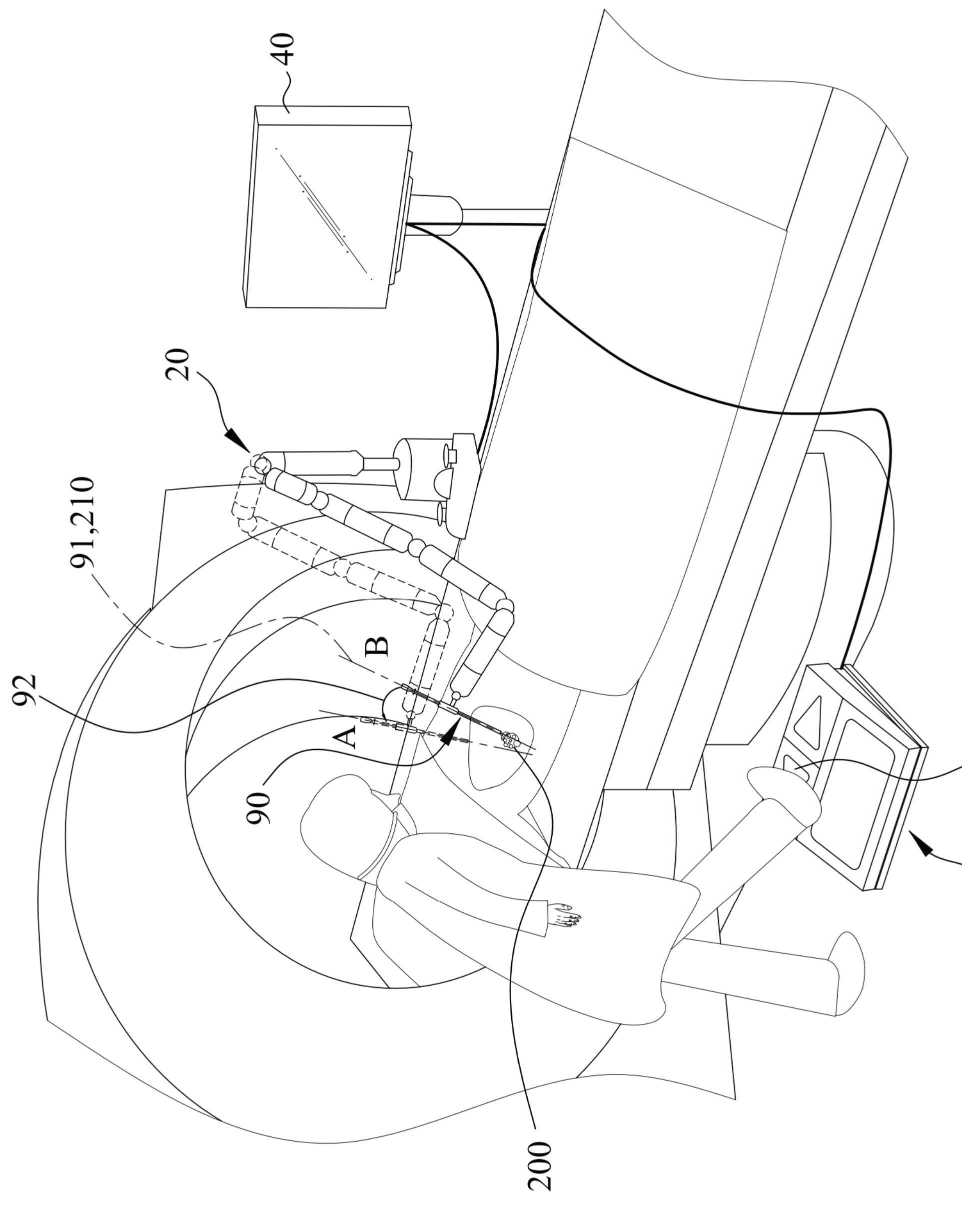


FIG. 13

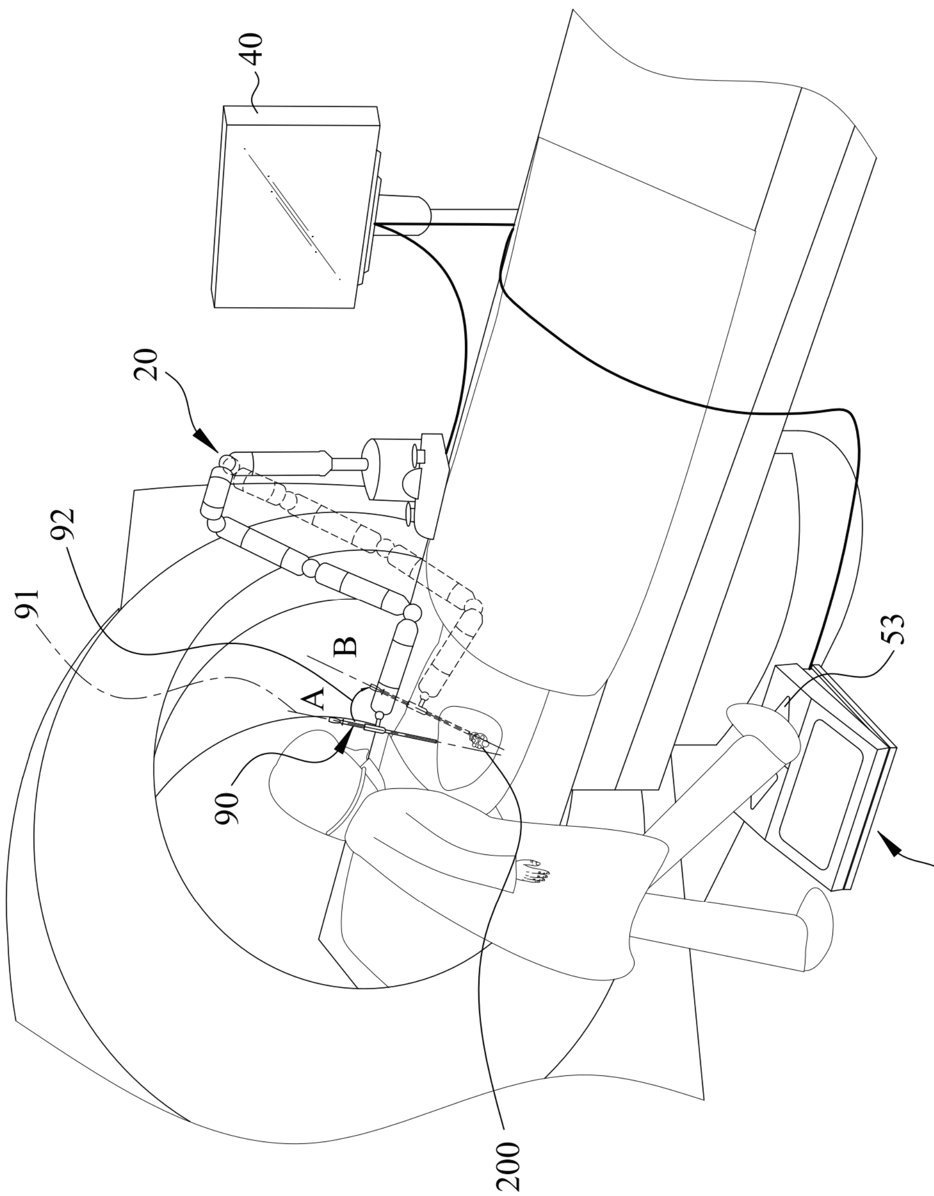


FIG. 14

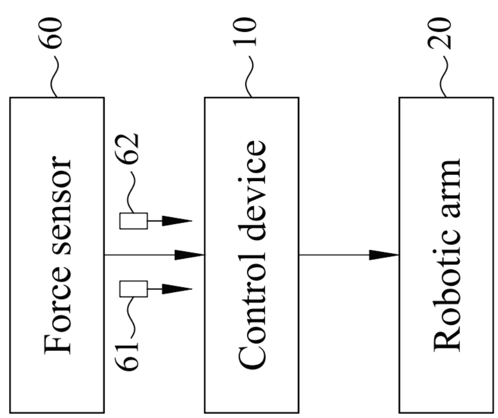

Force sensor
60
61
62
Control device
10
Robotic arm
20

FIG. 15

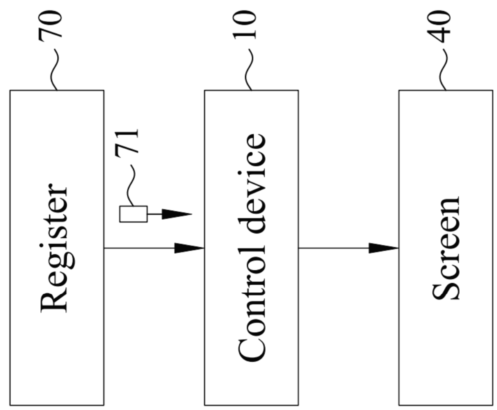

Register
70
71
Control device
10
Screen
40

FIG. 16

PUNCTURE GUIDING SYSTEM AND METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a puncture guiding system and method.

2. The Prior Arts

Techniques such as fine needle aspiration (FNA) biopy or percutaneous ablation usually need to be guided by diagnostic detection devices such as ultrasound or computed tomography (CT) before practitioners can determine the correct position of the cannula on the patient's body and the correct position of the needle on the cannula, and control the movement of the robotic arm through the control system. The robotic arm can control the cannula carrying the needle to move to the target to obtain tumor cells or complete ablation therapy.

Typically, the diagnostic testing device is near one end of the bed, and the robotic arm is near the side of the bed. The control system includes a table, a chair, an input device, an image capture device, and a screen. The chair is placed beside the table, the input device and the screen are located on the table, and the image capture device is put near the bed. The input device includes a computer, a keyboard, a mouse, a console, and a control panel. It is conceivable that except for the image capture device, the other components of the control system are arranged in groups, which are quite bulky and are not suitable to be installed on the side of the bed, otherwise the practitioners may be hindered by the bulky components from performing the operation.

However, if the practitioner is operating alone, after placing the cannula on the patient's body, the practitioner must walk from the side of the bed to the control system to confirm on the screen that the cannula is in the correct position.

Furthermore, if the practitioner is operating alone, after confirming that the cannula is placed in the correct position, the practitioner must walk from the side of the control system to the side of the bed to further manually move the position of the cannula to adjust the moving path of the cannula. After adjusting the moving path of the cannula, the practitioner must walk from the side of the bed to the control system to confirm on the screen whether the moving path of the cannula is correct. After confirming the moving path of the cannula, the practitioner can remotely control the robotic arm through the control system.

The problem with the above operation method is: first, the practitioners need to walk back and forth between the bed and the control system, which is time-consuming, laborious, and inefficient: second, the practitioners usually need to go through several corrections to adjust the moving path of the cannula, which is time-consuming and labor-intensive, and the efficiency is low.

In addition, the general robotic arm is usually fixed, and practitioners have no way to move the robotic arm arbitrarily.

Moreover, during walking, the practitioner's body is likely to collide with the robotic arm, causing the moving path of the cannula to deviate. Once the cannula moves on the deviated moving path, the needle on the cannula will excessively pull on the patient's wound.

In addition, the image capture device must constantly take pictures of the robot arm and send the photos to the computer, so that the computer can output the image of the real-time position of the robot arm to the screen, and the screen can display the moving trajectory of the robot arm and the cannula, which is costly and inefficient, as well as increases the patient's radiation exposure.

Finally, the average robotic arms tend to move too fast or too large, causing the needle on the cannula to bend or break, and excessively pulling on the patient's wound.

SUMMARY OF THE INVENTION

A primary objective of the present invention is to provide a puncture guiding system and method, wherein the cannula moves more stably, slowly and safely, and the movement accuracy of the robotic arm reaches millimeter level or less.

Another objective of the present invention is to provide a puncture guiding system and method, which can facilitate single-person bedside operation and observation of the position and moving trajectory of the robotic arm and cannula.

Another objective of the present invention is to provide a puncture guiding system and method, which can activate the robotic arm to be manually moved through a dual mechanism.

Yet another objective of the present invention is to provide a puncture guiding system and method, which is capable of sensing whether the robotic arm is impacted by an external force, and immediately controlling the robotic arm to stop moving.

A further objective of the present invention is to provide a puncture guiding system and method, which is capable of memorizing the real-time position of the robotic arm in space at any time, so as to calculate the target position of the robotic arm and set the moving path of the cannula.

Another objective of the present invention is to provide a puncture guiding system and method, which is capable of controlling the low-speed movement of the robotic arm.

For achieving the foregoing objectives, the present invention provides a puncture guiding system, comprising: a control device, a robotic arm, a diagnostic detection device, a screen, and a foot pedal. The control device has an image reconstruction module. The robotic arm is electrically connected to the control device, has a manual mode and a fixed mode, and is disposed with a cannula, which is to be placed at a first position a patient's body. The diagnosis detection device is electrically connected to the control device to scan the patient's body to obtain a plurality of two-dimensional (2D) images of the cannula and tissues near the first position. The image reconstruction module receives the plurality of 2D images and constructs a three-dimensional (3D) image. The screen is electrically connected to the control device, receives and displays the plurality of 2D images, 3D images, or a combination thereof. The foot pedal is electrically connected to the control device and includes a switching button, a first moving button, and a second moving button; wherein the control device controls the robotic arm to switch to the manual mode or the fixed mode according to the actuation of the switching button: wherein, in the manual mode, the robotic arm is manually moved to adjust the position of the cannula to a second position, and the control device sets the path between the first position and the second position as a moving path of the cannula: wherein, in the fixed mode, the control device controls the robotic arm to move according to the actuation of the first moving button to drive the cannula to move from the second position to the first position along the moving path, and the control device moves the cannula from the second position to the first position along the moving path according to the actuation of the second moving button, wherein the screen displays the movement trajectories of the robotic arm and the cannula.

In some embodiments, the image reconstruction module defines a spatial relationship between the cannula and a target object according to the plurality of 2D images and constructs a 3D image: when the cannula is at the first position, an axis of the cannula and an axis of the target object are not aligned; when the cannula is at the second position, the axis of the cannula is aligned with the axis of the target object.

In some embodiments, when the switching button is activated, the foot pedal transmits a first switching signal to the control device, and the control device controls the robotic arm to switch to the manual mode according to the first switching signal.

In some embodiments, when the switching button is not activated, the foot pedal transmits a second switching signal to the control device, and the control device controls the robotic arm to switch to the fixed mode according to the second switching signal.

In some embodiments, in the fixed mode, when the first moving button is activated and the second moving button is not activated, the foot pedal transmits a first moving signal to the control device, the control device controls the movement of the robotic arm according to the first moving signal, the robotic arm drives the cannula to move from the second position to the first position along the moving path, and the screen displays the movement trajectories of the robotic arm and the cannula.

In some embodiments, in the fixed mode, when the second moving button is activated and the first moving button is not activated, the foot pedal transmits a second moving signal to the control device, the control device controls the movement of the robotic arm according to the second moving signa, the robotic arm drives the cannula to move from the first position to the second position along the moving path, and the screen displays the movement trajectories of the robotic arm and the cannula.

In some embodiments, the puncture guiding system further comprises a force sensor, disposed on the robotic arm and electrically connected to the control device; wherein, when the robotic arm switches to manual mode and the force sensor detects that the robotic arm is manually moved, the force sensor sends a first sensing signal to the control device, and the control device controls the robotic arm to be manually moved according to the first sensing signal.

In some embodiments, the puncture guiding system further comprises a force sensor, disposed on the robotic arm and electrically connected to the control device; wherein, when the robotic arm switches to the fixed mode and the force sensor senses that the robotic arm is impacted by an external force, the force sensor sends a second sensing signal to the control device, and the control device controls the robotic arm to stop moving according to the second sensing signal.

In some embodiments, the puncture guiding system further comprises a register disposed on the robotic arm and electrically connected to the control device; wherein, when the robotic arm switches to manual mode, the register stores a real-time spatial position of the robotic arm, the control device recalculates a moving target position of the robotic arm according to the real-time spatial position of the robotic arm provided by the register, so as to set the moving path of the cannula, and the movement trajectories of the robotic arm and the cannula are displayed on the screen.

In some embodiments, in the fixed mode, a moving speed of the robotic arm is 0.2-1 cm per second in the fixed mode.

In order to achieve the aforementioned objectives, the present invention provides a puncture guiding method, comprising the following steps: controlling a robotic arm to drive a cannula to be placed at a first position on a patient's body, the cannula being installed on the robotic arm: providing a diagnostic detection device to scan the patient's body to obtain a plurality of 2D images of the cannula and tissues near the first position: constructing a 3D image based on the plurality of 2D images; providing a screen to display the plurality of 2D images and 3D images, or any combination of both: providing a foot pedal, the foot pedal comprising: a switching button, a first moving button, and a second moving button: according to the activation of the switching button, controlling the robotic arm to switch to a manual mode or a fixed mode: in the manual mode, the robotic arm being manually moved to adjust the position of the cannula to a second position, and the path between the first position and the second position being defined as a moving path of the cannula, and the screen displaying the movement trajectories of the cannula and the robotic arm; in the fixed mode, according to the activation of the first moving button, controlling the movement of the robotic arm to drive the cannula to move from the second position to the first position along the moving path, and the screen displaying the movement trajectories of the robotic arm and the cannula; and in the fixed mode, according to the activation of the second moving button, controlling the movement of the robotic arm to drive the cannula to move from the first position to the second position along the moving path, and the screen displaying the movement trajectories of the robotic arm and the cannula.

In some embodiments, the image reconstruction module defines a spatial relationship between the cannula and a target object according to the plurality of 2D images and constructs a 3D image: when the cannula is at the first position, an axis of the cannula and an axis of the target object are not aligned: when the cannula is at the second position, the axis of the cannula is aligned with the axis of the target object.

In some embodiments, when the switching button is activated, the foot pedal transmits a first switching signal to a control device, and the control device controls the robotic arm to switch to the manual mode according to the first switching signal.

In some embodiments, when the switching button is not activated, the foot pedal transmits a second switching signal to a control device, and the control device controls the robotic arm to switch to the fixed mode according to the second switching signal.

In some embodiments, in the fixed mode, when the first moving button is activated and the second moving button is not activated, the foot pedal transmits a first moving signal to a control device, the control device controls the movement of the robotic arm according to the first moving signal, the robotic arm drives the cannula to move from the second position to the first position along the moving path, and the screen displays the movement trajectories of the robotic arm and the cannula.

In some embodiments, in the fixed mode, when the second moving button is activated and the first moving button is not activated, the foot pedal transmits a second moving signal to a control device, the control device controls the movement of the robotic arm according to the second moving signa, the robotic arm drives the cannula to move from the first position to the second position along the moving path, and the screen displays the movement trajectories of the robotic arm and the cannula.

In some embodiments, when the robot arm is switched to the manual mode and a force sensor detects that the robot arm is manually moved, the force sensor sends a first sensing signal to the control device, and the control device controls the robotic arm to be moved manually according to the first sensing signal.

In some embodiments, when the robotic arm switches to the fixed mode and a force sensor detects that the robotic arm is impacted by an external force, the force sensor sends a second sensing signal to the control device, and the control device controls the robot arm to stop moving according to the second sensing signal.

In some embodiments, when the robotic arm is switched to the manual mode, a register stores the real-time spatial position of the robotic arm, and the control device recalculates the moving target position of the robotic arm according to the real-time spatial position of the robotic arm provided by the register, so as to set the moving path of the cannula, and the movement trajectories of the robotic arm and the cannula are displayed on the screen.

In some embodiments, in the fixed mode, a moving speed of the robotic arm is 0.2-1 cm per second.

The effect of the present invention is that the present invention can control the robotic arm through the foot pedal, the movement of the cannula is relatively stable, slow and safe, and the movement accuracy of the robotic arm reaches the millimeter level or less, and the cannula can move along the moving path to the destination without deviation.

Furthermore, the present invention can facilitate a practitioner to operate alone the entire surgical process such as fine needle puncture, scanning, and setting the moving path, and at the same time observe the position and movement trajectories of the robotic arm and cannula on the screen, and control the robotic arm by stepping on the foot pedal. As such, the practitioner can free up both hands to do things, save time and effort, achieve high operating efficiency, and save labor costs.

In addition, the present invention can activate the robotic arm through the dual mechanisms of the foot pedal and the force sensor, so that the robotic arm can be manually moved, thereby improving the operation safety.

Moreover, the present invention can detect whether the robotic arm is impacted by an external force in a fixed mode through the force sensor, and immediately control the robotic arm to stop moving, preventing the cannula from moving on the deviated path and causing the cannula to making the needle excessively pulls on the patient's wound.

Furthermore, the present invention can store the real-time spatial position of the robot arm at any time through the register to calculate the moving target position of the robot arm, and set the moving path of the cannula, as well as cooperate with the screen to display the movement trajectories of the robot arm and the cannula. While standing on the bedside and controlling the robotic arm by stepping on the foot pedal, the practitioner can observe on the screen whether the position of the cannula and the moving path are correct. As such, the practitioner can easily move the cannula to the correct position in one step, without repeated corrections, and the operation efficiency is high, and there is no need to install an additional image capture device and employ another person to assist in the operation: thereby, saving costs and reducing unnecessary radiation exposure for the patients.

In addition, the present invention can limit the movement of the robotic arm at a low speed in a fixed mode, which not only prevents the needle on the cannula from being bent or broken, but also avoids excessive pulling on the patient's wound.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be apparent to those skilled in the art by reading the following detailed description of a preferred embodiment thereof, with reference to the attached drawings, in which:

FIG. **1** is a perspective view of a puncture guiding system of the present invention:

FIG. **2** is a schematic structural view of the puncture guiding system of the present invention:

FIG. **3** is a flow chart of a puncture guiding method of the present invention:

FIG. **4** is a schematic view of step S**1** of the puncture guiding method of the present invention.

FIG. **5** is a schematic view of a single 2D image obtained by the diagnostic detection device of the present invention:

FIG. **6** is a schematic diagram of a plurality of 2Dl images obtained by the diagnostic detection device of the present invention and the image reconstruction module defining the spatial relationship between the cannula and the target:

FIG. **7** is a schematic structural view of image conversion and output in the present invention:

FIG. **8** is a schematic diagram of the screen displaying the cannula and the 2D and 3D images near the first position of the present invention:

FIG. **9** is a schematic view of the operation of the robotic arm of the present invention in a manual state:

FIG. **10** is a schematic diagram of the screen displaying the cannula and the 2D and 3D images in the vicinity of the second position of the present invention:

FIG. **11** is a structural schematic view of the foot pedal controlling the robotic arm through the control device of the present invention:

FIG. **12** is a schematic diagram of the screen displaying the movement trajectories of the robot arm and the cannula in the present invention:

FIG. **13** is a schematic view of the robotic arm driving the cannula to move from the second position to the first position along the moving path of the present invention:

FIG. **14** is a schematic view of the robotic arm driving the cannula to move from the first position to the second position along the moving path of the present invention:

FIG. **15** is a block diagram of the force sensor controlling the robotic arm through the control device of the present invention; and

FIG. **16** is a block diagram of the register and the control device of the present invention to set the moving path and display the movement trajectories on the screen.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The accompanying drawings are included to provide a further understanding of the invention, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

Refer to FIG. **1** and FIG. **2**. The present invention provides a puncture guiding system, including a control device **10**, a robotic arm **20**, a diagnostic detection device **30**, a screen **40**, a foot pedal **50**, a force sensor **60**, and a register **70**. The control device **10** has an image reconstruction module **11**. The robotic arm **20** is located on a first side of a bed **80**, is electrically connected to the control device **10**, has a manual mode **21** and a fixed mode **22**, and is disposed with a cannula **90**. The diagnostic detection device **30** is located at a first end of the bed **80** and is electrically connected to the control device **10**. The screen **40** is located on the first side of the bed **80** and is electrically connected to the control device **10**. The foot pedal **50** is located on a second side of the bed **80**, is electrically connected to the control device **10**, and includes a switching button **51**, a first moving button **52**, and a second moving button **53**. The force sensor **60** is disposed on the robot arm **20** and electrically connected to the control device **10**. The register **70** is disposed on the robot arm **20** and electrically connected to the control device **10**.

Referring to FIG. **3** to FIG. **14**, the present invention provides a puncture guiding method, which includes the following steps:

Step S**1** is to, as shown in FIG. **3** and FIG. **4**, control the robotic arm **20** to drive the cannula **90** to a first position A on the body of a patient **100**, and the cannula **90** is installed on the robotic arm **20**.

In step S**2**, as shown in FIG. **3**, and FIG. **5** to FIG. **7**, a diagnostic detection device **30** is provided to scan the body of the patient **100** to obtain a plurality of 2D images **31** of the cannula **90** and tissues near the first position A. More specifically, the tissue near the first position A includes a target object **200** and the tissue around the target object **200**. The target object **200** can be any tissue in the patient's body, such as a tumor.

Step S**3** is to, as shown in FIG. **3** and FIG. **7**, construct a 3D image **111** according to the plurality of 2D images **31**.

Step S**4** is to, as shown in FIG. **3**, FIG. **7**, and FIG. **8**, provide a screen **40** to display the plurality of 2D images **31**, 3D images **111**, or a combination thereof. FIG. **8** shows a 3D image **111** at the lower right of the screen **40**, and FIG. **8** shows a 2D image **31** at the upper left, lower left, and upper right of the screen **40**. In other embodiments, the screen **40** can display only the 2D image **31** or the 3D image **111**.

In step S**5**, as shown in FIG. **1** and FIG. **3**, a foot pedal **50** is provided, and the foot pedal **50** includes a switching button **51**, a first moving button **52**, and a second moving button **53**.

Step S**6** is to, as shown in FIG. **3** and FIG. **9**, control the robotic arm **20** to switch to the manual mode **21** or the fixed mode **22** according to the activation of the switching button **51**.

In step S**7**, as shown in FIG. **3**, and FIG. **9** to FIG. **12**, in the manual mode **21**, the robotic arm **20** is manually moved to adjust the position of the cannula **90** to a second position B, and a path between the first position A and the second position B is set as a moving path **92** of the cannula **90**, and the screen **40** displays the movement trajectories of the robot arm **20** and the cannula **90**.

Step S**8** is to, as shown in FIG. **3** and FIG. **13**, in the fixed mode **22**, according to the activation of the first moving button **52**, control the movement of the robotic arm **20** and drive the cannula **90** along the moving path **92** from the second position B to the first position A, the screen **40** displays the movement trajectories of the robot arm **20** and the cannula **90**.

In step S**9**, as shown in FIG. **3** and FIG. **14**, in the fixed mode **22**, according to the activation of the second moving button **53**, the movement of the robotic arm **20** is controlled to drive the cannula **90** along the moving path **92** from the first position A to the second position B, the screen **40** displays the movement trajectories of the robot arm **20** and the cannula **90**.

As such, the present invention can control the robotic arm **20** through the foot pedal **50**, the movement of the cannula **90** is relatively stable, slow and safe, the movement accuracy of the robotic arm **20** reaches the millimeter level or less, and the cannula **90** can be moved very precisely along the moving path **92** to the target position without deviation.

Furthermore, step S**1** actually has two operation modes. Regarding the first mode of operation, the cannula **90** is first installed on the robotic arm **20**, and then the switching button **51** is stepped on to switch the robotic arm **20** to the manual mode **21**. At this point, the practitioner can manually move the robotic arm **20**, so that the cannula **90** is placed at a first location A on the body of the patient **100**. Regarding the second mode of operation, the cannula **90** is first placed at the first position A of the body of the patient **100**, and then the switching button **51** is stepped with the foot, so that the robotic arm **20** is switched to the manual mode **21**. At this point, the practitioner can manually move the robotic arm **20** to beside the cannula **90**, and finally install the cannula **90** on the robotic arm **20**.

As shown in FIG. **1**, in a preferred embodiment, the diagnostic detection device **30** is a computed tomography scanner that senses the cannula **90** through an image segmentation algorithm (for example, a histogram method or a level set method). Therefore, the 2D image **31** is a 2D slice image generated by a computed tomography scanner, and is output to the image reconstruction module **11** in the format of DICOM.

As shown in FIGS. **5** to **7**, in step S**3** of the preferred embodiment, the image reconstruction module **11** receives the plurality 2D images **31**, defines the spatial relationship between the cannula **90** and the target object **200** according to the plurality of 2D **31** and then a 3D image **111** is constructed. As shown in FIGS. **4**, **5**, **12**, and **14**, when the cannula **90** is at the first position A, an axis **91** of the cannula **90** is not aligned with an axis **210** of the target **200**; that is to say, the cannula **90** and the target object **200** are not aligned, so the position of the cannula **90** needs to be adjusted. As shown in FIG. **5**, FIG. **9**, FIG. **12** and FIG. **13**, when the cannula **90** is in the second position B, the axis **91** of the cannula **90** is aligned with the axis **210** of the target object **200**; that is to say, the cannula **90** is aligned with the target object **200**.

As shown in FIG. **3**, and FIG. **9** to FIG. **12**, in step S**6** of the preferred embodiment, when the switching button **51** is activated, the foot pedal **50** sends a first switching signal **501** to the control device **10**, and the control device **10**, according to the first switch signal **501**, controls the robot arm **20** to switch to the manual mode **21**. As shown in FIG. **3**, FIG. **13**, and FIG. **14**, in step S**6** of the preferred embodiment, when the switching button **51** is inactivated, the foot pedal **50** sends a second switching signal **502** to the control device **10**, and the control device **10**, according to the second switch signal **502**, controls the robot arm **20** to switch to the fixed mode **21**.

In step S**7** of the preferred embodiment, as shown in FIG. **3**, FIG. **9**, and FIG. **12**, the control device **10** sets the path between the first position A and the second position B as the moving path **92** of the cannula **90**, and the screen **40** displays the movement trajectories of the robot arm **20** and the cannula **90**.

In step S**8** of the preferred embodiment, as shown in FIG. **3**, FIG. **9**, and FIG. **13**, in the fixed mode **22**, when the first moving button **52** is activated and the second moving button

53 is not activated, the foot pedal **50** transmits a first moving signal **503** to the control device **10**, the control device **10** controls the movement of the robotic arm **20** according to the first moving signal **503**, and the robotic arm **20** drives the cannula **90** to move from the second position B to the first position A along the moving path **92**, and the screen **40** displays the movement trajectories of the robot arm **20** and the cannula **90**.

In step S**9** of the preferred embodiment, as shown in FIG. **3**, FIG. **11**, and FIG. **14**, in the fixed mode **22**, when the second movement button **53** is activated and the first movement button **52** is not activated, the foot pedal **50** transmits a second moving signal **504** to the control device **10**, the control device **10** controls the movement of the robotic arm **20** according to the second moving signal **504**, and the robotic arm **20** drives the cannula **90** to move from the first position A to the second position B along the moving path **92**, and the screen **40** displays the movement trajectories of the robot arm **20** and the cannula **90**.

A practitioner may install a needle (not shown) on the cannula **90** before performing the above method. Therefore, in step S**1**, the needle is inserted into the first position A of the body of the patient **100**; in steps S**7**-S**9**, the needle moves along with the cannula **90**. In particular, after the cannula **90** is moved to the second position B, the needle is moved to the target object **200** in step S**9**.

The practitioner can also install a needle (not shown) on the cannula **90** after the cannula **90** moves to the second position B in step S**9**, and then insert the needle into the second position B of the patient's body. The needle moves to the target object **200**.

As such, the present invention can provide a single practitioner to operate the entire surgical process such as puncture, scanning, and setting the moving path **92**, and at the same time observe the position and movement trajectories of the robotic arm **20** and the cannula **90** through the screen **40**, as well as step on the foot pedal **50** to control the robotic arm **20**. Therefore, the practitioner can free up both hands to do things, save time and effort, achieve high operating efficiency, and save labor costs.

Furthermore, because the foot pedal **50** is small in size and placed on the ground, it will not affect the operation of the practitioners and does not take up space, so it is suitable to be placed on one side of the bed **80**, and the screen **40** can be arranged on the other side of the bed **80**. Therefore, the present invention can provide a practitioner standing on the side of the bed **80** to perform the surgical procedure without leaving the side of the bed **80** at all.

As shown in FIG. **15**, in a preferred embodiment, when the robotic arm **20** is switched to the manual mode **21** and a force sensor **60** is provided to sense that the robotic arm **20** is manually moved, the force sensor **60** transmits a first sensing signal **61** to the control device **10**, and the control device **10** controls the robotic arm **20** to be manually moved according to the first sensing signal **61**, so that the practitioner can move the robotic arm **20** at will to complete step S**1** or step S**7**. Therefore, the present invention can activate the robotic arm **20** through the dual mechanism of the foot pedal **50** and the force sensor **60**, and only then the robotic arm **20** is allowed to be moved manually, thereby improving the safety of operation.

As shown in FIG. **15**, in a preferred embodiment, when the robotic arm **20** switches to the fixed mode **22** and the force sensor **60** senses that the robotic arm **20** is impacted by an external force, the force sensor **60** transmits a second sensing signal **62** to the control device **10**, and the control device **10** controls the robotic arm **20** to stop moving according to the second sensing signal **62**. Therefore, the present invention can sense whether the robotic arm **20** is hit by an external force in the fixed mode **22** through the force sensor **60**, and immediately control the robotic arm **20** to stop moving, preventing the cannula **90** from moving on a deviated path **92** which will cause the needles on the cannula **90** to pull excessively on the patient's **100** wound.

As shown in FIG. **16**, in a preferred embodiment, when the robot arm **20** is switched to the manual mode **21**, a register **70** is provided to store the real-time spatial position **71** of the robot arm **20**, and the control device **10**, according to the t real-time spatial position **71** provided by the register **70**, recalculates the moving target position of the robotic arm **20** to set the moving path **92** of the cannula **90**, and displays the movement trajectories of the robotic arm **20** and the cannula **90** on the screen **40**. Therefore, the present invention can store the real-time position **71** of the robot arm **20** in the register **70**, so as to recalculate the moving target position of the robot arm **20** and set the moving path **92** of the cannula **90**, and uses the screen **40** to display the movement trajectories of the robot arm **20** and the cannula **90**. The practitioner can observe the position of the cannula **90** and whether the moving path **92** is correct on the screen **40** while standing on the side of the bed **80** and controlling the robotic arm **20** by stepping on the foot pedal **50**. In this way of operation, the practitioner can easily move the cannula **90** to the correct position at a step without repeated corrections, the operation efficiency is improved, and there is no need to additionally install an image capture device and employs another person to assist in the operation, so as to reduce the patient's radiation exposure and costs.

In a preferred embodiment, in the fixed mode **22**, the moving speed of the robotic arm **20** is 0.2-1 cm per second. Therefore, the present invention can limit the movement of the robotic arm **20** at a low speed in the state of the fixed mode **22**, which not only prevents the needles on the cannula **90** from being bent or broken, but also prevents the needles on the cannula **90** from excessively pulling on the patient's **100** wound.

Although the present invention has been described with reference to the preferred embodiments thereof, it is apparent to those skilled in the art that a variety of modifications and changes may be made without departing from the scope of the present invention which is intended to be defined by the appended claims.

What is claimed is:

1. A puncture guiding system, comprising:

a control device, having an image reconstruction module;

a robotic arm, electrically connected to the control device, having a manual mode and a fixed mode, and disposed with a cannula to be placed at a first position a patient's body:

a diagnostic detection device, electrically connected to the control device to scan the patient's body to obtain a plurality of two-dimensional (2D) images of the cannula and tissues near the first position; the image reconstruction module receiving the plurality of 2D images to construct a three-dimensional (3D) image:

a screen, electrically connected to the control device, for receiving and displaying the plurality of 2D images, 3D images, or a combination of both; and

a foot pedal, electrically connected to the control device and comprising a switching button, a first moving button, and a second moving button;

wherein the control device controlling the robotic arm to switch to the manual mode or the fixed mode according to an actuation of the switching button;

wherein, in the manual mode, the robotic arm being manually moved to adjust the position of the cannula to a second position, and the control device setting a path between the first position and the second position as a moving path of the cannula;

wherein, in the fixed mode, the control device controlling the robotic arm to move according to an actuation of the first moving button to drive the cannula to move from the second position to the first position along the moving path, and the control device moving the cannula from the second position to the first position along the moving path according to an actuation of the second moving button; and

wherein the screen displaying the movement trajectories of the robotic arm and the cannula.

2. The puncture guiding system according to claim **1**, wherein the image reconstruction module defines a spatial relationship between the cannula and a target object according to the plurality of 2D images and constructs a 3D image: when the cannula is at the first position, an axis of the cannula and an axis of the target object are not aligned; when the cannula is at the second position, the axis of the cannula is aligned with the axis of the target object.

3. The puncture guiding system according to claim **1**, wherein when the switching button is activated, the foot pedal transmits a first switching signal to the control device, and the control device controls the robotic arm to switch to the manual mode according to the first switching signal.

4. The puncture guiding system according to claim **1**, wherein when the switching button is not activated, the foot pedal transmits a second switching signal to the control device, and the control device controls the robotic arm to switch to the fixed mode according to the second switching signal.

5. The puncture guiding system according to claim **1**, wherein in the fixed mode, when the first moving button is activated and the second moving button is not activated, the foot pedal transmits a first moving signal to the control device, the control device controls the movement of the robotic arm according to the first moving signal, the robotic arm drives the cannula to move from the second position to the first position along the moving path, and the screen displays the movement trajectories of the robotic arm and the cannula.

6. The puncture guiding system according to claim **1**, wherein in the fixed mode, when the second moving button is activated and the first moving button is not activated, the foot pedal transmits a second moving signal to the control device, the control device controls the movement of the robotic arm according to the second moving signa, the robotic arm drives the cannula to move from the first position to the second position along the moving path, and the screen displays the movement trajectories of the robotic arm and the cannula.

7. The puncture guiding system according to claim **1**, further comprising a force sensor, disposed on the robotic arm and electrically connected to the control device: wherein, when the robotic arm switching to manual mode and the force sensor detecting that the robotic arm being manually moved, the force sensor sending a first sensing signal to the control device, and the control device controlling the robotic arm to be manually moved according to the first sensing signal.

8. The puncture guiding system according to claim **1**, further comprising a force sensor, disposed on the robotic arm and electrically connected to the control device: wherein, when the robotic arm switching to the fixed mode and the force sensor detecting that the robotic arm being impacted by an external force, the force sensor sending a second sensing signal to the control device, and the control device controlling the robotic arm to stop moving according to the second sensing signal.

9. The puncture guiding system according to claim **1**, further comprising a register disposed on the robotic arm and electrically connected to the control device; wherein, when the robotic arm switching to manual mode, the register stores a real-time spatial position of the robotic arm, the control device recalculating a moving target position of the robotic arm according to the real-time spatial position of the robotic arm provided by the register, so as to set the moving path of the cannula, and the screen displaying the movement trajectories of the robotic arm and the cannula.

10. The puncture guiding system according to claim **1**, wherein the robotic arm has a moving speed of 0.2-1 cm per second in the fixed mode.

11. A puncture guiding method, comprising the following steps:

controlling a robotic arm to drive a cannula to be placed at a first position on a patient's body, the cannula being installed on the robotic arm;

providing a diagnostic detection device to scan the patient's body to obtain a plurality of 2D images of the cannula and tissues near the first position:

constructing a 3D image based on the plurality of 2D images: providing a screen to display the plurality of 2D images and 3D images, or any combination of both:

providing a foot pedal, the foot pedal comprising: a switching button, a first moving button, and a second moving button: according to the activation of the switching button, controlling the robotic arm to switch to a manual mode or a fixed mode:

in the manual mode, the robotic arm being manually moved to adjust the position of the cannula to a second position, and the path between the first position and the second position being defined as a moving path of the cannula, and the screen displaying the movement trajectories of the cannula and the robotic arm:

in the fixed mode, according to the activation of the first moving button, controlling the movement of the robotic arm to drive the cannula to move from the second position to the first position along the moving path, and the screen displaying the movement trajectories of the robotic arm and the cannula; and

in the fixed mode, according to the activation of the second moving button, controlling the movement of the robotic arm to drive the cannula to move from the first position to the second position along the moving path, and the screen displaying the movement trajectories of the robotic arm and the cannula.

12. The puncture guiding method according to claim **11**, wherein the image reconstruction module defines a spatial relationship between the cannula and a target object according to the plurality of 2D images and constructs a 3D image: when the cannula is at the first position, an axis of the cannula and an axis of the target object are not aligned; when the cannula is at the second position, the axis of the cannula is aligned with the axis of the target object.

13. The puncture guiding method according to claim **11**, wherein when the switching button is activated, the foot pedal transmits a first switching signal to the control device, and the control device controls the robotic arm to switch to the manual mode according to the first switching signal.

14. The puncture guiding method according to claim **11**, wherein when the switching button is not activated, the foot pedal transmits a second switching signal to the control device, and the control device controls the robotic arm to switch to the fixed mode according to the second switching signal.

15. The puncture guiding method according to claim **11**, wherein in the fixed mode, when the first moving button is activated and the second moving button is not activated, the foot pedal transmits a first moving signal to a control device, the control device controls the movement of the robotic arm according to the first moving signal, the robotic arm drives the cannula to move from the second position to the first position along the moving path, and the screen displays the movement trajectories of the robotic arm and the cannula.

16. The puncture guiding method according to claim **11**, wherein in the fixed mode, when the second moving button is activated and the first moving button is not activated, the foot pedal transmits a second moving signal to the control device, the control device controls the movement of the robotic arm according to the second moving signa, the robotic arm drives the cannula to move from the first position to the second position along the moving path, and the screen displays the movement trajectories of the robotic arm and the cannula.

17. The puncture guiding method according to claim **11**, wherein when the robotic arm switches to manual mode and a force sensor is provided to detect that the robotic arm is manually moved, the force sensor sends a first sensing signal to a control device, and the control device controls the robotic arm to be manually moved according to the first sensing signal.

18. The puncture guiding method according to claim **11**, wherein when the robotic arm switches to the fixed mode and a force sensor is provided to detect that the robotic arm is impacted by an external force, the force sensor sends a second sensing signal to the control device, and the control device controls the robotic arm to stop moving according to the second sensing signal.

19. The puncture guiding method according to claim **11**, wherein when the robotic arm switches to manual mode, a register is provided to store a real-time spatial position of the robotic arm, the control device recalculates a moving target position of the robotic arm according to the real-time spatial position of the robotic arm provided by the register, so as to set the moving path of the cannula, and the screen displays the movement trajectories of the robotic arm and the cannula.

20. The puncture guiding method according to claim **11**, wherein the robotic arm has a moving speed of 0.2-1 cm per second in the fixed mode.

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