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Konzept für ein navigiertes mikro-chirurgisches Assistenz System für die Mittelohrchirurgie

Concept for a navigated micro surgical assistant system for middle ear surgery

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Introduction

In the field of micro surgery e.g. middle ear surgery the surgeon is very often confronted with very small and sensitive structures. In this context there are some general problems: 1) The size of these structures wich should be manipulated are hard at the edge of the human manipulating skill of approximately 0.5 mm. 2) While getting access to the operation field the surgeon has to mill with extensive force, whereas shortly after he has to do precise and tremble free positioning of the surgical instrument. 3) In many cases the surgeon decides to use a microscope for the surgery (figure 1). Thereby the coordination of the optical sensed scene and the handling of the haptic sensed surgical instrument is very difficult to combine to a precise work. These problems could lead into complications (injury of sensitive structures like nerves or vessels) or cost-intensive following surgeries.

To achieve lower complication rates and a better quality a combination of navigation and robotic assistant system is concepted for supporting the work of a surgeon and eliminating the described problems.

Material and Methods

During the first realization step the navigation system was implemented (figure 2). It consists of a tracking system MicronTracker (Claron Technology, Canada, Toronto), lokalisators for instrument and patient and a visualization computer with a touchscreen monitor. For the visualization of the 3D-scene CT-Data taken before the surgery are integrated. Due to the fact that the accuracy of a pure freehanded navigation is insufficient

to achieve the demanded accuracy of 100 µm, a 2 d.o.f. manipulator is developed parallel to the first realization step (figure 3).

The used tracking system is compact in size (157x39x42 mm^3) and based on a new principle of black-white pattern recognition. This system is currently only available for evaluation. The following accuracy measurements have been carried out to show the usability of the system in surgery. Experiment 1: Error distribution over the work area of the camera. Experiment 2: Influence of intensive surgery-light (80,000 to 150,000 Lux) on the error. Both measurements where taken for the noise of one measurement point as well as for the distance between two measurement points.

Results and Discussion

The experiments have shown that the error between two measurement points rise by increasing camera distance. The work area along the camera to object axis is between 300 and 1500 mm. The mean error in the essential work area between 500 and 1000 mm is 0.31 mm with a standard deviation of 0.09 mm (Noise: 0.13 mm). Under influence of surgery light the mean error rise to 0.39 mm with a standard deviation of 0.14 mm (Noise: 0.17 mm). With a new design of the localisator pattern the mean error under lamp light is reduced to 0.11 mm with a standard deviation of 0.11 mm (Noise: 0.16 mm).

The maximum error is higher than the demanded error of 100 µm therefore it is absolute necessary to combine the tracking system with an accurate manipulator.

Caption:
Figure 1: surgery with usage of a microscope
Figure 2: complete system of the navigation system and MicronTracker system
Figure 3: combination of a manipulator and navigation system with surgery-light