



(51) International Patent Classification:

A61B 1/267 (2006.01) A61B 8/12 (2006.01)  
A61B 5/06 (2006.01) A61B 8/13 (2006.01)  
A61B 5/113 (2006.01) A61K 49/22 (2006.01)

(21) International Application Number:

PCT/IB2018/000624

(22) International Filing Date:

24 May 2018 (24.05.2018)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/510,729 24 May 2017 (24.05.2017) US

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ,

(54) Title: METHODS FOR USING RADIAL ENDOBRONCHIAL ULTRASOUND PROBES FOR THREE-DIMENSIONAL RECONSTRUCTION OF IMAGES AND IMPROVED TARGET LOCALIZATION

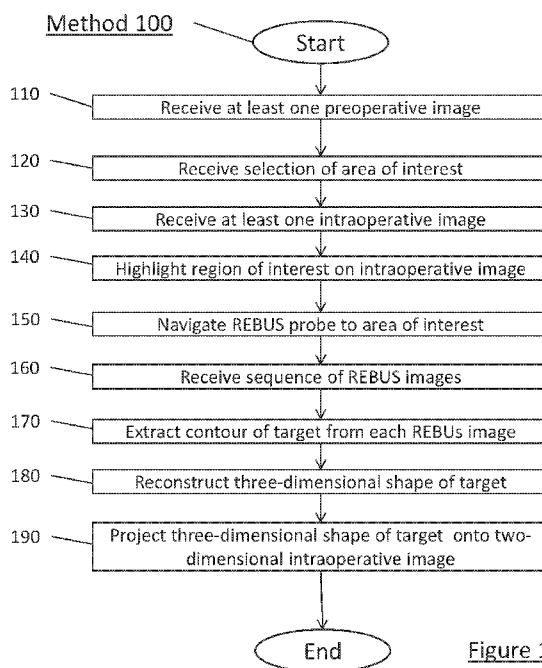


Figure 1

(57) Abstract: A method, including obtaining at least one preoperative image from an imaging modality; identifying, on the at least one preoperative image, at least one element located within an area of interest; obtaining at least one intraoperative image; highlighting the at least one element on the at least one intraoperative image; navigating a radial endobronchial ultrasound probe to the area of interest using the at least highlighted at least one element; acquiring a plurality of radial endobronchial ultrasound images; extracting a plurality of two-dimensional representations of the element, each of the plurality of two-dimensional representations of the element being extracted from a corresponding one of the plurality of radial endobronchial ultrasound images; reconstructing a three-dimensional representation of the element from the plurality of two-dimensional representations of the element; and projecting a two-dimensional



UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

**Published:**

- *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))*

**(88) Date of publication of the international search report:**

07 February 2019 (07.02.2019)

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB18/00624

## A. CLASSIFICATION OF SUBJECT MATTER

IPC - A61B 1/267, 5/06, 5/113, 8/12, 8/13; A61K 49/22 (2018.01)

CPC - A61B 1/267, 5/06, 5/113, 8/12, 8/13; A61K 49/22

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)

See Search History document

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

See Search History document

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

See Search History document

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	→ ZANG et al. "3D SEGMENTATION AND RECONSTRUCTION OF ENDOBRONCHIAL ULTRASOUND"; SPIE Medical Imaging, Vol. 8675; Publication [online]. 2013. [retrieved 16 September 2018]. Retrieved from the Internet: <URL: <a href="https://pdfs.semanticscholar.org/873d/634cf8f03e86b755526890b7fcb8012c5d6.pdf">https://pdfs.semanticscholar.org/873d/634cf8f03e86b755526890b7fcb8012c5d6.pdf</a> >; pp. 1-15.	1-10
A	→ SORGER et al. "A MULTIMODAL IMAGE GUIDING SYSTEM FOR NAVIGATED ULTRASOUND BRONCHOSCOPY (EBUS): A HUMAN FEASIBILITY STUDY"; PLoS ONE; Publication [online]. February 2017 [retrieved 16 September 2018]. Retrieved from the Internet: <URL: <a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5300184/pdf/pone.0171841.pdf">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5300184/pdf/pone.0171841.pdf</a> >; pp. 1-15	1-10
A	US 2016/0287210 A1 (BOSTON SCIENTIFIC SCIMED, INC.,) 06 October 2016; entire document	1-10

 Further documents are listed in the continuation of Box C. See patent family annex.

\* 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

"&amp;" document member of the same patent family

Date of the actual completion of the international search

27 September 2018 (27.09.2018)

Date of mailing of the international search report

**26 NOV 2018**

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB18/00624

**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 1-10; Group II: Claims 11-13; Group III: Claims 14-17

\*\*\*-Continued within extra sheet-\*\*\*

- 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.:  
1-10

**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-\*\*\*-

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 1-10 are directed towards a method comprising reconstructing a three-dimensional representation.

Group II: Claims 11-13 are directed towards a method comprising generating a database.

Group III: Claims 14-17 are directed towards a method comprising selecting a confirmed position of the radial endobronchial ultrasound probe.

The inventions listed as Groups I-III 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 at least highlighting the at least one element on the at least one intraoperative image; extracting a plurality of two-dimensional representations of the element, each of the plurality of two-dimensional representations of the element being extracted from a corresponding one of the plurality of radial endobronchial ultrasound images; reconstructing a three-dimensional representation of the element from the plurality of two-dimensional representations of the element; and projecting a two-dimensional projection of the three-dimensional representation of the element on at least one of the at least one intraoperative image, which are not present in Groups II-III.

The special technical features of Group II include at least generating a database of pairs of the intraoperative and endobronchial ultrasound images, each pair corresponding to a specific probe tip position and orientation in the preoperative image coordinate system; removing the radial endobronchial ultrasound probe from the area of interest; navigating a further endobronchial tool to the area of interest; acquiring a further plurality of intraoperative images; extracting a position of the further endobronchial tool from the further plurality of intraoperative images; identifying one of the pairs in the database that corresponds most closely to the position of the further endobronchial tool, which are not present in Groups I and III.

The special technical features of Group III include at least selecting a confirmed position of the radial endobronchial ultrasound probe; acquiring at least one intraoperative image of the area of interest while the radial endobronchial ultrasound probe is positioned in the confirmed position; and overlaying the confirmed position of the endobronchial ultrasound probe on at least one of the at least one intraoperative image, which are not present in Groups I-II.

The common technical features shared by Groups I-III are navigating a radial endobronchial ultrasound probe to an area of interest; acquiring a plurality of radial endobronchial ultrasound images and a plurality of intraoperative images; and extracting a radial endobronchial ultrasound probe tip position.

However, these common features are previously disclosed by US 2016/0287210 A1 to BOSTON SCIENTIFIC SCIMED, INC., (hereinafter "BOSTON"). BOSTON discloses navigating a radial endobronchial ultrasound probe to an area of interest (operator to navigate the shaft 102 through tortuous anatomy and/or towards a site of interest; paragraph [0020]); acquiring a plurality of radial endobronchial ultrasound images (ultrasound sensor disposed radially outward of a distal portion; EBUS may be used to image, ultrasound sensor 850 may be used to generate images of the passageway 502; paragraphs [0005], [0041]) and a plurality of intraoperative images (ultrasound can provide real-time images, avoiding a delay between capturing an image of an area of interest and performing a medical procedure on that area; paragraph [0018]); and extracting a radial endobronchial ultrasound probe tip position (area 211 may be integrated into distal portion of the shaft 102; area 211 may be identified in an ultrasound image; upon locating a target site in the body via ultrasound imaging, the area 211 may be aligned with the target site; paragraph [0027]).

Since the common technical features are previously disclosed by the BOSTON reference, these common features are not special and so Groups I-III lack unity.