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61/666,399 29 June 2012 (29.06.2012) US(71) Applicant: **CHILDREN'S NATIONAL MEDICAL CENTER** [US/US]; 111 Michigan Avenue, N.W., Washington, DC 20010-2970 (US).(72) Inventors: **KIM, Peter**; c/o Children's National Medical Center, 111 Michigan Avenue, N.W., Washington, DC 20010-2970 (US). **KRIEGER, Axel**; c/o Children's National Medical Center, 111 Michigan Avenue, N.W., Washington, DC 20010-2970 (US). **KIM, Yonjae**; c/o Children's National Medical Center, 111 Michigan Avenue, N.W., Washington, DC 20010-2970 (US). **SHADEMAN, Azad**; c/o Children's National Medical Center, 111 Michigan Avenue, N.W., Washington, DC 20010-2970 (US). **LEONARD, Simon**; c/o Children's National Medical

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[Continued on next page]

(54) Title: AUTOMATED SURGICAL AND INTERVENTIONAL PROCEDURES

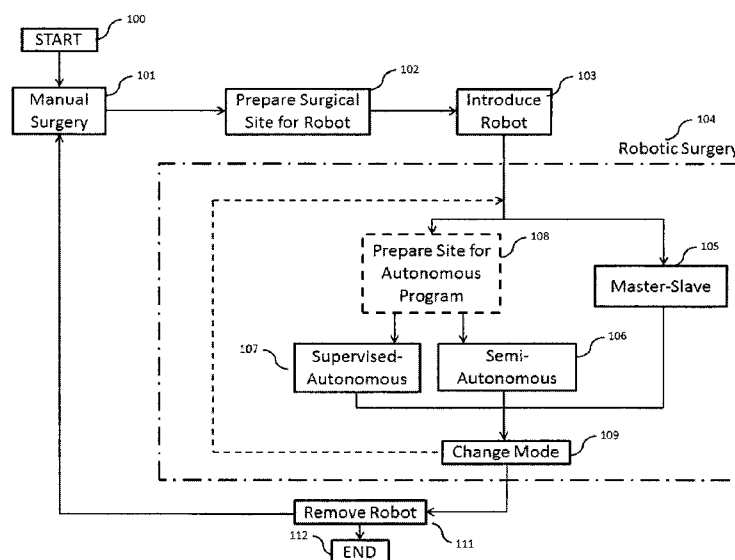


FIG. 1

(57) Abstract: Described herein are an apparatus and methods for automating subtasks in surgery and interventional medical procedures. The apparatus consists of a robotic positioning platform, an operating system with automation programs, and end-effector tools to carry out a task under supervised autonomy. The operating system executes an automation program, based on one or a fusion of two or more imaging modalities, guides real-time tracking of mobile and deformable targets in unstructured environment while the end-effector tools execute surgical interventional subtasks that require precision, accuracy, maneuverability and repetition. The apparatus and methods make these medical procedures more efficient and effective allowing a wider access and more standardized outcomes and improved safety.

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- *with international search report (Art. 21(3))*
- *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))*

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US13/48911

A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - A61B 19/00 (2014.01) USPC - 606/144, 700/245, 901/2 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 19/00 (2014.01) USPC Classification(s): 606/144, 700/245, 901/2 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); ProQuest; IEEE; Google/Google Scholar; Surgery robot*, surgical robot*, tool*, sensor*, user interface*		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 8,107,717 B2 (SUTHERLAND, G et al.) 01 May 2012; abstract, figure 1A and 1B, column 3 lines 61-62, column 4 lines 1-5, 15-18, and 76, column 5 lines 1-3 and 5-6, column 11 lines 62-65, and column 12 lines 50-54.	1-4, 6, and 9
Y		5, 7, 8, and 10-16
Y	US 2011/0082369 A1 (MOHR, C et al.) 07 April 2011; paragraphs [0020] and [0025].	5
Y	US 6,460,810, B2 (JAMES, T) 08 October 2002; title, column 1 lines 61-65.	7
Y	US 8,196,870 B2 (GRYNIEWSKI, L et al.) 12 June 2012; column 6 lines 11-13.	8
Y	US 7,008,373 B2 (STOIANOVICI, D et al.) 07 March 2006; abstract, column 6 lines 11-12, 18-19, and 22-26.	10 and 15
Y	US 8,182,494 B1 (YENCHO, S et al.) 22 May 2012; abstract.	11
Y	US 2011/0257661 A1 (CHOI, S et al.) 20 October 2011; abstract, paragraph [0010].	12
Y	US 8,197,507 B2 (GARCIA, P et al.) 12 June 2012; abstract, column 3 lines 10-11.	13 and 14
Y	US 8,046,054 B2 (KIM, Y et al.) 25 October 2011; abstract.	16
☐ 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		
Date of the actual completion of the international search 20 February 2014 (20.02.2014)		Date of mailing of the international search report 18 MAR 2014
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201		Authorized officer: Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US13/48911

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:

Group I: Claims 1-16; Group II: Claims 17-30

-Please see Supplemental Page-

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.:
1-16

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.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US13/48911

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

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 fee must be paid.

Group I: Claims 1-16 are directed toward a system for performing an automated surgical procedure.

Group II: Claims 17-30 are directed toward a computer-implemented method of generating an automated surgical program.

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 sensor; a user interface; a feedback device; a surgical tool; and a track processing module, which are not present in Group II.

The special technical features of Group II include processing clinical data to produce a 3D spatial and temporal data of a surgery; obtaining surgical robot specifications and clinical parameters; and generating the automated surgical program, which are not present in Group I.

The common technical feature shared by Groups I-II is an automated surgical program, comprising: a surgical robot; processing data; and generating commands to the surgical robot. However, this common feature is previously disclosed by US 2011/0257661 A1 (Choi). Choi discloses an automated surgical program (automatically controlling the operation of a surgery; Abstract and paragraph [0018]), comprising: a surgical robot (liposuction surgical robot; Abstract); processing data (a robot arm driven by a particular control signal received from the control unit; Abstract); and generating commands to the surgical robot (generate and transmit control signals for driving the surgical robot; Abstract and paragraph [0074]).

Since the common technical feature is previously disclosed by the Choi reference, this common feature is not special and so Groups I-II lack unity.