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Miniaturized Instrument-Mounted Navigation System

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Introduction

Currently existing optical navigation systems have ergonomic disadvantages such as size, the “line of sight” problem and extended registration procedures. The operation room becomes crowded by additional installations and competitive supporting devices around the patient. These points reduce and limit the acceptance of navigation systems for further applications. But especially for surgical quality management, navigation systems have a high potential as objective measurement systems [1].

Methods

Our presented work introduces a miniaturized navigation system which overcomes the limitations of current navigation systems. It has been developed in a joint research project between a technical university, a university hospital and an industrial partner. The system consists of a stereo camera system which recognizes miniaturized ceramic markers. The prototype is handheld and can be mounted directly onto a surgical instrument.

Results

Several miniaturised measuring system prototypes with high resolution cameras mounted directly onto a surgical instrument have been developed and tested. Corresponding algorithm and software developments include calibration, marker identification, network components and surgical planning modules. The accuracy of the presented system was evaluated with an XYZ positioning stage. After intrinsic and extrinsic camera calibration with a 3D calibration specimen, a translation accuracy of 0.038mm (RMS) has been measured using 124 locations distributed inside the working volume. The orientation of the markers in space has been quantified in an accuracy of 0.267 degrees (RMS).
Hard and software components have been tested in an ex vivo study. The prototype was mounted onto a surgical drill and was used for preoperatively planned navigated drilling.

Conclusion

The development of the miniaturized measuring system was successful. It minimizes the distance between situ and camera, which promises an increased accuracy, a reduced “line of sight problem” and intuitive handling. In the next iteration of the development process, the usability and accuracy of the system will be improved.

[1] S. Linke, R. Elfring, C. Buschmann, K. Rademacher (2010). Influence of optical tracking markers on localization accuracy. 10th Annual Meeting of CAOS-International, p. 213-216.