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[Continued on next page]

(54) Title: COMPUTER-ASSISTED SURGERY SYSTEM WITH USER INTERFACE

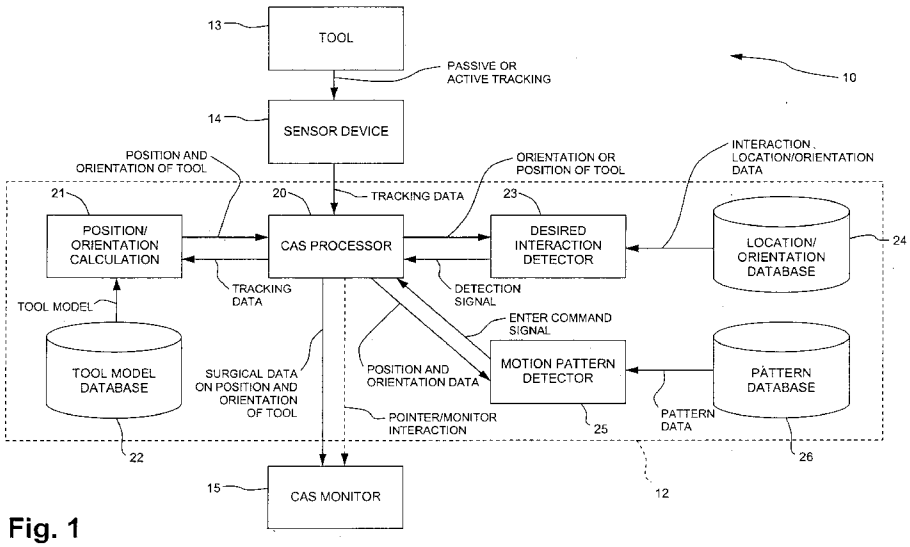

Fig. 1

(57) Abstract: A method for establishing an interaction between an operator and a monitor of a computer-assisted surgery system comprises tracking a tool manipulated by the operator for providing surgical data calculated from the position/orientation of the tool. A desired interaction is identified from the operator by tracking the tool reaching a specific position and/or a specific orientation. An interactive action is activated on a monitor as a function of the desired interaction, the interactive action being unrelated to said surgical data. A motion of the tool is converted to additional interactions related to said interactive action. A computer-assisted surgery system is also provided.

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— *with international search report*

COMPUTER-ASSISTED SURGERY SYSTEM WITH USER INTERFACE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority on United States Provisional Patent Application No. 60/945,626, filed on June 22, 2007.

FIELD OF THE APPLICATION

[0002] The present application generally relates to optical tracking systems and, more particularly but not exclusively, to interactions between a tool operator and a tracking system.

BACKGROUND OF THE ART

[0003] There are many advantages to being able to operate a computer-aided surgery (CAS) system in an operating room. For a system that allows real-time display of the relative positions of three-dimensional models of anatomical structures and of a surgical tool by tracking of the latter, this means being able to select a component or section of an image displayed on a monitor and perform operations on it, such as zooming in and out, rotating it, etc. It also means enabling a surgeon to digitize points, whereby the latter may, for instance, define a profile of an operated bodily part. Moreover, CAS systems provide real-time calculated data to the operator, including angles, distances, orientations, etc.

[0004] The interaction between the surgeon and the CAS system presents some difficulties. For one thing, the surgeon operates in a sterile zone, whereas components of the CAS system are in a non-sterile zone. To perform some computer-related operations, such as controlling the monitor displays, the surgeon is required to interact with the CAS system. For instance, the act of selecting an object on a screen is typically done with a computer mouse, the mouse directing a visible cursor to the desired point on the

image. However, due to the need for all objects in the sterile zone of the operating room to be sterile, a mouse cannot readily be used in the sterile zone to perform such actions.

[0005] It is possible to have a person other than the surgeon interacting with the CAS system. In this case, the surgeon, or other person manipulating a surgical tool, needs to verbalize specific instructions to the person interacting with the CAS system in order to obtain the desired results. Another known way to interact with a CAS system is to use a keypad in a sterile bag. These techniques are both tedious and inefficient.

[0006] U.S. Publication No. 2007/0073137, by Schoenfeld, describes a virtual mouse for use in surgical navigation. The virtual mouse involves a probe and an input pad, both tracked by the CAS system. The CAS system, therefore, interprets movements of the probe on the input pad as movements of the virtual mouse, thereby resulting in actions on the monitors (e.g., movements of an on-screen pointer). In order to simulate mouse clicks, the optical markers are occluded or blocked, and the CAS system recognizes such selective gesturing as a trigger.

SUMMARY OF THE APPLICATION

[0007] It is therefore an aim of the present invention to provide a novel system with user interface in computer-assisted surgery.

[0008] It is a further aim of the present invention to provide a novel method for establishing an interaction between an operator and a CAS monitor.

[0009] Therefore, in accordance with a first embodiment of the present application, there is provided a method for establishing an interaction between an operator and a monitor of a computer-assisted surgery system, comprising: tracking a tool manipulated by the operator for providing surgical data calculated from the position/orientation of the tool; identifying a desired interaction from the

operator by tracking the tool reaching at least one of a specific position and a specific orientation; activating an interactive action on a monitor as a function of the desired interaction, the interactive action being unrelated to said surgical data; and converting a motion of the tool to additional interactions related to said interactive action.

[0010] Further in accordance with the first embodiment of the present application, activating an interactive action comprises activating a selection pointer on the monitor, and converting a motion of the tool comprises converting the motion of the tool to displacements of the selection pointer on the monitor, whereby the selection pointer moves on the monitor display according to movements of the tool as manipulated by the operator.

[0011] Further in accordance with the first embodiment of the present application, converting a motion of the tool to additional interactions comprises converting any one of pivoting motions and translational motions of the tool to equivalent motions of the selection pointer on the monitor.

[0012] Further in accordance with the first embodiment of the present application, converting a motion of the tool further comprises converting a specific motion pattern of the tool to an enter command associated with the position of the selection pointer on the monitor display.

[0013] Further in accordance with the first embodiment of the present application, identifying a desired interaction comprises tracking the tool reaching a generally upright orientation with a tip of the tool pointing upwardly.

[0014] Further in accordance with the first embodiment of the present application, identifying a desired interaction comprises tracking a tip of the tool reaching a divot in a support surface.

[0015] In accordance with a second embodiment of the present application, there is provided a computer-assisted surgery system comprising: a tool having a trackable reference so as to be tracked for position; a sensor device for tracking of the tool; a computer-assisted surgery

processing unit having: a position/orientation calculator for determining at least one of a position and an orientation of the tool for the processing unit to output surgical data as a function of the position of the tool; a desired interaction detector for monitoring at least one of the position and the orientation of the tool, and to send a detection signal to the processing unit when the tool is in at least one of a specific position and a specific orientation; a monitor for displaying a graphical user interface, the graphical user interface activating a selection pointer or triggering an action unrelated to said surgical data when the tool is in said specific position and/or specific orientation, with movements of the tool in said specific position and/or specific orientation resulting in movements of the selection pointer in the graphical user interface or interactions related to the triggered action.

[0016] Further in accordance with the second embodiment of the present application, a motion pattern detector for monitors the motion of the tool when the selection pointer is activated, to convert a specific motion pattern of the tool in an enter command.

[0017] Further in accordance with the second embodiment of the present application, the specific position detected by the desired interaction detector comprises a tip of the tool reaching a divot in a support surface.

[0018] Further in accordance with the second embodiment of the present application, the specific orientation detected by the desired interaction detector comprises a generally upright orientation of the tool, with a tip of the tool pointing upwardly.

[0019] It is pointed that the expression "database" as used hereinafter is referred to a collection of information recorded and organized in such as way so as to be retrievable by a processor. The expression "database" is therefore not limited by specific items of hardware.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Fig. 1 is a block diagram of a user interface system for computer-assisted surgery in accordance with an embodiment of the present disclosure;

[0021] Fig. 2 is a perspective view of a surgical tool as used with the user interface system of Fig. 1, for interactions of an operator with a monitor;

[0022] Fig. 3 is a flowchart illustrating a method of establishing an interaction between an operator and CAS monitor using tool tracking, in accordance with another embodiment of the present disclosure; and

[0023] Fig. 4 is a schematic view of a surgical tool oriented for interaction with the user interface system of Fig. 1, in accordance with another embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] Referring now to the drawings, and more particularly to Fig. 1, a computer-assisted surgery (CAS) with user interface is generally shown at 10. The CAS system 10 has a CAS unit 12. The CAS unit 12 is a processing unit that calculates surgical data from the tracking of tools.

[0025] More specifically, the operator manipulates a tool 13 that is tracked by a sensor device 14. The sensor device 14 is connected to the CAS unit 12, whereby the CAS unit 12 receives tool tracking data from the sensor device 14. A CAS monitor 15 is also connected to the CAS unit 12, and outputs surgical data related to the position and/or orientation of the tool 13, in the form of visual representations, calculated values (e.g., distances, angles), amongst other possibilities.

[0026] The tracking of the tool 13 by the sensor device 14 uses active or passive detection. As a few non-exhaustive examples, the tracking involves optically-detectable retroreflective markers, accelerometers or gyroscopes with communication systems or RF tracking which are illustrated hereinafter. The user interface system 10

exclusively involves wireless tracking between the tool 13 and the sensor device 14.

[0027] The CAS unit 12 has a CAS processor 20 that receives and processes data received from the sensor device 14, and that outputs calculated surgical data to the CAS monitor 15. A position/orientation calculator 21 receives the tracking data from the sensor device 14, and calculates a position and orientation of the tool 13 from the tracking data. The calculation is performed by the position/orientation calculator 21 as a function of a calibration of the tool 13 executed initially, or as an optional alternative as a function of a model of the tool 13 as provided by the tool model database 22 (for instance the model being a geometric relation between a working tip of the tool 13 and a reference marker).

[0028] During surgery, the sterile zone often includes more than the limited area in which the surgery is effected. It is therefore desired to identify a location of the sterile zone located away from the bodily part being operated upon, namely a zone in which there is interaction between tool and bodily part. At this location, the tool 13 is selectively used as an interface with the CAS monitor 15 for the purposes of commanding the CAS system 10, in similar fashion to the use of a mouse to command a computer through a graphical user interface.

[0029] Accordingly, when the tool 13 reaches a given position, a desired interaction detector 23 associated with the CAS processor 20 identifies this action as a desired interaction from the operator. The desired interaction detector 23 typically identifies this action by comparing the tracked position of the tool 13 with location data stored in the location database 24. The location data can be obtained from an initial step of calibration in which an area is identified as user interface area. As a preferred embodiment, the location data is a specific tip position at which a tip of the tool 13 is positioned for interaction.

[0030] As an alternative, when the tool 13 reaches a given orientation, the desired interaction detector 23 identifies this action as a desired interaction from the operator. For instance, as illustrated in Fig. 4, the given orientation comprises the operator orienting and maintaining the tool 13 in a generally upright orientation, with the tip of the tool 13 pointed upwardly and away from the body of the patient. The desired interaction detector 23 typically identifies this action by comparing the tracked orientation of the tool 13 with orientation data stored in the location/orientation database 24. In the case of a detection of orientation, the tool does not need to be brought to a specific zone of the sterile field for an interaction to be initiated.

[0031] Therefore, upon detecting a desired interaction from the position and/or orientation of the tool 13, the desired interaction detector 23 sends a detection signal to the CAS processor 20.

[0032] The CAS processor 20 therefore stops outputting surgical data pertaining to the position and orientation of the tool 13, and activates a selection pointer on the CAS monitor 15.

[0033] Thereafter, movements of the tool 13 within the selected position or orientation result in movements of the selection pointer on the screen of the CAS monitor 15. For instance, a lateral or a pivoting movement of the tool 13 in the upright orientation may result in a scrolling motion of the selection pointer, or in a change of application or task during the computer-assisted surgical procedure.

[0034] Additionally, a motion pattern detector 25 is provided to detect "enter" or "stop scrolling" signals from the interface tool 13. The motion pattern detector 25 is provided in association with the CAS processor 20, so as to receive position and orientation data pertaining to the tool 13, as provided by the CAS processor 20. The motion pattern detector 25 has a pattern database 26 to compare actual patterns of motion of the tool 13 with pattern data.

Accordingly, the motion pattern detector 25 identifies specific motion patterns effected by the tool 13 as an "enter" command. In an embodiment, the tool 13 which was pivoted from its vertical position is simply returned to its vertical position.

[0035] Referring now to Fig. 2, one embodiment of the tool 13 is generally shown with respect to a surface S. It is pointed out that the tool 13 may take a plurality of forms. The tool 13 has a working tip 30 at an end of a working shaft 31 and a handle portion 32. A blade 33 is secured to the tool 13. More precisely, the blade 33 is positioned adjacent to the junction between the handle portion 32 and the working shaft 31. The blade 33 comprises detectable spheres 34. The spheres 34 are detachable from the blade 33, and are snap-fitted to connectors 35 (one shown) on the blade 33.

[0036] In the embodiment of Fig. 2, the detectable spheres 34 are each coated with a retroreflective layer in order to be detected by, for instance, an infrared sensor using axial illumination. It is pointed out that other shapes could be used as alternative embodiments to retro-reflective spheres. As an example, straight cylinders, corner reflectors, flat geometric tokens or the like having retroreflective properties could also be used. It is preferred that the detectable devices be passive, such that they are wireless, but active wireless applications are known. For instance, it is possible to use active detectable devices, such as wireless magnetic sensors.

[0037] In a preferred embodiment using the registration pointer illustrated in Fig. 2, a divot D is provided in user interface area S. When the tip 30 of the tool 13 is positioned in the divot D, the CAS system 10 determines that an interaction of the user with the graphical user interface of the monitor 15 is desired. As mentioned previously, the CAS processor 20 (Fig. 1) therefore activates the selection pointer on the monitor 15.

[0038] As an alternative embodiment, it is considered to simply move the tool 13 to a portion of the sterile zone within the range of the sensor device 14, but distally positioned from the surgical field. For instance, a portion of the surgical table or the sterilized sheets covering the patient can be used as interface location.

[0039] Moreover, it is considered to have an interface location on the screen of the CAS monitor 15. As an image of the tool 13 (i.e., surgical data) moves on the screen of the CAS monitor 15 as a result of tracking of the tool 13, the image can be brought to the interface location on the screen by manipulation of the tool 13, to switch from surgical data to pointer mode. A reverse movement or other operation can return the tracking to surgical data mode.

[0040] Thereafter, movements of the tool 13 within the user interface area A are converted to movements of the selection pointer on the monitor 15. As the tip 30 is maintained in the divot D, it is suggested to use the registration pointer 13 as a joystick, with the tip 30/divot D as center of rotation for all movements of the tool 13.

[0041] The motion pattern for the tool 13 of Fig. 2 may be a quick up-and-down motion of the tool 13, with the tip 30 temporarily separated from the divot D, for the user to perform an "enter" or "select" command, equivalent to a click on a mouse. This motion pattern of the tool 13 can be used when the desired interaction detector 23 detects an orientation of the tool 13 (or a position and an orientation of the tool 13) as a desired interaction.

[0042] The motion pattern for the tool 13 of Fig. 2 may also be an axial rotation of the tool 13 indicating to the CAS system 10 that the operator has selected a value (i.e., equivalent to an "enter" command). A "scroll and select" action can be performed as well by combining motion patterns and movements of the tool 13.

[0043] As an alternative, the interface tool 13 as described previously is combined with a foot pedal that will be used to enter commands, for instance when the selection

pointer is on an item in the graphical user interface of the monitor 15.

[0044] Referring to Fig. 3, a method for establishing an interaction between an operator and a CAS monitor, using for instance the CAS system 10, is generally shown at 10.

[0045] In Step 41, a tool is tracked for position and orientation using wireless tracking technology. The position and orientation data is used by a CAS system to calculate surgical data, such as angles, distances, etc.

[0046] In Decision 42, the position and/or the orientation of the tool is monitored, such that an action is triggered when the tool reaches the specific position (Fig. 2) and/or the specific orientation (Fig. 4).

[0047] In Step 43, once the specific position and/or the specific orientation has been reached, the action is that a selection pointer is activated on the CAS monitor, and a motion of the tool within the specific position is converted to displacements of the selection pointer on the CAS monitor.

[0048] Step 43 is performed while the tool is within the specific position and/or the specific orientation.

[0049] In Decision 44, the motion patterns of the tool are monitored, such that an action is triggered when the tool effects a specific motion pattern.

[0050] In Step 45, once the specific motion pattern has been recognized, the action is that an "enter" command is activated, for an item selected by the selection pointer.

CLAIMS:

1. A method for establishing an interaction between an operator and a monitor of a computer-assisted surgery system, comprising:

tracking a tool manipulated by the operator for providing surgical data calculated from the position/orientation of the tool;

identifying a desired interaction from the operator by tracking the tool reaching at least one of a specific position and a specific orientation;

activating an interactive action on a monitor as a function of the desired interaction, the interactive action being unrelated to said surgical data; and

converting a motion of the tool to additional interactions related to said interactive action.

2. The method according to claim 1, wherein activating an interactive action comprises activating a selection pointer on the monitor, and converting a motion of the tool comprises converting the motion of the tool to displacements of the selection pointer on the monitor, whereby the selection pointer moves on the monitor display according to movements of the tool as manipulated by the operator.

3. The method according to claim 2, wherein converting a motion of the tool to additional interactions comprises converting any one of pivoting motions and translational motions of the tool to equivalent motions of the selection pointer on the monitor.

4. The method according to claim 1, wherein converting a motion of the tool further comprises converting a specific motion pattern of the tool to an enter command associated with the position of the selection pointer on the monitor display.

5. The method according to claim 1, wherein identifying a desired interaction comprises tracking the tool reaching a generally upright orientation with a tip of the tool pointing upwardly.

6. The method according to claim 1, wherein identifying a desired interaction comprises tracking a tip of the tool reaching a divot in a support surface.

7. A computer-assisted surgery system comprising:

a tool having a trackable reference so as to be tracked for position;

a sensor device for tracking of the tool;

a computer-assisted surgery processing unit having:

a position/orientation calculator for determining at least one of a position and an orientation of the tool for the processing unit to output surgical data as a function of the position of the tool;

a desired interaction detector for monitoring at least one of the position and the orientation of the tool, and to send a detection signal to the processing unit when the tool is in at least one of a specific position and a specific orientation;

a monitor for displaying a graphical user interface, the graphical user interface activating a selection pointer or triggering an action unrelated to said surgical data when the tool is in said specific position and/or specific orientation, with movements of the tool in said specific position and/or specific orientation resulting in movements of the selection pointer in the graphical user interface or interactions related to the triggered action.

8. The computer-assisted surgery system according to claim 7, further comprising a motion pattern detector for monitoring the motion of the tool when the selection pointer

is activated, to convert a specific motion pattern of the tool in an enter command.

9. The computer-assisted surgery system according to claim 7, wherein the specific position detected by the desired interaction detector comprises a tip of the tool reaching a divot in a support surface.

10. The computer-assisted surgery system according to claim 7, wherein the specific orientation detected by the desired interaction detector comprises a generally upright orientation of the tool, with a tip of the tool pointing upwardly.

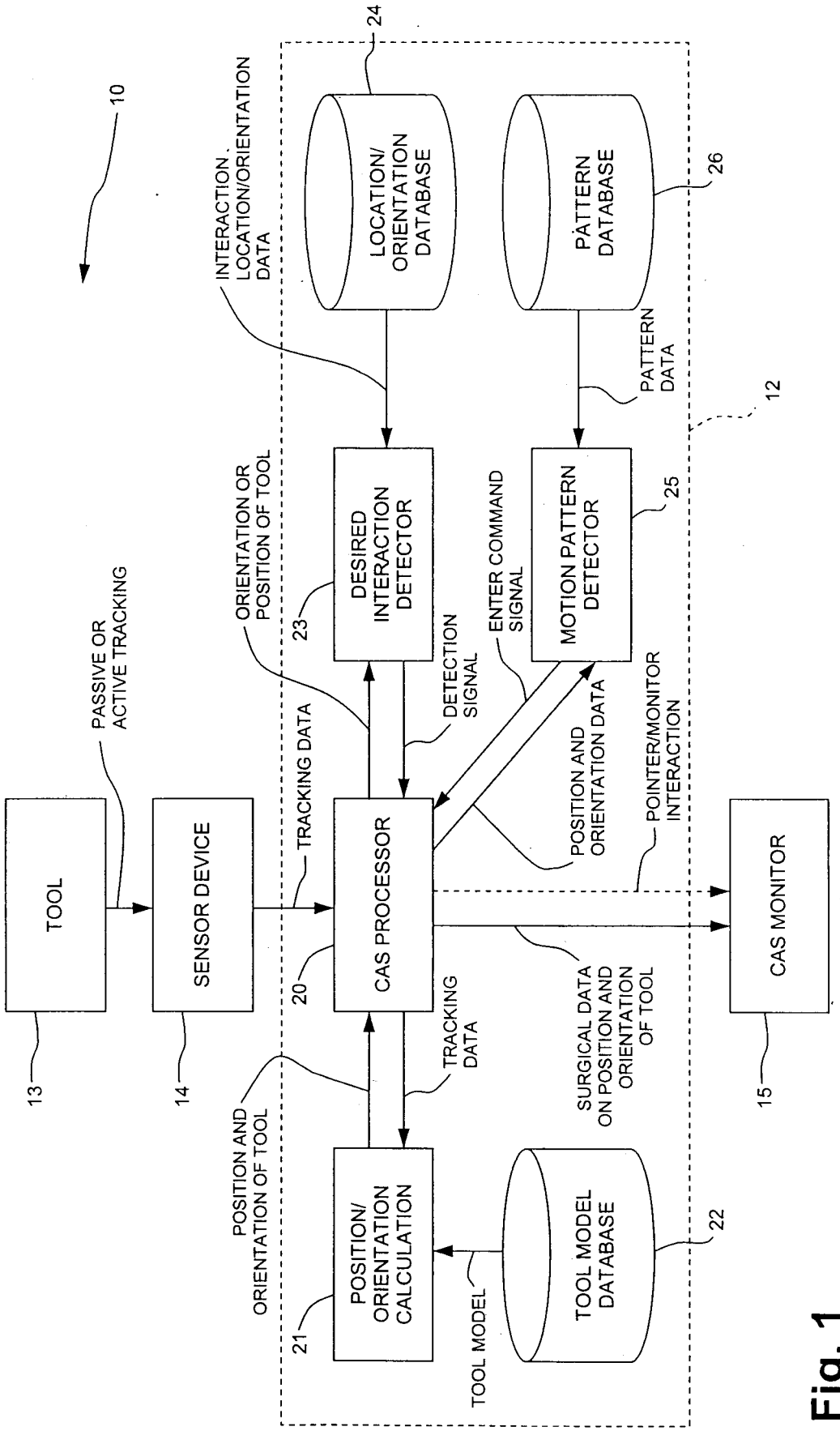
10
TOOL
13
PASSIVE OR ACTIVE TRACKING
SENSOR DEVICE
14
TRACKING DATA
CAS PROCESSOR
20
ORIENTATION OR POSITION OF TOOL
DESIRED INTERACTION DETECTOR
23
DETECTION SIGNAL
ENTER COMMAND SIGNAL
MOTION PATTERN DETECTOR
25
POSITION AND ORIENTATION DATA
POINTER/MONITOR INTERACTION
CAS MONITOR
15
SURGICAL DATA ON POSITION AND ORIENTATION OF TOOL
TRACKING DATA
POSITION AND ORIENTATION OF TOOL
POSITION/ ORIENTATION CALCULATION
21
TOOL MODEL
TOOL MODEL DATABASE
22
INTERACTION, LOCATION/ORIENTATION DATA
LOCATION/ ORIENTATION DATABASE
24
PATTERN DATABASE
26
PATTERN DATA
12

Fig. 1

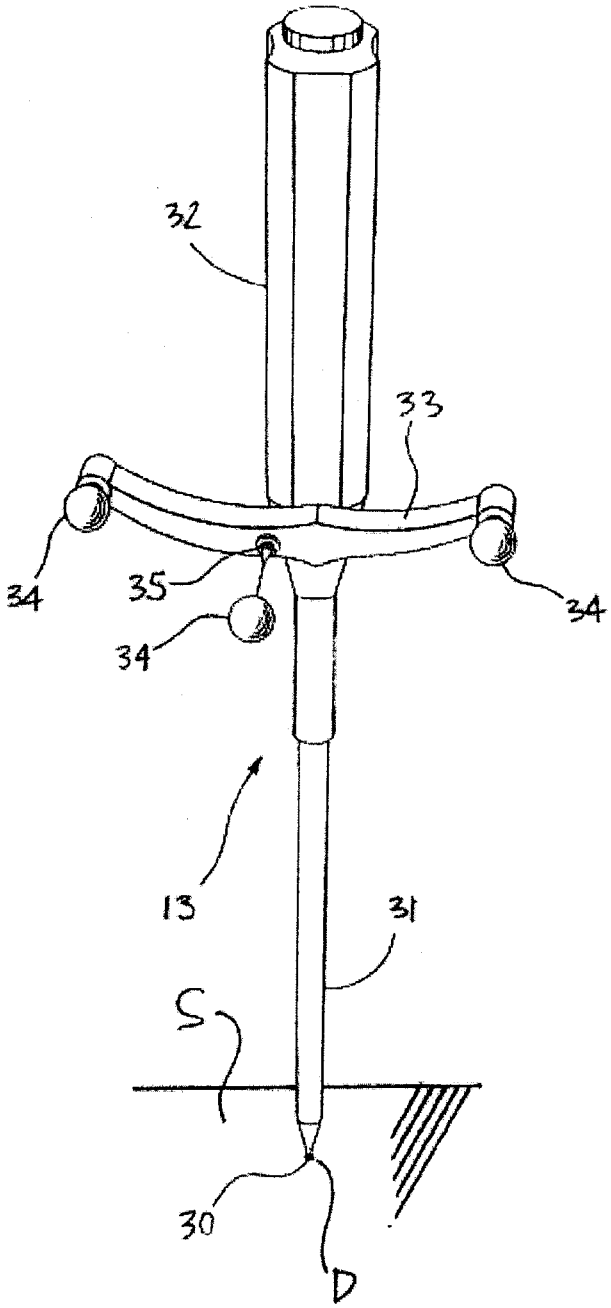

Fig. 2

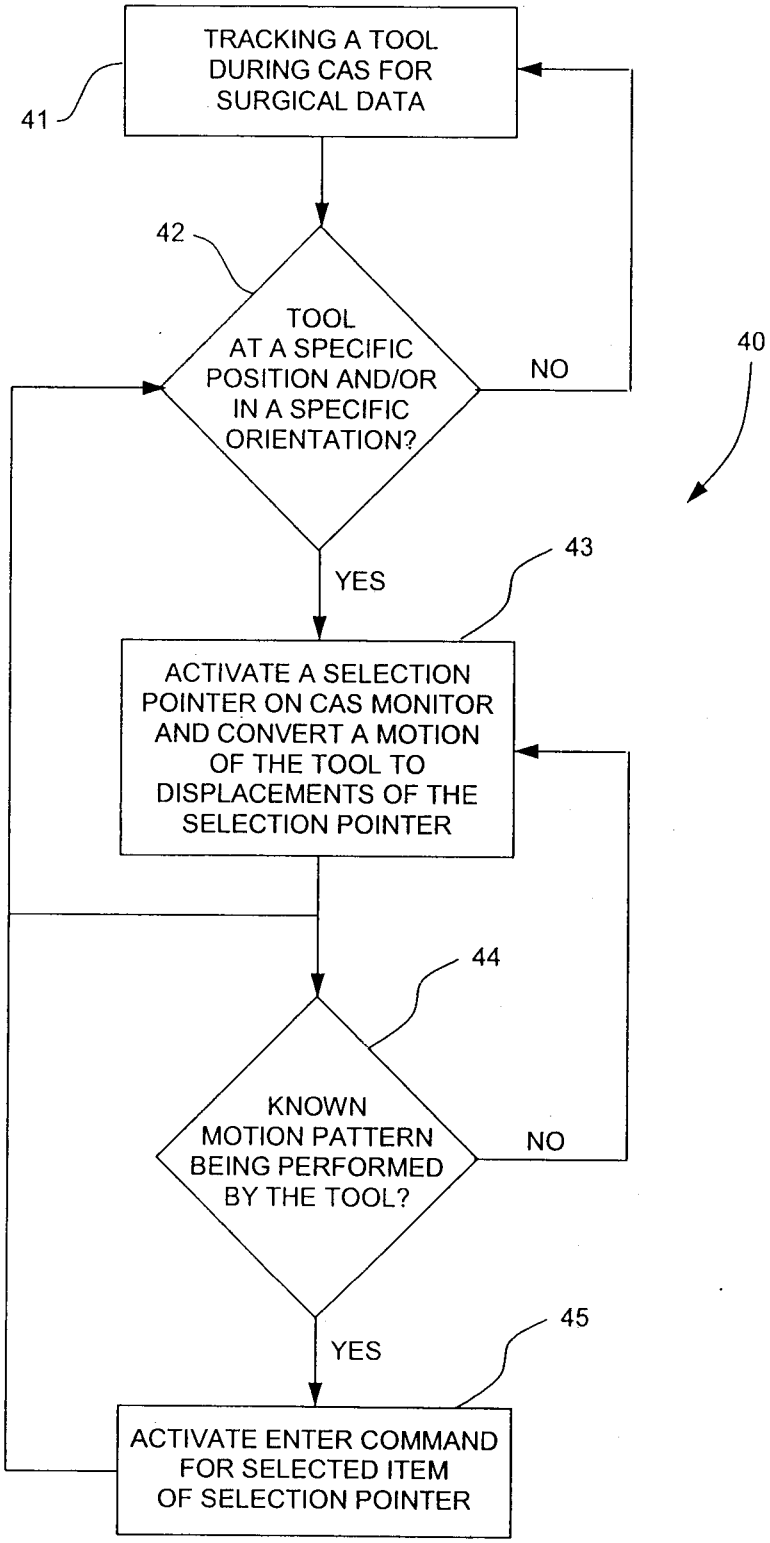
TRACKING A TOOL DURING CAS FOR SURGICAL DATA
41
42
TOOL AT A SPECIFIC POSITION AND/OR IN A SPECIFIC ORIENTATION?
NO
40
YES
43
ACTIVATE A SELECTION POINTER ON CAS MONITOR AND CONVERT A MOTION OF THE TOOL TO DISPLACEMENTS OF THE SELECTION POINTER
44
KNOWN MOTION PATTERN BEING PERFORMED BY THE TOOL?
NO
YES
45
ACTIVATE ENTER COMMAND FOR SELECTED ITEM OF SELECTION POINTER

Fig. 3

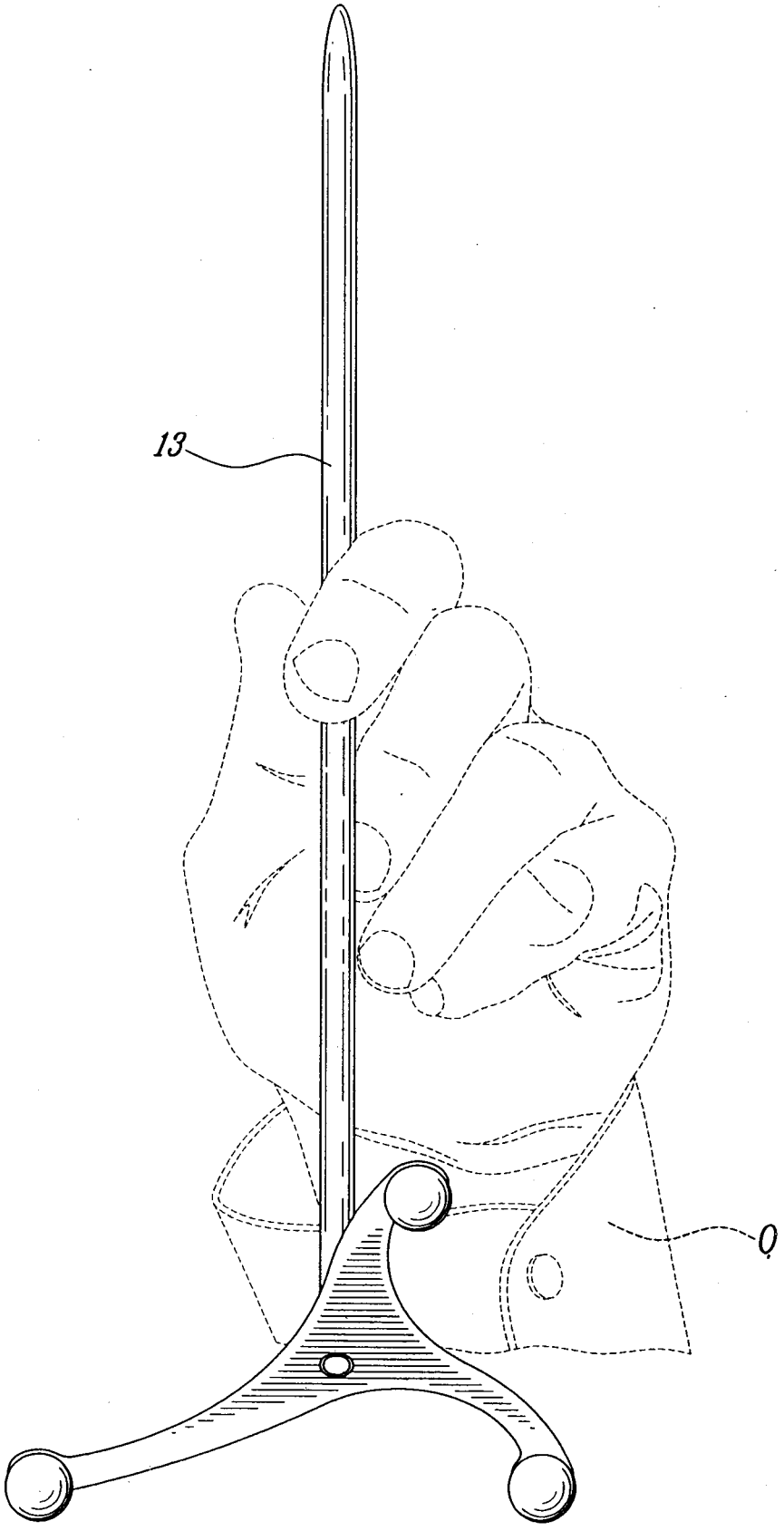

Fig.4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2008/001187

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***A61B 19/00*** (2006.01)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC (2008.04): A61, G06
ECLA :A61B-019/00B, G06F-003/01G USCL: 704

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Questel-Orbit (Qpat), USPTO (Keywords: gesture, motion, recongnition, computer assisted surgery, surgical navigation, track+, motion, orientation, location, position, interface, pointer)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US20040193413 A1 (WILSON, A. et al.) 30 September 2004 (30-09-2004) *Claims 11, 15, Figures 14, 20, paragraphs 0007, 0019, 0039, 0053, 0054, 0058, 0064, 0083, 0088, 0089, 0127 - 0130, 0135, 0139, 0141*	7 - 10
P, X	WO 2007137093 A2 (MARSDEN, R. et al.) 29 Novembre 2007 (29-11-2007) *Paragraphs 0006, 0013 - 0015, claims 1 - 11*	7 -10
A	US20060036947 A1 (Jelley, W. et al.) 16 February 2006 (16-02-206 *Whole document*	
A	US20070016008 A1 (Schoenefeld, R.) 18 January 2007 (18-01-2007) *Whole document*	
A	US20070073137 A1 (Schoenefeld, R.) 29 March 2007 (29-03-2007) *Whole document*	

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

* Special categories of cited documents :
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 Septembre 2008 (20-09-2008)	9 October 2008 (09-10-2008)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476	Vincent Pellerin 819- 953-3558

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2008/001187

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

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

1. [X] Claim Nos. : 1 - 6

because they relate to subject matter not required to be searched by this Authority, namely :

A method for establishing an interaction between an operator and a computer, is not an acceptable method in a the sense of this Authority. The International Search Authority is therefore not required to search under PCT Article 17(2)(a)(i), PCT Rule 39.1(iii) and 39.1(v).

2. [ ] Claim Nos. :

because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically :

3. [ ] Claim Nos. :

because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claim Nos. :

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim Nos. :

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

[ ] The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

[ ] No protest accompanied the payment of additional search fees.

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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