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Device and method for connecting a medical instrument to a position-detecting system

Abstract

The invention relates to a device for connecting a medical instrument to a position-detecting system, the device having a localization element. The medical instrument has an instrument shaft, an instrument tip and an operating point. At least one localization element for determining position information for the device within a coordinate system of the position-detecting system can be provided on the device, the device having at least one retaining means for attaching the localization element to the medical instrument.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS

(1) This application is the U.S. National Stage of International Application Number PCT/EP2014/065030 filed on Jul. 14, 2014 which application claims priority under 35 USC § 119 to German Patent Application No. 102013214067.3 filed on Jul. 17, 2013, which applications are hereby incorporated by reference in their entirety.

TECHNICAL FIELD

(2) The invention relates to a device for connecting a medical instrument, in particular a medical instrument for invasive surgical interventions, to a location-detecting system, the medical instrument having an instrument shaft, an instrument tip and a working point.

BACKGROUND OF THE INVENTION

(3) In this context, a location-detecting system is intended to mean a system which delivers location information to a medical instrument. The location information is useful in order to use an instrument in combination with imaging devices such as tomographs or tomographically obtained image data. In this context, location information is intended to mean the position and the orientation of the medical instrument in relation to a reference coordinate system. A reference coordinate system is a coordinate system of a location-detecting device or of a location-detecting system. The location information may be acquired by means of a location-detecting device with a corresponding measuring system.

(4) During the conduct of invasive surgical interventions, preoperatively obtained image data of the patient, for example computed tomography recordings, are often used as planning data. Furthermore, it is usual to record images of the patient intraoperatively, i.e. with an endoscope, and to represent these together with the preoperatively compiled data on a monitor, respectively as an individual image or overlaid. In this way, for example, tissue to be removed or nerve paths or vessels lying in the operation region and potentially at risk from the surgical intervention can be made more clearly visible to the surgeon. This representation of the image data can therefore assist the surgeon to use the medical apparatus employed during the operation as efficiently as possible and with the least possible damage to the patient's surrounding tissue. In this case, the surgeon must first navigate the medical instrument as accurately as possible along a determined path into a usually preoperatively established intervention region in the patient's body and carry out the operative measures, for example the removal of tissue parts, as precisely as possible in the intervention region. Following the operative measures, the medical instrument must be navigated back out of the patient's body while being monitored. Therefore, invasive surgical interventions often require a high degree of accuracy of the location information of medical instruments which is being ascertained.

(5) Furthermore, the mental correlation between the image data provided and the control of the medical instruments can easily lead to orientation problems for the surgeon and therefore to operational mistakes and/or lengthening of the operation.

(6) For this reason, position-detecting or location-detecting systems are regularly used as an orientation aid for the surgeon during the operation, for example in order to assist navigation of medical instruments, in particular surgical instruments. During the operation, such systems record the coordinate transformation between the patient and at least one medical instrument. In many location-detecting systems, location information of a multiplicity of different medical instruments can be determined. The location information obtained is generally visualized on a monitor together

with the preoperative planning data and/or the intraoperative image data. To this end, Localization elements, the location information of which is recorded by a measuring system as a location-detecting device, are arranged at particular positions of the patient as well as on the medical instruments.
(7) In this way, the location information of the localization elements in the location-detecting system can initially be determined.
(8) Such location-detecting systems may for example comprise optical, ultrasound-assisted or electromagnetic localization elements. For example, electromagnetic location-detecting systems which have a field generator are known. The field generator generates a generally alternating AC electric field in an operation region. Localization elements which have coils are arranged on a medical instrument to be navigated in this operation region. The AC electromagnetic field induces in these coils characteristic currents as a function of the orientation of the respective coil relative to the AC electromagnetic field, and the location information of the coils can be determined from these currents.
(9) It is furthermore known to provide various medical instruments, for example pointer instruments, siphons, forceps, needles, scalpels, electrotomes, cauterizers, etc., with localization elements for determining the location information for such a location-detecting system and to register the respective medical instrument in the location-detecting system. During the registration of the medical instrument, the location of a reference—usually the working point of the instrument tip—relative to the localization element arranged on the medical instrument is calibrated and transmitted to the location-detecting system. The location of the reference point and orientation of the medical instrument in the coordinate system of the location-detecting system are therefore known and can be represented on the monitor together with the existing image data.
(10) A requirement for registration of a medical instrument in a location-detecting system is that the medical instrument has at least one localization element. However, there are many medical instruments which do not have such a localization element and cannot therefore be used in a location-detecting system.

SUMMARY OF THE INVENTION

(11) It is therefore an object of the present invention to provide a device for connecting a medical instrument to a location-detecting system, so that medical instruments which do not have their own localization element can be registered in a location-detecting system, in order that location information of the respective medical instrument can be determined by the location-detecting system and, for example, can be represented on a monitor.
(12) According to the invention, the object is achieved by a device having a localization element for connecting a medical instrument to a location-detecting system, the medical instrument having an instrument shaft, an instrument tip and a working point. At least one localization element for determining location information, for instance orientation and position, of the device relative to a reference point can be arranged on the device. The device furthermore has a holding means for fastening to the medical instrument.
(13) Preferably, the holding means has an instrument holder, at least a subsection of the medical instrument being engageable with the instrument holder and being fastenable to the instrument holder by at least one fixing means. The instrument holder may be for example, configured in the shape of a cup or a cylinder. Preferably, the instrument holder is configured in order to hold a subregion of the medical instrument. Furthermore, the instrument holder can preferably be fitted onto the medical instrument on the instrument tip side, i.e. the distal end of the medical instrument, and can be displaced along an instrument longitudinal axis on the instrument. Preferably, the instrument holder is fastened to the instrument shaft by the fixing means.
(14) Preferably, the fixing means comprises a screw. The screw can for example be screwed into the device so that, as a result, its preferably flattened screw tip presses against an instrument shaft section which the instrument holder comprises, so as to hold the medical instrument in the

instrument holder.
(15) In a preferred embodiment of the invention, the fixing means has a clamping device, in order to hold the medical instrument in the instrument holder. The clamping device may for example have clamping jaws, which are to be clamped to the medical instrument by means of a screw mechanism.
(16) Preferably, the device has a sensor holder which can hold the localization element. In this case, both embodiments in which the localization element is to be held reversibly and embodiments in which the localization element is to be held irreversibly in the sensor holder are provided.
(17) In a preferred embodiment of the invention, the sensor holder and the localization element have guide means, by means of which the sensor element and localization element can be connected to one another, or engaged with one another, in such a way that the sensor holder and the localization element can be displaced relative to one another on a guide path. In this case, for example, the sensor holder may have a rail-shaped part and the localization element may have a corresponding carriage-shaped part. As an alternative the sensor holder may have a carriage-shaped part and the localization element may have a rail-shaped part.
(18) Preferably, the guide means of the sensor holder and/or of the localization element are configured in such a way that a relative movement of the sensor holder and the localization element is possible only as far as a defined point on the guide path. To this end, at least a part of the guide path may, for example, have a tooth or a stop.
(19) Preferably, the guide means of the sensor holder and/or of the localization element have a retaining means with a spring element, the localization element being fixable in a predefined position on the guide path by the retaining means. The retaining means is preferably configured to trigger the fixing by the movement of the localization element along the guide path. To this end, the rail-shaped part of the guide means may for example have a groove, and the carriage-shaped part of the guide means may have a resiliently held wedge, which can be tilted by the spring force into the groove of the rail-shaped part and therefore cause the fixing.
(20) In a preferred embodiment of the invention the localization element is arranged firmly on the holding means. Removal of the localization element from the holding means is not provided in this embodiment.
(21) Preferably, the device has an outer surface with an essentially cylindrical shape. The outer surface may, however, also be configured with an essentially cuboid or quadrilateral shape.
(22) In an advantageous configuration of the invention, the device is configured in order to be connected to a control unit of the location-detecting system by a cable, in order to transmit signals from the localization element to the control unit of the location-detecting system. To this end, the device may have a cable or a connection for a cable, for example a jack socket. As an alternative, the device may send the signals of the localization element to the control unit of the location-detecting system via a radio device. In such a wireless embodiment, the device preferably has means for providing a supply current, for example an accumulator or battery.
(23) Preferably, the holding means has a channel extending in the longitudinal direction of the holding means. The channel is open at both end sides of the holding means, so that at least the instrument tip of the medical instrument can be passed through the channel.
(24) Furthermore, preferably, the channel has an essentially oval cross section. The advantage of the oval cross section is, in particular, that the holding means can be displaced along a curved region of an instrument longitudinal axis of a flexurally stiff and curved instrument tip.
(25) According to the invention, a localization element held on the medical instrument by the device can be calibrated to the working point of the medical instrument. This may, for example, be done by a method in which a reference point is approached with the working point of the instrument tip, and at the same time the location and orientation of the localization element held on the instrument are detected. When the reference point is reached, the localization element is therefore calibrated to the instrument tip. Preferably, at the moment when the working point of the

instrument tip reaches the reference point, the working point is automatically calibrated. This is, for example, made possible by a pressure sensor at the reference point, or an electrical circuit which is closed by contact of the working point of the instrument tip with the reference point. As an alternative or in addition, the method may provide that, as a starting condition for calibration of the localization element to the instrument tip, a check is made whether the reference point to be approached lies within a search sector which relates to the localization element held/to be held on the medical instrument. The search sector may be differently specifiable depending on the instrument. Preferably, the search sector is configured in the shape of a wedge. The wedge axis lies, in particular, coaxially with a longitudinal axis of the instrument tip and/or coaxially with a channel of the holding means, intended for the instrument to be passed through. The wedge tip preferably points toward and/or preferably lies at the center of the localization element. Preferably, the search sector is specified in such a way that an instrument tip lies inside the search sector when the localization element is held on the medical instrument.

(26) As an alternative (or in addition), the device may also be configured in such a way that automatic calibration is carried out when the working point (i.e. for example the instrument tip) remains at the reference point for a predetermined time. After successful calibration, the location data of the working point of the instrument tip may be determined by the location-detecting system by means of the location information provided by the respective localization element.

(27) Particularly preferably, the reference point is arranged on a localization element which is connected to the location-detecting system and is registered. The localization element may likewise be the localization element of an instrument, so that two medical instruments can easily be registered at the same time within the location-detecting system. The exact position of the reference point within the location-detecting system can therefore be determined easily. The reference point arranged on the localization element is suitable for calibrating a new instrument, equipped with a further localization element, to the working point of the instrument. Such a calibration process may therefore also be carried out intraoperatively. A further or alternative reference point may be a localization element which is arranged on the patient and is configured for determining the location information of the patient within the location-detecting system.

(28) It is particularly preferred for the reference point to be configured as a depression or an elevation (for example on a second instrument), in order to allow self-centering of a corresponding medical instrument at the reference point. A depression-shaped reference point is particularly suitable for self-centering of an instrument having a tip-shaped instrument tip with the reference point, since the instrument tip can be introduced into the depression and therefore guided along an inner surface of the depression to the midpoint thereof. Furthermore, preferably, the midpoint of the depression has a further local indentation with a smaller depression radius, into which an instrument tip can be introduced. The approaching of the depression midpoint with the instrument tip is therefore further facilitated. A reference point configured as an elevation is particularly suitable for the calibration of instruments which comprise a tubular instrument tip having an inner channel, for example siphons.

(29) Preferably, the localization element has a sensor coil. Sensor coils are suitable for use in position-detecting systems having an AC electromagnetic field generated by a field generator.

(30) Particularly preferably, the location-detecting system is configured in order to register and simultaneously manage a plurality of localization elements. The location information of a plurality of medical instruments equipped with localization elements can therefore simultaneously be determined as well as graphically and/or digitally represented. The management of a plurality of localization elements may, for example, be carried out by means of multiplexing. In the case of multiplexing, the registered localization elements are driven at a predetermined clock rate so that only one particular localization element is respectively driven by the location-detecting system at one time. In this case, it is advantageous that the location-detecting system can discriminate between active and inactive instruments. Inactive instruments may therefore be blocked out by the

location-detecting system, for example by a corresponding filter, or the corresponding localization elements may be deactivated in order to increase the stability of the signals of the localization elements of the active instruments.
(31) To this end, the multiplexer may, for example, be configured so that initially all the localization elements are activated and driven at the predetermined clock rate. As soon as a localization element of an instrument arranged in an operation region is detected, the remaining localization elements are deactivated or the corresponding instruments are blocked out until the active instrument leaves the operation region again. For the residence time of the active instrument in the Operation region, the corresponding localization element is preferably detected continuously by the location-detecting system. The location-detecting system may preferably be configured manually in order to detect a larger number than one instrument, for example two, simultaneously in the operation region by means of multiplexing, and only to deactivate the remaining localization elements or block out the corresponding instruments when this predetermined number of active instruments arranged in the operation region is reached.
(32) In an alternative configuration of the invention, a device may be provided in order to unblock a particular instrument manually and/or activate the respective localization element. This may, for example, be done by means of a pressure sensor arranged on the instrument handle, which automatically detects when the instrument is being held in the hand. The control may be configured in such a way that the corresponding instrument remains active and unblocked until another instrument is activated, or unblocked. The system may be configured in order to manage a plurality of active instruments simultaneously. Furthermore, the system may be configured in order not to automatically deactivate or block out an activated instrument arranged in the operation region. This ensures that an instrument, for example, remains active for at least as long as it is arranged inside the operation region.
(33) As an alternative, the instrument rack may, for example, be configured in order to detect inactive instruments which are placed on an instrument rack and forward this information to the location-detecting system, so that the location-detecting system deactivates or blocks out these inactive instruments.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) The invention will now be explained in more detail with the aid of an exemplary embodiment with reference to the figures. In the figures:
(2) FIG. **1** shows a schematic side view of a medical instrument with localization element fitted thereon;
(3) FIG. **2** shows the view of the medical instrument of FIG. **1**, a further localization element being arranged on the instrument tip; and
(4) FIG. **3** shows a front view of a control unit with localization element coupled thereto, a localization element being arranged on a medical instrument.
DETAILED DESCRIPTION
(5) The medical instrument **10** represented in FIG. **1** has an instrument shaft **12** and an instrument tip **14**. The instrument shaft **12** has a distal shaft region **12***a* and a handle region **12***b*, a proximal tip region **14***b* of the instrument tip **14** being arranged on the distal shaft region **12***a*. The instrument shaft **12** may be configured in one piece or in several pieces, separately, with the instrument tip **14**.
(6) The instrument tip **14** has a distal tip region **14***a*, on the end of which facing away from the proximal tip region **14***b* a working point **16** is arranged. The instrument tip **14** furthermore has a curved region **15**, which is next to the distal tip region **14***a*. In alternative embodiments, the instrument tip **14** may also have curvatures stronger (smaller radius) than represented, or further

curvatures. The instrument shaft **12** and the instrument tip **14** have an essentially round cross section.

(7) A localization element **20** is arranged next to the distal shaft region **12***a* on the proximal tip region **14***b* of the instrument tip **14**. According to the embodiment shown, the distal shaft region **12***a* has a conical taper extending in the direction of the instrument tip **14**, which can be engaged at least partially with the localization element **20**. The localization element **20** is secured against displacement along a longitudinal axis of the instrument tip **14** by means of a clamping screw **22** on the proximal tip region of the instrument tip. Furthermore, the localization element **20** has a cable **18** for connection to a control unit **26** shown in FIG. **3**.

(8) By means of a reference point **24**, the localization element **20** can be calibrated to the working point **16** of the medical instrument **10** for calibration. The calibration process may be carried out essentially automatically by the operator bringing the working point **16** of the medical instrument **10** into contact with the reference point **24** and, for example, maintaining this state for a predetermined time—for example from 1 to 2 seconds. As an alternative, for example, the reference point **24** may have a sensor (not represented here) which detects the moment of contact of the working point **16** with the reference point **24** and forwarding a corresponding signal to the control unit **26**, so that the control unit **26** can record the location data of the localization element **20** at the time of contact of the working point **16** with the reference point **24** and therefore complete the calibration measurement. After calibration has been carried out, the location information of the working point **16** of the medical instrument in an operation region can be determined by means of the sensor signals transmitted from the localization element **20** to the location-detecting system.

(9) As shown by FIG. **2**, a plurality of localization elements **20** may be arranged according to the invention on a medical instrument **10**, One localization element **20** is already arranged in this view on the proximal tip region **14***b* of the instrument tip **14** as previously in FIG. **1**, while a further localization element **20** is furthermore held on the distal tip region **14***a* and can be displaced toward the proximal tip region **14***b* along the tip longitudinal axis. The advantage of using a plurality of localization elements **20** on a medical instrument **10** is that the localization elements **20** provide mutually complementary and partially redundant location information, and measurement variations or measurement errors can therefore be detected by the control unit **26** of the location-detecting system.

(10) Likewise shown in FIG. **2** is a wedge-shaped search sector **27**. The search sector **27** relates to the localization element **20** held on the medical instrument **10** in the proximal tip region **14***b*. The wedge axis z lies coaxially with the longitudinal axis of the instrument tip **14**. The wedge tip of the wedge-shaped search sector **27** points toward and lies at the center of the localization element **20** which is held in the proximal tip region **14***b*. The wedge-shaped search sector **27** therefore starts from the localization element **20** and extends and widens in the distal direction. Preferably, it ends at a defined distance from the localization element **20** and therefore defines a search space delimited on all sides. The search sector **27** is in the present case specified in such a way that an instrument tip **14** lies inside the search sector **27** when the localization element **20** is held on the medical instrument **10**. The search sector **27** may also have a different shape, and need not be wedge-shaped. The purpose of the search sector **27** is to trigger automatic calibration only when it is found that the position data of the reference point **24**, detected by the location-detecting system, lie inside the position data space (set of position data falling within the search sector) spanned by the search sector **27**. In embodiments of the medical instrument **10** with an instrument shaft **12** and instrument tip **14** which can be separated from one another, the localization element **20** may be configured in order to be fitted directly onto the proximal tip region **14***b* when the instrument shaft **12** and the instrument tip **14** are separated from one another. After the fitting of the localization element **20**, the instrument shaft **12** and the instrument tip **14** may be reconnected to one another.

(11) As an alternative, embodiments are provided in which the localization element **20** can be fitted onto the instrument shaft **12**. To this end, in principle, the same holding means as for fastening to

the instrument tip **14** are suitable, the dimensions of the instrument shaft **12** needing to be taken into account.

(12) According to the invention, a control unit **26** (as represented in FIG. **3**) may be connected to a plurality of localization elements **20**, preferably in each case by a cable **18**. In this case, one or more localization elements **20** may respectively be arranged on a medical instrument **10**. Furthermore, the localization elements **20** may be arranged on different medical instruments **10**, only one medical instrument **10** being shown in FIG. **3**. The control unit **26** may have a filter in order to block out inactive instruments **10**, which are arranged for example on an instrument rack (not represented). In this way, the stability of the signals of the active instruments **10** is increased.

LIST OF REFERENCES

(13) **10** medical instrument **12** instrument shaft **12***a* distal shaft region **12***b* handle region **14** instrument tip **14***a* distal tip region **14***b* proximal tip region **15** curved region **16** working point **18** cable **20** localization element **22** clamping screw **24** reference point. **26** control unit **27** search sector z cone axis

Claims

1. A location-detecting system for determining location information of a medical instrument intraoperatively, the location-detecting system comprising: a reference point, wherein a location of the reference point within a coordinate system of the location-detecting system is determinable; and an instrument tracking device comprising at least one holding means for fastening the instrument tracking device to the medical instrument so that the medical instrument is connected to the location-detecting system, wherein said medical instrument comprises an instrument shaft and an instrument tip having a working point, said instrument tracking device comprising at least one localization element arranged on the instrument tracking device that is configured for use with the reference point and working point, wherein said reference point and said working point are not the same, to calibrate the at least one localization element to the working point, the at least one localization element comprising a sensor coil; and a control unit for recording location data of the at least one localization element, wherein the instrument tracking device is connectable by a cable to the control unit so that the at least one localization element can transmit sensor signals representing said location data of the instrument tracking device and the medical instrument fastened thereto to the control unit, and wherein the location-detecting system is configured: to detect location and orientation of the instrument tracking device within the coordinate system of the location-detecting system and to automatically calibrate said localization element of the instrument tracking device to the working point of said medical instrument when the location-detecting system detects that the reference point lies within a search sector of the at least one localization element of the instrument tracking device fastened to the medical instrument, wherein the search sector is configured in a wedge shape, wherein the wedge is aligned coaxially with a longitudinal axis of the instrument, or aligned coaxially with a channel of the holding means, or both.

2. The location-detecting system according to claim 1, wherein the at least one holding means comprises an instrument holder, wherein at least a subsection of the medical instrument is engageable with the instrument holder and is fastenable to the instrument holder by at least one fixing means of the instrument tracking device.

3. The location-detecting system according to claim 2, wherein the fixing means comprises a screw, which is configured to be screwed into the instrument tracking device such that a flattened tip of the screw presses against a section of the instrument shaft thereby holding the medical instrument in the instrument holder.

4. The location-detecting system according to claim 2, wherein the fixing means comprises a clamping device.

5. The location-detecting system according to claim 1, wherein the instrument tracking device

comprises a sensor holder configured to hold the localization element.
6. The location-detecting system according to claim 1, wherein the localization element is arranged irreleasably on the at least one holding means.
7. The location-detecting system according to claim 1, wherein the instrument tracking device comprises a cylindrical outer surface.
8. The location-detecting system according to claim 1, wherein the at least one holding means comprises a channel extending in a longitudinal direction, wherein the channel is open at both end sides of the at least one holding means, and wherein at least the instrument tip of the medical instrument is passable through the channel.
9. The location-detecting system according to claim 8, wherein the channel comprises an oval cross section.
10. A method for using the instrument tracking device of the location-detecting system according to claim 1, wherein the instrument tracking device is fastened to the medical instrument and wherein the at least one localization element is calibrated to the working point of the medical instrument, the method comprising: approaching a reference point with the working point of the instrument tip, and simultaneously detecting the location and orientation of the localization element held on the medical instrument, and wherein when the working point of the instrument tip reaches the reference point, the working point is automatically calibrated, or automatic calibration is carried out when the working point remains at the reference point for a predetermined time.
11. The location-detecting system according to claim 1, wherein the location-detecting system is configured to have as a starting condition for calibration of the localization element to the instrument tip to determine whether the reference point to be approached lies within the search sector.
12. The location-detecting system according to claim 1, wherein the reference point is formed to have a depression configured to receive and self-center a corresponding medical instrument.
13. The location-detecting system according to claim 12, wherein the depression further comprises a local indentation at a midpoint of the depression, wherein the local indentation has a radius smaller than the depression and is configured to receive an instrument tip.
14. The method according to claim 10, wherein the search sector wedge has a tip that points toward, lies at a center of the localization element, or both.