

Image-guided Surgical Microscope

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Introduction

We present an image-guided surgical microscope system using augmented reality image overlays added onto one of the views of the operating microscope. With this system, segmented objects, outlines of risk regions, access pathways or 3D objects, previously extracted from preoperative tomographic images can be directly displayed as augmented reality overlays on the microscope image.

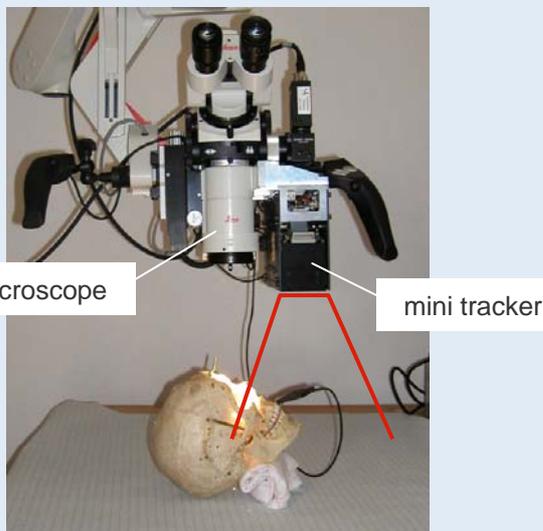


Fig.1: The Image-guided surgical microscope with mounted mini-tracker

Results

The measured overall overlay accuracy using a grid test was 0.95 mm (rms), and 1.05 mm using a plastic skull. An error analysis of the individual contributing error sources lead to the following results: the two major contributions of error originated from the manual, pair-point registration of the object (0.1 mm for the grid, 0.3 mm for the plastic skull) and from the tracking inaccuracies by the mini-tracker, (0.2 mm rms error). The error of the microscope calibration, which includes errors in the estimation of the intrinsic and extrinsic parameters and errors inherent to the calibration standard amounts to 0.05 mm (rms), while the error originating from the calibration of the image injection module was 0.05 mm (rms). The obtained results (see example in figure 2) are satisfactory in order to proceed to clinical applications.

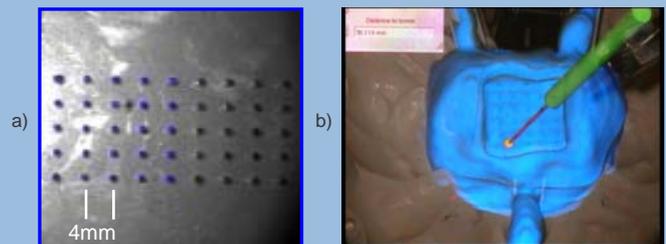


Fig.2: a) shows a microscope view of the test object consisting of a grid of spheres (diam. 1mm) with the corresponding CT cut-view overlaid in blue. b) shows an example of displaying 3D objects; a simulated tumor in blue and a virtual pointer in green. Also the distance from the pointer to the tumor is calculated.

Methods

Unlike other systems [1,2], the novelty of our design consists in mounting a precise mini-tracker [3] directly on the microscope to track the motion of the surgical tools and the patient (see figure 1). The rigid fixation of the camera on the microscope offers the advantage that it's not necessary to track the microscope. The microscope optic calibration was achieved using a calibration routine based on Heikkilä's model [4]. The mini-tracker tracks active LEDs in the infra-red range within an active volume of 30 x 30 x 30 cm with a precision of 0.2 mm (rms). Correctly scaled and rendered cut-views of the preoperative CT stack corresponding to the current field of view of the microscope were injected as augmented reality overlays onto the microscope view. An accuracy study, using a calibration grid and a phantom head equipped with fiducial markers has been carried out and the contribution of the individual error sources has been analyzed.

Discussion

A novel image-guided microscope architecture, which allows injection of overlay images onto the optical views of the microscope has been presented. The new architecture offers higher overlay accuracy and better ergonomics at lower costs. The presented accuracy study and the obtained results indicate that the system would be suitable for clinical use.

References

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