UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NO. | ISSUE DATE | PATENT NO. | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/574,524 | 05/11/2021 | 11004271 | N3039.10001US03 | 4647 |

97149 7590 04/21/2021

Maschoff Brennan
1389 Center Drive, Suite 300
Park City, UT 84098

# ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

**Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)**
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Steven Cvetko, Ph.D, Draper, UT;
Novarad Corporation, American Fork, UT;
Wendell Arlen Gibby, Mapleton, UT;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/574,524 | 09/18/2019 | Steven Cvetko, Ph.D | N3039.10001US03 | 4647 |

97149 7590 04/12/2021

Maschoff Brennan
1389 Center Drive, Suite 300
Park City, UT 84098

| EXAMINER |
|---|
| GRAY, RYAN M |

| ART UNIT | PAPER NUMBER |
|---|---|
| 2611 | |

| NOTIFICATION DATE | DELIVERY MODE |
|---|---|
| 04/12/2021 | ELECTRONIC |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

d@mabr.com

| **Corrected**<br>***Notice of Allowability*** | **Application No.**<br>16/574,524 | **Applicant(s)**<br>Cvetko, Ph.D et al. | |
|---|---|---|---|
| | **Examiner**<br>RYAN M GRAY | **Art Unit**<br>2611 | **AIA (FITF) Status**<br>Yes |

***-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--***

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to QPIDS filed 3/22/21.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-20 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   **Certified copies:**

   a) ☐ All  b) ☐ Some  *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.**

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   **Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).**

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

1. ☐ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/RYAN M GRAY/
Primary Examiner, Art Unit 2611

UNITED STATES PATENT AND TRADEMARK OFFICE

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Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

# NOTICE OF ALLOWANCE AND FEE(S) DUE

97149 7590 01/29/2021

Maschoff Brennan
1389 Center Drive, Suite 300
Park City, UT 84098

| EXAMINER |
|---|
| GRAY, RYAN M |

| ART UNIT | PAPER NUMBER |
|---|---|
| 2611 | |

DATE MAILED: 01/29/2021

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/574,524 | 09/18/2019 | Steven Cvetko, Ph.D | N3039.10001US03 | 4647 |

TITLE OF INVENTION: AUGMENTING REAL-TIME VIEWS OF A PATIENT WITH THREE-DIMENSIONAL DATA

| APPLN. TYPE | ENTITY STATUS | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | SMALL | $600 | $0.00 | $0.00 | $600 | 04/29/2021 |

**THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.**

**THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.**

**HOW TO REPLY TO THIS NOTICE:**

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

**IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.**

## PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

97149 7590 01/29/2021
Maschoff Brennan
1389 Center Drive, Suite 300
Park City, UT 84098

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

**Certificate of Mailing or Transmission**

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

| (Typed or printed name) |
|---|
| (Signature) |
| (Date) |

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/574,524 | 09/18/2019 | Steven Cvetko, Ph.D | N3039.10001US03 | 4647 |

TITLE OF INVENTION: AUGMENTING REAL-TIME VIEWS OF A PATIENT WITH THREE-DIMENSIONAL DATA

| APPLN. TYPE | ENTITY STATUS | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | SMALL | $600 | $0.00 | $0.00 | $600 | 04/29/2021 |

| EXAMINER | ART UNIT | CLASS-SUBCLASS |
|---|---|---|
| GRAY, RYAN M | 2611 | 345-426000 |

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑ Issue Fee ❑ Publication Fee (if required) ❑ Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____


Medivis Exhibit 1002

PTOL-85 Part B (08-18) Approved for use through 01/31/2020 OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
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| 16/574,524 | 09/18/2019 | Steven Cvetko, Ph.D | N3039.10001US03 | 4647 |

97149 7590 01/29/2021

Maschoff Brennan
1389 Center Drive, Suite 300
Park City, UT 84098

| EXAMINER | |
|---|---|
| GRAY, RYAN M | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 2611 | |

DATE MAILED: 01/29/2021

**Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)**
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

## OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

## Privacy Act Statement

**The Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

| Notice of Allowability | Application No. 16/574,524 | Applicant(s) Cvetko, Ph.D et al. | |
|---|---|---|---|
| | Examiner RYAN M GRAY | Art Unit 2611 | AIA (FITF) Status Yes |

***-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--***

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to amendments filed 10/19/2020.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-20 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   **Certified copies:**

   a) ☐ All  b) ☐ Some  *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.**

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   **Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).**

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☐ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/RYAN M GRAY/
Primary Examiner, Art Unit 2611

***Notice of Pre-AIA or AIA Status***

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

***Reasons for Allowance***

The following is an examiner's statement of reasons for allowance:

Reasons for allowance remain the same as discussed in the non-final office action dated 8/6/2020.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Any inquiry concerning this communication or earlier communications from the examiner should be directed to RYAN M GRAY whose telephone number is (571)272-4582. The examiner can normally be reached on Monday through Friday, 9:00am-5:30pm (EST).

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kee Tung can be reached on (571)272-7794. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/RYAN M GRAY/
Primary Examiner, Art Unit 2611

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

| | | |
|---|---|---|
| In re application of | Steven Cvetko, Ph.D | |
| Application No.: | 16/574,524 | Art Unit 2611 |
| Filed: | 09-18-2019 | |
| Conf. No.: | 4647 | |
| For: | AUGMENTING REAL-TIME VIEWS OF A PATIENT WITH THREE-DIMENSIONAL DATA | |
| Examiner: | RYAN M. GRAY | |
| Customer No.: | 97149 | |
| Attorney Docket No.: | N3039.10001US03 | |

## AMENDMENT AND RESPONSE TO OFFICE ACTION

In response to the Non-final Office Action dated August 6, 2020 (the "Office Action"), please consider the following:

**Amendments to the Claims** are reflected in the listing of claims which begins on page 2 of this paper.

**Remarks** begin on page 7 of this paper.


Medivis Exhibit 1002

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 40881637 |
| **Application Number:** | 16574524 |
| **International Application Number:** | |
| **Confirmation Number:** | 4647 |
| **Title of Invention:** | AUGMENTING REAL-TIME VIEWS OF A PATIENT WITH THREE-DIMENSIONAL DATA |
| **First Named Inventor/Applicant Name:** | Steven Cvetko, Ph.D |
| **Customer Number:** | 97149 |
| **Filer:** | John Thomas Gadd |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | N3039.10001US03 |
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| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | | N3039-10001US03_Amendment_and_Response_2020-10-19.pdf | 69003<br>7ea75ae9d37cc7f9df2d34ef5d6c54476984cdbc | yes | 11 |

| | Multipart Description/PDF files in .zip description | | |
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| | **Document Description** | **Start** | **End** |
| | Applicant Arguments/Remarks Made in an Amendment | 7 | 11 |
| | Claims | 2 | 6 |
| | Amendment/Req. Reconsideration-After Non-Final Reject | 1 | 1 |
| **Warnings:** | | | |
| **Information:** | | | |
| | **Total Files Size (in bytes):** | 69003 | |

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**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

## REMARKS

The paper is in response to the Office Action. The foregoing amendment amends claims 7 and 8. Claims 1-20 remain pending. Applicants respectfully request reconsideration of the application in view of the above amendments to the claims and the following remarks. For Examiner's convenience and reference, Applicants present remarks in the order that the Office Action raises the corresponding issues.

In connection with the prosecution of this case and any related cases, Applicants have, and/or may, discuss various aspects of the disclosure of the cited references as those references are then understood by Applicants. Because such discussion could reflect an incomplete or incorrect understanding of one or more of the references, the position of Applicants with respect to a reference is not necessarily fixed or irrevocable. Applicants thus hereby reserve the right, both during and after prosecution of this case, to modify the views expressed with regard to any reference.

Please note that Applicants do not intend the following remarks to be an exhaustive enumeration of the distinctions between any cited references and the claims. Rather, Applicants present the distinctions below solely by way of example to illustrate some of the differences between the claims and the cited references. Finally, Applicants request that Examiner carefully review any references discussed below to ensure that Applicants' understanding and discussion of any reference is consistent with Examiner's understanding.

Unless otherwise explicitly stated, the term "Applicants" is used herein generically and may refer to a single inventor, a set of inventors, an appropriate assignee, or any other entity or person with authority to prosecute this application.

### Examiner's Interview

Applicants thank Examiner for the WebEx interview of October 19, 2020 (the "Interview"). The amendments and remarks herein reflect the substance of the Interview. In particular, claim 7 is further amended to emphasize that "a virtual ***inserted portion*** of the medical instrument" ***is*** "***projected*** into the projected inner layer of the patient" while "the ***visible portion*** of the medical instrument ***is viewed as a non-image actual view***." As discussed during the Interview, this is patentably distinct from the teachings of the cited portions of Maier which do ***not***

appear to teach projecting ***only an inserted portion*** of the medical instrument as a virtual inserted portion while a visible portion of the medical instrument is view as a non-image actual view. Instead, the cited portions of Maier appear to teach displaying a 3D representation of the ***entire*** instrument.

## Obviousness Type Double Patenting Rejections

The Office Action rejects claims 1-6 under the judicially created doctrine of obviousness-type double patenting over U.S. Patent Nos. 10,475,244 and 9,892,564. Applicants submit herewith a terminal disclaimer relative to U.S. Patent Nos. 10,475,244 and 9,892,564, rendering the rejections moot. Applicants therefore respectfully request that Examiner withdraw the obviousness-type double patenting rejections of claims 1-6.

## Rejections under 35 U.S.C. § 103(a)

The Office Action rejects claims 7 and 10 under 35 U.S.C. § 103(a) over Saget et al. (U.S. Patent No. 10,052,170) in view of Maier-Hein et al. (U.S. Publication No. 2013/0245461) and rejects claims 8-9 under 35 U.S.C. § 103(a) over Saget and Maier-Hein in view of Thomas et al. (U.S. Publication No. 2018/0303558).

Applicants do not necessarily agree with Examiner's statements regarding at least (1) whether the cited reference(s) disclose each and every element recited in the claims, (2) whether the cited reference(s) teach the combination presented in the claims, (3) whether the cited reference(s) disclose or inherently include the features that the Office Action asserts that the reference(s) include, and (4) whether the reference(s) or any other source provide a reason to combine the teachings of the reference(s).

Nevertheless, in the interest of expediting prosecution, Applicants have herein amended independent claims 7.

For example, amended independent claim 7 recites "automatically tracking a real-time position of a medical instrument with respect to a real-time position of the outer layer of the patient, ***including an inserted portion of the medical instrument that is inserted into the patient through the outer layer of the patient and including a visible portion of the medical instrument that is not inserted into the patient through the outer layer of the patient***." Support for this amendment can be found at least in paragraphs [0033]-[0035] of the specification and FIG. 1 of the drawings.

In the rejection of claim 7, the Office Action concedes that the former version of this limitation is not taught in Saget, but asserts that the former version of this limitation is taught in paragraph [0143] of Maier. *See* Office Action, pages 8-9. Although this cited portion of Maier does teach that "An insertion instrument, such as a needle, may additionally be tracked, and its position and/or orientation may then likewise be visualized on the display," this cited portion of Maier does ***not*** appear to tracking "***an inserted portion of the medical instrument that is inserted into the patient through the outer layer of the patient***" as well as tracking "***a visible portion of the medical instrument that is not inserted into the patient through the outer layer of the patient***" as recited in amended claim 7. Applicants respectfully submit that the ***specific*** tracking of "***an inserted portion of the medical instrument that is inserted into the patient through the outer layer of the patient***" and of "***a visible portion of the medical instrument that is not inserted into the patient through the outer layer of the patient***" as recited in amended claim 7 is patentably distinct from the ***general*** tracking of the instrument taught in this cited portion of Maier. For example, this cited portion of Maier does ***not*** appear to teach anything regarding tracking "***an inserted portion of the medical instrument that is inserted into the patient through the outer layer of the patient***," which may enable, in some embodiments, the following example:

> "Then, in the event that the user 104 inserts some portion of the object 118 into the outer layer of the patient 106, the AR headset 108 may display a virtual inserted portion 118a of the object 118 projected into the projected inner layer of the patient 106 from the 3D data. In this manner, the virtual inserted portion 118a of the object 118 may be projected onto the real-time view of the user 104 even when the actual inserted portion of the object 118 is hidden from the real-time view of the user 104."

*See* Specification, paragraph [0033].

Further, amended independent claim 7 also recites "while the inserted portion of the medical instrument ***is inserted into the patient through the outer layer*** of the patient, ***displaying***, in the AR headset, a ***virtual inserted portion*** of the medical instrument ***projected into the projected inner layer of the patient while the visible portion of the medical instrument is viewed as a non-image actual view***." Support for this amendment can be found at least in paragraphs [0033]-[0035] of the specification and FIG. 1 of the drawings. In the rejection of claim 7, the Office Action concedes that the former version of this limitation is not taught in Saget, but asserts that the former version of this limitation is taught in paragraphs [0152]-[0153] of Maier. *See* Office Action, pages 8-9. Although these cited portions of Maier do teach "projecting the shape of the instrument into the intensity image," displaying "a 3D representation of the instrument," and compensating "for

the change of the needle trajectory relative to a patient's skin depending on the breathing state," this cited portion of Maier does not appear to teach displaying "a ***virtual inserted portion*** of the medical instrument ***projected into the projected inner layer of the patient***" while "the inserted portion of the medical instrument ***is inserted into the patient through the outer layer*** of the patient" and "while the visible portion of the medical instrument ***is viewed as a non-image actual view***" as recited in amended claim 7. Applicants respectfully submit that the ***specific*** displaying of "a ***virtual inserted portion*** of the medical instrument ***projected into the projected inner layer of the patient***" while "the inserted portion of the medical instrument ***is inserted into the patient through the outer layer*** of the patient" and "while the visible portion of the medical instrument ***is viewed as a non-image actual view***" as recited in claim 7 is patentably distinct from the ***general*** projecting of the shape of the instrument into an image or the display of a planned trajectory (see paragraph [0151]) of the instrument as taught in this cited portions of Maier. For example, these cited portions of Maier do ***not*** appear to teach anything regarding tracking the inserted portion of the instrument that is ***beneath the outer surface*** of the patient, and displaying "a ***virtual inserted portion*** of the medical instrument ***projected into the projected inner layer of the patient***" that matches this tracked inserted portion as recited in claim 7. Further, although paragraph [0150] of Maier appears to teach a "guidance monitor" that helps the user "advance the needle until the desired depth has been reached," this paragraph of Maier does ***not*** appear to teach that this "guidance monitor" accomplishes this task by displaying "a ***virtual inserted portion*** of the medical instrument ***projected into the projected inner layer of the patient***" that matches this tracked portion. Finally, as discussed in the interview, the cited portions of Maier do ***not*** appear to teach projecting ***only an inserted portion*** of the medical instrument as a virtual inserted portion while a visible portion of the medical instrument is view as a non-image actual view. Instead, the cited portions of Maier appear to teach displaying a 3D representation of the ***entire*** instrument.

The amendments presented herein, taken as a whole, render the rejections moot. Applicants note that portions of the claims other than those specifically amended and/or mentioned above may contribute to patentability. In light of the references as now understood by Applicants and the amendments made herein, claim 7 appears to be allowable. Applicants therefore respectfully request that Examiner withdraw the rejections under 35 U.S.C. §103 of claim 7 and of claims 8-10 which depend therefrom.

## Allowable Subject Matter

The Office Action acknowledges that claims 1-6 and 11-20 are directed to allowable subject matter. Applicants thank Examiner for the careful review and allowance of those claims. Applicants agree with Examiner that claims 1-6 and 11-20 are patentable, but respectfully disagree with Examiner's statement of reasons for allowance as set forth in the Office Action. Applicants submit that it is the claim as a whole, rather than any particular element, that makes each of the claims allowable. No single element should be construed as the reason for allowance of a claim because it is each of the elements of a claim that makes it allowable. Therefore, Applicants do not concede that the reasons for allowable subject matter given by Examiner are the only reasons that make, or would make, the claims allowable and do not make any admission or concession concerning Examiner's statement in the Office Action.

## CONCLUSION

In view of the foregoing, and consistent with the discussion during the Interview, Applicants submit that the pending claims are allowable. In the event that Examiner finds remaining impediment to a prompt allowance of this application that may be clarified through a telephone interview or overcome by an Examiner's Amendment, Examiner is requested to contact the undersigned attorney.

Dated this 19th day of October, 2020.

Respectfully submitted,

**/John T. Gadd/**

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## AMENDMENTS TO THE CLAIMS

This listing of claims replaces all prior versions and listings of claims in the application:

1. **(Original)** A method for augmenting real-time, non-image actual views of a patient with three-dimensional (3D) data, the method comprising:

identifying 3D data for the patient, the 3D data including an outer layer of the patient and multiple inner layers of the patient; and

displaying, in an augmented reality (AR) headset, one of the inner layers of the patient from the 3D data projected onto real-time, non-image actual views of the outer layer of the patient, the projected inner layer of the patient from the 3D data being confined within a volume of a virtual 3D shape.

2. **(Original)** The method as recited in claim 1, wherein:

the virtual 3D shape is a virtual box; and

the virtual box includes a top side, a bottom side, a left side, a right side, a front side, and a back side.

3. **(Original)** The method of claim 1, wherein:

the virtual 3D shape is configured to be controlled to toggle between displaying and hiding lines of the virtual 3D shape; and

the virtual 3D shape is configured to be controlled to reposition two-dimensional (2D) slices and/or 3D slices of the projected inner layer of the patient from the 3D data.

4. **(Original)** The method of claim 1, wherein lines of the virtual 3D shape are displayed.

5. **(Original)** The method of claim 1, wherein lines of the virtual 3D shape are hidden.

6. **(Original)** One or more non-transitory computer-readable media storing one or more programs that are configured, when executed, to cause one or more processors to perform the method as recited in claim 1.

7. **(Currently Amended)** A method for augmenting real-time, non-image actual views of a patient with three-dimensional (3D) data, the method comprising:

identifying 3D data for the patient, the 3D data including an outer layer of the patient and multiple inner layers of the patient;

displaying, in an augmented reality (AR) headset, one of the inner layers of the patient from the 3D data projected onto real-time, non-image actual views of the outer layer of the patient;

automatically tracking a real-time position of a medical instrument with respect to a real-time position of the outer layer of the patient, including an inserted portion of the medical instrument that is inserted into the patient through the outer layer of the patient and including a visible portion of the medical instrument that is not inserted into the patient through the outer layer of the patient; and

while [[a]] the inserted portion of the medical instrument is inserted into the patient through the outer layer of the patient, displaying, in the AR headset, a virtual inserted portion of the medical instrument projected into the projected inner layer of the patient while the visible portion of the medical instrument is viewed as a non-image actual view.

8. **(Currently Amended)** The method as recited in claim 7, wherein:

the medical instrument is formed from a material that a sensor of the AR headset is able to sense even after the inserted portion of the medical instrument has been inserted into the patient through the outer layer of the patient; and

the automatically tracking includes the sensor of the AR headset automatically tracking the real-time position of the medical instrument with respect to the real-time position of the outer layer of the patient.

9. **(Original)** The method as recited in claim 7, wherein:

the medical instrument further includes an attachment attached thereto that is formed from a material that a sensor of the AR headset is able to sense even after the attachment has been inserted into the patient through the outer layer of the patient; and

the automatically tracking includes the sensor of the AR headset automatically tracking the real-time position of the attachment with respect to the real-time position of the outer layer of the patient.

10. **(Original)** One or more non-transitory computer-readable media storing one or more programs that are configured, when executed, to cause one or more processors to perform the method as recited in claim 7.

11. **(Original)** A method for augmenting real-time, non-image actual views of a patient with three-dimensional (3D) data, the method comprising:

identifying 3D data for the patient, the 3D data including an outer layer of the patient and multiple inner layers of the patient, the multiple inner layers of the patient having an original color gradient;

altering the original color gradient of the multiple inner layers to be lighter than the original color gradient in order to be better visible when projected onto real-time, non-image actual views of the outer layer of the patient; and

displaying, in an augmented reality (AR) headset, one of the inner layers of the patient from the 3D data projected onto real-time, non-image actual views of the outer layer of the patient, the projected inner layer of the patient from the 3D data being having the altered color gradient.

12. **(Original)** The method as recited in claim 11, wherein the altered color gradient represents a tissue hardness tissue property of the multiple inner layers of the patient.

13. **(Original)** The method as recited in claim 11, wherein the altered color gradient represents a tissue relaxivity tissue property of the multiple inner layers of the patient.

14. **(Original)** The method as recited in claim 11, wherein the altered color gradient represents a tissue echogenicity tissue property of the multiple inner layers of the patient.

15. **(Original)** The method as recited in claim 11, wherein the altered color gradient represents a tissue enhancement amount tissue property of the multiple inner layers of the patient.

16. **(Original)** The method as recited in claim 11, wherein the altered color gradient represents a tissue enhancement speed tissue property of the multiple inner layers of the patient.

17. **(Original)** The method as recited in claim 11, wherein the altered color gradient represents a tissue density tissue property of the multiple inner layers of the patient.

18. **(Original)** The method as recited in claim 11, wherein the altered color gradient represents a tissue radioactivity tissue property of the multiple inner layers of the patient.

19. **(Original)** The method as recited in claim 11, wherein the altered color gradient represents a tissue water content tissue property of the multiple inner layers of the patient.

20. **(Original)** One or more non-transitory computer-readable media storing one or more programs that are configured, when executed, to cause one or more processors to perform the method as recited in claim 11.

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
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| 16/574,524 | 09/18/2019 | Steven Cvetko, Ph.D | N3039.10001US03 | 4647 |

97149 7590 08/06/2020

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| EXAMINER |
|---|
| GRAY, RYAN M |

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**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

d@mabr.com

| Office Action Summary | Application No. 16/574,524 | Applicant(s) Cvetko, Ph.D et al. | |
|---|---|---|---|
| | Examiner RYAN M GRAY | Art Unit 2611 | AIA (FITF) Status Yes |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☑ Responsive to communication(s) filed on 9/18/2019.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims***

5) ☑ Claim(s) 1-20 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☑ Claim(s) 11-20 is/are allowed.

7) ☑ Claim(s) 1-10 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

**Application Papers**

10)☐ The specification is objected to by the Examiner.

11)☑ The drawing(s) filed on 9/18/19 is/are: a)☑ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

**Priority under 35 U.S.C. § 119**

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

**Certified copies:**

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☑ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

***Notice of Pre-AIA or AIA Status***

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

***Double Patenting***

The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on nonstatutory double patenting provided the reference application or patent either is shown to be commonly owned with the examined application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. See MPEP § 717.02 for applications subject to examination under the first inventor to file provisions of the AIA as explained in MPEP § 2159. See MPEP §§ 706.02(l)(1) - 706.02(l)(3) for applications not subject to examination under the first inventor to

file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/patent/patents-forms. The filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

**Claims 1-6 rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1, 7, 12-16 of U.S. Patent No. 10,475,244.**

Although the claims at issue are not identical, they are not patentably distinct from each other because '524 is broader in scope than '244 and '244 discloses corresponding limitations in each of claims 1-6 of '524. Table 1 below shows an example claim mapping. Table 2 below shows the corresponding claims.

| 16/574,524 | US Patent 10,475,244 |
|---|---|
| 1. A method for augmenting real-time, non-image actual views of a patient with three-dimensional (3D) data, the method comprising: | 1. A method for augmenting real-time, non-image actual views of a patient with three-dimensional (3D) data, the method comprising: |
| identifying 3D data for the patient, the 3D data including an outer layer of the patient and multiple inner layers of the patient; and | identifying 3D data for a patient, the 3D data including an outer layer of the patient and multiple inner layers of the patient; and |
| displaying, in an augmented reality (AR) headset, one of the inner layers of the patient from the 3D data projected onto real-time, | displaying, in an augmented reality (AR) headset, one of the inner layers of the patient from the 3D data projected onto real-time, |

| | |
|---|---|
| non-image actual views of the outer layer of the patient,<br><br>the projected inner layer of the patient from the 3D data being confined within a volume of a virtual 3D shape. | non-image actual views of the outer layer of the patient,<br><br>the projected inner layer of the patient from the 3D data being confined within a volume of a virtual spatial difference 3D shape. |

| **16/574,524** | **US Patent 10,475,244** |
|---|---|
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**Claims 1, 3-6 rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1, 8-10, 14 of U.S. Patent No. 9,892,564.**

Although the claims at issue are not identical, they are not patentably distinct from each other because '524 is broader in scope than '564 and '564 discloses corresponding limitations in each of claims 1-6 of '524. Table 1 below shows an example claim mapping. Table 2 below shows the corresponding claims.

| **16/574,524** | **US Patent 9,892,564** |
|---|---|
| 1. A method for augmenting real-time, non-image actual views of a patient with three-dimensional (3D) data, the method comprising:<br><br>identifying 3D data for the patient, the 3D data including an outer layer of the patient and multiple inner layers of the patient; and | 1. A method for augmenting real-time views of a patient with three-dimensional (3D) data, the method comprising:<br><br>identifying 3D data for a patient, the 3D data including an outer layer of the patient and multiple inner layers of the patient;<br><br>determining virtual morphometric measurements, including size and shape, of the outer layer of the patient from the 3D data;<br><br>mapping a 3D space; |

| | |
|---|---|
| | registering a real-time position of the outer layer of the patient in the 3D space by mapping the position of the outer layer of the patient within the 3D space;<br><br>determining real-time morphometric measurements, including size and shape, of the outer layer of the patient;<br><br>automatically registering a virtual position of the outer layer of the patient from the 3D data to align with the registered real-time position of the outer layer of the patient in the 3D space using the virtual morphometric measurements and using the real-time morphometric measurements; and |
| displaying, in an augmented reality (AR) headset, one of the inner layers of the patient from the 3D data projected onto real-time, non-image actual views of the outer layer of the patient,<br><br>the projected inner layer of the patient from the 3D data being confined within a volume of a virtual 3D shape. | displaying, in an augmented reality (AR) headset, one of the inner layers of the patient from the 3D data projected onto real-time views of the outer layer of the patient,<br><br>the projected inner layer of the patient from the 3D data being confined within a volume of a virtual spatial difference box, the real-time views being non-image actual views. |

| **16/574,524** | **US Patent 9,892,564** |
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***Claim Rejections - 35 USC § 103***

The following is a quotation of 35 U.S.C. 103 which forms the basis for all obviousness rejections set forth in this Office action:

> A patent for a claimed invention may not be obtained, notwithstanding that the claimed invention is not identically disclosed as set forth in section 102, if the differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains. Patentability shall not be negated by the manner in which the invention was made.

Use of ~~**strikethough**~~ indicates a limitation is not explicitly disclosed by the reference alone.

Claim(s) 7, 10 is/are rejected under 35 U.S.C. 103 as being unpatentable over Saget (US Patent 10,052,170) in view of Maier (US 2013/0245461)

Claim 7

Saget discloses **a method for augmenting real-time, non-image actual views of a patient with three- dimensional (3D) data** (Saget, Col. 1: "system is provided that allows head-up displays (HUD) with mixed reality (MR) that includes augmented reality (AR) and/or holography to allow for live visualization of gridded avatars in order to allow for accurate positioning and alignment of implants and/or bones"), **the method comprising:**

**identifying 3D data for the patient, the 3D data including an outer layer of the patient and multiple inner layers of the patient;**

**displaying, in an augmented reality (AR) headset, one of the inner layers of the patient from the 3D data projected onto real-time, non-image actual views of the outer layer of the patient** (Saget, Col. 4-5: "A volumetric head-up display (HUD) 200 is configured to be capable of rendering volumetric contact-analog augmented reality graphic elements (e.g., 3-dimensional or "3-D" graphic elements rendered into the same space as the real environment) with correctly reproduced depth cues. The head-up display projects graphic elements, such as contact-analog augmented reality implant, instrument, or bone models directly to the user along with the grid display. The benefit of this type of direct display is the user does not need to look up to view a separate screen as the surgical images are viewed simultaneously");

~~automatically tracking a real-time position of a medical instrument with respect to a real-time position of the outer layer of the patient; and~~

~~while a portion of the medical instrument is inserted into the patient through the outer layer of the patient, displaying, in the AR headset, a virtual portion of the medical instrument projected into the projected inner layer of the patient.~~

Saget does not explicitly disclose, but Maier makes obvious **automatically tracking a real-time position of a medical instrument with respect to a real-time position of the outer layer of the patient** (Maier, ¶ 143: "An insertion instrument, such as a needle, may additionally be tracked, and its position and/or orientation may then likewise be visualized on the display means."); **and**

**while a portion of the medical instrument is inserted into the patient through the outer layer of the patient, displaying, in the AR headset, a virtual portion of the medical instrument projected into the projected inner layer of the patient** (Maier, ¶ 153: "Rather than projecting the shape of the instrument into the intensity image of the camera, a 3D representation of the instrument may likewise be displayed… The registration compensate movement of the surface, such as may be caused by breathing, in order to provide a corrected indication of the relative position of the instrument with respect to the anatomical structure. This may compensate for the change of the needle trajectory relative to a patient's skin depending on the breathing state").

Before the effective date of this application, it would have been obvious to one of ordinary skill in the art to track an instrument. Saget discloses use of instrument tracking and

would therefore benefit from maier's tracking in order to improve instrument positioning relative to a live patient.

Claim 10

The same teachings and rationales in claim 7 are applicable to claim 10.

Claim(s) 8-9 is/are rejected under 35 U.S.C. 103 as being unpatentable over Saget (US Patent 10,052,170) in view of Maier (US 2013/0245461) and Thomas (US 2018/0303558)

Claim 8

The cited prior art does not explcilty disclose, but Thomas makes obvious **wherein: the medical instrument is formed from a material that a sensor of the AR headset is able to sense even after the medical instrument has been inserted into the patient through the outer layer of the patient; and the automatically tracking includes the sensor of the AR headset automatically tracking the real-time position of the medical instrument with respect to the real-time position of the outer layer of the patient** (Thomas, ¶ 43: "A tracked instrument is typically identified by a sensing a grouping of active or passive fiduciary markers 507 where by a rigid body, such as a tool, is identified by the tracking system, and whereby the position and pose in 3D of a tracked instrument, such as a tool, is determinable. Typically, a minimum of 3 active or passive fiduciary markers 507 are placed on a tracked tool to define the instrument. In many embodiments, four active or passive fiduciary markers 507 are used to track each tool. By tracking the 3D location of the tool, the system may render the tool on the display being observed by the surgeon 501 so that the surgeon 501 is able to view the tool together with images from the scope

and/or images from pre-operative scans. In this manner, the surgeon 501 is guided in manipulating the tool relative to the patient's anatomy and/or pre-operative imaging data.")

Before the effective date of this application, it would have been obvious to one of ordinary skill in the art to use a material such as an optical marker. Both Maier and Saget discloses instrument tracking and would therefore be able to substitute methods depending on the desired tracking method.

Claim 9

The cited prior art does not explicitly disclose, but Thomas makes obvious **the medical instrument further includes an attachment attached thereto that is formed from a material that a sensor of the AR headset is able to sense even after the attachment has been inserted into the patient through the outer layer of the patient; and the automatically tracking includes the sensor of the AR headset automatically tracking the real-time position of the attachment with respect to the real-time position of the outer layer of the patient** (Thomas, ¶¶ 3, 32: "Optical tracking systems, used during a medical procedure, track the position of a part of the instrument that is within line-of-site of the optical tracking camera. These optical tracking systems also require a reference to the patient to know where the instrument is relative to the target (e.g., a tumour) of the medical procedure…The tracked instrument may include at least one fiducial marker 212 mounted in fixed relation to the at least one OR item, e.g., the robotic arm 202 and the at least one instrument, e.g., the access port 206.")

Before the effective date of this application, it would have been obvious to one of ordinary skill in the art to use a material such as an optical marker. Both Maier and Saget

discloses instrument tracking and would therefore be able to substitute methods depending on the desired tracking method.

***Allowable Subject Matter***

The following is an examiner's statement of reasons for allowance:

Regarding Claims 1-6:

Maier-Hein (US 2013/0245461) discloses see-through augmented reality using registration of a surgical image with an actual view of the patient:

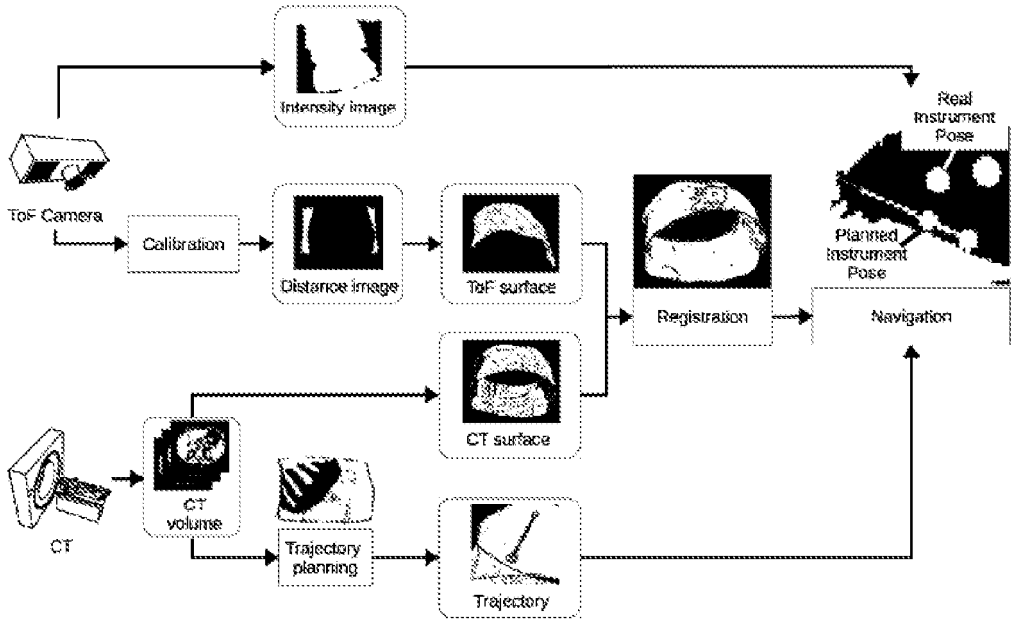



Figure 3

Hannaford (US Patent 9,538,962) discloses projection of 4D images onto a patient through a headset.

Neither reference suggest projection onto real-time actual views of the patient, layers confined to a 3D shape.

Saget (US Patent 10,052,170) discloses projection onto real actual views of the patient using a grid. Saget refers to grids as inclusive of 3D shapes but does not suggest confining inner layers to the volume of the 3D shape.

Regarding Claims 11-20:

Saget discloses projection onto real actual views of the patient, but does not disclose altering a color gradient as claimed.

Guo (US 2018/0020992) discloses a 3D shape and altered color gradients (See Fig. 7B):

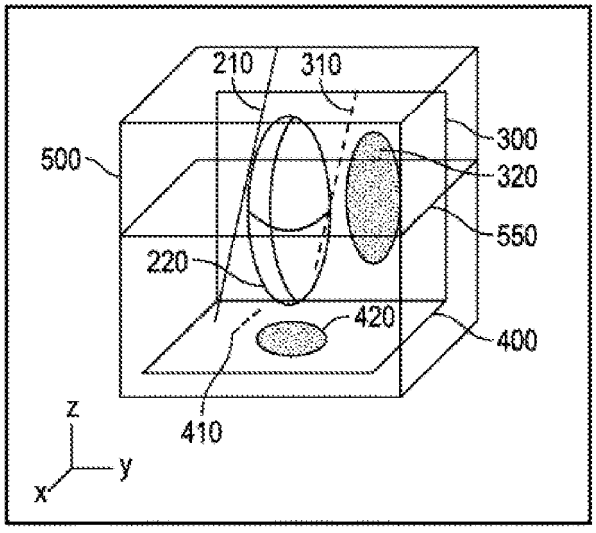
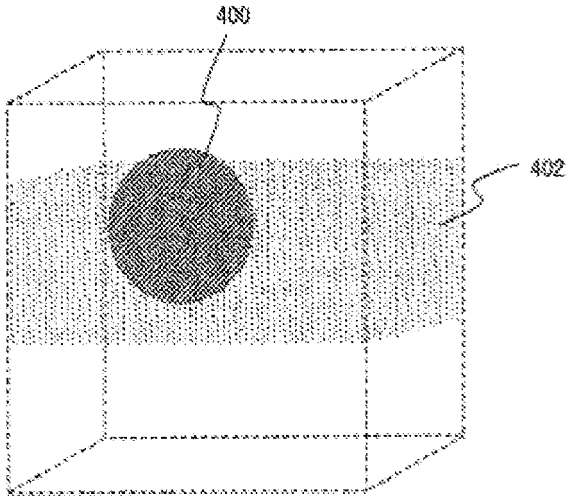



FIG. 7B

Inoue (US 2013/017729) also discloses a similar technique in Fig. 6:

FIG.6




Neither reference suggest application to projection on to real-time actual views by lightening the layer to improve visibility.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled “Comments on Statement of Reasons for Allowance.”

***Conclusion***

Any inquiry concerning this communication or earlier communications from the examiner should be directed to RYAN M GRAY whose telephone number is (571)272-4582. The examiner can normally be reached on Monday through Friday, 9:00am-5:30pm (EST).

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kee Tung can be reached on (571)272-7794. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see https://ppair-my.uspto.gov/pair/PrivatePair. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/RYAN M GRAY/
Primary Examiner, Art Unit 2611

| Notice of References Cited | Application/Control No. 16/574,524 | Applicant(s)/Patent Under Reexamination Cvetko, Ph.D et al. | |
|---|---|---|---|
| | Examiner RYAN M GRAY | Art Unit 2611 | Page 1 of 1 |

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| | K | | | | | |
| | L | | | | | |
| | M | | | | | |

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**NON-PATENT DOCUMENTS**

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*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
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| APPLICATION NUMBER | FILING or 371(c) DATE | GRP ART UNIT | FIL FEE REC'D | ATTY.DOCKET.NO | TOT CLAIMS | IND CLAIMS |
|---|---|---|---|---|---|---|
| 16/574,524 | 09/18/2019 | 2611 | 785 | N3039.10001US03 | 20 | 3 |

**CONFIRMATION NO. 4647**

**CORRECTED FILING RECEIPT**

97149
Maschoff Brennan
1389 Center Drive, Suite 300
Park City, UT 84098

OC000000111809290

Date Mailed: 10/11/2019

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

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**Inventor(s)**

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Wendell Arlen Gibby, Mapleton, UT;

**Applicant(s)**

Novarad Corporation, American Fork, UT;

**Power of Attorney:** The patent practitioners associated with Customer Number 97149

**Domestic Priority data as claimed by applicant**

This application is a CON of 15/894,595 02/12/2018
which is a CON of 15/474,702 03/30/2017 PAT 9892564

**Foreign Applications** for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
*Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.*

**Permission to Access Application via Priority Document Exchange:** Yes

**Permission to Access Search Results:** Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

**If Required, Foreign Filing License Granted:** 10/01/2019

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/574,524**

**Projected Publication Date:** 01/09/2020

**Non-Publication Request:** No

**Early Publication Request:** No
**** SMALL ENTITY ****
**Title**

AUGMENTING REAL-TIME VIEWS OF A PATIENT WITH THREE-DIMENSIONAL DATA

**Preliminary Class**

345

**Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications:** No

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# AUGMENTING REAL-TIME VIEWS OF A PATIENT WITH THREE-DIMENSIONAL DATA

## CROSS-REFERENCE TO A RELATED APPLICATION

**[0001]** This application is a continuation of U.S. Patent Application No. 15/894,595, filed February 12, 2018, which is a continuation of U.S. Patent Application No. 15/474,702, filed March 30, 2017, now U.S. Patent No. 9,892,564, each of which is incorporated herein by reference in its entirety for all that it discloses.

## BACKGROUND

**[0002]** Augmented reality (AR) systems generally take a user's live view of a real-world environment and augment that view with computer-generated virtual elements such as video, sound, or graphics. As a result, AR systems function to enhance a user's current perception of reality.

**[0003]** One common problem faced by AR systems is accurately aligning the position of a virtual element with a live view of a real-world environment. This alignment process is often done manually or is done automatically only after manual placement of non-anatomical fiducials. In either case, the manual process can be time consuming, cumbersome, and inaccurate.

**[0004]** Another common problem faced by AR systems is proper placement of virtual controls for managing virtual elements. Virtual controls, while intended to aide a user in interacting with virtual elements, are often placed in positions in the live view that render them more of a hindrance than a help to the user.

**[0005]** The subject matter claimed herein is not limited to embodiments that solve any disadvantages or that operate only in environments such as those described above. Rather, this background is only provided to illustrate one example technology area where some embodiments described herein may be practiced.

SUMMARY

**[0006]** In one embodiment, a method for augmenting real-time views of a patient with three-dimensional (3D) data may include various acts. For example, the method may include identifying 3D data for a patient with the 3D data including an outer layer of the patient and multiple inner layers of the patient. The method may also include determining virtual morphometric measurements of the outer layer of the patient from the 3D data. The method may further include registering a real-time position of the outer layer of the patient in a 3D space. The method may also include determining real-time morphometric measurements of the outer layer of the patient. The method may further include automatically registering the position of the outer layer of the patient from the 3D data to align with the registered real-time position of the outer layer of the patient in the 3D space using the virtual morphometric measurements and using the real-time morphometric measurements. The method may also include displaying, in an augmented reality headset, one of the inner layers of the patient from the 3D data projected onto real-time views of the outer layer of the patient.

**[0007]** In another embodiment, a method for augmenting real-time views of a patient with 3D data may include various acts. For example, the method may include identifying 3D data for a patient with the 3D data including an outer layer of the patient and multiple inner layers of the patient. The method may also include displaying, in an augmented reality headset, one of the inner layers of the patient from the 3D data projected onto real-time views of the outer layer of the patient. The method may further include generating, in the augmented reality headset, a virtual user interface that includes options for altering the display of the projected inner layer of the patient from the 3D data. The method may also include displaying, in the augmented reality headset, the virtual user interface projected onto real-time views due to a focal orientation of the augmented

reality headset not being focused on the patient. The method may further include hiding, in the augmented reality headset, the virtual user interface due to the focal orientation of the augmented reality headset being focused on the patient.

**[0008]** It is to be understood that both the foregoing summary and the following detailed description are explanatory and are not restrictive of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

**[0009]** Embodiments will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

**[0010]** FIG. 1 illustrates an example augmented reality (AR) environment in which real-time views of a patient may be augmented with three-dimensional (3D) data;

**[0011]** FIGS. 2A-2F are photographs of the AR environment of FIG. 1 with a first patient;

**[0012]** FIG. 3 is a photograph of the AR environment of FIG. 1 with a second patient;

**[0013]** FIGS. 4A-4B are photographs of the AR environment of FIG. 1 with a third patient;

**[0014]** FIG. 5 illustrates an example computer system that may be employed in augmenting real-time views of a patient with 3D data; and

**[0015]** FIGS. 6A-6E are a flowchart of an example method of augmenting real-time views of a patient with 3D data.

DETAILED DESCRIPTION

**[0016]** Medical imaging may be employed to create visual representations of the interior of a patient. More particularly, medical imaging may be employed to reveal internal structures hidden by an outer layer of a patient, such as the skin, for various purposes such as training, research, diagnosis, and treatment.

**[0017]** Conventional medical imaging systems may create three-dimensional (3D) data for a patient and then display that 3D data as an image or images on a computer display. While viewing images of a patient on a computer display, detached from the actual patient, may be useful in training, research, diagnosis, and treatment, viewing, such detached viewing may also result in some problems.

**[0018]** For example, where a surgeon needs to remove a tumor from a patient's brain, the surgeon may view an image of the patient's brain on a computer display. After viewing the location of the tumor on the computer display, the surgeon may then shift his view from the computer display to the actual patient on an operating table and attempt to identify the approximate location on the actual patient of the tumor inside the patient's brain. This method of identifying the approximate location of the tumor can be difficult and error-prone. For example, the surgeon may accidentally identify the left side of the brain in the image as having the tumor when in reality the tumor is in the right side of the brain. This error may lead to the surgeon erroneously making an unnecessary incision on the left side of the patient's skull.

**[0019]** In another example, where a doctor needs to perform knee surgery on a patient, the doctor may view an image of the patient's knee on a computer display. After viewing the problematic area of the knee on the computer display, the doctor may then shift his view from the computer display to the actual patient on an operating table and attempt to identify the problematic area of the knee on the actual patient for the surgery. This method of identifying the problematic area of the knee can be difficult and error-prone. For example, the doctor may accidentally pull up images of the wrong patient on the computer display, without realizing that the patient on the operating table does not match the images on the computer display. This error may lead to the

surgeon erroneously making an incision in the wrong location due to natural variation of problematic areas of the knee from one patient to the next.

**[0020]** The embodiments disclosed herein may provide various benefits over a conventional medical imaging system. In particular, the embodiments disclosed herein may, for example, augment real-time views of a patient with 3D data. In some embodiments, the 3D data of a patient may be automatically aligned, or registered, with a real-time view of the actual patient and then images derived from the 3D data may be projected onto the real-time view of the patient. Thus, these embodiments may enable a medical professional to view a virtual interior of the patient while looking at the actual patient without any time consuming, cumbersome, and inaccurate manual alignment and/or without any time consuming, cumbersome, and inaccurate manual placement of non-anatomical fiducial. When used in training, research, diagnosis, or treatment, these embodiments may enable a medical professional to more easily and more accurately locate a target location within a patient.

**[0021]** For example, when employed in the brain surgery example discussed above, these embodiments may avoid the surgeon getting confused on the location of the tumor between the right and left sides of the brain, and may thereby avoid the surgeon making an unnecessary incision on the wrong side of the skull during the surgery to remove the tumor. Similarly, when employed in the knee surgery example discussed above, these embodiments may avoid the doctor using 3D data for the wrong patient because the automatic alignment may fail or may indicate a low confidence that the automatic alignment was correct, thus alerting the doctor that the patient data may not be for the patient currently on the operating table.

**[0022]** Further, in some embodiments, the augmenting of real-time views of a patient with 3D data may include the display of a virtual user interface and other virtual controls for altering the

images projected onto the real-time view of the patient. This virtual user interface and these other virtual controls may be projected to avoid obstructing the medical professional's field of view when viewing the patient, to maintain a relatively constant focal length for the medical professional, and/or to maintain the orientation of the virtual user interface facing the medical professional. In this way, these embodiments may allow the medical professional to quickly and easily alter the images projected onto the real-time view of the patient.

**[0023]** Turning to the figures, FIG. 1 illustrates an example augmented reality (AR) environment 100. In some embodiments, the environment 100 may include a 3D space 102, a user 104, a patient 106, and an AR headset 108 which may be in communication with a server 112 over a network 110. In some embodiments, the environment 100 may also include a virtual user interface 114, a virtual spatial difference box 116, a virtual inserted portion 118a of an object 118, and a virtual cursor 122, all shown in dashed lines to indicate that these virtual elements are generated by the AR headset 108 and only viewable by the user 104 through the AR headset 108.

**[0024]** In some embodiments, the 3D space 102 may be any 3D space including, but not limited to, an operating room with an operating table 103 (as illustrated in FIG. 1), an office, a classroom, or a laboratory. In some embodiments, the 3D space 102 may be a space where the user 104 may view the patient 106 while wearing the AR headset 108.

**[0025]** In some embodiments, the user 104 may be any user of the AR headset 108 including, but not limited to, a medical professional (as illustrated in FIG. 1), an instructor, a researcher, a patient, or a caregiver of a patient. For example, a medical professional may use the AR headset 108 in order to perform a medical procedure on the patient 106. Similarly, a researcher or an instructor may use the AR headset 108 while performing medical research or instructing medical students. Further, a caregiver of the patient 106, or the patient 106 himself, may use the AR headset

108 when a medical professional is attempting to explain a suggested medical procedure for the patient 106.

**[0026]** In some embodiments, the patient 106 may be any animal, either conscious or unconscious, either living or dead, either whole or missing one or more body parts. For example, the patient 106 may be a living human adult (as illustrated in FIG. 1) who has been rendered unconscious in order to undergo a medical procedure by the user 104. In another example, the patient 106 may be a cadaver of a human adult that will undergo a dissection for research or training purposes. In another example, the patient 106 may be a conscious animal that is being evaluated by a veterinarian in order to diagnose a medical condition. In another example, the patient 106 may be a single limb or organ of a deceased human.

**[0027]** In some embodiments, the AR headset 108 may be any computer system in the form of an AR headset that is capable of augmenting real-time views of the patient 106 with 3D data. For example, the AR headset 108 may be employed by the user 104 in order to augment a real-time view of the patient 106 with one or more inner layers of the patient 106 including, but not limited to, bones 106b (as illustrated in FIG. 1), muscles, organs, or fluids. In some embodiments, the AR headset 108 may perform this augmenting of a real-time view of the patient 106 regardless of the current position of the user 104 in the 3D space 102. For example, the user 104 may walk around the operating table 103 and view the patient 106 from any angle within the 3D space 102, and all the while the AR headset 108 may continually augment the real-time view of the patient 106 with one or more inner layers of the patient 106, so that both the patient 106 and the 3D data of the patient 106 may be viewed by the user 104 from any angle within the 3D space 102. The AR headset 108 may perform this augmenting of a real-time view of the patient 106 with 3D data

according to the method 600 disclosed herein in connection with FIGS. 6A-6E. In some embodiments, the AR headset 108 may be a modified version of the Microsoft HoloLens.

**[0028]** In some embodiments, the network 110 may be configured to communicatively couple the AR headset 108 and the server 112 or other computer system(s). In some embodiments, the network 110 may be any wired or wireless network, or combination of multiple networks, configured to send and receive communications between systems and devices. In some embodiments, the network 110 may include a Personal Area Network (PAN) such as a Bluetooth network, a Local Area Network (LAN) such as a WiFi network, a Metropolitan Area Network (MAN), a Wide Area Network (WAN), or a Storage Area Network (SAN). In some embodiments, the network 110 may also be coupled to, or may include, portions of a telecommunications network for sending data in a variety of different communication protocols, such as a cellular network.

**[0029]** In some embodiments, the server 112 may be any computer system capable of functioning in connection with the AR headset 108. In some embodiments, the server 112 may be configured to communicate in real-time with the AR headset 108 in order to convey 3D data to, or receive data from, the AR headset 108. In addition, the server 112 may be employed to offload some or all of the data storage or processing desired by the AR headset 108.

**[0030]** In some embodiments, the virtual user interface 114 may be any virtual user interface generated by the AR headset 108 that includes options for altering the display of the projected inner layer(s) of the patient 106 from the 3D data of the patient 106. For example, the options included in the virtual user interface 114 may include, but are not limited to, options that cause the AR headset 108 to:

(1) quit viewing the augmented view of the patient 106,

(2) display a demo of the capabilities of the AR headset 108,

(3) adjust the characteristics of the 3D data that is projected onto the patient 106, such as the brightness and color of the projected 3D data,

(4) adjust the alignment of the 3D data with the patient 106,

(5) display the virtual spatial difference box 116,

(6) display a slice of the 3D data instead of a volume of the 3D data,

(7) drag the 3D data in a direction of the user 104, such as in the repositioning of a slice of the 3D data,

(8) display different slices of the 3D data including, but not limited to, axial slices, coronal slices, sagittal slices, and oblique slices, and

(9) perform other advanced features of the AR headset 108.

The virtual user interface 114 may further include other information that may be useful to the user 104. For example, the virtual user interface 114 may include real-time vital signs for the patient 106 such as heart-rate, blood-pressure, and respiration-rate. In another example, the virtual user interface 114 may include a stopwatch showing the amount of time the patient 106 has been unconscious.

**[0031]** In some embodiments, the AR headset 108 may be configured to display the virtual user interface 114 at a comfortable distance from the user 104 and/or in a comfortable orientation for the user 104. For example, the AR headset 108 may be configured to display the virtual user interface 114 at a focal distance D2 from the AR headset 108 that is about equal to a real-time distance D1 of the patient 106 from the AR headset 108. This distance may be comfortable for the user because it may avoid the user 104 from having to refocus his eyes when shifting his focus between the patient 106 and the virtual user interface 114, even as the user moves around the 3D space 102 and even as the user moves closer to and further away from the patient 106. In another

example, the AR headset 108 may be configured to display the virtual user interface 114 at a focal orientation that is oriented perpendicularly to a focal orientation 120 of the AR headset 108. This orientation may be comfortable for the user 104 because it may cause the virtual user interface 114 to constantly face the user 104 head-on regardless of the current focal orientation 120 of the AR headset 108, even as the user moves around the 3D space 102 and even as the user generally faces toward or faces away from the patient 106.

**[0032]** In some embodiments, the virtual spatial difference box 116 may be generated by the AR headset 108 to confine within a volume of the virtual spatial difference box 116 the projected inner layer of the patient 106 from the 3D data. For example, the projected bones 106b of the patient 106 may be confined within the virtual spatial difference box 116 in FIG. 1. In some embodiments, the virtual spatial difference box 116 may also assist the user when navigating the projected 3D data by providing a frame of reference for the user 104. For example, this frame of reference may assist the user when moving axial slices, coronal slices, sagittal slices, or oblique slices of the 3D data within the virtual spatial difference box 116. Slices may be two-dimensional (2D) slices and/or 3D slices. 3D slices may include curved slices, such as curved slices that follow the natural curve of an anatomical feature, or slices that have a depth as well as a height and width. The user 104 may move these slices using hand gestures that require the user 104 to generally move his hand in the directions of the lines of the virtual spatial difference box 116, so the display of the virtual spatial difference box 116 may make these hand movements easier for the user 104.

**[0033]** In some embodiments, the virtual inserted portion 118a of the object 118 may correspond to any portion of the object 118 that the user 104 wishes to insert into the patient 106 though an outer layer of the patient 106. For example, the object 118 may include, but is not limited to, a scalpel (as illustrated in FIG. 1), a scope, a drill, a probe, another medical instrument, or even

the hand of the user 104. Similar to the registration of the real-time position of the outer layer of the patient 106, the position of the outer layer of the object 118 may also be registered. However, unlike the patient 106, which may remain relatively still in the environment 100, the object 118 may be frequently moved in the environment 100, such that the real-time position of the object 118 may be automatically tracked in the 3D space 102 with respect to the registered positions of the outer layer of the patient 106. Then, in the event that the user 104 inserts some portion of the object 118 into the outer layer of the patient 106, the AR headset 108 may display a virtual inserted portion 118a of the object 118 projected into the projected inner layer of the patient 106 from the 3D data. In this manner, the virtual inserted portion 118a of the object 118 may be projected onto the real-time view of the user 104 even when the actual inserted portion of the object 118 is hidden from the real-time view of the user 104.

**[0034]** In some embodiments, the object 118 may be specifically designed to enable more accurate tracking of the object 118 by the AR headset 108. For example, where the object 118 is a relatively small medical instrument, such as a syringe with a needle, the object 118 may be enhanced to be more easily sensed by sensors of the AR headset 108. For example, these medical instruments may be sized larger to be more easily sensed (by a visual sensor for example), may be given a specific shape to be more easily sensed (such as by shaping the tip of the syringe to which the needle attaches as a sphere), may be made more visible to be more easily sensed (such as by adding a reflective strip or a light strip), or may be made from a material that is more easily sensed (such as by being made from metal to be more easily sensed by a metal detector sensor).

**[0035]** Further, in some embodiments, an attachment may be added to the object 118, such as to a handle of the object 118, to enable more accurate tracking of the object 118 by the AR headset 108. For example, the attachment may include any of the enhancements noted above to make the

attachment more easily sensed by sensors of the AR headset 108 and, by virtue of the attachment being attached to the object 118, thereby also making the object 118 more easily sensed by sensors of the AR headset 108. Further, the attachment may be designed to attach to the portion of the object 118 that is intended to be inserted into the patient 106, such as the tip of the object 118, so that sensors of the AR headset 108 can actually sense the attachment inside the patient 106. For example, a small magnetic-field-emitting attachment may be attached to a tip of the object 118, and a magnetic sensor of the AR headset 108 may then be able to sense the exact location of the attachment within the patient 106, thereby helping to improve the accuracy of the virtual inserted portion 118a displayed to the user 104.

**[0036]** In some embodiments, the virtual cursor 122 may be a virtual cursor generated by the AR headset 108 on the virtual user interface 114, on another virtual control, or at any other position in the 3D space 102. In some embodiments, the position of the virtual cursor 122 may correspond to the focal orientation 120 of the AR headset 108, which may correspond to the orientation of the head of the user 104. The virtual cursor 122 may be employed by the user 104 to select one or more options of the virtual user interface 114, sometimes in connection with one or more other actions by the user 104, such as a blink of the user's eyes, or one or more hand gestures of the user 104, such as the tapping together of two fingers in the field of view of the AR headset 108.

**[0037]** Modifications, additions, or omissions may be made to the environment 100 without departing from the scope of the present disclosure. For example, in some embodiments, multiple users each wearing an AR headset 108 may be simultaneously present in the 3D space 102 in order to simultaneously view the patient 106 augmented with 3D data of the patient 106. In another example, multiple patients may be simultaneously present in the 3D space 102 in order to allow the user 104 wearing the AR headset 108 to simultaneously view the multiple patients augmented

with 3D data of the patients. In another example, multiple users each wearing an AR headset 108 and multiple patients may simultaneously be present in the 3D space. In another example, video of the view from the AR headset 108 may be captured by the AR headset 108 and then sent to a remote location, such as to the server 112 over the network 110 or to a remote AR headset or Virtual Reality (VR) headset for viewing by another user. This example may enable the remote user to guide the local user 104 through a medical procedure on the patient 106. Further, although the environment 100 is generally disclosed to be in the context of a user 104 viewing a patient 106, it is understood that the environment 100 may be more broadly defined as any environment where a user wishes to view one or more inner layers of any object, such as a tree, a rock, an oilfield, or a planet.

**[0038]** In another example, the AR headset 108 may additionally or alternatively be controlled by the user 104 using voice commands. For example, the user 104 may employ voice commands because his hands are occupied with surgery or other medical treatment on the patient 106, and therefore controlling the AR headset 108 headset using hand gestures is not convenient. In this example, the voice commands may be employed to control the virtual user interface 114 (e.g., to select an option on the virtual user interface 114), the virtual spatial difference box 116 (e.g., to toggle between displaying and hiding the virtual spatial difference box 116 or to reposition slices of 3D data displayed in the virtual spatial difference box 116), or the virtual cursor 122 (e.g., to toggle between displaying and hiding the virtual cursor 122 projected onto the patient 106), or some combination thereof. Further, in this example, the voice commands may be employed separately from any other virtual controls. For example, voice commands may be employed to toggle between displaying and hiding, or to adjust the level of transparency of, the 3D data projected onto the patient 106, which may be useful while the user 104 is performing surgery on

the patient 106 and may allow the user 104 to only view the projected 3D data when it is needed and to avoid viewing the projected 3D data, or make the 3D data more transparent, when the 3D data becomes a distraction. In another example, controls of the AR headset 108, such as the virtual user interface 114, may present options to the user 104, at least in part, audibly. The audible presentation of options may allow the user 104 to first hear voice options (e.g., potential voice commands) before actually speaking voice commands. The audible presentation of options may also allow the user 104 to maintain the focal orientation 120 of the AR headset 108, and/or the visual focus of the user 104, on the patient 106 while still being able to interact with a virtual control that is not currently in his field of vision and/or that is currently hidden by the AR headset 108.

**[0039]** FIGS. 2A-2F are photographs of the AR environment 100 of FIG. 1 with a first patient. As disclosed in FIG. 2A, a user may wear an AR headset that augments a real-time view of the first patient with 3D data of the first patient. Also disclosed in FIG. 2A, the user may employ hand gestures in order to manipulate virtual controls of the AR headset. FIGS. 2B-2F disclose actual views from the perspective of the user wearing an AR headset. As disclosed in FIG. 2B, a user may employ a hand gesture in order to have an axial slice of 3D data representing a CT image of the patient's brain projected onto a real-time view of the first patient. As disclosed in FIG. 2C, a virtual spatial difference box may be employed by the user to view the same axial slice of the 3D data representing the CT image of the first patient's brain. As disclosed in FIG. 2D, as the user wearing the AR headset walks counter-clockwise around the first patient, the same axial slice of the 3D data representing the CT image of the first patient's brain may be viewed from different angles in the 3D space. As disclosed in FIGS. 2E and 2F, the user may manipulate one or more

options of a virtual user interface to change from viewing the axial slice to a sagittal slice, and then from the sagittal slice to a coronal slice, respectively.

**[0040]** FIG. 3 is a photograph of the AR environment of FIG. 1 in use with a second patient. In particular, FIG. 3 discloses an actual view from the perspective of the user wearing an AR headset. As disclosed in FIG. 3, the AR headset may update, in real-time, the displaying of a virtual user interface to cause the virtual user interface to be continually positioned at a focal distance from the AR headset that is about equal to the real-time distance of the second patient from the AR headset. Further, the AR headset may update, in real-time, the displaying of the virtual user interface to cause the virtual user interface to continually be oriented perpendicularly to the focal orientation of the AR headset.

**[0041]** FIGS. 4A-4B are photographs of the AR environment of FIG. 1 with a third patient. In particular, FIGS. 4A-4B disclose an actual view from the perspective of the user wearing an AR headset. As disclosed in a comparison of FIGS. 4A and 4B, the AR headset may be configured to display the virtual user interface projected onto a real-time view (as disclosed in FIG. 4B) while a focal orientation of the AR headset is not focused on the third patient, but then hide the virtual user interface while the focal orientation of the AR headset is focused on the third patient. In this manner, the AR headset may avoid the virtual user interface from obstructing the view of the third patient. In some embodiments, and since the third patient is generally positioned below a horizontal view, the AR headset may avoid the virtual user interface from obstructing the view of the third patient by displaying the virtual user interface when the focal orientation of the AR headset is above horizontal and by hiding the virtual user interface when the focal orientation of the AR headset is at or below horizontal. In these embodiments, the user can view the virtual user interface by simply looking up at any time while wearing the AR headset.

**[0042]** As disclosed in the photographs of FIGS. 2A-4B, the projected inner layers of the 3D data of the three patients may be colored using color gradients that represent tissue properties and that are altered, from standard color gradients, to be visible when projected onto the real-time views of the outer layer of the three patients. For example, in some embodiments where the 3D data includes one or more of CT scan images and X-ray images, the tissue properties represented by the color gradient may include tissue hardness ranging from softest tissue to hardest tissue. In other embodiment, the tissue properties represented by the color gradient may include, but are not limited to, one or more of relaxivity, echogenicity, enhancement amount, enhancement speed, density, radioactivity, and water content. In order for the color gradient to be easily visible by the user wearing the AR headset, the color gradient may be altered to be lighter in color than standard color gradients used on computer displays since darker color gradients may blend into the view of the patient when projected onto the patient.

**[0043]** FIG. 5 illustrates an example computer system 500 that may be employed in augmenting views of a patient with 3D data. In some embodiments, the computer system 500 may be part of any of the systems or devices described in this disclosure. For example, the computer system 500 may be part of any of the AR headset 108 or the server 112 of FIG. 1.

**[0044]** The computer system 500 may include a processor 502, a memory 504, a file system 506, a communication unit 508, an operating system 510, a user interface 512, and an AR module 514, which all may be communicatively coupled. In some embodiments, the computer system 500 may be, for example, a desktop computer, a client computer, a server computer, a mobile phone, a laptop computer, a smartphone, a smartwatch, a tablet computer, a portable music player, an embedded computer, an AR headset, a VR headset, or any other computer system.

**[0045]** Generally, the processor 502 may include any suitable special-purpose or general-purpose computer, computing entity, or processing device including various computer hardware or software modules and may be configured to execute instructions stored on any applicable computer-readable storage media. For example, the processor 502 may include a microprocessor, a microcontroller, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), a Field-Programmable Gate Array (FPGA), or any other digital or analog circuitry configured to interpret and/or to execute program instructions and/or to process data, or any combination thereof. In some embodiments, the processor 502 may interpret and/or execute program instructions and/or process data stored in the memory 504 and/or the file system 506. In some embodiments, the processor 502 may fetch program instructions from the file system 506 and load the program instructions into the memory 504. After the program instructions are loaded into the memory 504, the processor 502 may execute the program instructions. In some embodiments, the instructions may include the processor 502 performing one or more blocks of the method 600 of FIGS. 6A-6E.

**[0046]** The memory 504 and the file system 506 may include computer-readable storage media for carrying or having stored thereon computer-executable instructions or data structures. Such computer-readable storage media may be any available non-transitory media that may be accessed by a general-purpose or special-purpose computer, such as the processor 502. By way of example, and not limitation, such computer-readable storage media may include non-transitory computer-readable storage media including Read-Only Memory (ROM), Electrically Erasable Programmable Read-Only Memory (EEPROM), Compact Disc Read-Only Memory (CD-ROM) or other optical disk storage, magnetic disk storage or other magnetic storage devices, flash memory devices (e.g., solid state memory devices), or any other storage media which may be used

to carry or store desired program code in the form of computer-executable instructions or data structures and which may be accessed by a general-purpose or special-purpose computer. Combinations of the above may also be included within the scope of computer-readable storage media. Computer-executable instructions may include, for example, instructions and data configured to cause the processor 502 to perform a certain operation or group of operations, such as one or more blocks of the method 600 of FIGS. 6A-6E. These computer-executable instructions may be included, for example, in the operating system 510, in one or more applications, such as the AR module 514, or in some combination thereof.

**[0047]** The communication unit 508 may include any component, device, system, or combination thereof configured to transmit or receive information over a network, such as the network 110 of FIG. 1. In some embodiments, the communication unit 508 may communicate with other devices at other locations, the same location, or even other components within the same system. For example, the communication unit 508 may include a modem, a network card (wireless or wired), an infrared communication device, a wireless communication device (such as an antenna), and/or chipset (such as a Bluetooth device, an 802.6 device (e.g., Metropolitan Area Network (MAN)), a WiFi device, a WiMax device, a cellular communication device, etc.), and/or the like. The communication unit 508 may permit data to be exchanged with a network and/or any other devices or systems, such as those described in the present disclosure.

**[0048]** The operating system 510 may be configured to manage hardware and software resources of the computer system 500 and may be configured to provide common services for the computer system 500.

**[0049]** The user interface 512 may include any device configured to allow a user to interface with the computer system 500. For example, the user interface 512 may include a display, such as

an LCD, LED, or other display, such as an AR lens, that is configured to present video, text, application user interfaces, and other data as directed by the processor 502. The user interface 512 may further include a mouse, a track pad, a keyboard, a touchscreen, volume controls, other buttons, a speaker, a microphone, a camera, any peripheral device, or other input or output device. The user interface 512 may receive input from a user and provide the input to the processor 502. Similarly, the user interface 512 may present output to a user.

**[0050]** The AR module 514 may be one or more computer-readable instructions stored on one or more non-transitory computer-readable media, such as the memory 504 or the file system 506, that, when executed by the processor 502, is configured to perform one or more methods, such as one or more of the blocks of the method 600 of FIGS. 6A-6E. In some embodiments, the AR module 514 may be part of the operating system 510 or may be part of an application of the computer system 500, or may be some combination thereof.

**[0051]** Modifications, additions, or omissions may be made to the computer system 500 without departing from the scope of the present disclosure. For example, although each is illustrated as a single component in FIG. 5, any of the components 502-514 of the computer system 500 may include multiple similar components that function collectively and are communicatively coupled. Further, although illustrated as a single computer system, it is understood that the computer system 500 may include multiple physical or virtual computer systems that are networked together, such as in a cloud computing environment, a multitenancy environment, or a virtualization environment.

**[0052]** FIGS. 6A-6E are a flowchart of an example method 600 for augmenting views of a patient with 3D data. The method 600 may be performed, in some embodiments, by a device or system, such as by the AR module 514 of FIG. 5 executing on the AR headset 108 and/or on the

server 112 of FIG. 1. In these and other embodiments, the method 600 may be performed by one or more processors based on one or more computer-readable instructions stored on one or more non-transitory computer-readable media. The method 600 will now be described in connection with FIGS. 1, 2A-2F, 3, 4A-4B, 5, and 6A-6E. Although the method 600 is described below as being performed by an AR headset, it is understood that the method 600 may alternatively be performed by another computer system or combination of computer systems.

**[0053]** At block 602, an AR headset may identify 3D data for a patient. For example, the AR headset 108 of FIG. 1 may identify, at block 602, 3D data for the patient 106.

**[0054]** In some embodiments, 3D data for the patient 106 of FIG. 1 may be captured or generated using one or more methods, either in real-time while the patient 106 is in the environment 100 and/or prior to the patient 106 entering the environment 100. For example, some of the 3D data may be obtained prior to the patient 106 entering the environment 100, and then the 3D data may be augmented with additional 3D data that is obtained in real-time while the patient 106 in in the environment 100. For example, 3D data of the patient 106 may include, but is not limited to, MRI images, Computerized Tomography (CT) scan images, X-ray images, Positron Emission Tomography (PET) images, ultrasound images, fluorescence images, Infrared Thermography (IRT) images, or Single-Photon Emission Computed Tomography (SPECT) scan image, or some combination thereof. Any of these images may be in the form of still images or video images. For example, the method 600 may employ still X-ray images of the skeletal system of the patient 106 (as illustrated in FIG. 1). In another example, the method 600 may employ video images of an ultrasound of a beating heart of the patient 106. In another example, the method 600 may be capable of toggling between a still image of the heart and a real-time video of the heart beating.

**[0055]** Although obtained using a variety of different methods, 3D data for a patient may, in some embodiments, include an outer layer of the patient and multiple inner layers of the patient. For example, the outer layer of the patient 106 of FIG. 1 may include the skin 106a of the patient 106 and/or the clothing 107 worn by the patient 106 in FIG. 1. In another example, the outer layer of a cadaver may be a tissue layer other than skin, such as a layer of muscle or fat, where the skin has been removed from the cadaver. The inner layers of the patient 106 may include, but are not limited to, interior bones 106b (as illustrated in FIG. 1), muscles, organs, or fluids of the patient 106. 3D data may include a 2D image, such as an X-ray image, because when the 2D image is projected into a 3D space the 2D image has 3D significance. For example, 3D data for the patient 106 may include a 2D X-ray image that may be projected onto the skin 106a or the clothing 107 of the patient 106. 3D data may also include a time element, which is sometimes referred to as four-dimensional (4D) data. For example, 3D data may include video that includes not only 3D images, but also include 3D images changing over time. The multiple inner layers may be layers that go all the way through the patient 106, or may be layers that only go to a certain partial depth into the patient 106. For example, some forms of 3D data, such as 3D data derived from a millimeter wave scanner, may only be configured to reveal items stored between the outer clothing and the skin of a patient. The 3D data may additionally or alternatively be data that only generally corresponds to the patient 106, instead of specifically corresponding to the patient 106, such as 3D data derived from a preset anatomy atlas. The 3D data may also be a combination of various types of 3D data.

**[0056]** In some embodiments, care may be taken to position the patient 106 of FIG. 1 on the operating table 103 in the same relative position and/or orientation that the patient 106 was in when the 3D data was captured. Alternatively, when the patient 106 is positioned in a different position

and/or orientation on the operating table 103 than the patient 106 was in when the 3D data was captured or generated, the AR headset 108 may deform the 3D data to match the different position and/or orientation of the patient 106.

**[0057]** At block 604, an AR headset may determine virtual morphometric measurements of the outer layer of the patient from the 3D data. For example, the AR headset 108 of FIG. 1 may determine, at block 604, virtual morphometric measurements of the outer layer of the patient 106 from the 3D data. The determining of these virtual morphometric measurements may involve the AR headset 108 analyzing the 3D data in order to determine the size and shape of the outer layer of the patient from the 3D data. In some embodiments, the virtual morphometric measurements of the outer layer may involve generating a point cloud of the outer layer that represents the size and shape of the outer layer. For example, where the outer layer is represented by triangles or other polygonal shapes, the point cloud may include some or all of the vertices of the polygonal shapes.

**[0058]** At block 606, an AR headset may register a real-time position of the outer layer of the patient in a 3D space. For example, the AR headset 108 of FIG. 1 may register, at block 606, a real-time position of the skin 106a and clothing 107 of the patient 106 in the 3D space 102. In some embodiments, the AR headset 108 may include one or more sensors that are configured to map the 3D space 102, and map the real-time position of the outer layer of the patient 106 within the 3D space 102. These sensors may include, but are not limited to, infrared sensors, sound sensors, photographic sensors, fluoroscopy sensors, accelerometers, gyroscopes, or magnetometers.

**[0059]** At block 608, an AR headset may determine real-time morphometric measurements of the outer layer of the patient. For example, the AR headset 108 of FIG. 1 may determine, at block 608, real-time morphometric measurements of the skin 106a and clothing 107 of the patient 106.

In some embodiments, the sensors employed in the registration at block 606 may also be employed to determine the real-time size and shape of the skin 106a and clothing 107 of the patient 106. In some embodiments, this may involve generating a point cloud of the skin 106a and clothing 107 of the patient 106 that represents the size and shape of the skin 106a and clothing 107.

**[0060]** At block 610, an AR headset may automatically register the position of the outer layer of the patient from the 3D data to align with the registered real-time position of the outer layer of the patient in the 3D space. For example, the AR headset 108 of FIG. 1 may automatically register, at block 610, the position of the outer layer of the patient 106 from the 3D data to align with the registered real-time position of the skin 106a and clothing 107 of the patient 106 in the 3D space 102. In some embodiments, this automatic registration may include automatically aligning the point cloud generated at block 604 with the point cloud generated at block 608 using point set registration. The automatic registration at block 610 may be less time consuming, less cumbersome, and less error-prone than manual methods of aligning an outer layer of a patient from 3D data with a real-time outer layer of the patient. Further, in some embodiments, the block 610 may be performed without using any non-anatomical fiducial, which may avoid the time consuming, cumbersome, and inaccurate placement of non-anatomical fiducials.

**[0061]** At block 612, an AR headset may display one of the inner layers of the patient from the 3D data projected onto real-time views of the outer layer of the patient. For example, the AR headset 108 of FIG. 1 may display, at block 612, the bones 106b of the patient 106 from the 3D data projected onto real-time views of the skin 106a and clothing 107 of the patient 106. In another example, a CT scan image of the brain of the patient is projected onto the top of the head of the patient in FIGS. 2B and 2C, or onto the side of the head of the patient in FIG. 2E.

**[0062]** At block 614, an AR headset may generate a confidence score that the automatic registration is correct and, at block 616, an AR headset may present the confidence score to a user. For example, the AR headset 108 of FIG. 1 may generate, at block 614, a confidence score that the automatic registration that was performed at block 612 is correct and present the confidence score to the user 104 visually, audibly, or in some other presentation format. In some embodiments, the AR headset 108 may generate this confidence score as part of the point set registration performed at block 612. For example, the confidence score may be a score between 0% and 100% indicating the level of confidence that the outer layer of the 3D data matches the outer layer of the patient 106. Where the confidence score is relatively high, the user 104 may proceed with training, research, diagnosis, or treatment on the patient 106 using the AR headset 108 with confidence that the 3D data being projected onto the patient 106 does, in reality, correspond to the patient 106. On the other hand, where the confidence score is relatively low, the user 104 may halt any training, research, diagnosis, or treatment on the patient 106 using the AR headset 108 because there may be legitimate doubts as to whether the 3D data being projected onto the patient 106 does, in reality, correspond to the patient 106.

**[0063]** At block 618, an AR headset may determine real-time morphometric measurements of an object prior to insertion of the object into the patient through the outer layer of the patient. For example, the AR headset 108 of FIG. 1 may determine, at block 618, real-time morphometric measurements of the object 118 prior to insertion of the object 118 into the patient 106 through the outer layer of the patient 106. In some embodiments, the determination at block 618 may be performed in a manner similar to the determination at block 608. In other embodiments, especially for a standard object, such as a standard medical instrument, the determination at block 618 may

be performed by accessing morphometric measurements of the standard object found in design documents for the standard object.

**[0064]** At block 622, an AR headset may track a real-time position of the object in the 3D space with respect to the registered positions of the outer layer of the patient in the 3D space and with respect to the registered position of the outer layer of the patient from the 3D data. For example, the AR headset 108 of FIG. 1 may automatically track, at block 622, the real-time position of the object 118 in the 3D space 102 with respect to the registered position of the skin 106a and the clothing 107 of the patient 106 in the 3D space 102 and with respect to the registered position of the outer layer of the patient 106 from the 3D data.

**[0065]** At block 624, while a portion of the object is inserted into the patient through the outer layer of the patient, an AR headset may display a virtual portion of the object projected into the projected inner layer of the patient from the 3D data. For example, while a portion of the object 118 of FIG. 1 is inserted into the patient 106 through the clothing 107 of the patient 106, the AR headset 108 may display a virtual inserted portion 118b of the object 118 projected into the projected bones 106b of the patient 106 from the 3D data.

**[0066]** At block 626, an AR headset may display a virtual spatial difference box projected onto real-time views of the patient. For example, the AR headset 108 of FIG. 1 may display, at block 626, the virtual spatial difference box 116 projected onto real-time views of the patient 106. In some embodiments, the virtual spatial difference box 116 may confine within a volume of the virtual spatial difference box 116 the projected inner layer of the patient 106 from the 3D data, such as the projected bones 106b of FIG. 1.

**[0067]** At block 628, an AR headset may generate a virtual user interface that includes options for altering the display of the projected inner layer of the patient from the 3D data. For example,

the AR headset 108 of FIG. 1 may generate, at block 628, the virtual user interface 114 that includes options for altering the display of the projected bones 106b of the patient 106 from the 3D data.

**[0068]** At block 630, an AR headset may display the virtual user interface projected onto real-time views while a focal orientation of the AR headset is not focused on the patient. For example, the AR headset 108 of FIG. 1 may display, at block 630, the virtual user interface 114 projected onto real-time views while the focal orientation 120 of the AR headset 108 is not focused on the patient 106.

**[0069]** At block 632, an AR headset may hide the virtual user interface while the focal orientation of the AR headset is focused on the patient. For example, the AR headset 108 of FIG. 1 may hide, at block 632, the virtual user interface 114 while the focal orientation 120 of the AR headset 108 is focused on the patient 106. In some embodiments, blocks 630 and 632 may avoid the virtual user interface 114 from obstructing any view of the patient 106.

**[0070]** At block 634, an AR headset may determine a real-time distance of the patient from the AR headset. For example, the AR headset 108 of FIG. 1 may determine, at block 634, the real-time distance D1 of the patient 106 from the AR headset 108. This real-time distance D1 may be, for example, the real-time distance to the center of the patient 106, to the center of an area of focus of the patient 106, to a slice of the 3D data currently being viewed on the patient 106, or some other point or general area on the patient 106.

**[0071]** At block 636, an AR headset may update, in real-time, the display of the virtual user interface to cause the virtual user interface to be continually positioned at a focal distance from the AR headset that is about equal to the real-time distance of the patient from the AR headset. For example, the AR headset 108 of FIG. 1 may update, in real-time, at block 636, the display of the

virtual user interface 114 to cause the virtual user interface 114 to be continually positioned at a focal distance D2 from the AR headset 108 that is about equal to the real-time distance D1 of the patient 106 from the AR headset 108. This focal distance D2 may be comfortable for the user 104 because it may avoid the user 104 having to change the focus of his eyes when shifting his focus between the patient 106 and the virtual user interface 114.

**[0072]** At block 638, an AR headset may update, in real-time, the display of the virtual user interface to cause the virtual user interface to continually be oriented perpendicularly to the focal orientation of the AR headset. For example, the AR headset 108 of FIG. 1 may update, in real-time, at block 638, the display of the virtual user interface 114 to cause the virtual user interface 114 to continually be oriented perpendicularly to the focal orientation 120 of the AR headset 108. Where the virtual user interface 114 is positioned above the AR headset 108, as disclosed in FIG. 1, orienting the virtual user interface 114 perpendicularly to the AR headset 108 may cause the top of the virtual user interface 114 to be tilted slightly downward toward the AR headset 108, as disclosed in FIG. 1. This orientation may be comfortable for the user 104 because it may cause the virtual user interface 114 to constantly face the user 104 head-on regardless of the current focal orientation 120 of the AR headset 108 and regardless of where the user 104 is standing in the 3D space 102.

**[0073]** At block 640, an AR headset may display a virtual cursor projected onto real-time views and/or onto the virtual user interface while a focal orientation of the AR headset is not focused on the patient. For example, the AR headset 108 of FIG. 1 may display, at block 640, the virtual cursor 122 projected onto real-time views and/or onto the virtual user interface 114 while the focal orientation 120 of the AR headset 108 is not focused on the patient 106.

**[0074]** At block 642, an AR headset may hide the virtual cursor while a focal orientation of the AR headset is focused on the patient. For example, the AR headset 108 of FIG. 1 may hide, at block 642, the virtual cursor 122 while the focal orientation 120 of the AR headset 108 is focused on the patient 106. In some embodiments, blocks 640 and 642 may avoid the virtual cursor 122 from obstructing any view of the patient 106. In some embodiment, the AR headset 108 of FIG. 1 may only selectively hide, at block 642, the virtual cursor 122 while the focal orientation 120 of the AR headset 108 is focused on the patient 106. In these embodiments, there may be situations where the user 104 may desire to use the virtual cursor 122 while the focal orientation 120 of the AR headset 108 is focused on the patient 106, such as when the user 104 is using an annotation tool to annotate the view of the patient 106 and/or to annotate the projected 3D data (e.g., a cross-hairs annotation that may remain projected on the patient 106 even when other 3D data has been hidden, for example, to assist in keeping track of a location of interest during surgery), or when the user 104 is using a measuring tool to make a measurement of the view of the patient 106 and/or to measure the projected 3D data.

**[0075]** In some embodiments, the method 600 may accomplish automatic alignment between 3D data of a patient and the actual patient. Further, this automatic alignment may be accomplished without manual alignment and/or without manual placement of non-anatomical fiducials, thus achieving automatic alignment more easily and more accurately that conventional forms of manual alignment.

**[0076]** Although the blocks of the method 600 are illustrated in FIGS. 6A-6E as discrete blocks, various blocks may be divided into additional blocks, combined into fewer blocks, reordered, expanded, or eliminated, depending on the desired implementation. For example, in some embodiments, blocks 602-612 may be performed without performing any of blocks 614-642.

Further, in some embodiments, only blocks 602 and 612 may be performed, without blocks 604-610, such as where the registration and alignment between the patient and the 3D data is performed manually instead of automatically, in connection with any of blocks 614-616, 618-624, 626, or 628-642. Further, in some embodiments, blocks 628-632 may be performed without blocks 634-642. Also, in some embodiments, blocks 628-636 may be performed without blocks 638-642, blocks 628-632 and 638 may be performed without blocks 634-636 and 640-642, or blocks 628-632 and 640-642 may be performed without block 634-638. Further, in some embodiments, any of the blocks 614-642 may be performed in parallel.

**[0077]** In another example, the method 600 may further include dealing with the problem of automatic registration either before or after a patient is covered in surgical draping. For example, block 610 may be performed prior to covering a patient in surgical draping, and then the 3D data may be projected at block 612 onto the surgical draping. However, if block 610 is performed after a patient is covered in surgical draping, the method 600 may be modified to deal with the problem of the surgical draping obscuring a suitable outer layer of the patient. One such modification to the method 600 may include employing surgical draping that is sufficiently transparent that the AR headset can penetrate the surgical draping and find a more suitable outer layer of the patient. Another such modification may include placing visual markers on the outer layer of the patient in positions (such as in a particular pattern) that will remain visible after surgical draping and that can be noted during block 612. Then, even when large portions of the patient are covered in relatively opaque surgical draping, as long as the visual markers are still visible, an automatic re-registration can be performed using the visual markers as reference points. Another such modification includes placing extra-visual markers on the outer layer or the patient, or possibly inside the patient, in positions (such as in a particular pattern) that will not remain visible after

surgical draping but that can be noted during block 612, either because they are visible during block 612 or because they are sensed by a sensor during block 612. These extra-visual markers may be made of a material that can be detected underneath the surgical draping by sensors in the AR headset, even though the extra-visual makers are not visible to the AR headset. For example, a metal detector sensor may detect metallic extra-visual markers (such as metallic mesh markers or a metallic marker inserted under the skin or into a body cavity), an infrared sensor may detect infrared-detectible extra-visual markers, a magnetic detector sensor may detect magnetic-field-emitting extra-visual markers, or a radio frequency detector may detect radio-frequency-emitting extra-visual markers. Then, even when large portions of the patient are covered in relatively opaque surgical draping, as long as the sensors in the AR headset are able to detect the positions of the extra-visual markers underneath the surgical draping, an automatic re-registration can be performed using the extra-visual markers as reference points.

**[0078]** Further, it is understood that the method 600 may improve the functioning of an AR system itself and may improve the field of AR. For example, the functioning of the AR headset 108 of FIG. 1 may itself be improved by the method 600 by automatically registering a virtual position of the outer layer of the patient 106 from the 3D data to align with the registered real-time position of the outer layer (e.g. skin 106a and clothing 107) of the patient 106 in the 3D space 102 using the virtual morphometric measurements and using the real-time morphometric measurements and, in some instances, without using any non-anatomical fiducial. This automatic registration may be performed more easily and more accurately than conventional AR systems which employ manual registration or registration using manual placement of non-anatomical fiducials.



Medivis Exhibit 1002

**[0079]** As indicated above, the embodiments described herein may include the use of a special purpose or general purpose computer (e.g., the processor 502 of FIG. 5) including various computer hardware or software modules, as discussed in greater detail below. Further, as indicated above, embodiments described herein may be implemented using computer-readable media (e.g., the memory 504 or file system 506 of FIG. 5) for carrying or having computer-executable instructions or data structures stored thereon.

**[0080]** In some embodiments, the different components and modules described herein may be implemented as objects or processes that execute on a computing system (e.g., as separate threads). While some of the methods described herein are generally described as being implemented in software (stored on and/or executed by general purpose hardware), specific hardware implementations or a combination of software and specific hardware implementations are also possible and contemplated.

**[0081]** In accordance with common practice, the various features illustrated in the drawings may not be drawn to scale. The illustrations presented in the present disclosure are not meant to be actual views of any particular apparatus (e.g., device, system, etc.) or method, but are merely example representations that are employed to describe various embodiments of the disclosure. Accordingly, the dimensions of the various features may be arbitrarily expanded or reduced for clarity. In addition, some of the drawings may be simplified for clarity. Thus, the drawings may not depict all of the components of a given apparatus (e.g., device) or all operations of a particular method.

**[0082]** Terms used herein and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as "open" terms (e.g., the term "including" should be interpreted as

"including, but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes, but is not limited to," etc.).

**[0083]** Additionally, if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to embodiments containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations.

**[0084]** In addition, even if a specific number of an introduced claim recitation is explicitly recited, it is understood that such recitation should be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, etc." or "one or more of A, B, and C, etc." is used, in general such a construction is intended to include A alone, B alone, C alone, A and B together, A and C together, B and C together, or A, B, and C together, etc. For example, the use of the term "and/or" is intended to be construed in this manner.

**[0085]** Further, any disjunctive word or phrase presenting two or more alternative terms, whether in the summary, detailed description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For

example, the phrase "A or B" should be understood to include the possibilities of "A" or "B" or "A and B."

**[0086]** Additionally, the use of the terms "first," "second," "third," etc., are not necessarily used herein to connote a specific order or number of elements. Generally, the terms "first," "second," "third," etc., are used to distinguish between different elements as generic identifiers. Absence a showing that the terms "first," "second," "third," etc., connote a specific order, these terms should not be understood to connote a specific order. Furthermore, absence a showing that the terms first," "second," "third," etc., connote a specific number of elements, these terms should not be understood to connote a specific number of elements. For example, a first widget may be described as having a first side and a second widget may be described as having a second side. The use of the term "second side" with respect to the second widget may be to distinguish such side of the second widget from the "first side" of the first widget and not to connote that the second widget has two sides.

**[0087]** The foregoing description, for purpose of explanation, has been described with reference to specific embodiments. However, the illustrative discussions above are not intended to be exhaustive or to limit the invention as claimed to the precise forms disclosed. Many modifications and variations are possible in view of the above teachings. The embodiments were chosen and described to explain practical applications, to thereby enable others skilled in the art to utilize the invention as claimed and various embodiments with various modifications as may be suited to the particular use contemplated.

CLAIMS

1. A method for augmenting real-time, non-image actual views of a patient with three-dimensional (3D) data, the method comprising:

identifying 3D data for the patient, the 3D data including an outer layer of the patient and multiple inner layers of the patient; and

displaying, in an augmented reality (AR) headset, one of the inner layers of the patient from the 3D data projected onto real-time, non-image actual views of the outer layer of the patient, the projected inner layer of the patient from the 3D data being confined within a volume of a virtual 3D shape.

2. The method as recited in claim 1, wherein:

the virtual 3D shape is a virtual box; and

the virtual box includes a top side, a bottom side, a left side, a right side, a front side, and a back side.

3. The method of claim 1, wherein:

the virtual 3D shape is configured to be controlled to toggle between displaying and hiding lines of the virtual 3D shape; and

the virtual 3D shape is configured to be controlled to reposition two-dimensional (2D) slices and/or 3D slices of the projected inner layer of the patient from the 3D data.

4. The method of claim 1, wherein lines of the virtual 3D shape are displayed.

5. The method of claim 1, wherein lines of the virtual 3D shape are hidden.

6. One or more non-transitory computer-readable media storing one or more programs that are configured, when executed, to cause one or more processors to perform the method as recited in claim 1.

7. A method for augmenting real-time, non-image actual views of a patient with three-dimensional (3D) data, the method comprising:

identifying 3D data for the patient, the 3D data including an outer layer of the patient and multiple inner layers of the patient;

displaying, in an augmented reality (AR) headset, one of the inner layers of the patient from the 3D data projected onto real-time, non-image actual views of the outer layer of the patient;

automatically tracking a real-time position of a medical instrument with respect to a real-time position of the outer layer of the patient; and

while a portion of the medical instrument is inserted into the patient through the outer layer of the patient, displaying, in the AR headset, a virtual portion of the medical instrument projected into the projected inner layer of the patient.

8. The method as recited in claim 7, wherein:

the medical instrument is formed from a material that a sensor of the AR headset is able to sense even after the medical instrument has been inserted into the patient through the outer layer of the patient; and

the automatically tracking includes the sensor of the AR headset automatically tracking the real-time position of the medical instrument with respect to the real-time position of the outer layer of the patient.

9. The method as recited in claim 7, wherein:

the medical instrument further includes an attachment attached thereto that is formed from a material that a sensor of the AR headset is able to sense even after the attachment has been inserted into the patient through the outer layer of the patient; and

the automatically tracking includes the sensor of the AR headset automatically tracking the real-time position of the attachment with respect to the real-time position of the outer layer of the patient.

10. One or more non-transitory computer-readable media storing one or more programs that are configured, when executed, to cause one or more processors to perform the method as recited in claim 7.

11. A method for augmenting real-time, non-image actual views of a patient with three-dimensional (3D) data, the method comprising:

identifying 3D data for the patient, the 3D data including an outer layer of the patient and multiple inner layers of the patient, the multiple inner layers of the patient having an original color gradient;

altering the original color gradient of the multiple inner layers to be lighter than the original color gradient in order to be better visible when projected onto real-time, non-image actual views of the outer layer of the patient; and

displaying, in an augmented reality (AR) headset, one of the inner layers of the patient from the 3D data projected onto real-time, non-image actual views of the outer layer of the patient, the projected inner layer of the patient from the 3D data being having the altered color gradient.

12. The method as recited in claim 11, wherein the altered color gradient represents a tissue hardness tissue property of the multiple inner layers of the patient.

13. The method as recited in claim 11, wherein the altered color gradient represents a tissue relaxivity tissue property of the multiple inner layers of the patient.

14. The method as recited in claim 11, wherein the altered color gradient represents a tissue echogenicity tissue property of the multiple inner layers of the patient.

15. The method as recited in claim 11, wherein the altered color gradient represents a tissue enhancement amount tissue property of the multiple inner layers of the patient.

16. The method as recited in claim 11, wherein the altered color gradient represents a tissue enhancement speed tissue property of the multiple inner layers of the patient.

17. The method as recited in claim 11, wherein the altered color gradient represents a tissue density tissue property of the multiple inner layers of the patient.

18. The method as recited in claim 11, wherein the altered color gradient represents a tissue radioactivity tissue property of the multiple inner layers of the patient.

19. The method as recited in claim 11, wherein the altered color gradient represents a tissue water content tissue property of the multiple inner layers of the patient.

20. One or more non-transitory computer-readable media storing one or more programs that are configured, when executed, to cause one or more processors to perform the method as recited in claim 11.

ABSTRACT

Augmenting real-time views of a patient with three-dimensional (3D) data. In one embodiment, a method may include identifying 3D data for a patient with the 3D data including an outer layer and multiple inner layers, determining virtual morphometric measurements of the outer layer from the 3D data, registering a real-time position of the outer layer of the patient in a 3D space, determining real-time morphometric measurements of the outer layer of the patient, automatically registering the position of the outer layer from the 3D data to align with the registered real-time position of the outer layer of the patient in the 3D space using the virtual morphometric measurements and using the real-time morphometric measurements, and displaying, in an augmented reality (AR) headset, one of the inner layers from the 3D data projected onto real-time views of the outer layer of the patient.

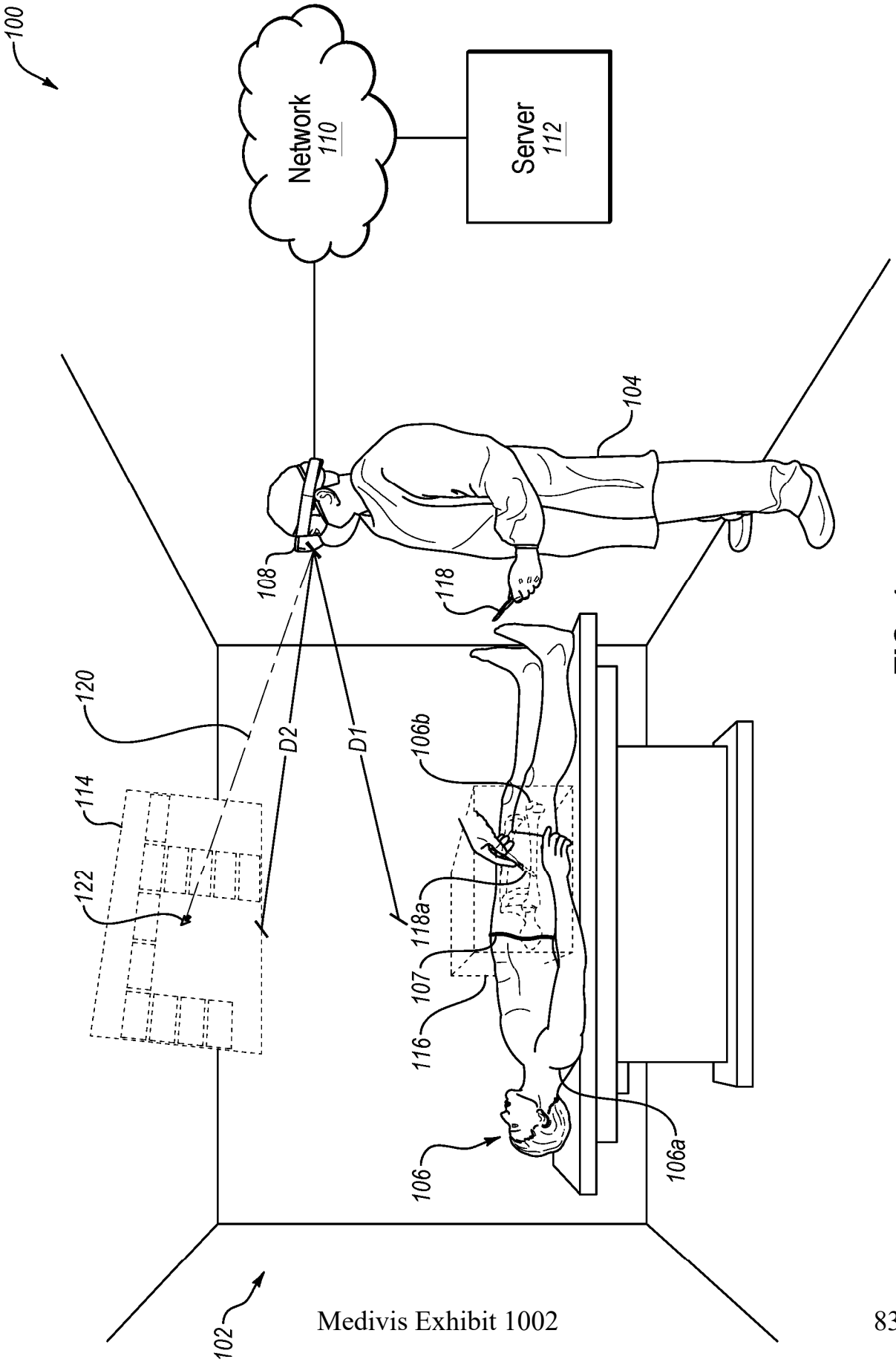

100
Network
110
Server
112
104
108
118
120
D2
D1
106b
114
122
118a
107
116
106
106a
102

FIG. 1

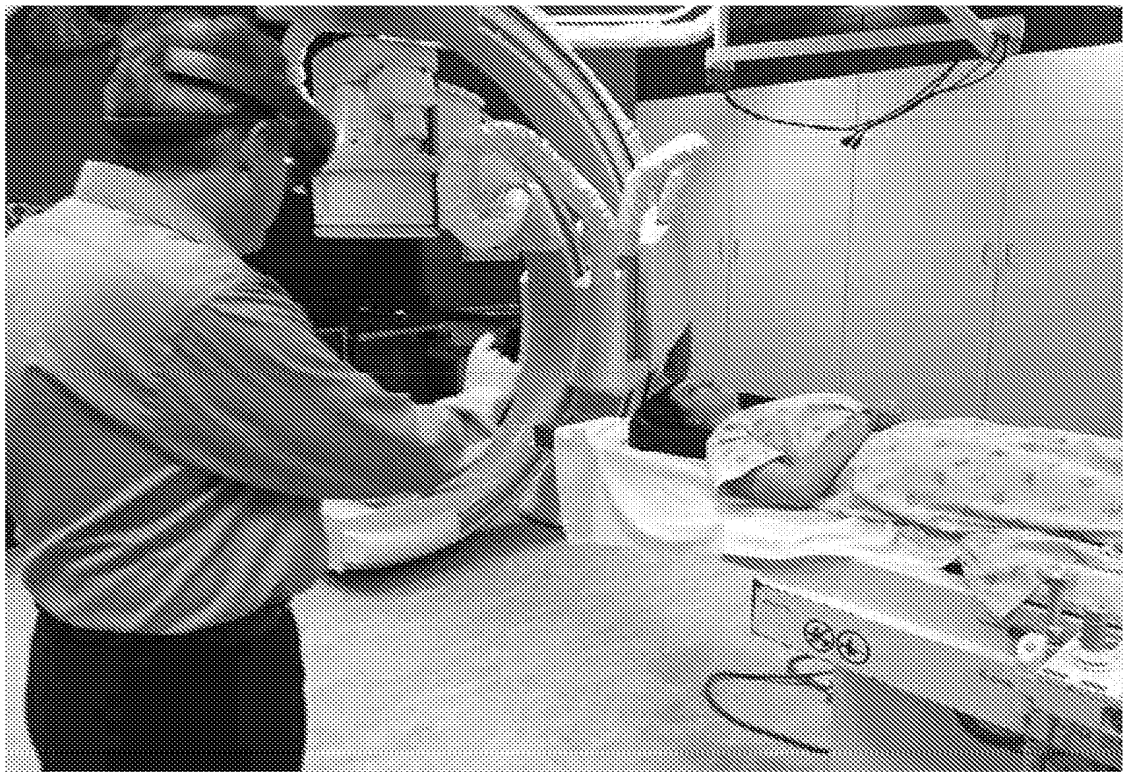


FIG. 2A

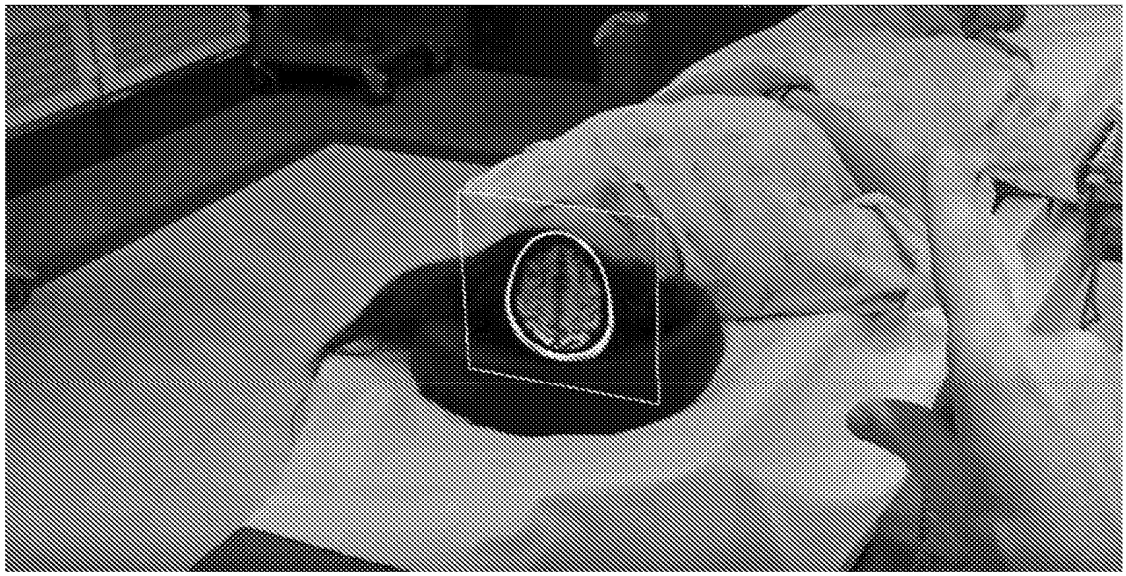


FIG. 2B

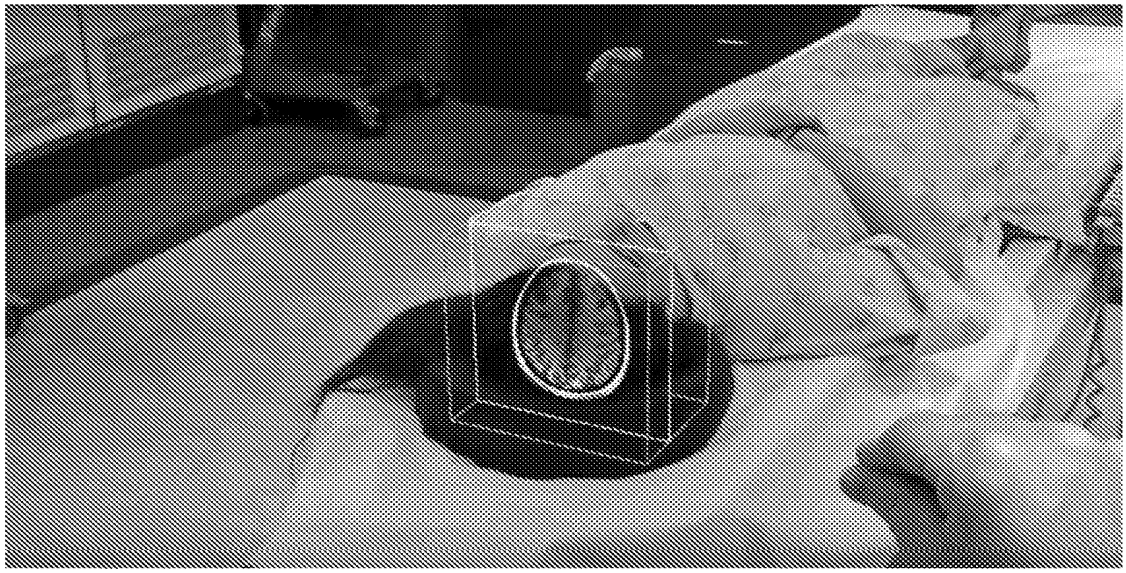


FIG. 2C

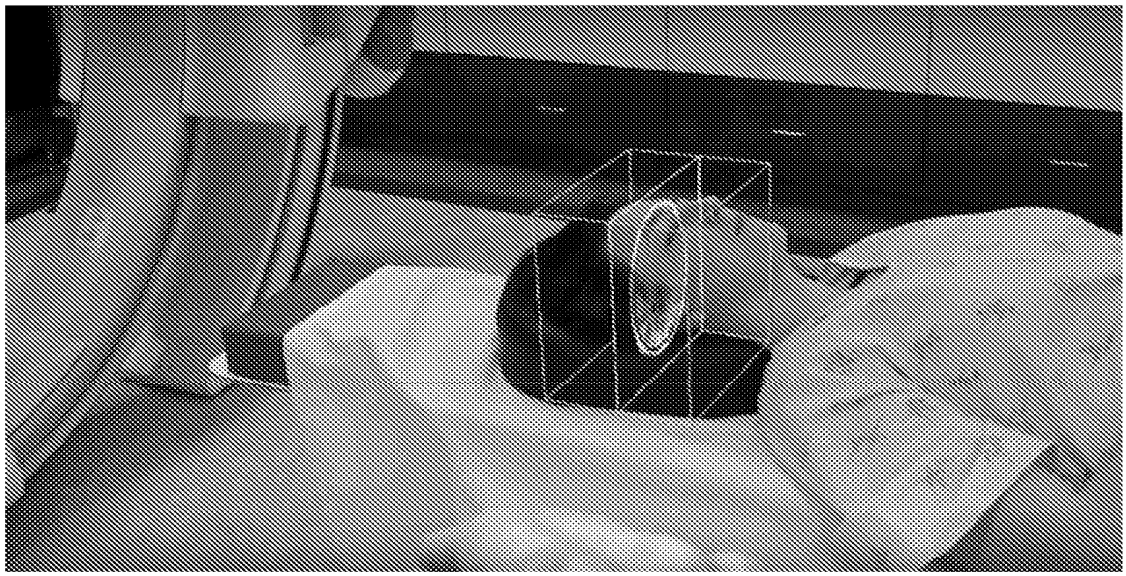


FIG. 2D

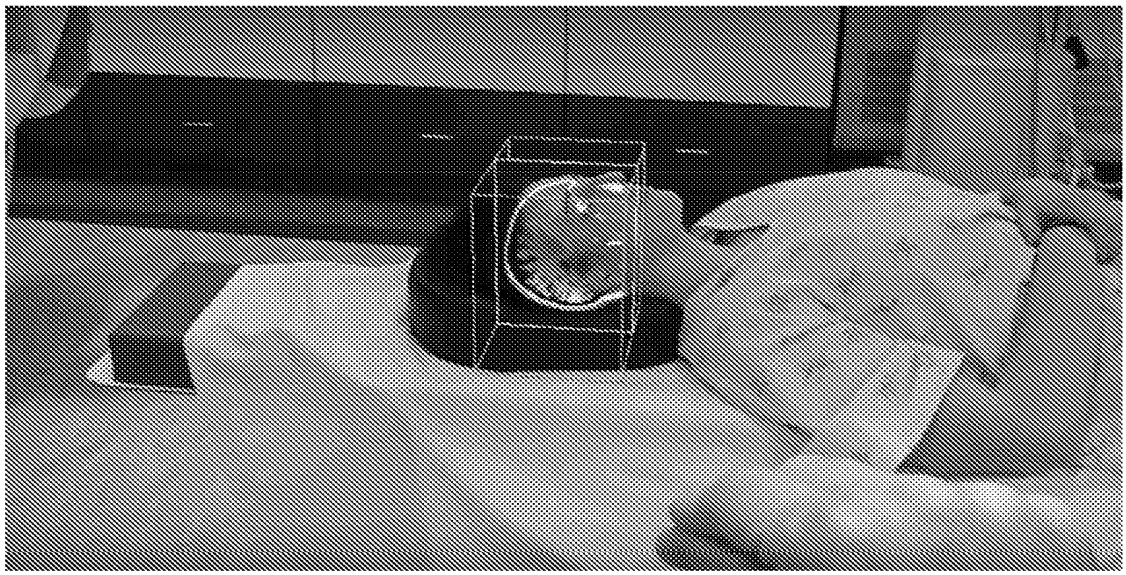


FIG. 2E

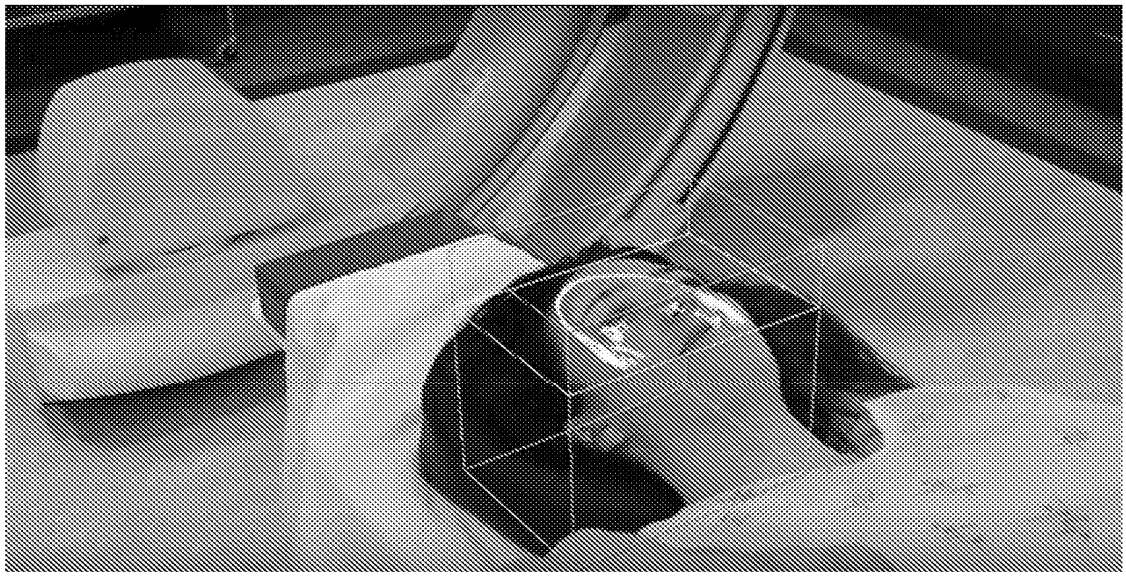


FIG. 2F

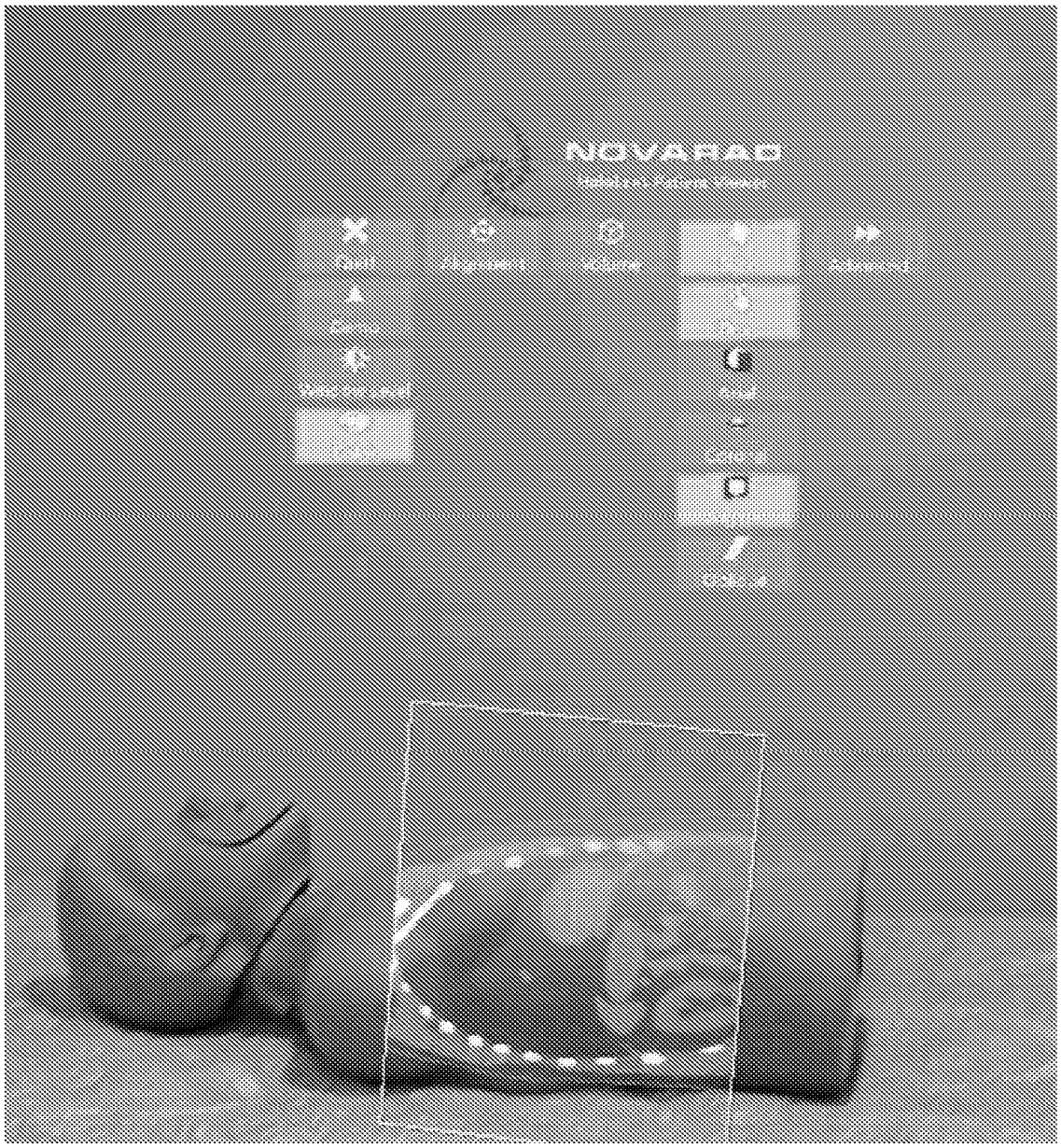



FIG. 3



FIG. 4A



FIG. 4B

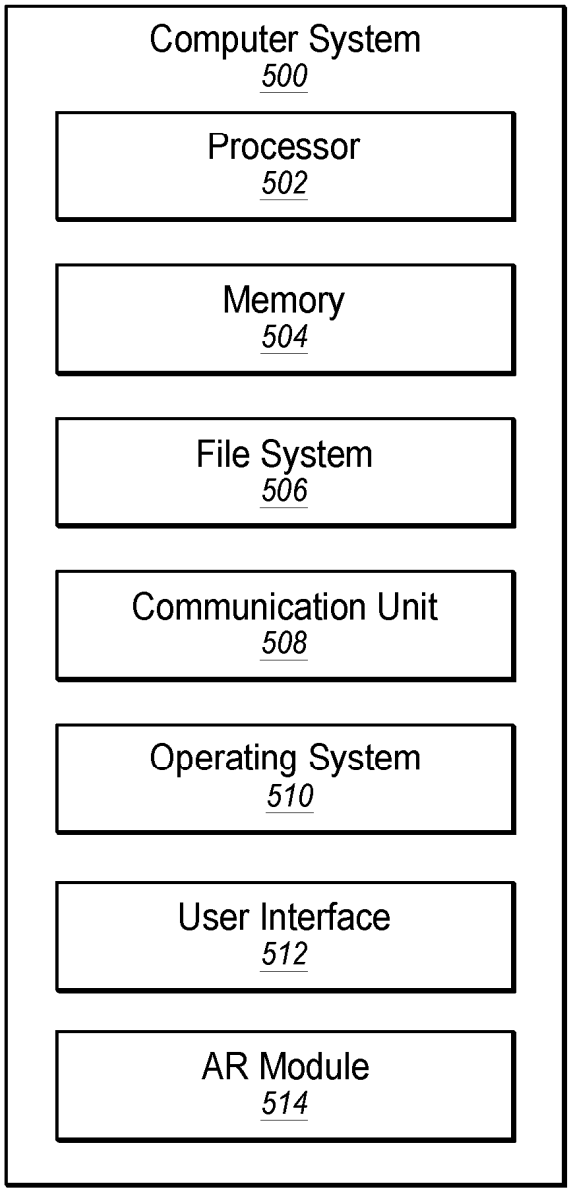

Computer System
500
Processor
502
Memory
504
File System
506
Communication Unit
508
Operating System
510
User Interface
512
AR Module
514

FIG. 5

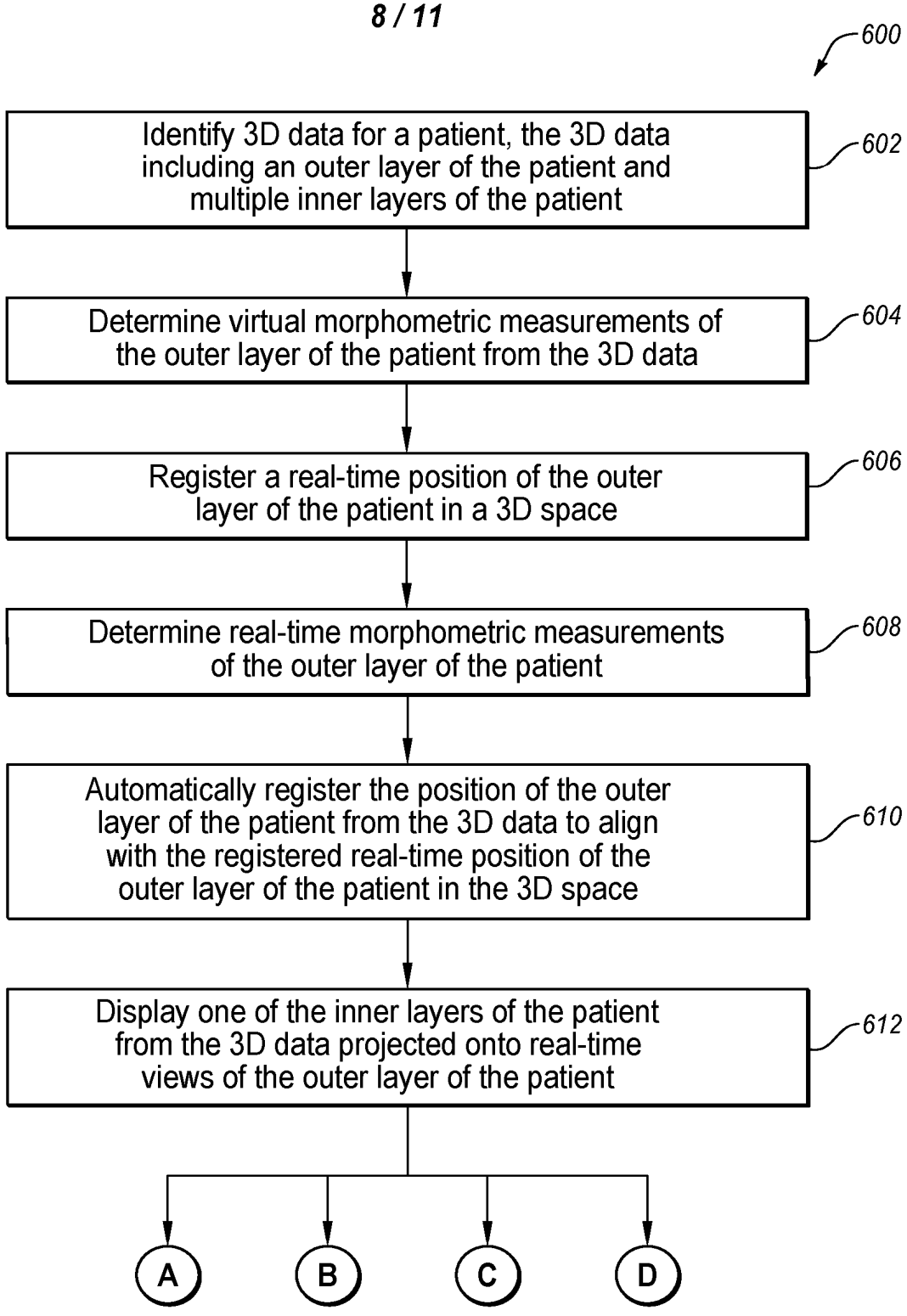

600
Identify 3D data for a patient, the 3D data including an outer layer of the patient and multiple inner layers of the patient
602
Determine virtual morphometric measurements of the outer layer of the patient from the 3D data
604
Register a real-time position of the outer layer of the patient in a 3D space
606
Determine real-time morphometric measurements of the outer layer of the patient
608
Automatically register the position of the outer layer of the patient from the 3D data to align with the registered real-time position of the outer layer of the patient in the 3D space
610
Display one of the inner layers of the patient from the 3D data projected onto real-time views of the outer layer of the patient
612
A
B
C
D

*FIG. 6A*

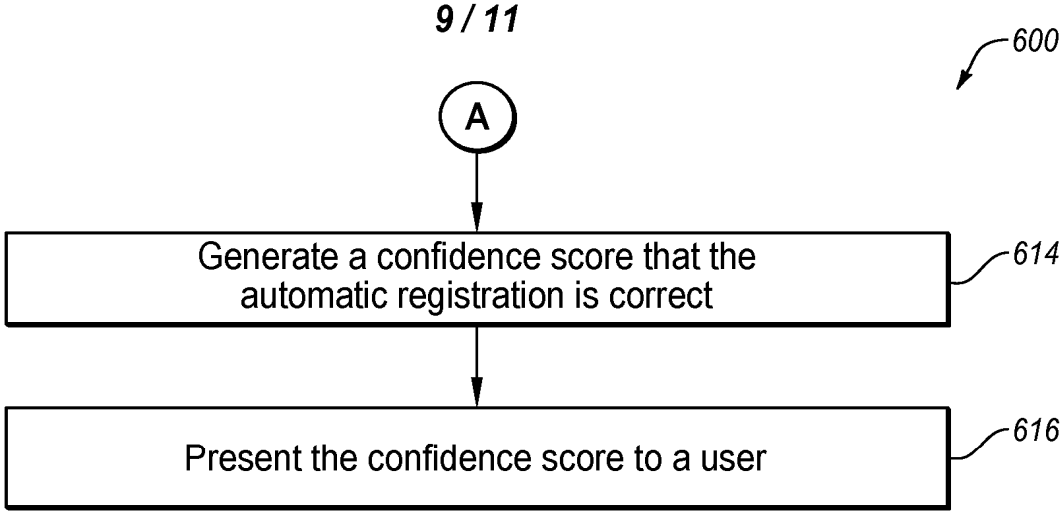

600
A
Generate a confidence score that the automatic registration is correct
614
Present the confidence score to a user
616

FIG. 6B

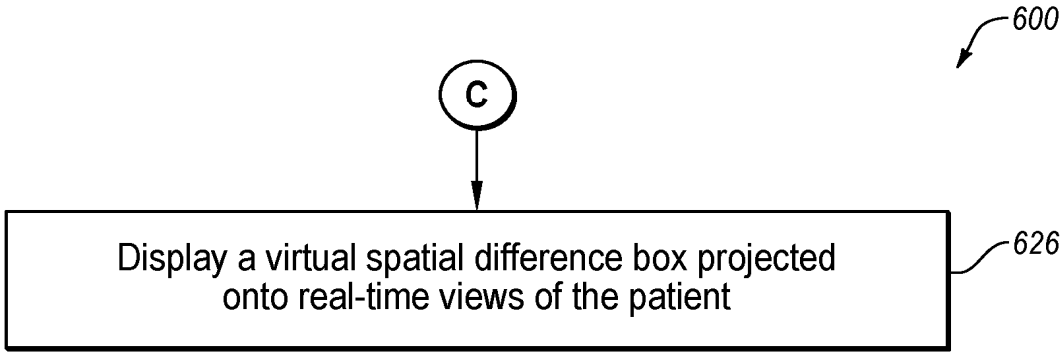

600
C
Display a virtual spatial difference box projected onto real-time views of the patient
626

FIG. 6C

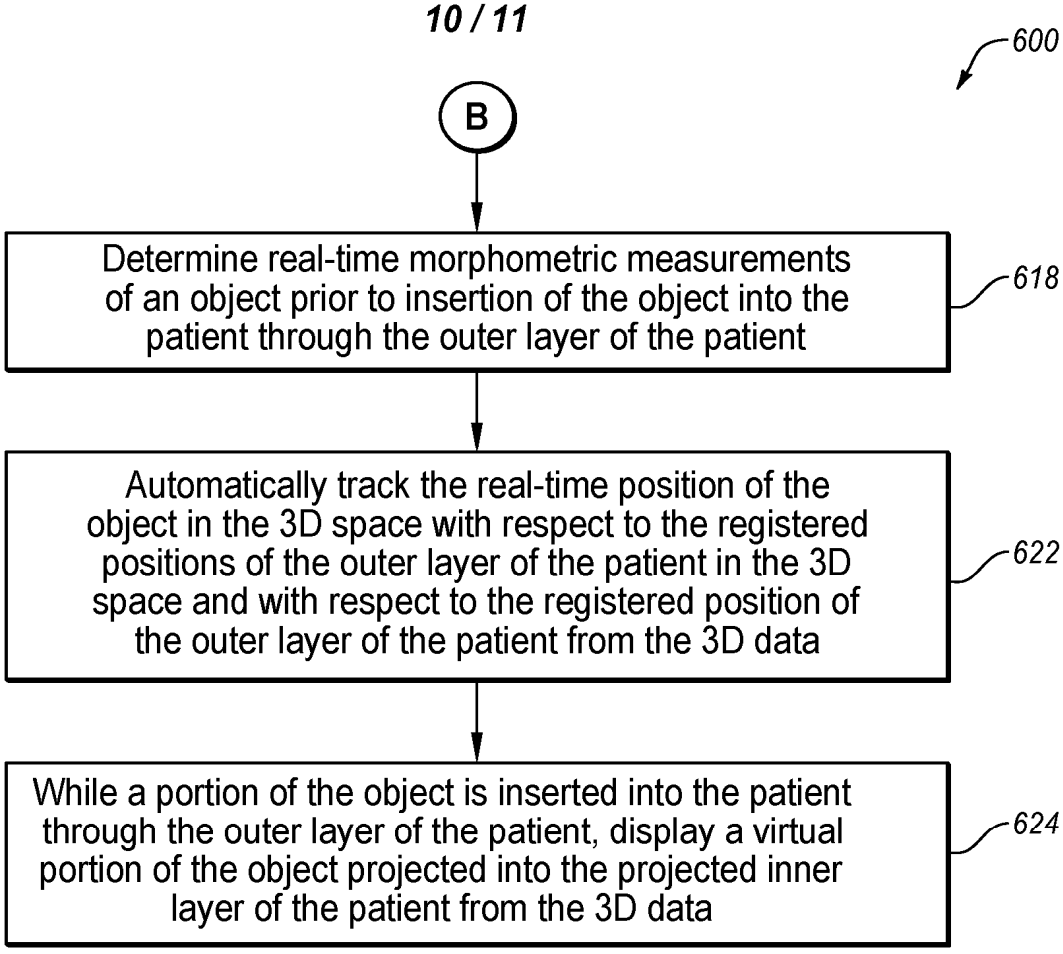

600
B
Determine real-time morphometric measurements of an object prior to insertion of the object into the patient through the outer layer of the patient
618
Automatically track the real-time position of the object in the 3D space with respect to the registered positions of the outer layer of the patient in the 3D space and with respect to the registered position of the outer layer of the patient from the 3D data
622
While a portion of the object is inserted into the patient through the outer layer of the patient, display a virtual portion of the object projected into the projected inner layer of the patient from the 3D data
624

FIG. 6D

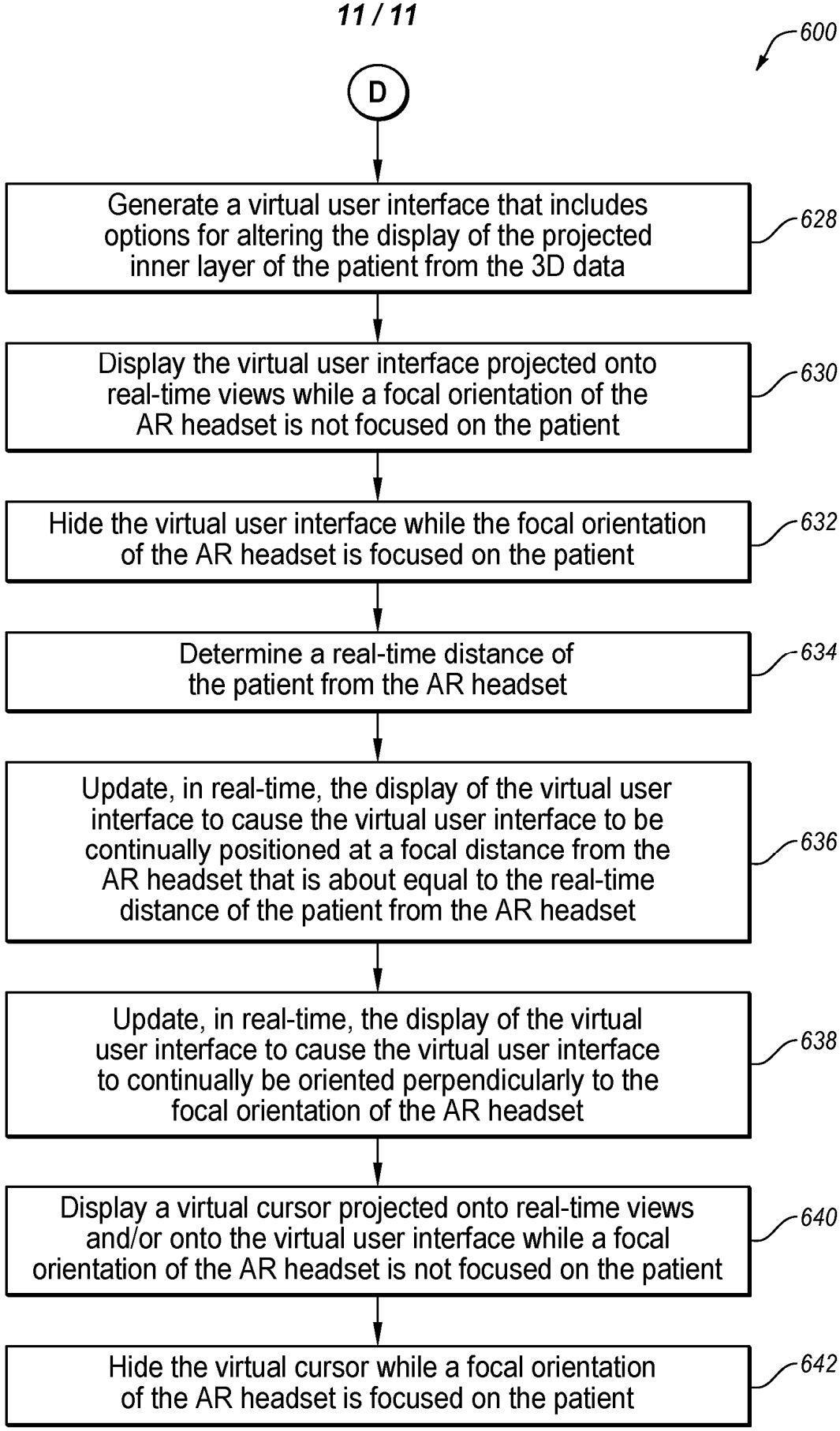

600
D
Generate a virtual user interface that includes options for altering the display of the projected inner layer of the patient from the 3D data
628
Display the virtual user interface projected onto real-time views while a focal orientation of the AR headset is not focused on the patient
630
Hide the virtual user interface while the focal orientation of the AR headset is focused on the patient
632
Determine a real-time distance of the patient from the AR headset
634
Update, in real-time, the display of the virtual user interface to cause the virtual user interface to be continually positioned at a focal distance from the AR headset that is about equal to the real-time distance of the patient from the AR headset
636
Update, in real-time, the display of the virtual user interface to cause the virtual user interface to continually be oriented perpendicularly to the focal orientation of the AR headset
638
Display a virtual cursor projected onto real-time views and/or onto the virtual user interface while a focal orientation of the AR headset is not focused on the patient
640
Hide the virtual cursor while a focal orientation of the AR headset is focused on the patient
642

FIG. 6E