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(54) **MEDICAL ROBOT**

MEDIZINISCHER ROBOTER

ROBOT MÉDICAL

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Description

Technical Field

[0001] Embodiments of the present invention relate to a medical robot, and more particularly, to a medical robot that may be aimed at a treatment area accurately and rapidly.

Background Art

[0002] Radiation therapy is a form of treatment to kill cancer cells using high-energy radiation. Radiation refers to a material mediating propagation or a phenomenon of energy propagating through a space, and an X-ray is a typical example of the radiation.

[0003] Radiation therapy is one of the three most prevalent cancer treatments, in company with surgery and chemotherapy. In general, radiation therapy may not require hospitalization, take a few to about 30 minutes per day, and be painless during treatment.

[0004] As radiation therapy apparatuses, X-Knife (Radionics, U.S.A.), Novalis Tx (BrainLAB, Germany), Peacok (NOMOS Corp., U.S.A.), Trilogy (Varian Medical System, U.S.A.), and CyberKnife (Accuray Inc., U.S.A.) are known. Many of the radiation therapy apparatuses are evolving to reduce an error occurring during treatment and increase an accuracy based on technology of Image Guided Radiotherapy (IGRT) and a linear accelerator.

[0005] CyberKnife is a high-precision stereotactic radiation therapy exclusive apparatus that may intensively irradiate a tumor portion in various directions by providing a small linear accelerator to a robot arm freely moving with six joints.

[0006] CyberKnife may provide a precise treatment by tracking coordinates of a gold marker inserted into a body and a skeleton image using real-time image guided technology, without an invasive fixing device. In addition, contrary to Gamma Knife used to treat brain tumors, CyberKnife may be used to treat cancer throughout a human body. Further, CyberKnite may be used for fractionated radiation therapy administered a few times, rather than once.

[0007] Recently, research is being conducted on CyberKnife. For example, Korean Patent Application No. 2009-0038051, filed on April 30, 2009, discloses "System for radiotherapy planning information viewer".

[0008] US 2013/223597 A1 discloses an X-ray facility, having at least one x-ray emitter, an x-ray detector and an isocenter arranged along a central beam path between the x-ray emitter and the x-ray detector. The x-ray emitter and the x-ray detector are arranged on separate support arms. At least one rotary device is provided on each support arm, by way of which the x-ray emitter or the x-ray detector can be rotated about an axis of rotation intersecting the isocenter and not corresponding to the central beam. Wherein the axes of rotation match rotary devices assigned to one another on different support arms.

[0009] US 2010/104068 A1 discloses a method and apparatus for radiation treatment planning are described. The method includes receiving a plurality of radiation treatment-planning parameters, and sequentially optimizing the plurality of radiation treatment-planning parameters.

[0010] WO 2010/030463 A1 discloses a robotic treatment delivery system including a linear accelerator (LINAC), and a robotic manipulator coupled to the LINAC. The robotic manipulator is configured to move the LINAC along seven or more degrees of freedom, at least one of the seven degrees of freedom being a redundant degree of freedom.

Disclosure of Invention

Technical Goals

[0011] An aspect of the present invention provides a medical robot that may be aimed at a target point rapidly and accurately through relative movements of a robot arm unit and a bed.

[0012] Another aspect of the present invention also provides a medical robot that may increase a directivity with respect to a target point through easy control, thereby reducing a treatment or surgery time.

[0013] Still another aspect of the present invention also provides a medical robot that may reduce an overall weight by reducing a number of drive members through a compact design.

[0014] Yet another aspect of the present invention also provides a medical robot that may prevent a mutual collision between robot arm units by rotating a plurality of robot arm units independently and incoherently.

[0015] Further another aspect of the present invention also provides a medical robot that may efficiently enable an emitting member to be aimed at an object by adjusting a position of a bed.

Technical solutions

[0016] According to an aspect of the present invention, there is provided a medical robot including a bed on which an object is to be disposed, and a robot arm unit disposed above or below the bed, and including an emitting member movable within a trajectory on a sphere having a center at which a target point is disposed. The bed and the robot arm unit can move relatively in a vertical or horizontal direction, and the object may be repositioned to the target point by relatively moving the bed and the robot arm unit in the vertical or horizontal direction, and the emitting member may move to face the target point.

[0017] Further the robot arm unit comprises a first central member; a first link member to rotate on a longitudinal axis (XA) of the first central member; a second link member connected to another end of the first link member to rotate on a first axis (XI); a third link member connected to a portion of the first central member, the portion differing from a portion to which the first link member is connected, to rotate on the longitudinal axis of the first central member, and a fourth link member connected to another end of the third link member to rotate on a second axis (X2); wherein respective end portions of the second link member and the fourth link member are provided with the emitting member, wherein the first link member, the second link member, the third link member and the fourth link member are provided in form of an arc, and the first link member and the third link member may rotate in different directions or at different velocities.

[0018] The robot arm unit may include an upper robot arm to rotate above the bed, and a lower robot arm to rotate below the bed. An emitting member of the upper robot arm and an emitting member of the lower robot arm may be disposed to face an identical target point.

[0019] The upper robot arm and the lower robot may be disposed within trajectories on spheres having an identical center.

[0020] The robot arm unit may include a plurality of link members and a plurality of drive members, the plurality of link members may be disposed on concentric spheres having an identical center, and extension lines of axes of the drive members may be positioned at the center.

[0021] The center of the concentric spheres may match the target point.

[0022] The robot arm unit may include a first central member, a first link member to rotate on a longitudinal axis of the first central member, a first drive member disposed at one end of the first link member to transmit a torque to the first link member, a second link member connected to another end of the first link member to rotate on a first axis, and a second drive member disposed between the first link member and the second link member to transmit a torque to the second link member.

[0023] The robot arm unit may further include a third link member connected to a portion of the first central member, the portion differing from a portion to which the first link member is connected, to rotate on the longitudinal axis of the first central member, a third drive member disposed at one end of the third link member to transmit a torque to the third link member, a fourth link member connected to another end of the third link member to rotate on a second axis, and a fourth drive member disposed between the third link member and the fourth link member to transmit a torque to the fourth link member.

[0024] The robot arm unit may further include a second central member disposed on an axis identical to the longitudinal axis of the first central member and spaced apart from the center by a distance corresponding to a distance between the first central member and the center, a fifth link member to rotate on a longitudinal axis of the second central member, a fifth drive member disposed at one end of the fifth link member to transmit a torque to the fifth link member, a sixth link member connected to another end of the fifth link member to rotate on a third axis, and a sixth drive member disposed between the fifth link member and the sixth link member to transmit a torque to the sixth link member.

[0025] The robot arm unit may further include a seventh link member connected to a portion of the second central member, the portion differing from a portion to which the fifth link member is connected, to rotate on the longitudinal axis of the second central member, a seventh drive member disposed at one end of the seventh link member to transmit a torque to the seventh link member, an eighth link member connected to another end of the seventh link member to rotate on a fourth axis, and an eighth drive member disposed between the seventh link member and the eighth link member to transmit a torque to the eighth link member.

[0026] The longitudinal axis of the first central member, the longitudinal axis of the second central member, the first axis, the second axis, the third axis, and the fourth axis may be positioned at the center.

[0027] The first axis, the second axis, the third axis, and the fourth axis may be formed to be perpendicular to tangential directions of end portions of the first link member, the second link member, the third link member, the fourth link member, the fifth link member, the sixth link member, the seventh link member, and the eighth link member.

[0028] The first link member and the second link member may be disposed farther away from the center than the third link member and the fourth link member, and the fifth link member and the sixth link member may be disposed farther away from the center than the seventh link member and the eighth link member.

[0029] When the third link member is disposed between the first link member and the second link member, lengths of the third link member and the fourth link member may be shorter than a length of the first link member.

[0030] The third link member and the fourth link member may be disposed closer to the center than the second link member, and the fourth link member may be disposed closer to the center than the third link member.

[0031] When the seventh link member is disposed between the fifth link member and the sixth link member, lengths

of the seventh link member and the eighth link member may be shorter than a length of the fifth link member.
[0032] The seventh link member and the eighth link member may be disposed closer to the center than the sixth link member, and the eighth link member may be disposed closer to the center than the seventh link member.
[0033] The robot arm unit may further include emitting members provided at respective end portions of the second link member, the fourth link member, the sixth link member, and the eighth link member to face the center.
[0034] The emitting members may be disposed to be perpendicular to tangential directions of the end portions of the second link member, the fourth link member, the sixth link member, and the eighth link member.
[0035] The medical robot may further include a position adjustment element to adjust a position of the bed.

Brief Description of Drawings

[0036]

FIG. 1 illustrates a medical robot according to an embodiment of the present invention.
FIG. 2 illustrates a disposition of a robot arm unit in a medical robot according to an embodiment of the present invention.
FIG. 3 illustrates a radiation range of emitting members of a medical robot according to an embodiment of the present invention.
FIG. 4 illustrates angle adjustment elements disposed in a medical robot according to an embodiment of the present invention.
FIG. 5 illustrates a direction of an emitting member in a medical robot according to an embodiment of the present invention.
FIG. 6 illustrates spherical coordinates.

Best Mode for Carrying Out the Invention

[0037] Reference will now be made in detail to embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below in order to explain the present invention by referring to the figures.
[0038] FIG. 1 illustrates a medical robot 10 according to an embodiment of the present invention, FIG. 2 illustrates a disposition of a robot arm unit 200 in the medical robot 10 according to an embodiment of the present invention, FIG. 3 illustrates a radiation range of emitting members 300 of the medical robot 10 according to an embodiment of the present invention, and FIG. 4 illustrates angle adjustment elements 310 disposed in the medical robot 10 according to an embodiment of the present invention.
[0039] Referring to FIG. 1, the medical robot 10 may include a bed 100 and a robot arm unit 200.
[0040] An object may be disposed on the bed 100. The object may be, for example, a patient.
[0041] When the medical robot 10 is used as a cyberknife, the object may be a cancer patient requiring radiation therapy or a tumor removing surgery. In this example, a target point T may be a treatment or surgery area, for example, a position of a tumor.
[0042] A position adjustment element 110 may be disposed at the bed 100 to adjust a position of the bed 100.
[0043] As shown in FIG. 1, when the position adjustment element 110 moves in a direction of an arrow, the bed 100 may also move in the direction of the arrow.
[0044] The position of the bed 100 or the object may be freely adjusted and thus, the target point T may be repositioned.
[0045] In detail, the bed 100 may move in a direction vertical or horizontal to the ground.
[0046] Accordingly, the bed 100 and the robot arm unit 200 may move relatively in the vertical or horizontal direction.
[0047] When the bed 100 is fixed, the position of the object may be fixed. By moving the robot arm unit 200, an irradiation position of an emitting member 300 or a position at which radiation is emitted from the emitting member 300 may be moved relatively with respect to the bed 100.
[0048] The object may be repositioned to the target point T by relatively moving the bed 100 with respect to the robot arm unit 200 through the position adjustment element 110, and the emitting member 300 may move to face the target point T.
[0049] Thus, the emitting member 300 provided at the robot arm unit 200 may be efficiently aimed at the target point T of the object disposed on the bed 100, which will be described in detail hereinafter.
[0050] The robot arm unit 200 may be disposed above or below the bed 100.
[0051] The robot arm unit 200 may include an upper robot arm 210 and a lower robot arm 220. The emitting member 300 may be provided at an end portion of each of the upper robot arm 210 and the lower robot arm 220.
[0052] In this example, radiation may be emitted from the emitting member 300, and the radiation may be emitted or irradiated toward the target point T of the object.

[0053] Referring to FIG. 2, the upper robot arm 210 and the lower robot arm 220 may be disposed within trajectories on spheres having an identical center, for example, the identical target point T.

[0054] The emitting member 300 of the upper robot arm 210 and the emitting member 300 of the lower robot arm 220 may move in response to rotation of the upper robot arm 210 and the lower robot arm 220. Thus, the emitting members 300 may move along spherical trajectories of the upper robot arm 210 and the lower robot arm 220. The emitting members 300 may be disposed to face the identical target point T.

[0055] Accordingly, radiation emitted from the emitting member 300 provided on the upper robot arm 210 and radiation emitted from the emitting member 300 provided on the lower robot arm 220 may be concentrated on a single singular point. The emitting members 300 may be easily aimed at a treatment area.

[0056] The upper robot arm 210 and the lower robot arm 220 may be disposed to be spaced apart from each other based on the bed 100.

[0057] Through such a disposition of the upper robot arm 210 and the lower robot arm 220, the upper robot arm 210 and the lower robot arm 220 may operate incoherently, and a mutual collision between the upper robot arm 210 and the lower robot arm 220 may be prevented.

[0058] The upper robot arm 210 and the lower robot arm 220 may respectively include a plurality of link members and a plurality of drive members.

[0059] For example, the upper robot arm 210 may include a first link member 211, a second link member 212, a third link member 215, and a fourth link member 216.

[0060] The first link member 211 may be provided at a first central member 202 to rotate on a longitudinal axis X_A of the first central member 202.

[0061] The first central member 202 may be disposed in a vertical direction on an inner side of a frame provided on an outer side of the medical robot 10.

[0062] The first link member 211 may be disposed on a sphere having a center at the target point T, and provided in a form of an arc.

[0063] The first link member 211 may have a longer length than the second link member 212, the third link member 215, and the fourth link member 216, and be disposed farthest away from the target point T.

[0064] The second link member 212 may be connected to another end of the first link member 211.

[0065] The second link member 212 may rotate based on a first axis X_1.

[0066] The first axis X_1 may be angled with respect to the longitudinal axis X_A of the first central member 202.

[0067] The third link member 215 may be connected to a portion of the first central member 202, the portion differing from a portion to which the first link member 211 is connected.

[0068] The third link member 215 may rotate on the longitudinal axis X_A of the first central member 202.

[0069] For example, the first link member 211 may be connected to an upper portion of the first central member 202, and the third link member 215 may be connected to a lower portion of the first central member 202.

[0070] The fourth link member 216 may be connected to another end of the third link member 215.

[0071] The fourth link member 216 may rotate on a second axis X_2.

[0072] The second axis X_2 may be angled with respect to the longitudinal axis X_A of the first central member 202.

[0073] The upper robot arm 210 may further include a first drive member 213, a second drive member 214, a third drive member 217, and a fourth drive member 218.

[0074] The first drive member 213 may be included in the first central member 202. Although not illustrated in detail, the first central member 202 may include a space in which the first drive member 213 is to be disposed.

[0075] The first drive member 213 may transmit a torque to the first link member 211.

[0076] The second drive member 214 may transmit a torque to the second link member 212. The second drive member 214 may be disposed to face the target point T along the first axis X_1.

[0077] Similar to the first drive member 213, the third drive member 217 may be included in the first central member 202. The first central member 202 may include a space in which the third drive member 217 is to be disposed.

[0078] The third drive member 217 may transmit a torque to the third link member 215.

[0079] The first drive member 213 and the third drive member 217 may be provided integrally or separately. For example, when the first drive member 213 and the third drive member 217 are provided separately, the first link member 211 and the third link member 215 may rotate in different directions or at different velocities.

[0080] The fourth drive member 218 may transmit a torque to the fourth link member 216. The fourth drive member 218 may be disposed to face the target point T along the second axis X_2.

[0081] In this example, extension lines of the longitudinal axis X_A of the first central member 202, the first axis X_1, and the second axis X_2 may be positioned at the target point T.

[0082] The emitting member 300 provided at the second link member 212 and the emitting member 300 provided at the fourth link member 216 may be provided in a vertical direction with respect to the second link member 212 and the fourth link member 216, and disposed to face the target point T.

[0083] In addition to the extension lines of the longitudinal axis X_A of the first central member 202, the first axis X_1, and the second axis X_2, the emitting members 300 and the drive members 213, 214, 217, and 218 may also be disposed to face the target point T. Thus, radiations may be emitted or irradiated from the emitting members 300 toward the target point T.

[0084] The lower robot arm 220 may include a fifth link member 221, a sixth link member 222, a seventh link member 225, and an eighth link member 226.

[0085] The fifth link member 221 may rotate on a longitudinal axis X_B of a second central member 204.

[0086] The second central member 204 may be disposed in a vertical direction on the inner side of the frame provided on the outer side of the medical robot 10.

[0087] The first central member 202 and the second central member 204 may be provided on an identical axis. The second central member 204 may be spaced apart from the target point T by a distance corresponding to a distance between the first central member 202 and the target point T.

[0088] The fifth link member 221 may be disposed on a sphere having a center at the target point T, and provided in a form of an arc.

[0089] The sixth link member 222 may be connected to another end of the fifth link member 221.

[0090] The sixth link member 222 may rotate on a third axis X_3.

[0091] The third axis X_3 may be angled with respect to the longitudinal axis X_B of the second central member 204.

[0092] The seventh link member 225 may be connected to a portion of the second central member 204, the portion differing from a portion to which the fifth link member 221 is connected.

[0093] The seventh link member 225 may rotate on the longitudinal axis X_B of the second central member 204.

[0094] For example, the fifth link member 221 may be connected to a lower portion of the second central member 204, and the seventh link member 225 may be connected to an upper portion of the second central member 204.

[0095] The eighth link member 226 may be connected to another end of the seventh link member 225.

[0096] The eighth link member 226 may rotate on a fourth axis X_4.

[0097] The fourth axis X_4 may be angled with respect to the longitudinal axis X_B of the second central member 204.

[0098] The lower robot arm 220 may further include a fifth drive member 223, a sixth drive member 224, a seventh drive member 227, and an eighth drive member 228.

[0099] The fifth drive member 223 may be included in the second central member 204. The fifth drive member 223 may transmit a torque to the fifth link member 221.

[0100] The sixth drive member 224 may transmit a torque to the sixth link member 222. The sixth drive member 224 may be disposed to face the target point T along the third axis X_3.

[0101] Similar to the fifth drive member 223, the seventh drive member 227 may be included in the second central member 204. The seventh drive member 227 may transmit a torque to the seventh link member 225.

[0102] The fifth drive member 223 and the seventh drive member 227 may be provided integrally or separately. For example, when the fifth drive member 223 and the seventh drive member 227 are provided separately, the fifth link member 221 and the seventh link member 225 may rotate in different directions or at different velocities.

[0103] The eighth drive member 228 may transmit a torque to the eighth link member 226. The eighth drive member 228 may be disposed to face the target point T along the fourth axis X_4.

[0104] In this example, extension lines of the longitudinal axis X_B of the second central member 204, the third axis X_3, and the fourth axis X_4 may be positioned at the target point T.

[0105] The emitting member 300 provided at the sixth link member 222 and the emitting member 300 provided at the eighth link member 226 may be provided in a vertical direction with respect to the sixth link member 222 and the eighth link member 226, and disposed to face the target point T.

[0106] In addition to the extension lines of the longitudinal axis X_B of the second central member 204, the third axis X_3, and the fourth axis X_4, the emitting members 300 and the drive members 223, 224, 227, and 228 may also be disposed to face the target point T. Thus, radiations may be emitted or irradiated from the emitting members 300 toward the target point T.

[0107] In the drawings, the upper robot arm 210 and the lower robot arm 220 are provided in similar or identical forms. However, the forms of the upper robot arm 210 and the lower robot arm 220 are not limited thereto. The upper robot arm 210 and the lower robot arm 220 may be provided in any form in which the emitting member 300 provided at the upper robot arm 210 and the emitting member 300 provided at the lower robot arm 220 are disposed to face the identical target point T.

[0108] To prevent a mutual collision when the plurality of link members 211, 212, 215, 216, 221, 222, 225, and 226 of the upper robot arm 210 and the lower robot arm 220 rotates simultaneously, the plurality of link members 211, 212, 215, 216, 221, 222, 225, and 226 may be disposed as follows.

[0109] The first link member 211 and the second link member 212 may be disposed farther away from the target point T than the third link member 215 and the fourth link member 216, and the fifth link member 221 and the sixth link member 222 may be disposed farther away from the target point T than the seventh link member 225 and the eighth link member 226.

[0110] When the third link member 215 is disposed between the first link member 211 and the second link member 212, the length of the third link member 215 may be shorter than the length of the first link member 211, and the fourth link member 216 may be disposed closer to the target point T than the second link member 212.

[0111] When the seventh link member 225 is disposed between the fifth link member 221 and the sixth link member 222, the length of the seventh link member 225 may be shorter than the length of the fifth link member 221, and the eighth link member 226 may be disposed closer to the target point T than the sixth link member 222.

[0112] The upper robot arm 210 may emit radiation above the bed 100, and the lower robot arm 220 may emit radiation below the bed 100.

[0113] Referring to FIG. 3, the upper robot arm 210 may emit radiation within an area A and an area B, and the lower robot arm 220 may emit radiation within an area C and an area D.

[0114] The area A indicates a range of radiation emitted from the emitting member 300 by means of the first link member 211 and the second link member 212, the area B indicates a range of radiation emitted from the emitting member 300 by means of the third link member 215 and the fourth link member 216, the area C indicates a range of radiation emitted from the emitting member 300 by means of the fifth link member 221 and the sixth link member 222, and the area D indicates a range of radiation emitted from the emitting member 300 by means of the seventh link member 225 and the eighth link member 226.

[0115] The area A, the area B, the area C, and the area D may be positioned at the target point T, and the upper robot arm 210 and the lower robot arm 220 may emit radiations toward different areas.

[0116] As described above, the upper robot arm 210 may have a spherical trajectory of rotation above the bed 100, and the lower robot arm 220 may have a spherical trajectory of rotation below the bed 100. Thus, the upper robot arm 210 and the second robot arm 220 may have independent motions with respect to each other, thereby preventing mutual interference.

[0117] Referring to FIG. 4, the angle adjustment elements 310 may be provided at the emitting members 300 or end portions of the second link member 212, the fourth link member 216, the sixth link member 222, and the eighth link member 226 to move the emitting members 300 at a relatively small angle.

[0118] Through the angle adjustment elements 310, the medical robot 10 may more efficiently operate the emitting members 300 to be aimed at the target point T. For example, the angle adjustment elements 310 may be useful when a minute angle adjustment is required after the emitting members 300 are aimed at the target point T by means of the drive members 213, 214, 217, 218, 223, 224, 227, and 228.

[0119] All axes of the drive members 213, 214, 217, 218, 223, 224, 227, and 228 may face the target point T. Thus, the emitting members 300 may be continuously aimed at the target point T while the link members 211, 212, 215, 216, 221, 222, 225, and 226 are rotating. The foregoing may be achieved based on a structural disposition of the link members 211, 212, 215, 216, 221, 222, 225, and 226 and the drive members 213, 214, 217, 218, 223, 224, 227, and 228.

[0120] In particular, radiations may be emitted in a state in which the link members 211, 212, 215, 216, 221, 222, 225, and 226 of the robot arms 210 and 220 are stationary. Thus, radiations may not be emitted while the link members 211, 212, 215, 216, 221, 222, 225, and 226 of the robot arms 210 and 220 are moving to subsequent emission points.

[0121] However, when the robot arms 210 and 220 include the plurality of link members 211, 212, 215, 216, 221, 222, 225, and 226, radiations may be emitted in a state in which remaining link members are stationary while one of the link members 211, 212, 215, 216, 221, 222, 225, and 226 is moving. Thus, a treatment or surgery time may be reduced.

[0122] In addition, when the plurality of robot arms 210 and 220 is provided, the treatment or surgery time may be reduced more efficiently.

[0123] Hereinafter, a kinematical analysis on a structure of the medical robot 10 will be described in detail.

[0124] The following may be expressed based on forward kinematics.

[Equation 1]

$$x = f(\theta)$$

[0125] In the Equation 1, θ denotes a joint angle, and x denotes a location and direction of an end-effector.

[0126] Coordinates of an emitting member may be estimated based on an angle at which link members are connected to each other.

[0127] In addition, when a Denavit-Hartenberg (D-H) convention is used, the kinematics of the robot may include four parameters, for example, a link length a of a line member, a link offset d, a link distortion α, and a joint angle θ.

[0128] In this example, when a joint rotates around a z axis, transformation matrices may be expressed as follows.

[Transformation Matrix 1]

$$
{}^{0}_{1}T = \begin{bmatrix} c\theta1 & -c\alpha1\ s\theta1 & s\alpha1\ s\theta1 & 0 \\ s\theta1 & c\alpha1\ c\theta1 & -s\alpha1\ c\theta1 & 0 \\ 0 & s\alpha1 & c\alpha1 & R \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

[Transformation Matrix 2]

$$
{}^{1}_{2}T = \begin{bmatrix} c\theta2 & -c\alpha2\ s\theta2 & s\alpha2\ s\theta2 & 0 \\ s\theta2 & c\alpha2\ c\theta2 & -s\alpha2\ c\theta2 & 0 \\ 0 & s\alpha2 & c\alpha2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

[0129] In Transformation Matrices 1 and 2, s denotes sine, and c denotes cosine.

[0130] Through the above transformation matrices, a transformation matrix may be derived as follows.

[Transformation Matrix 3]

$$
{}^{0}_{2}T = \begin{bmatrix} c\theta1\ c\theta2 - c\alpha1\ s\theta1\ s\theta2 & s\alpha1\ s\alpha2\ s\theta1 - c\alpha2\ (c\alpha1\ c\theta2\ s\theta1 + c\theta1\ s\theta2) & c\alpha2\ s\alpha1\ s\theta1 + s\alpha2\ (c\alpha1\ c\theta2\ s\theta1 + c\theta1\ s\theta2) & 0 \\ c\theta2\ s\theta1 + c\alpha1\ c\theta1\ s\theta2 & -c\theta1\ s\alpha1\ s\alpha2 + c\alpha2\ (c\alpha1\ c\theta1\ c\theta2 - s\theta1\ s\theta2) & -c\theta1\ (c\alpha2\ s\alpha1 + c\alpha1\ c\theta2\ s\alpha2) + s\alpha2\ s\theta1\ s\theta2 & 0 \\ s\alpha1\ s\theta2 & c\alpha2\ c\theta2\ s\alpha1 + c\alpha1\ s\alpha2 & c\alpha1\ c\alpha2 - c\theta2\ s\alpha1\ s\alpha2 & R \\ 0 & 0 & 0 & 1 \end{bmatrix}
$$

[0131] The above transformation matrix may represent a case in which two link members are provided. A point to which relocation is to be performed by a translation, an offset, a scale, or a rotation on a three-dimensional (3D) coordinate system may be estimated using the transformation matrix.

[0132] In addition, a location and direction of the emitting member or the end-effector may be expressed as follows.

[Transformation Matrix 4]

$$ {}_{2}^{0}T = \begin{bmatrix} {}^{0}x_2 & {}^{0}y_2 & {}^{0}z_2 & {}^{0}p_2 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

[Transformation Matrix 5]

$$ {}^{0}p_2 = \begin{bmatrix} 0 \\ 0 \\ R \end{bmatrix} $$

[0133] In this example, the location of the emitting member or the end-effector may be constantly uniform.

[0134] FIG. 5 illustrates a direction of the emitting member 300 in the medical robot 10.

[0135] Referring to FIG. 5, the emitting member 300 may face a z axis, and have a roll movement of rotating on the z axis, a yaw movement of oscillating up and down based on the z axis, and a pitch movement of rotating up and down based on the z axis.

[0136] In this example, a roll direction may be insignificant in the emitting member 300.

[0137] Only a z-vector may be considered for a direction of the emitting member 300. Thus, Transformation Matrix 2 may be arranged as follows.

[Transformation Matrix 6]

$$ {}^{0}z_2 = \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix} = \begin{bmatrix} c\alpha 2\ s\alpha 1\ s\theta 1 + s\alpha 2\ (c\alpha 1\ c\theta 2\ s\theta 1 + c\theta 1\ s\theta 2) \\ -\ c\theta 1\ (c\alpha 2\ s\alpha 1 + c\alpha 1\ c\theta 2\ s\alpha 2) + s\alpha 2\ s\theta 1\ s\theta 2 \\ c\alpha 1\ c\alpha 2\ -\ c\theta 2\ s\alpha 1\ s\alpha 2) \end{bmatrix} $$

[0138] A desired direction of the emitting member 300 may be designated as spherical coordinates α and β of FIG. 6. When the direction of the emitting member 300 is given as α and β of FIG. 6, rotation matrices corresponding to the direction may be expressed as follows.

[Rotation Matrix 1]

$$ R_{spherical} = R_{z,\alpha} R_{y,\beta} = \begin{bmatrix} c\alpha\, c\beta & -s\alpha & c\alpha\, s\beta \\ s\alpha\, c\beta & c\alpha & s\alpha\, s\beta \\ -s\beta & 0 & c\beta \end{bmatrix} $$

[Rotation Matrix 2]

$$ R_{spherical} = \begin{bmatrix} x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \\ x_3 & y_3 & z_3 \end{bmatrix} $$

[0139] Based on α and β from Rotation Matrices 1 and 2, ${}^0x_2 = [x_1, x_2, x_3]^T$, ${}^0y_2 = [y_1, y_2, y_3]^T$, and ${}^0z_2 = [z_1, z_2, z_3]^T$ may be determined, and θ_1 and θ_2 may also be determined.

[0140] Such a relationship may be expressed by inverse kinematics as follows.

[Equation 2]

$$\theta = f(x)^{-1}$$

[0141] In Equation 2, x denotes a vector ${}^0z_2 = [z_1, z_2, z_3]^T$ and, θ denotes a vector including θ_1 and θ_2. Equation 2 may be an inverse function of Equation 1.

[0142] The joints angles θ_1 and θ_2 may be calculated based on orthonormal vectors ${}^0x_2$, ${}^0y_2$, and ${}^0z_2$. An intuitive method of calculating such vectors may be performed using spherical coordinates. When a direction is given as α and β, a rotation matrix corresponding to the direction may be expressed as follows.

[Rotation Matrix 3]

$$R_{spherical} = R_{z,\alpha}R_{y,\beta} = \begin{bmatrix} c\alpha\, c\beta & -s\alpha & c\alpha\, s\beta \\ s\alpha\, c\beta & c\alpha & s\alpha\, s\beta \\ -s\beta & 0 & c\beta \end{bmatrix}$$

[0143] In this example, constituent elements of the vectors may correspond to ${}^0x_2 = [x_1, x_2, x_3]^T$, ${}^0y_2 = [y_1, y_2, y_3]^T$, and $0z_2 = [z_1, z_2, z_3]^T$.

[0144] The following Equations may be extracted from Transformation Matrix 3.

[Equation 3]

$$x_3 = s\alpha_1 s\theta_2$$

$$z_3 = c\alpha_1 c\alpha_2 - c\theta_2 s\alpha_1 s\alpha_2$$

[0145] In Equation 3, θ_2 may be induced as follows.

[Equation 4]

$$s\theta_2 = x_3 - s\alpha_1$$

$$c\theta_2 = \frac{z_3 + c\alpha_1 c\alpha_2}{s\alpha_1 s\alpha_2}$$

$$\tan\theta_2 = \frac{s\alpha_1 s\alpha_2 (x_3 - s\alpha_1)}{z_3 + c\alpha_1 c\alpha_2}$$

$$\theta_2 = \arctan 2(x_3 - s\alpha_1, \frac{z_3 + c\alpha_1 c\alpha_2}{s\alpha_1 s\alpha_2})$$

[0146] A function arctan2, an arctangent function including two input variables, may be used due to a stability of being close to zero input values and a characteristic of a final angle returning to an appropriate quadrant.

[0147] θ_1 may be calculated as follows.

[0148] The following Equations 5 through 7 may be obtained from Transformation Matrix 4.

[Equation 5]

$$(x_2 = c\theta_2 s\theta_1 + c\alpha_1 c\theta_1 s\theta_2)c\alpha_1 s\theta_2$$
$$(x_1 = -s\theta_1 c\alpha_1 s\theta_2 + c\theta_1 c\theta_2)c\theta_2$$

[Equation 6]

$$c\alpha_1 s\theta_2 x_2 + c\theta_2 x_1 = c^2\alpha_1 s^2\theta_2 c\theta_1 + c^2\theta_2 c\theta_1$$
$$c\theta_1 = \frac{c\alpha_1 s\theta_2 x_2 + c\theta_2 x_1}{c_1^{\alpha} s^2\theta_2 + c^2\theta_2}$$

[Equation 7]

$$z_1 = (c\alpha_2 s\alpha_1 + s\alpha_2 c\alpha_1 c\theta_2)s\theta_1 + s\alpha_2 s\theta_2 c\theta_1$$
$$z_2 = -(c\alpha_2 s\alpha_1 + s\alpha_2 c\alpha_1 c\theta_2)c\theta_1 + s\alpha_2 s\theta_2 s\theta_1$$

[0149] In addition, the following may be assumed.

[Equation 8]

$$a = c\alpha_2 s\alpha_1 + s\alpha_2 c\alpha_1$$
$$b = s\alpha_2 s\theta_2$$

[0150] Through Equations 7 and 8, the following may be calculated.

[Equation 9]

$$a(z_1 = as\theta_1 + bc\theta_1)$$
$$b(z_2 = -ac\theta_1 + bs\theta_1)$$
$$az_1 = a^2 s\theta_1 + abc\theta_1$$
$$bz_2 = b^2 s\theta_1 - abc\theta_1$$
$$az_1 + bz_2 = (a^2 + b^2)s\theta_1$$
$$s\theta_1 = \frac{az_2 + bz_2}{a^2 + b^2}$$

[0151] Through Equations 6 and 9, θ_1 may be calculated as follows.

[Equation 10]

$$\theta_1 = \arctan 2\left(\frac{az_1 + bz_2}{a^2 + b^2}, \frac{c\alpha_1 s\theta_2 x_2 + c\theta_2 x_1}{c^2\alpha_1 s^2\theta_2 + c^2\theta_2}\right)$$

[0152] From Equations 4 and 10, the two joint angles θ_1 and θ_2 may be determined. A Jacobian matrix will be described hereinafter.

[0153] A linear mapping between a θ-space and an x-space may be as follows. Equation 1 may be differentiated as follows.

[Jacobian Matrix 1]

$${}^0\dot{x} = {}^0J\,\dot{\theta}$$

$${}^0J = \begin{bmatrix} {}^0z_0 \times ({}^0p_n - {}^0p_0) & {}^0z_1 \times ({}^0p_n - {}^0p_1) \\ {}^0z_0 & {}^0z_1 \end{bmatrix}$$

[0154] The Transformation Matrix 1 may be expressed as follows.

[Rotation Matrix 7]

$$ {}^{0}_{1}T = \begin{bmatrix} {}^{0}x_{1} & {}^{0}y_{1} & {}^{0}z_{1} & {}^{0}p_{1} \\ 0 & 0 & 0 & 1 \end{bmatrix} = $$

cθ1	- cα1 sθ1	sα1 sθ1	0
sθ1	cα1 cθ1	- sα1 cθ1	0
0	sα1	cα1	R
0	0	0	1

[0155] Thus, the Jacobian matrix may be expressed as follows.

[Jacobian Matrix 2]

$$ {}^{0}J = \begin{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \times \left(\begin{bmatrix} 0 \\ 0 \\ R \end{bmatrix} - \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \right) & \begin{bmatrix} s\alpha 1\ s\theta 1 \\ -\ s\alpha 1\ c\theta 1 \\ c\alpha 1 \end{bmatrix} \times \left(\begin{bmatrix} 0 \\ 0 \\ R \end{bmatrix} - \begin{bmatrix} 0 \\ 0 \\ R \end{bmatrix} \right) \\ \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} & \begin{bmatrix} s\alpha 1\ s\theta 1 \\ -\ s\alpha 1\ c\theta 1 \\ c\alpha 1 \end{bmatrix} \end{bmatrix} $$

[Jacobian Matrix 3]

$$ {}^{0}J = \begin{bmatrix} {}^{0}z_{0} \times ({}^{0}p_{n} - {}^{0}p_{0}) & {}^{0}z_{1} \times ({}^{0}p_{n} - {}^{0}p_{1}) \\ {}^{0}z_{0} & {}^{0}z_{1} \end{bmatrix} $$

$$ = \begin{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \times \left(\begin{bmatrix} 0 \\ 0 \\ R \end{bmatrix} - \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \right) & \begin{bmatrix} s\alpha 1\ s\theta 1 \\ -\ s\alpha 1\ c\theta 1 \\ c\alpha 1 \end{bmatrix} \times \left(\begin{bmatrix} 0 \\ 0 \\ R \end{bmatrix} - \begin{bmatrix} 0 \\ 0 \\ R \end{bmatrix} \right) \\ \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} & \begin{bmatrix} s\alpha 1\ s\theta 1 \\ -\ s\alpha 1\ c\theta 1 \\ c\alpha 1 \end{bmatrix} \end{bmatrix} $$

$$ = \begin{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} & \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} \\ \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} & \begin{bmatrix} s\alpha 1\ s\theta 1 \\ -\ s\alpha 1\ c\theta 1 \\ c\alpha 1 \end{bmatrix} \end{bmatrix} $$

[Jacobian Matrix 4]

$$J = \begin{bmatrix} 0 & s\alpha 1\, s\theta 1 \\ 0 & -s\alpha 1\, c\theta 1 \\ 1 & c\alpha 1 \end{bmatrix}$$

[0156] Through Jacobian Matrix 4, when only an angular velocity is considered and a translational velocity is not considered, a singularity may not be achieved except for a case in which $\alpha = n\pi$ and $n \in N$ are satisfied.

[0157] As described above, a relationship between a motion of a link member and a motion of an emitting member may be expressed through a Jacobian matrix.

[0158] In detail, a location of the emitting member may be estimated based on a current location of a link member. Conversely, to enable the emitting member to face a central point or a target, an operation of a link member may be controlled based on a current location of the emitting member.

[0159] Furthermore, when a plurality of robot arms is provided, the plurality of robot arms may be controlled to operate collaboratively through a Jacobian matrix.

[0160] According to embodiments, a medical robot may be aimed at a target point rapidly and accurately through relative movements of a robot arm unit and a bed. The medical robot may increase directivity with respect to the target point through easy control, thereby reducing a treatment or surgery time. The medical robot may reduce an overall weight by reducing a number of drive members through a compact design. The medical robot may include separate robot arm units which may be detached or added as necessary, thereby increasing or decreasing a degree of freedom and achieving a flexible design.

[0161] Although a few exemplary embodiments of the present invention have been shown and described, the present invention is not limited to the described exemplary embodiments.

Claims

1. A medical robot (10) comprising:

a bed (100) on which an object is to be disposed; and
a robot arm unit (200) disposed above or below the bed (100), and comprising an emitting member (300) movable within a trajectory on a sphere having a center at which a target point (T) is disposed,
wherein the bed (100) and the robot arm unit (200) can move relatively in a vertical or horizontal direction, and the object is repositioned to the target point (T) by relatively moving the bed (100) and the robot arm unit (200) in the vertical or horizontal direction, and the emitting member (300) moves to face the target point (T),
characterized in that the robot arm unit (200) comprises:

a first central member (202);
a first link member (211) to rotate on a longitudinal axis (X_A) of the first central member (202);
a second link member (212) connected to another end of the first link member (211) to rotate on a first axis (X_1);
a third link member (215) connected to a portion of the first central member (202), the portion differing from a portion to which the first link member (211) is connected, to rotate on the longitudinal axis of the first central member (202), and
a fourth link member (216) connected to another end of the third link member (215) to rotate on a second axis (X_2);
wherein respective end portions of the second link member (212) and the fourth link member (216) are provided with the emitting member (300),
wherein the first link member (211), the second link member (212), the third link member (215) and the fourth link member (216) are provided in form of an arc, and the first link member (211) and the third link member (215) may rotate in different directions or at different velocities.

2. The medical robot (10) of claim 1, wherein the robot arm unit (200) comprises:

an upper robot arm (210) to rotate above the bed (100); and
a lower robot arm (220) to rotate below the bed,
wherein an emitting member (300) of the upper robot arm (210) and an emitting member (300) of the lower robot arm (220) are disposed to face an identical target point (T).

3. The medical robot (10) of claim 2, wherein the upper robot arm (210) and the lower robot (220) are disposed within trajectories on spheres having an identical center.

4. The medical robot (100) of claim 1, wherein the robot arm unit (200) comprises a plurality of link members (211, 212, 215, 216, 217, 221, 222, 225, 226) and a plurality of drive members (213, 214, 215, 216, 223, 224, 225, 226, 227), the plurality of link members (211, 212, 215, 216, 217, 221, 222, 225, 226) is disposed on concentric spheres having an identical center, and extension lines of axes of the drive members (213, 214, 215, 216, 223, 224, 225, 226, 227) are positioned at the center.

5. The medical robot (10) of claim 4, wherein the center of the concentric spheres matches the target point (T).

6. The medical robot (10) of claim 1, wherein the robot arm unit (200) further comprises:

a first drive member (213) disposed at one end of the first link member (211) to transmit a torque to the first link member (211); and
a second drive member (214) disposed between the first link member (211) and the second link member (212) to transmit a torque to the second link member (212).

7. The medical robot (10) of claim 6, wherein the robot arm unit (200) further comprises:

a third drive member (217) disposed at one end of the third link member (215) to transmit a torque to the third link member (215); and
a fourth drive member (218) disposed between the third link member (215) and the fourth link member (216) to transmit a torque to the fourth link member (216).

8. The medical robot (10) of claim 7, wherein the robot arm unit (200) further comprises:

a second central member (204) disposed on an axis (X_B) identical to the longitudinal axis (X_A) of the first central member (202) and spaced apart from the center by a distance corresponding to a distance between the first central member (202) and the center;
a fifth link member (221) to rotate on a longitudinal axis (X_B) of the second central member (204);
a fifth drive member (223) disposed at one end of the fifth link member (221) to transmit a torque to the fifth link member (221);
a sixth link member (222) connected to another end of the fifth link member (221) to rotate on a third axis (X_3); and
a sixth drive member (224) disposed between the fifth link member (221) and the sixth link member (222) to transmit a torque to the sixth link member (222).

9. The medical robot of (10) claim 8, wherein the robot arm unit (200) further comprises:

a seventh link member (225) connected to a portion of the second central member (204), the portion differing from a portion to which the fifth link member (221) is connected, to rotate on the longitudinal axis (X_B) of the second central member (204);
a seventh drive member (227) disposed at one end of the seventh link member (225) to transmit a torque to the seventh link member (225);
an eighth link member (226) connected to another end of the seventh link member (225) to rotate on a fourth axis (X_4); and
an eighth drive member (228) disposed between the seventh link member (225) and the eighth link member (226) to transmit a torque to the eighth link member (226).

10. The medical robot (10) of claim 9, wherein the longitudinal axis (X_A) of the first central member (202), the longitudinal axis (X_B) of the second central member (204), the first axis (X_1), the second axis (X_2), the third axis (X_3), and the fourth axis (X_4) are positioned at the center.

11. The medical robot (10) of claim 9, wherein the first axis (X_1), the second axis (X_2), the third axis (X_3), and the fourth axis (X_4) are formed to be perpendicular to tangential directions of end portions of the first link member (211), the second link member (212), the third link member (215), the fourth link member (216), the fifth link member (221), the sixth link member (222), the seventh link member (225), and the eighth link member (226).

12. The medical robot (10) of claim 8, wherein the first link member (211) and the second link member (212) are disposed farther away from the center than the third link member (215) and the fourth link member (216), and the fifth link member (221) and the sixth link member (222) are disposed farther away from the center (T) than the seventh link member (225) and the eighth link member (226).

13. The medical robot (10) of claim 7, wherein, when the third link member (215) is disposed between the first link member (211) and the second link member (212), lengths of the third link member (215) and the fourth link member (216) are shorter than a length of the first link member (211).

14. The medical robot (10) of claim 13, wherein the third link member (215) and the fourth link member (216) are disposed closer to the center than the second link member (212), and the fourth link member (216) is disposed closer to the center (T) than the third link member (215).

15. The medical robot (10) of claim 9, wherein, when the seventh link member (225) is disposed between the fifth link member (221) and the sixth link member (222), lengths of the seventh link member (225) and the eighth link member (226) are shorter than a length of the fifth link member (221).

16. The medical robot (10) of claim 15, wherein the seventh link member (225) and the eighth link member (226) are disposed closer to the center than the sixth link member (222), and the eighth link member (226) is disposed closer to the center than the seventh link member (225).

17. The medical robot (10) of claim 9, wherein respective end portions of the sixth link member (222), and the eighth link member (226) are provided with the emitting member (300) to face the center.

18. The medical robot (10) of claim 17, wherein the emitting members (300) are disposed to be perpendicular to tangential directions of the end portions of the second link member (212), the fourth link member (216), the sixth link member (222), and the eighth link member (226).

19. The medical robot (10) of claim 1, further comprising:
a position adjustment element (110) to adjust a position of the bed (100).

Patentansprüche

1. Medizinischer Roboter (10), umfassend:

ein Bett (100), auf dem ein Objekt angeordnet werden soll; und
eine Roboterarmeinheit (200), angeordnet über oder unter dem Bett (100) und umfassend ein emittierendes Glied (300), beweglich innerhalb einer Bahn auf einer Kugel mit einer Mitte, an der ein Zielpunkt (T) angeordnet ist,
wobei das Bett (100) und die Roboterarmeinheit (200) sich relativ in eine vertikale oder horizontale Richtung bewegen können, und
das Objekt durch relatives Bewegen des Betts (100) und der Roboterarmeinheit (200) in der vertikalen oder horizontalen Richtung neu positioniert wird, und das emittierende Glied (300) sich bewegt, um gegenüber dem Zielpunkt (T) zu sein,
dadurch gekennzeichnet, dass die Roboterarmeinheit (200) Folgendes umfasst:

ein erstes mittiges Glied (202);
ein erstes Verbindungsglied (211) zum Drehen auf einer Längsachse (X_A) des ersten mittigen Glieds (202);
ein zweites Verbindungsglieds (212), verbunden mit einem anderen Ende des ersten Verbindungsglieds (211), zum Drehen auf einer ersten Achse (X_1);
ein drittes Verbindungsglied (215), verbunden mit einem Abschnitt des ersten mittigen Glieds (202), der Abschnitt anders als ein Abschnitt, mit dem das erste Verbindungsglied (211) verbunden ist, zum Drehen

auf der Längsachse des ersten mittigen Glieds (202), und
ein viertes Verbindungsglied (216), verbunden mit einem anderen Ende des dritten Verbindungsglieds (215), zum Drehen auf einer zweiten Achse (X_2);
wobei jeweilige Endabschnitte des zweiten Verbindungsglieds (212) und des vierten Verbindungsglieds (216) mit dem emittierenden Glied (300) versehen sind,
wobei das erste Verbindungsglied (211), das zweite Verbindungsglied (212), das dritte Verbindungsglied (215) und das vierte Verbindungsglied (216) in Form eines Bogens bereitgestellt sind, und das erste Verbindungsglied (211) und das dritte Verbindungsglied (215) sich in verschiedene Richtungen oder mit verschiedenen Geschwindigkeiten bewegen können.

2. Medizinischer Roboter (10) nach Anspruch 1, wobei die Roboterarmeinheit (200) Folgendes umfasst:

einen oberen Roboterarm (210) zum Drehen über dem Bett (100); und
einen unteren Roboterarm (220) zum Drehen unter dem Bett,
wobei ein emittierendes Glied (300) des oberen Roboterarms (210) und ein emittierendes Glied (300) des unteren Roboterarms (220) angeordnet sind, um gegenüber einem identischen Zielpunkt (T) ausgerichtet zu sein.

3. Medizinischer Roboter (10) nach Anspruch 2, wobei der obere Roboterarm (210) und der untere Roboterarm (220) innerhalb von Bahnen auf Kugeln mit einer identischen Mitte angeordnet sind.

4. Medizinischer Roboter (100) nach Anspruch 1, wobei die Roboterarmeinheit (200) eine Vielzahl von Verbindungsgliedern (211, 212, 215, 216, 217, 221, 222, 225, 226) und eine Vielzahl von Antriebsgliedern (213, 214, 215, 216, 223, 224, 225, 226, 227) umfasst, die Vielzahl von Verbindungsgliedern (211, 212, 215, 216, 217, 221, 222, 225, 226) auf konzentrischen Kugeln mit einer identischen Mitte angeordnet sind und Verlängerungslinien von Achsen der Antriebsglieder (213, 214, 215, 216, 223, 224, 225, 226, 227) in der Mitte positioniert sind.

5. Medizinischer Roboter (10) nach Anspruch 4, wobei die Mitte der konzentrischen Kugeln mit dem Zielpunkt (T) übereinstimmt.

6. Medizinischer Roboter (10) nach Anspruch 1, wobei die Roboterarmeinheit (200) ferner Folgendes umfasst:

ein erstes Antriebsglied (213), angeordnet an einem Ende des ersten Verbindungsglieds (211), um ein Drehmoment an das erste Verbindungsglied (211) zu übertragen; und
ein zweites Antriebsglied (214), angeordnet zwischen dem ersten Verbindungsglied (211) und dem zweiten Verbindungsglied (212), um ein Drehmoment an das zweite Verbindungsglied (212) zu übertragen.

7. Medizinischer Roboter (10) nach Anspruch 6, wobei die Roboterarmeinheit (200) ferner Folgendes umfasst:

ein drittes Antriebsglied (217), angeordnet an einem ersten Ende des dritten Verbindungsglieds (215), um ein Drehmoment an das dritte Verbindungsglied (215) zu übertragen; und
ein viertes Antriebsglied (218), angeordnet zwischen dem dritten Verbindungsglied (215) und dem vierten Verbindungsglied (216), um ein Drehmoment an das vierte Verbindungsglied (216) zu übertragen.

8. Medizinischer Roboter (10) nach Anspruch 7, wobei die Roboterarmeinheit (200) ferner Folgendes umfasst:

ein zweites mittiges Glied (204), angeordnet auf einer Achse (X_B), identisch mit der Längsachse (X_A) des ersten mittigen Glieds (202) und beabstandet von der Mitte durch einen Abstand entsprechend einem Abstand zwischen dem ersten mittigen Glied (202) und der Mitte;
ein fünftes Verbindungsglied (221) zum Drehen auf einer Längsachse (X_B) des zweiten mittigen Glieds (204);
ein fünftes Antriebsglied (223), angeordnet an einem Ende des fünften Verbindungsglieds (221), um ein Drehmoment an das fünfte Verbindungsglied (221) zu übertragen;
ein sechstes Verbindungsglied (222), verbunden mit einem anderen Ende des fünften Verbindungselements (221) zum Drehen auf einer dritten Achse (X_3); und
ein sechstes Antriebsglied (224), angeordnet zwischen dem fünften Verbindungsglied (221) und dem sechsten Verbindungsglied (222), um ein Drehmoment an das sechste Verbindungsglied (222) zu übertragen.

9. Medizinischer Roboter (10) nach Anspruch 8, wobei die Roboterarmeinheit (200) ferner Folgendes umfasst:

ein siebtes Verbindungsglied (225), verbunden mit einem Abschnitt des zweiten mittigen Glieds (204), der Abschnitt anders als ein Abschnitt, mit dem das fünfte Verbindungsglied (221) verbunden ist, zum Drehen auf der Längsachse (X_B) des zweiten mittigen Glieds (204);
ein siebtes Antriebsglied (227), angeordnet an einem Ende des siebten Verbindungsglieds (225), um ein Drehmoment an das siebte Verbindungsglied (225) zu übertragen;
ein achtes Verbindungsglied (226), verbunden mit einem anderen Ende des siebten Verbindungsglieds (225) zum Drehen um eine vierte Achse (X_4); und
ein achtes Antriebsglied (228), angeordnet zwischen dem siebten Verbindungsglied (225) und dem achten Verbindungsglied (226), um ein Drehmoment an das achte Verbindungsglied (226) zu übertragen.

10. Medizinischer Roboter (10) nach Anspruch 9, wobei die Längsachse (X_A) des ersten mittigen Glieds (202), die Längsachse (X_B) des zweiten mittigen Glieds (204), die erste Achse (X_1), die zweite Achse (X_2), die dritte Achse (X_3) und die vierte Achse (X_4) in der Mitte positioniert sind.

11. Medizinischer Roboter (10) nach Anspruch 9, wobei die erste Achse (X_1), die zweite Achse (X_2), die dritte Achse (X_3) und die vierte Achse (X_4) gebildet sind, um senkrecht zu tangentialen Richtungen von Endabschnitten des ersten Verbindungsglieds (211), des zweiten Verbindungsglieds (212), des dritten Verbindungsglieds (215), des vierten Verbindungsglieds (216), des fünften Verbindungsglieds (221), des sechsten Verbindungsglieds (222), des siebten Verbindungsglieds (225) und des achten Verbindungsglieds (226) zu sein.

12. Medizinischer Roboter (10) nach Anspruch 8, wobei das erste Verbindungsglied (211) und das zweite Verbindungsglied (212) weiter von der Mitte entfernt angeordnet sind als das dritte Verbindungsglied (215) und das vierte Verbindungsglied (216) und das fünfte Verbindungsglied (221) und das sechste Verbindungsglied (222) weiter von der Mitte (T) entfernt angeordnet sind als das siebte Verbindungsglied (225) und das achte Verbindungsglied (226).

13. Medizinischer Roboter (10) nach Anspruch 7, wobei, wenn das dritte Verbindungsglied (215) zwischen dem ersten Verbindungsglied (211) und dem zweiten Verbindungsglied (212) angeordnet ist, Längen des dritten Verbindungsglieds (215) und des vierten Verbindungsglieds (216) kürzer sind als eine Länge des ersten Verbindungsglieds (211).

14. Medizinischer Roboter (10) nach Anspruch 13, wobei das dritte Verbindungsglied (215) und das vierte Verbindungsglied (216) näher der Mitte angeordnet sind als das zweite Verbindungsglied (212), und das vierte Verbindungsglied (216) näher der Mitte (T) angeordnet ist als das dritte Verbindungsglied (215).

15. Medizinischer Roboter (10) nach Anspruch 9, wobei, wenn das siebte Verbindungsglied (225) zwischen dem fünften Verbindungsglied (221) und dem sechsten Verbindungsglied (222) angeordnet ist, Längen des siebten Verbindungsglieds (225) und des achten Verbindungsglieds (226) kürzer sind als eine Länge des fünften Verbindungsglieds (221).

16. Medizinischer Roboter (10) nach Anspruch 15, wobei das siebte Verbindungsglied (225) und das achte Verbindungsglied (226) näher der Mitte angeordnet sind als das sechste Verbindungsglied (222), und das achte Verbindungsglied (226) näher der Mitte angeordnet ist als das siebte Verbindungsglied (225).

17. Medizinischer Roboter (10) nach Anspruch 9, wobei jeweilige Endabschnitte des sechsten Verbindungsglieds (222) und des achten Verbindungsglieds (226) mit dem emittierenden Glied (300) gegenüber der Mitte bereitgestellt sind.

18. Medizinischer Roboter (10) nach Anspruch 17, wobei die emittierenden Glieder (300) angeordnet sind, um senkrecht zu tangentialen Richtungen der Endabschnitte des zweiten Verbindungsglieds (212), des vierten Verbindungsglieds (216), des sechsten Verbindungsglieds (222) und des achten Verbindungsglieds (226) zu sein.

19. Medizinischer Roboter (10) nach Anspruch 1, ferner umfassend:
ein Positionsanpassungselement (110), um eine Position des Betts (100) anzupassen.

Revendications

1. Robot médical (10) comprenant :

un lit (100) sur lequel un objet doit être disposé ; et

une unité de bras de robot (200) disposée au-dessus ou au-dessous du lit (100), et comprenant un élément d'émission (300) mobile à l'intérieur d'une trajectoire sur une sphère ayant un centre au niveau duquel un point cible (T) est disposé,
dans lequel le lit (100) et l'unité de bras de robot (200) peuvent se déplacer relativement dans une direction verticale ou horizontale, et
l'objet est repositionné sur le point cible (T) en déplaçant relativement le lit (100) et l'unité de bras de robot (200) dans la direction verticale ou horizontale, et l'élément d'émission (300) se déplace de manière à faire face au point cible (T),
caractérisé en ce que l'unité de bras de robot (200) comprend :

un premier élément central (202) ;
un premier élément de liaison (211) prévu pour rotation sur un axe longitudinal (X_A) du premier élément central (202) ;
un deuxième élément de liaison (212) relié à une autre extrémité du premier élément de liaison (211) prévu pour rotation sur un premier axe (X_1) ;
un troisième élément de liaison (215) relié à une partie du premier élément central (202), la partie différant d'une partie à laquelle est relié le premier élément de liaison (211), prévu pour rotation sur l'axe longitudinal du premier élément central (202), et
un quatrième élément de liaison (216) relié à une autre extrémité du troisième élément de liaison (215) prévu pour rotation sur un deuxième axe (X_2) ;
dans lequel les parties d'extrémité respectives du deuxième élément de liaison (212) et du quatrième élément de liaison (216) sont pourvues de l'élément d'émission (300),
dans lequel le premier élément de liaison (211), le deuxième élément de liaison (212), le troisième élément de liaison (215) et le quatrième élément de liaison (216) sont prévus sous forme d'un arc, et le premier élément de liaison (211) et le troisième élément de liaison (215) peuvent tourner dans différentes directions ou à différentes vitesses.

2. Robot médical (10) selon la revendication 1, dans lequel l'unité de bras de robot (200) comprend :

un bras de robot supérieur (210) prévu pour rotation au-dessus du lit (100) ; et
un bras de robot inférieur (220) prévu pour rotation au-dessous du lit,
dans lequel un élément d'émission (300) du bras de robot supérieur (210) et un élément d'émission (300) du bras de robot inférieur (220) sont disposés pour faire face à un point cible (T) identique.

3. Robot médical (10) selon la revendication 2, dans lequel le bras de robot supérieur (210) et le bras de robot inférieur (220) sont disposés à l'intérieur de trajectoires sur des sphères ayant un centre identique.

4. Robot médical (100) selon la revendication 1, dans lequel l'unité de bras de robot (200) comprend une pluralité d'éléments de liaison (211, 212, 215, 216, 217, 221, 222, 225, 226) et une pluralité d'éléments d'entraînement (213, 214, 215, 216, 223, 224, 225, 226, 227), la pluralité d'éléments de liaison (211, 212, 215, 216, 217, 221, 222, 225, 226) est disposée sur des sphères concentriques ayant un centre identique, et les lignes de prolongement d'axes des éléments d'entraînement (213, 214, 215, 216, 223, 224, 225, 226, 227) sont positionnées au centre.

5. Robot médical (10) selon la revendication 4, dans lequel le centre des sphères concentriques correspond au point cible (T).

6. Robot médical (10) selon la revendication 1, dans lequel l'unité de bras de robot (200) comprend en outre :

un premier élément d'entraînement (213) disposé à une extrémité du premier élément de liaison (211) pour transmettre un couple au premier élément de liaison (211) ; et
un deuxième élément d'entraînement (214) disposé entre le premier élément de liaison (211) et le deuxième élément de liaison (212) pour transmettre un couple au deuxième élément de liaison (212).

7. Robot médical (10) selon la revendication 6, dans lequel l'unité de bras de robot (200) comprend en outre :

un troisième élément d'entraînement (217) disposé à une extrémité du troisième élément de liaison (215) pour transmettre un couple au troisième élément de liaison (215) ; et
un quatrième élément d'entraînement (218) disposé entre le troisième élément de liaison (215) et le quatrième

élément de liaison (216) pour transmettre un couple au quatrième élément de liaison (216).

8. Robot médical (10) selon la revendication 7, dans lequel l'unité de bras de robot (200) comprend en outre :

un second élément central (204) disposé sur un axe (X_B) identique à l'axe longitudinal (X_A) du premier élément central (202) et espacé du centre d'une distance correspondant à une distance entre le premier élément central (202) et le centre ;
un cinquième élément de liaison (221) prévu pour rotation sur un axe longitudinal (X_B) du second élément central (204) ;
un cinquième élément d'entraînement (223) disposé à une extrémité du cinquième élément de liaison (221) pour transmettre un couple au cinquième élément de liaison (221) ;
un sixième élément de liaison (222) relié à une autre extrémité du cinquième élément de liaison (221) prévu pour rotation sur un troisième axe (X_3) ; et
un sixième élément d'entraînement (224) disposé entre le cinquième élément de liaison (221) et le sixième élément de liaison (222) pour transmettre un couple au sixième élément de liaison (222).

9. Robot médical (10) selon la revendication 8, dans lequel l'unité de bras de robot (200) comprend en outre :

un septième élément de liaison (225) relié à une partie du second élément central (204), la partie différant d'une partie à laquelle est relié le cinquième élément de liaison (221), prévu pour rotation sur l'axe longitudinal (X_B) du second élément central (204) ;
un septième élément d'entraînement (227) disposé à une extrémité du septième élément de liaison (225) pour transmettre un couple au septième élément de liaison (225) ;
un huitième élément de liaison (226) relié à une autre extrémité du septième élément de liaison (225) prévu pour rotation sur un quatrième axe (X_4) ; et
un huitième élément d'entraînement (228) disposé entre le septième élément de liaison (225) et le huitième élément de liaison (226) pour transmettre un couple au huitième élément de liaison (226).

10. Robot médical (10) selon la revendication 9, dans lequel l'axe longitudinal (X_A) du premier élément central (202), l'axe longitudinal (X_B) du second élément central (204), le premier axe (X_1), le deuxième axe (X_2), le troisième axe (X_3) et le quatrième axe (X_4) sont positionnés au centre.

11. Robot médical (10) selon la revendication 9, dans lequel le premier axe (X_1), le deuxième axe (X_2), le troisième axe (X_3) et le quatrième axe (X_4) sont formés pour être perpendiculaires aux directions tangentielles de parties d'extrémité du premier élément de liaison (211), du deuxième élément de liaison (212), du troisième élément de liaison (215), du quatrième élément de liaison (216), du cinquième élément de liaison (221), du sixième élément de liaison (222), du septième élément de liaison (225) et du huitième élément de liaison (226).

12. Robot médical (10) selon la revendication 8, dans lequel le premier élément de liaison (211) et le deuxième élément de liaison (212) sont disposés plus loin du centre que le troisième élément de liaison (215) et le quatrième élément de liaison (216), et le cinquième élément de liaison (221) et le sixième élément de liaison (222) sont disposés plus loin du centre (T) que le septième élément de liaison (225) et le huitième élément de liaison (226).

13. Robot médical (10) selon la revendication 7, dans lequel, lorsque le troisième élément de liaison (215) est disposé entre le premier élément de liaison (211) et le deuxième élément de liaison (212), les longueurs du troisième élément de liaison (215) et du quatrième élément de liaison (216) sont plus courtes qu'une longueur du premier élément de liaison (211).

14. Robot médical (10) selon la revendication 13, dans lequel le troisième élément de liaison (215) et le quatrième élément de liaison (216) sont disposés plus près du centre que le deuxième élément de liaison (212), et le quatrième élément de liaison (216) est disposé plus près du centre (T) que le troisième élément de liaison (215).

15. Robot médical (10) selon la revendication 9, dans lequel lorsque le septième élément de liaison (225) est disposé entre le cinquième élément de liaison (221) et le sixième élément de liaison (222), les longueurs du septième élément de liaison (225) et le huitième élément de liaison (226) sont plus courtes qu'une longueur du cinquième élément de liaison (221).

16. Robot médical (10) selon la revendication 15, dans lequel le septième élément de liaison (225) et le huitième élément de liaison (226) sont disposés plus près du centre que le sixième élément de liaison (222), et le huitième élément de liaison (226) est disposé plus près du centre que le septième élément de liaison (225).

17. Robot médical (10) selon la revendication 9, dans lequel les parties d'extrémité respectives du sixième élément de liaison (222) et du huitième élément de liaison (226) sont pourvues de l'élément d'émission (300) en face du centre.

18. Robot médical (10) selon la revendication 17, dans lequel les éléments d'émission (300) sont disposés pour être perpendiculaires aux directions tangentielles des parties d'extrémité du deuxième élément de liaison (212), du quatrième élément de liaison (216), du sixième élément de liaison (222) et du huitième élément de liaison (226).

19. Robot médical (10) selon la revendication 1, comprenant en outre :
un élément de réglage de position (110) pour régler une position du lit (100).

FIG. 1

10

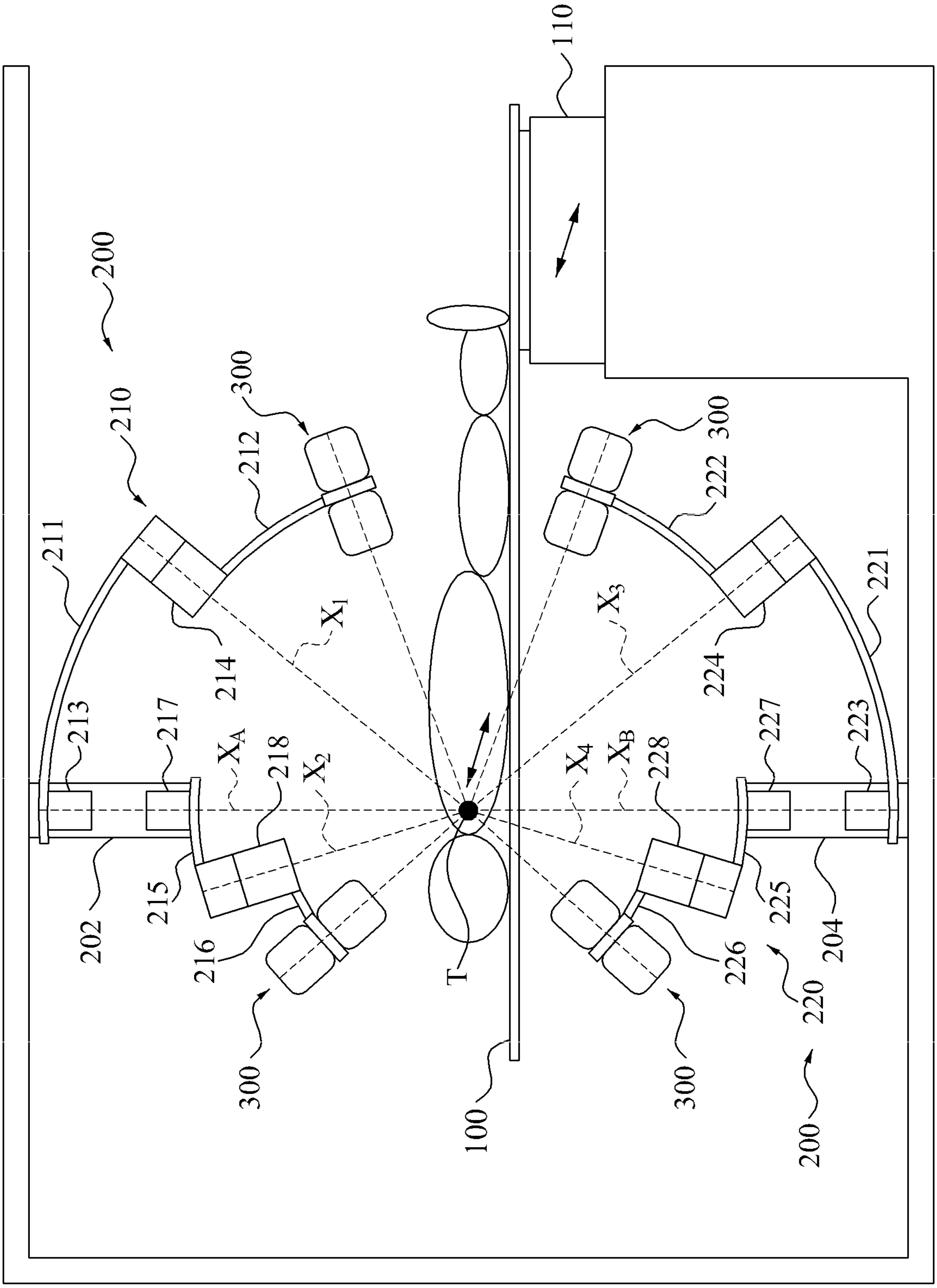
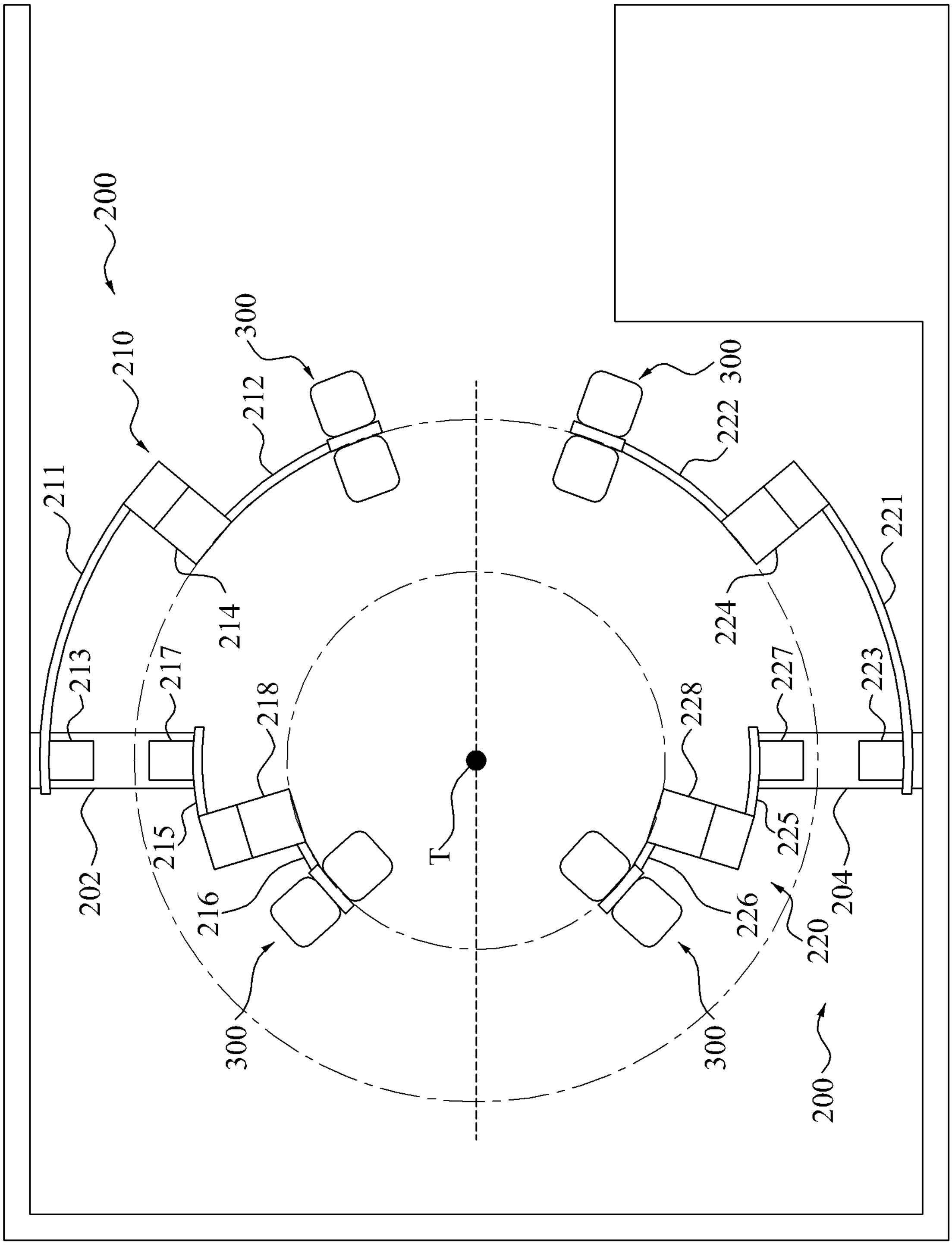

110
200
210
211
212
213
214
215
216
217
218
202
300
X_1
X_2
X_A
X_3
X_4
X_B
T
100
220
221
222
223
224
225
226
227
228
204

FIG. 2

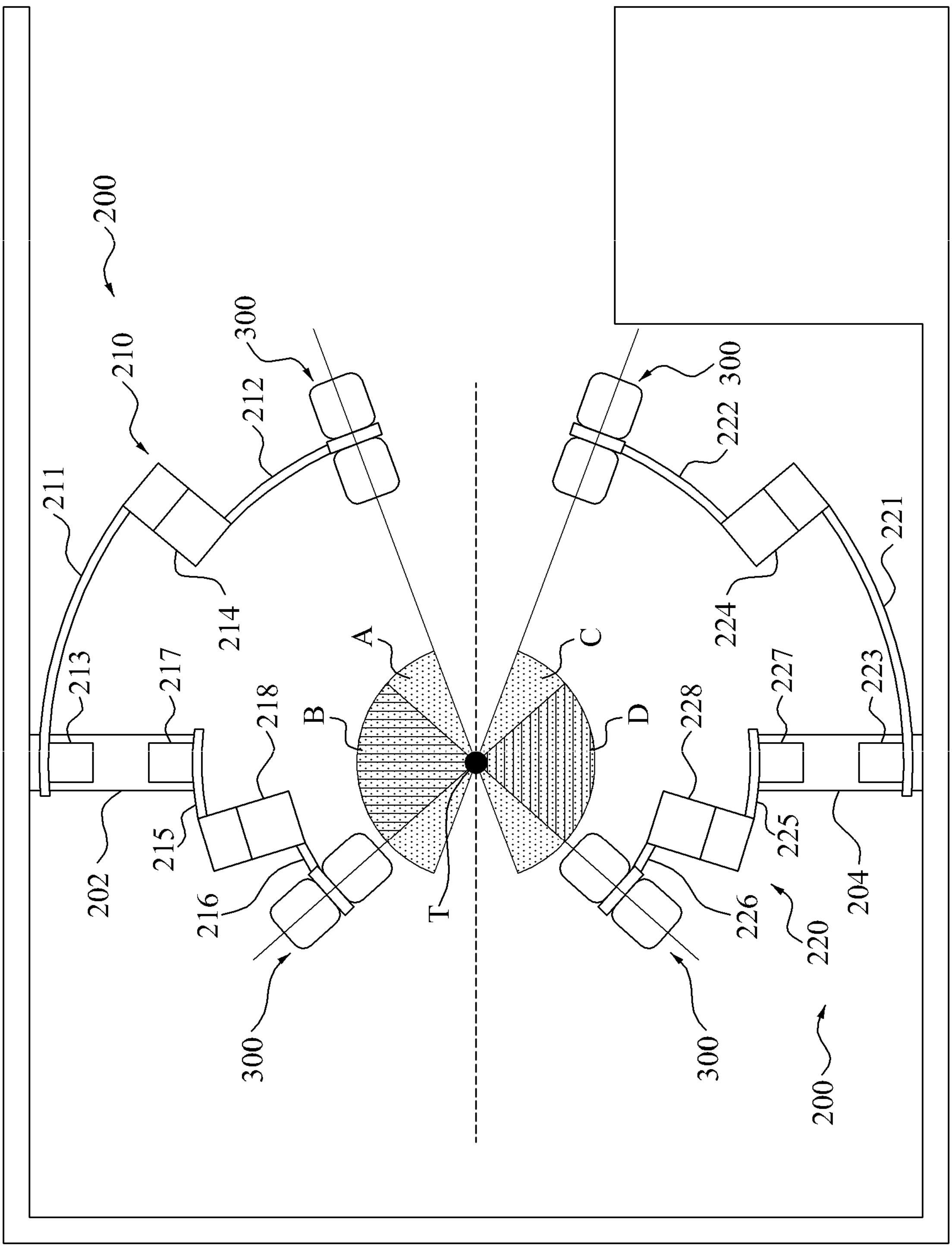
10



200
210
211
212
213
214
215
216
217
218
202
300
T
220
221
222
223
224
225
226
227
228
204

FIG. 3

10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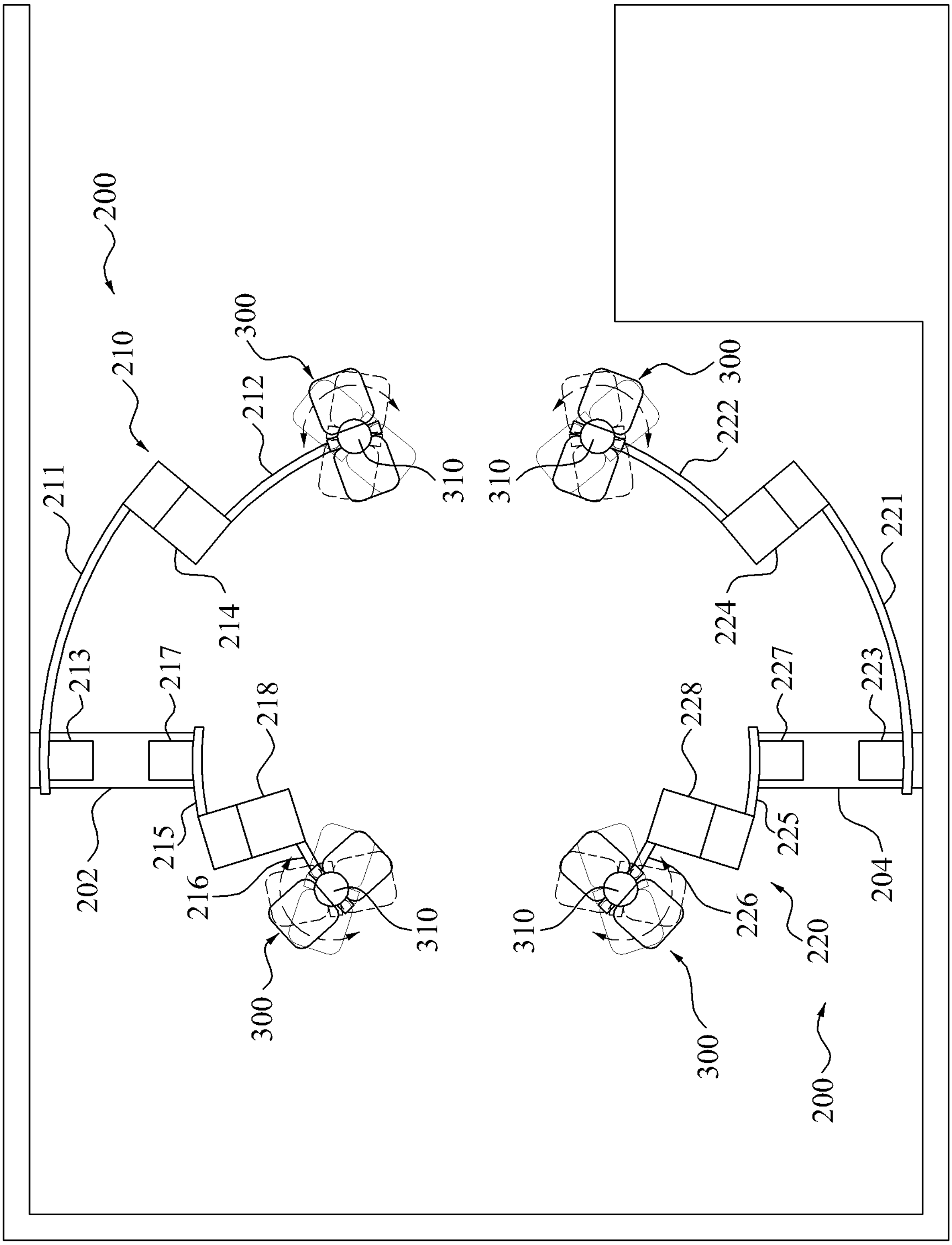
225
226
227
228
204

FIG. 4

10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223
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227
228
204
300
310
200

FIG. 5

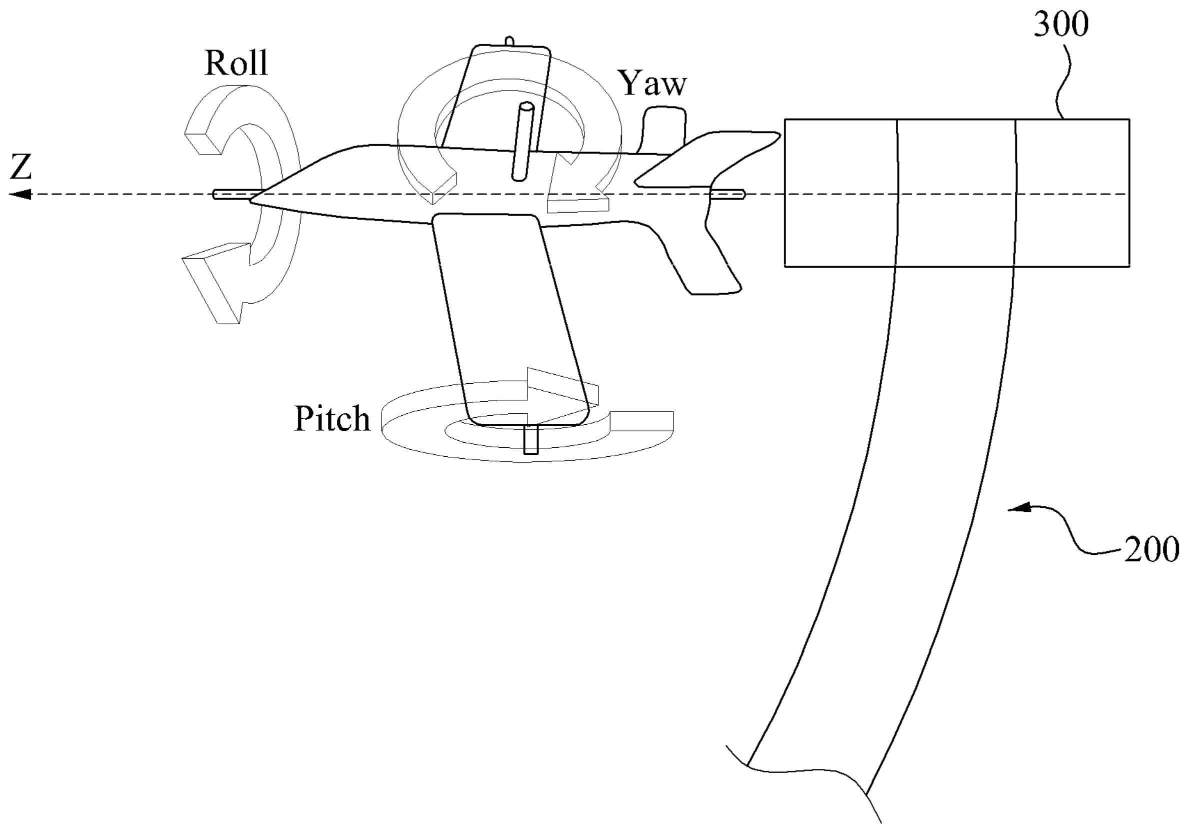
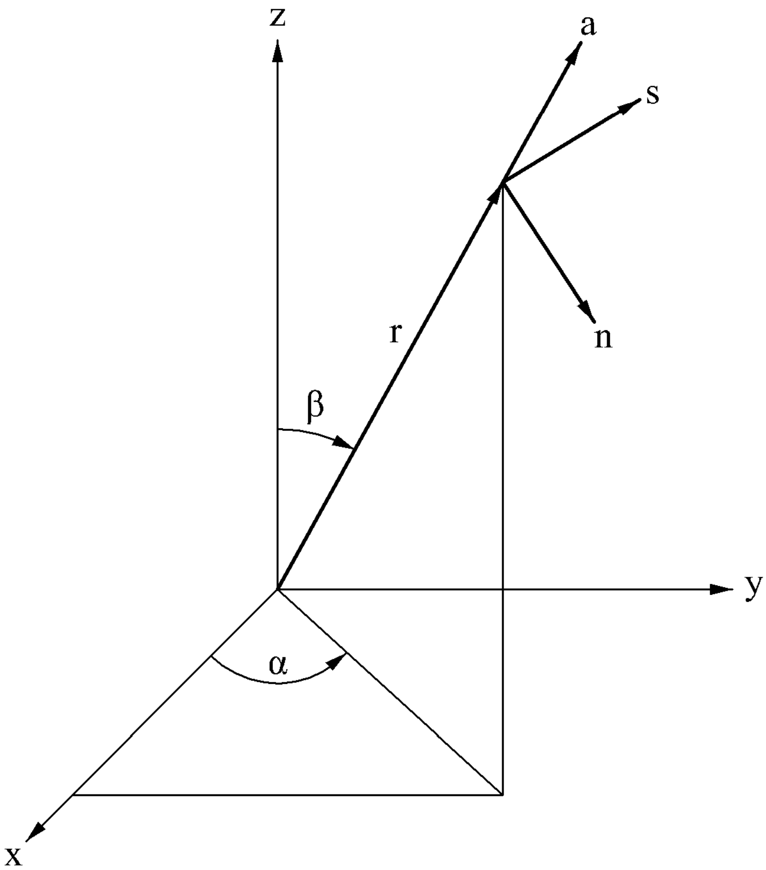


FIG. 6



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