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[Continued on next page]

(54) Title: PATIENT MOUNTED MRI AND CT COMPATIBLE ROBOT FOR NEEDLE GUIDANCE IN INTERVENTIONAL PROCEDURES

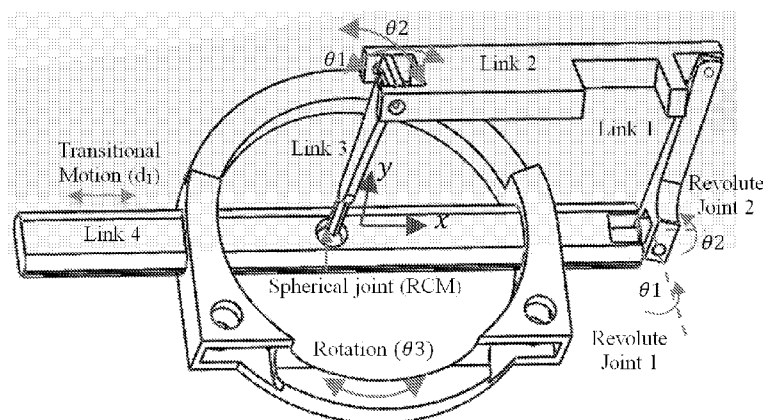


Fig. 8

(57) Abstract: A patient mountable robot includes a four link mechanism, three actuators, and a first robot base. The mechanism includes four links that form a closed loop structure. The four links include a base link that includes a spherical joint. The mechanism provides two rotational degrees of freedom about the spherical joint for a needle that is configured to pass through the spherical joint. A first actuator is attached to the mechanism and moves the mechanism to provide the first of the two rotational degrees of freedom. A second actuator is attached to the mechanism and moves the mechanism to provide the second of the two rotational degrees of freedom. The base link of the mechanism passes through the first robot base. A third actuator is attached to the first robot base and linearly translates the base link so that a translational degree of freedom is provided for the needle.



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- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))* (88) **Date of publication of the international search report:**
19 February 2015

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US14/42685

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A61B 5/05, 17/00, 19/00 (2014.01)

CPC - A61B 5/4893, 2017/003; B25J 9/104

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) Classification(s): A61B 5/05, 17/00, 19/00 (2014.01)

CPC Classification(s): A61B 5/4893, 2017/003, 2017/00477, 2019/2234, 2019/2249, 2019/5259, 2019/5276; B25J 9/104

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

MicroPatent (US-G, US-A, EP-A, EP-B, WO, JP-bib, DE-C,B, DE-A, DE-T, DE-U, GB-A, FR-A); Patbase; Google/Google Scholar; ProQuest; Pubmed/Medline: robot, patient, subject, mount, attach, couple, connect, fasten, four, links, linkages, actuator, base, stand, degrees, freedom, needle, cannula, catheter, joint, spherical, parallel, closed loop, CT, MRI, revolute, hinge

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 7950306 B2 (STUART, JM) May 31, 2011; figures 2-3; column 2, lines 30-60; column 3, lines 54-59; column 4, lines 49-52;	1-3, 11-15
Y	US 2012/0265051 A1 (FISCHER, GS et al.) October 18, 2012; figures 10a-b; paragraphs [0002], [0038], [0040], [0068], [0086]-[0087]	1-3, 11-15
Y	US 6247738 B1 (WINKEL, A et al.) June 19, 2001; figure 1; column 4, lines 1-15	3, 13
A	WO 96/19944 A1 (DANIELI, GS et al.) July 4, 1996; figures 1, 2	4-10
E, X	(MONFAREDÌ, R et al.) "A Prototype Body-Mounted MRI-Compatible Robot for Needle Guidance in Shoulder Arthrography" 2014 5th IEEE RAS & EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob). August 12-15, 2014; figure 2	1-15

☐ Further documents are listed in the continuation of Box C.


* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US14/42685

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-15 are directed toward a patient mountable robot comprising a four link mechanism.

Group II: Claims 16-19 are directed toward a process, comprising: mounting a robot to a patient at a target area of a body of the patient for a procedure.

Continued Within the Next Supplemental Box

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-15

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

-***-Continued from Box No. III - Observations where unity of invention is lacking-***-

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the special technical features of Group I include a four link mechanism including four links that form a closed loop structure, the four links including a base link that includes a spherical joint, and the four link mechanism provides two rotational degrees of freedom about the spherical joint for a needle that is configured to pass through the spherical joint; a first actuator attached to the four link mechanism that moves the four link mechanism to provide the first of the two rotational degrees of freedom; a second actuator attached to the four link mechanism that moves the four link mechanism to provide the second of the two rotational degrees of freedom; a first robot base through which the base link of the four link mechanism passes; and a third actuator attached to the first robot base that linearly translates the base link so that a translational degree of freedom is provided for the needle that is configured to pass through the spherical joint, which are not present in Group II; the special technical features of Group II include mounting a robot to a patient at a target area of a body of the patient for a procedure; moving the patient into a bore of an imaging scanner; obtaining a first image of the target area of the body with the imaging scanner; determining a target needle point for a needle of the robot and a skin entry point for the needle based on the first image; actuating the robot to align the needle along a line connecting the target needle point and the skin entry point, while the robot is mounted on the patient; inserting the needle that is aligned into the body of the patient, while the robot is mounted on the patient; obtaining a second image of the target area of the body with the imaging scanner to confirm that the needle is correctly placed; moving the patient out of the bore of the imaging scanner; and removing the robot from the patient, which are not present in Group I.

The common technical features of Groups I and II are a patient mountable robot.

These common technical features are disclosed by US 8,219,178 B2 to Smith et al. (hereinafter 'Smith'). Smith discloses a patient mountable robot (robot for performing medical procedure; frame mounted to patient's skin; claim 1).

Since the common technical features are previously disclosed by the Smith reference, the common features are not special and so Groups I and II lack unity.