The present invention relates generally to image guided surgery, and more specifically, to system and methods for tracking a medical instrument and assisting in navigating and/or positioning the instrument in a body structure during, for example, a surgical procedure. The system for tracking an instrument in a region of a patient comprises an optical tracking device (21) adapted to track a position of the instrument (15) during an insertion of the instrument into the patient, the optical tracking device including a light emitting unit (25) is arranged to, in operation, emit light pulses towards the instrument; and a light detecting unit (28) arranged to, in operation, receive reflecting light pulses from the instrument and wherein the light detecting unit is adapted to produce consecutive output signals representing a movement of the instrument relative a reference point; and wherein the optical tracking device is adapted to provide position data including a position of the instrument relatively the reference point. A feedback device (23) in communication with the tracking device is configured to gather the position data and to determine a present position of the instrument relative the reference point.
TRACKING OF A MEDICAL INSTRUMENT

Field of the invention

The present invention relates generally to image guided surgery, and more specifically, to systems and methods for tracking a medical instrument and assisting in navigating and/or positioning the instrument in a body structure during, for example, a surgical procedure.

Background of the invention

Image guided medical and surgical procedures utilize patient images obtained prior to or during a medical procedure to guide a physician performing the procedure. Recent advances in imagining technology including computed tomography (CT), magnetic resonance imagining (MRI), isocentric C-arm fluoroscopic imagining, and positron emission tomography (PET) has increased the interest in image guided medical procedures, for example, for diagnosis, during implantations or during treatment of neurological diseases and disorders by neurosurgery.

Generally, medical procedures such as, for example, diagnosis of tumors in the brain or neurological diseases, implantations of for example depth electrode or catheters in the brain, or treatment of tumors in the brain, neurological diseases and disorders by neurosurgery require a very high accuracy, often on a sub-millimeter level. Therefore, it would be very appealing to obtain an accurate and reliable way of tracking and navigating medical instruments in such medical procedures.

For example, when performing biopsies on different types of tumors, it would be useful with an accurate and reliable way of tracking and navigating medical instruments such as biopsy needles. During injections and aspirations by means of medical devices such as needles for injection of radioactive nuclides and cytostatic agents as well as puncture of cysts it would also be useful with an accurate and reliable way of tracking and
navigating medical instruments. Furthermore, in deep brain stimulation (DBS) therapy it would be useful with an accurate and reliable way of tracking and navigating medical instruments, in particular, stimulation electrodes. DBS therapy is used as a supplement to medication for treatment of neurological disorders including movement disorders. The surgical requirements for effective DBS demand accurate, sub-millimeter targeting of the region to be stimulated. There are a number of techniques for providing the neurologist and neurosurgeon with the data necessary to make a decision with respect to placement of a stimulating electrode. One standard procedure involves initial targeting of the position to be stimulated from a medical image such as a cranial magnetic resonance image (MRI) followed by acquisition of microelectrode data to refine the initial targeting. The microelectrode data is acquired by hand, plotted on graph paper, and compared to a printed brain atlas to determine the position in the patient’s brain that corresponds to a similar anatomic or physiologic position in the atlas. Due to the manual data acquisition and the use of printed brain atlas, there are several inherent limitations placed on microelectrode data acquisition.

Hence, there is a need within the art for accurate and reliable devices and methods for tracking a medical instrument and assisting in navigating and/or positioning the instrument in a body structure during, for example, a surgical procedure.

Furthermore, there is a need within the art for devices and methods for tracking a medical instrument and assisting in navigating and/or positioning the instrument in a body structure during, for example, a surgical procedure that provide the physician, for example, the neurosurgeon with accurate and prompt feedback of the instrument position.

**Summary of the invention**

Thus, an object of the present invention is to provide an improved system and method for accurately tracking a medical instrument and assisting in navigating and/or positioning the instrument in a body structure during, for example, a surgical procedure.
Another object of the present invention is to provide systems and methods for tracking a medical instrument and assisting in navigating and/or positioning the instrument in a body structure during, for example, a surgical procedure that provide the physician, for example, the neurosurgeon with accurate and prompt feedback of the instrument position.

These and other objects are fulfilled by the present invention as defined by the independent claims. Preferred embodiments are defined by the dependent claims.

According to an aspect of the present invention, there is provided a system for tracking an instrument in a region of a patient. The system comprises an optical tracking device adapted to track a position of the instrument during an insertion of the instrument into the patient, the optical tracking device including a light emitting unit is arranged to, in operation, emit light towards the instrument; and a light detecting unit arranged to, in operation, receive reflected light from the instrument, and wherein the light detecting unit is adapted to produce consecutive output signals representing a movement of the instrument relative to a reference point based on the output signals; and wherein the optical tracking device is adapted to provide position data including position changes of the instrument relatively to the reference point. A feedback device in communication with the tracking device is configured to gather the position data and to determine a present position of the instrument relative to the reference point.

According to another aspect of the present invention, there is provided a method for tracking an instrument in a region of a patient. The method comprises using an optical tracking device adapted to track a position of the instrument during an insertion of the instrument into the patient, the optical tracking device including a light emitting unit is arranged to, in operation, emit light towards the instrument; and a light detecting unit arranged to, in operation, receive reflected light from the instrument, and wherein the light detecting unit is adapted to produce consecutive output signals representing a movement of the instrument relative to a reference point based on the output signals. Further, the method includes providing position data including
a position of the instrument relatively the reference point and determining a
present position of the instrument relative to the reference point.

The present invention provides several advantages. For example, the
precision of instrument or electrode targeting to areas of, for example, the
brain during a medical procedure such as, for example, a surgical procedure
can be enhanced and improved due to the fact that the optical tracking device
obtains measurement data directly from the instrument itself. Further, the
operator or physician, for example, a neurosurgeon performing the medical
procedure can be provided with an accurate indication of the position of the
instrument or electrode relative to the target area in real time due to the
synchronization between the position data and image data over the target
region, for example, over a target located in the patient’s brain. Thus, the
physician e.g. the neurosurgeon is provided with an immediate feedback in
real time of a movement of the instrument or position change of the
instrument.

The present invention is particularly advantageous in medical
procedures such as, for example, diagnosis of tumors in the brain or
neurological diseases, implantations of for example depth electrode or
catheters in the brain, or treatment of tumors in the brain, neurological
diseases and disorders by neurosurgery requiring accuracy on a sub-
millimeter level. Examples of such procedures include biopsies on different
types of tumors, injections and aspirations by means of medical devices such
as needles for injection of radioactive nuclides and cytostatic agents as well
as puncture of cysts and deep brain stimulation (DBS) therapy.

According to an aspect of the present invention, the feedback device is
configured to synchronize the position data with image data of the region; and
superimpose a position indication for the instrument onto an image of the
region created by the image data by using the synchronized positional data
and image data.

According to an embodiment of the present invention, the tracking
system includes a display unit adapted to display the image of the region of
the patient with the superimposed position indication for the instrument.
Thereby, the precision of instrument or electrode targeting to areas of, for
example, the brain during a medical procedure such as, for example, a surgical procedure can be enhanced and improved further due to the fact that the optical tracking device obtains measurement data directly from the instrument itself (measuring directly on the instrument) and that the position is displayed for the physician. The operator or physician performing the medical procedure can be provided with a visual position indication in real time by overlaid position data for the instrument or electrode on images of e.g. the patient’s brain. Hence, the present invention enables visualization of instrument position data in combination with, for example, the patient’s cranial anatomy. The operator or physician, for example, a neurosurgeon is thereby provided with an immediate feedback of the present position of the instrument or electrode.

According to an embodiment of the present invention, the optical tracking device comprises a light emitting unit arranged to, in operation, emit light pulses towards the instrument and a light detecting unit arranged to, in operation, receive reflected light pulses from the instrument. The light detecting unit is adapted to produce consecutive output signals representing a movement of the instrument relative to the reference point. The feedback device uses this data representing a movement of the instrument to determine the actual position of the instrument relative to the target and the region of the patient in which the target is located by synchronizing the position data, i.e. the output signals from the optical tracking device with image data over the region and by superimposing the position indication for the instrument onto the image of the region. Thereby, the physician, e.g. a neurosurgeon, can automatically be provided with fast and accurate feedback of position changes of the instrument, for example, movements of the instrument in real time.

According to an embodiment of the present invention, the feedback device is adapted to determine a reference point by instructing the optical tracking device to perform a reference measurement on specific part of the instrument when the instrument is placed in an initial position, wherein position data for the initial position is obtained and the reference point is determined based on the position data. Thereby, the position data provided
by the optical tracking device can be related to a specific part of an instrument during a medical procedure. The physician can accordingly relate a position indication for the instrument to that specific part thereby increasing the accuracy of the position indication.

According to an embodiment of the present invention, the position data includes information of a linear movement along a longitudinal axis of the instrument relative to the reference point and/or a rotation of the instrument around the longitudinal axis.

According to an embodiment of the present invention, the feedback device is adapted to use the consecutive output signals from the optical tracker device so as to determine the linear movement and/or the rotation of the instrument.

According to an embodiment of the present invention, the image data is obtained from computed tomography, CT, magnetic resonance imagining, MRI, isocentric C-arm fluoroscopic imagining, or positron emission tomography, PET.

As the skilled person realizes, certain steps of the method according to the present invention, as well as preferred embodiments thereof, are suitable to realize as computer program or as a computer readable medium.

Further objects and advantages of the present invention will be discussed below by means of exemplifying embodiments.

**Brief description of the drawings**

The invention will hereinafter be described, by way of example, with reference to the accompanying drawings, in which:

Fig 1 is a partly exploded perspective view of a head of a patient and an implementation of the tracking system according to the present invention;

Fig. 2 is a perspective view of an embodiment of the optical tracking device according to the present invention;

Fig. 3 is a perspective view of a head of a patient and another implementation of the tracking system according to the present invention;

Fig. 4 is a detailed view of the implementation of the tracking system according to the present invention shown in Fig. 3;
Fig 5 is detailed view of the implementation of the tracking system according to the present invention shown in Fig. 3; and

Fig. 6 is block diagram showing the step of a method according to the present invention a general level.

5

Description of preferred embodiments

Reference is first made to fig 1 in which a field of application for the present invention is illustrated in a perspective view. The present invention will now be described in connection with tracking of a probe device. However, as a person skilled within the art realizes, the present invention can be used with other types of medical instruments, as shown in for example, Fig. 3, 4 and 5, where the instrument movement can be tracked by means of an optical tracking device. According to embodiments of the present invention, the optical tracking according to the present invention is based on light reflections from reflecting surfaces of the medical instrument.

With reference first to Fig. 1, an injection device is shown comprising an outer tube 4 of a suitable surgical material, for example, stainless steel. A distal tube portion 11 is adapted to be positioned adjacent to a target area 1 in the patient’s body. Further, the injection device comprises a proximal tube portion 13. A typical injection device has a length of about 200 mm and has an outer diameter of about 1 - 2 mm. In Fig. 1, the tube 4 is inserted in the patient’s skull 2 through a hole 3 in the cranial bone for guiding e.g. a probe 15 to the target area 1. The probe is preferably made of stainless steel.

A system 20 for tracking an instrument in a region of a patient according to the present invention comprises an optical tracking device 21 adapted to track a position of the probe 15 and to provide position data including position changes of the probe relative to a reference point. However, it should be noted that the tube 4 also can be tracked by using the present invention.

A reference point may be determined by performing a measurement session when the tip 16 of the probe 15 is adjacent to the optical tracking device 21. A feedback device 23 is, wirelessly or via a network, in communication with the tracking device 21 and is adapted to gather position
data obtained by the optical tracking device 21. The feedback device 23 is
configured to determine positions of the probe 15, e.g. a present position
relative a reference point. In embodiments of the present invention, the
feedback device 23 is adapted to synchronize the position data with image
data of the region and to superimpose a position indication for the probe 15
onto an image of the region created by the image data by using the
synchronized positional data and image data. For example, the image data
can be based on images obtained by means of computed tomography (CT),
magnetic resonance imagining (MRI), isocentric C-arm fluoroscopic
imagining, or positron emission tomography (PET).

Furthermore, a display unit 24 may be connected to the feedback
device 23 and is adapted to display an image of the region of the patient with
the superimposed position indication for probe 15. In embodiment of the
present invention, the display unit 24 is integrated in a computer device, such
as a laptop or a personal computer. The feedback device 23 may also be
integrated in a computer device, such as a laptop or a personal computer.
Alternatively, the feedback device 23 may be arranged at the optical tracking
device 21.

According to an embodiment of the present invention, the optical
tracking device 21 comprises a light emitting unit 25 adapted to emit light
pulses. In embodiments of the present invention, the light emitting unit 25 is a
light emitting diode emitting infra-red light. Preferably, the light emitting unit 25
is arranged to, in operation, emit light pulses 26 directed toward the probe 15,
for example, the tip 16 of the probe 15. Further, the optical tracking device 21
comprises a light detecting unit 28 arranged to, in operation, receive light
pulses 27 resulting from reflections of the emitted light pulses 26 on a
detector surface (not shown) of the light detecting unit 28. The light detecting
unit 28 is adapted to produce consecutive output signals each representing
an image captured by the detector surface.

In Fig. 2, an embodiment of an optical tracking device 21 is shown in
more detail. The optical tracking device 21 comprises a light emitting diode
25, which according to this embodiment emits light pulses via a lens system
30 arranged on a base plate 34 towards a surface of the instrument 31. The
light pulses are reflected on the surface of the instrument 31 and are received by the light detecting unit 28 (sensor) via the lens system 30 and are captured on the sensor surface (not shown). For example, irregularities in the surface structure of the instrument 31 or man-made identification means such as scores or marks may cause reflections that can be used to determine a position of the instrument 31.

The light emitting diode 25 and the sensor 28 are arranged on a PCB 33. Further, the optical tracking device 21 comprises a clip 35 for fixating the optical tracking device at, for example, an instrument guide as are shown in Figs. 3, 4 and 5.

Returning now to Fig. 1, a position data determining unit 29 is adapted to produce position data based on the consecutive output signals from the light detecting unit 28. The position determining unit 29 may also be adapted to deliver the position data to the feedback device 23 via cable or wirelessly.

Alternatively, in embodiments of the present invention, the light receiving unit 28 produces the position data and a position data transmitting unit 48 (see Fig. 4) is adapted to transmit the position data to the feedback device 23 via cable or wirelessly.

The position data includes information of a movement of the probe 15 relatively the reference point. In this illustrated example, the reference point is where the tip 16 of the probe 15 is just about to be inserted into the tube 4. Thereby, it is possible to track where the tip 16 of the probe 15 is located relatively to its starting point or initial point and relatively to the target 1.

Preferably, the position data includes information of a linear movement along an longitudinal axis of the probe 15 indicated with the arrow marked with X relatively the reference point and/or a rotation of the probe 15 around the longitudinal axis X, where the rotational direction is indicated with Y.

Accordingly, it is possible to track the instrument (i.e. in this embodiment the probe 15) in two dimensions, namely in X and Y directions, i.e. depth and rotation. The position change or movement of the probe 15 is determined by comparing consecutive output signals each representing an image captured by the light receiving unit 28.
With reference now to Fig. 3, 4 and 5, a further implementation or embodiment example of the present invention will be discussed. In this implementation, the present invention is used together with a Stop and Guide System in a Leksell Stereotactic system® provided by ELEKTA AB for stereotactic neurosurgery.

A stereotactical frame 40 based on the center-or-arc principle is fixated relative to a patient’s head 42 by means of adjustable fixations posts 43 having self-tapping screws. The Leksell Stereotactic system® is compatible with all types of imaging techniques such as CT, MR, X-ray, DSA or PET. The arc or frame 40 is positioned such that a center of a coordinate system with X-, Y- and Z-coordinates coincide with the selected cerebral target 45. In this example, a stop and guide system 46 is mounted on the frame 40 and a biopsy needle 47 is placed in the stop and guide system 46 for guiding the biopsy needle 47 to the target 45. As shown in Fig. 4 and 5, the optical tracking device 21 can be mounted at the stop and guide system 46 by means of the clip 35 for determining the position of the biopsy needle and, in particular, for determining a present position of the tip 49 of the needle 47 relative to an initial position of the tip 49. During operation, the biopsy needle 47 is advanced into the brain of the patient in the direction indicated by the arrow A. In this embodiment, a communication unit or bus 48 is arranged on the optical tracking device for, wirelessly or via cable, transferring position data to the feedback device 23.

With reference now to Fig. 6, an embodiment of the method for tracking a position of a medical instrument according to the present invention will be discussed. After the medical instrument has been properly mounted, installed or in other placed for operation on the patient, a reference measurement is performed at step S100. A reference point can be determined by instructing the optical tracking device 21 to perform a measurement on specific part of the instrument when the instrument is placed in an initial position, wherein position data for the initial position is obtained and the reference point is determined based on the position data. The instruction can be manually delivered by the neurosurgeon via, for example, a personal computer connected to the optical tracking device 21 or by the
feedback device 23 upon activation of a instrument tracking session, which
session may be initiated by the neurosurgeon. Then, at step S110, the optical
tracking device 21 will continuously deliver or provide position data of the
actual position of the medical instrument to the feedback device 23. As has
been described above, the position data is based on the movement of the
surface of the instrument passing the optical tracking device 21. Hence, the
feedback device 23 is continuously provided with real time position data
providing position data including a position of the instrument relatively a
reference point. Thereafter, at step S120, the position data is synchronized
with image data (obtained, for example, by means of computed tomography,
CT, magnetic resonance imagining, MRI, isocentric C-arm fluoroscopic
imagining, or positron emission tomography, PET) of the anatomic region of
the patient in which the target is located. At step S130, a position indication
for the instrument is superimposed onto an image of the region created by the
image data by using the synchronized positional data and image data. At step
S140, an image of the region of the patient with the superimposed position
indication for the instrument is displayed in real time.

Although exemplary embodiments of the present invention have been
shown and described, it will be apparent to those having ordinary skill in the
art that a number of changes, modifications, or alterations to the inventions as
described herein may be made. Thus, it is to be understood that the above
description of the invention and the accompanying drawings is to be regarded
as a non-limiting.

Finally, it is to be noted that an inclusion in the appended claims of
reference numerals used in the figures of drawings is purely for illustrative
purposes and not to be construed as having a limiting effect on the scope of
the claims.
1. A system for tracking an instrument in a region of a patient comprising:

an optical tracking device adapted to track a position of said instrument during an insertion of said instrument into said patient, said optical tracking device including a light emitting unit is arranged to, in operation, emit light towards said instrument; and a light detecting unit arranged to, in operation, receive reflected light from said instrument, and wherein said light detecting unit is adapted to produce consecutive output signals representing a movement of said instrument relative a reference point; and wherein said optical tracking device is adapted to provide position data including a position change of said instrument relatively said reference point based on the output signals; and

a feedback device in communication with said tracking device configured to gather said position data and to determine a present position of said instrument relative said reference point.

2. The system according to claim 1, wherein said feedback device is configured to:

synchronize said position data with image data of said region; and

superimpose a position indication for said instrument onto an image of said region created by said image data by using said synchronized positional data and image data.

3. The system according to claim 1 or 2, further comprising display unit adapted to display said image of said region of said patient with the superimposed position indication for said instrument.

4. The system according to claim 1 - 3, wherein said feedback device is adapted to determine a reference point by instructing said optical tracking device to perform a measurement on a specific part of
said instrument when said instrument is placed in an initial position, wherein position data for said initial position is obtained and said reference point is determined based on said position data.

5. The system according to claim 1-4, wherein said position data includes information of a linear movement along an longitudinal axis of said instrument relatively said reference point and/or a rotation of said instrument around said longitudinal axis.

6. The system according to claim 1-5, wherein said feedback device is adapted to use said consecutive output signals from said optical tracker device so as to determine said linear movement and/or said said rotation of said instrument.

7. The device according to claim 1-6, wherein said image data is obtained from computed tomography, CT, magnetic resonance imagining, MRI, isocentric C-arm fluoroscopic imagining, or positron emission tomography, PET.

8. A method for tracking an instrument in a region of a patient comprising:
   using an optical tracking device adapted to track a position of said instrument during an insertion of said instrument into said patient, said optical tracking device including a light emitting unit is arranged to, in operation, emit light towards said instrument; and a light detecting unit arranged to, in operation, receive reflected light from said instrument, and wherein said light detecting unit is adapted to produce consecutive output signals representing a movement of said instrument relative a reference point;
   providing position data including a position change of said instrument relatively said reference point; and
   determining a present position of said instrument relative said reference point.
9. The method according to claim 8, further comprising:
synchronizing said position data with image data of said region;
superimposing a position indication for said instrument onto an
image of said region created by said image data by using said
synchronized positional data and image data; and
tracking a position of said instrument during an insertion of said
instrument into said patient using said superimposed position
indication.

10. The method according to claim 9, further comprising displaying
said image of said region of said patient with the superimposed
position indication for said instrument.

11. The method according to claim 8 - 10, further comprising:
determining a reference point by performing a measurement on
specific part of said instrument when said instrument is placed in an
initial position, wherein position data for said initial position is obtained
and said reference point is determined based on said position data.

12. The method according to claim 8 - 11, wherein said position
data includes information of a linear movement along an longitudinal
axis of said instrument relatively said reference point and/or a rotation
of said instrument around said longitudinal axis.

13. The method according to claim 8 - 12, wherein said image data
is obtained from computed tomography, CT, magnetic resonance
imagining, MRI, isocentric C-arm fluoroscopic imagining, or positron
emission tomography, PET.
Performing a reference measurement

Providing position data

Synchronizing position data with image data

Superimposing a position indication for the instrument onto an image of region of the patient

Displaying an image of the region with the superimposed position indication

Fig. 6
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B17/34 A61B19/00
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Relevant to claim No.</th>
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<td>Y</td>
<td>figures 1B,5A,5B,6,7 paragraphs [0035], [0037]</td>
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<td>EP 1 574 825 AI (XITACT S A [CH]) 14 September 2005 (2005-09-14)</td>
<td>1-4, 6</td>
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<td>Y</td>
<td>paragraph [0042] - paragraph [0044]; figures 1, 6</td>
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<td>US 2003/208103 AI (SONNENSCHEIN ELAZAR [IL] ET AL) 6 November 2003 (2003-11-06)</td>
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<td>US 6 731 966 BI (SPIGELMAN ZACHARY S [US] ET AL) 4 May 2004 (2004-05-04) page 14, lines 67; figures 1,2</td>
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Further documents are listed in the continuation of Box C. 

See patent family annex.

* Special categories of cited documents:

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

"E" earlier document 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 referred to in 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.

"Z" member of the same patent family.

Date of the actual completion of the international search

29 July 2011

Date of mailing of the international search report

08/08/2011

Name and mailing address of the ISA/
European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax (+31-70) 340-3016

Authorized officer

Schi eBI, Werner
INTERNATIONAL SEARCH REPORT

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

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

1. [X] Claims Nos.: 8 - 13
   because they relate to subject matter not required to be searched by this Authority, namely:
   see FURTHER INFORMATION sheet PCT/ISA/2 10

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

3.  [ ] Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

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 an additional fees, this Authority did not invite payment of additional fees.

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

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

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.

Form PCT/ISA/21 0 (continuation of first sheet (2)) (April 2005)
Continuation of Box II.1

Claims Nos.: 8-13

Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery and therapy since using an optical tracking device to produce consecutive output signals representing movement of an instrument and providing a position change thereof inevitably implies movement of said instrument positioned in a target area of a brain (see fig. 1) and thus a surgical step.
<table>
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