AN INTERACTIVE ASSISTANCE SYSTEM FOR MINIMALLY INVASIVE NEUROSURGERY

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INTRODUCTION

In minimally invasive surgery, the visualization of critical anatomical structures is an ongoing challenge. Taking the real 3D nature of the patient’s condition and realistic surgery circumstances into account, the principle of augmented reality (AR) is employed for interactive navigation in neurosurgery. One promising approach is the Magic Lens concept, in which a physical lens (e.g. a tablet computer) is used to assist the surgeon’s intraoperative understanding of the tissue structures (context) with digital 3D models (focus). The objective of the CephaLens project is to develop such a mobile surgical assistance system with a tablet-based interaction concept for emergency external ventricle puncture.

This feature was incorporated in two tablet interaction modes with the aim of decreasing idle time during procedures (Fig. 2). The indirect interaction mode in which the tablet is placed in a docking station, follows the surgeon’s view while displaying the tracking pointer, and the direct interaction, where the tablet is picked up to enable increased spatial awareness.

RESULTS

The camera setup had an internal calibration error of $1.5 \pm 0.5$ mm with a mean tracking error of $0.05 \pm 0.007$ mm and $0.08 \pm 0.06$ mm for the patient’s head and navigation pointer, respectively. Patient registration was performed with a landmark-based approach with registration errors of $2.50 \pm 0.5$ mm. Surface models were reconstructed using a marching cubes algorithm for isosurface extraction from CT data (resolution approx. 4 mm). A preliminary study of the spatial overlap of the real patient’s head and the digital patient model was determined with a surface error of roughly 4.0 mm.

DISCUSSION & CONCLUSION

We developed a novel concept for a prototype assistance system in neurosurgical applications derived from a preceding prototype system. Compared to other AR principles of including the additional anatomical data in preexisting displays, e.g. a microscope or endoscope view, the lens view stands out thanks to its intuitive handling in the interaction mode, reduced hardware requirements and its mobile character. Tracking accuracy and robustness were highly dependent on the camera fixation. Moreover, how the tablet affects surgeon workflow and productivity is yet to be evaluated.