Potential, Limitations and Challenges of Markerless Registration with the DLR 3D-Modeller in Medical Applications

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Keywords: Contact Free Surface Based Registration, Handheld System, Accuracy Evaluation

1. Introduction

Registration is necessary whenever planning data (e.g. biopsy needle trajectories based on preoperative images) have to be transferred into the operation room (OR). In numerous medical interventions a successful registration is crucial for the quality of the medical procedure, including radio surgery and navigated surgery. Often standard approaches in clinical use are based either on artificial landmarks or anatomical landmarks, e.g. the manubrium.

Markerless methods using e.g. the patient skin or bone surface are in clinical use, too (e.g. z-touch from BrainLAB). However, contact free systems still lack of dexterity and accuracy and are a current research topic

This work analyses a markerless and contact free registration using the advanced DLR 3D-Modeller (3DMo). The 3D-Modeller allows for acquiring the patient surface intraoperatively using three different methods: a stereo camera sensor (SCS), a laser-range scan (LRS), and a light-stripe profiler (LSP).

Methods

Three plaster cast models are scanned 10 times with the LRS and LSP method. The scans are then registered with the preoperative data using an iterative closest point (ICP) algorithm and the results are compared with a registration based on titanium markers, considered as gold standard.

Results

Each scan of the plaster cast model takes only a few seconds (ranging from 10 s – 20 s for LSP and 15 s – 30 s for LRS). The LRS method takes more time since the 3DMo has to be positioned closer to the surface, and the range of recorded data is thus smaller than in case of the LSP method. However the LRS method is more robust against illumination changes and lighting conditions in the OR as compared to the LSP method. Mean deviations between gold standard and surface based methods are in the range of 1.6 mm to 2.2 mm.

Conclusion

A key advantage of markerless and contact free registration as opposed to artificial marker based registration is the non-invasiveness of the procedure. This work analyses two basic methods for surface based registration as implemented in the highly dextrous handheld DLR 3D-Modeller, namely the laser-range scan method and the light-stripe profiler method. To conclude, our evaluation of the presented registration procedure shows a sufficiently good accuracy to be applied in a variety of medical applications, ranging from port placement in minimally invasive surgery to osteotomies, image guided bone segment navigation, and foreign body removal. Further efforts have to be made to increase the accuracy of the entire system in order to be suitable for biopsy applications in brain surgery and other highly demanding surgical interventions. Another future step will be to evaluate the accuracy of the presented approach using real data from test subjects.