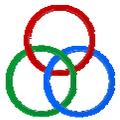




Image-guided Surgical Microscope

Jaime Garcia¹, Puja Malik¹, Jens Kowal¹, Gaetan Marti³, Ion Pappas¹, Marco Caversaccio²



¹M.E. Müller Institute for Surgical Technology and Biomechanics
University of Bern, Stauffacherstrasse 78, CH-3014 Bern, Switzerland

²Department of Head and Neck Surgery, Inselspital, University of Bern, Switzerland

³Virtual Reality and Artificial Intelligence Lab, EPFL, Lausanne, Switzerland

Introduction

We present an image-guided 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 or access pathways, previously extracted from preoperative tomographic images can be directly displayed as augmented reality overlays on the microscope image.

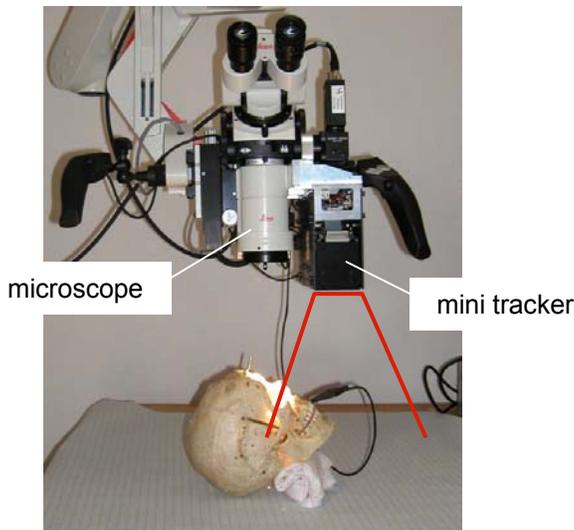


Fig.1: The Image-guided surgical microscope with mounted mini-tracker

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.

Results

The measured overall overlay accuracy for the calibration grid was 1 mm (rms). 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 (0.2 mm rms error) 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 0.06 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.

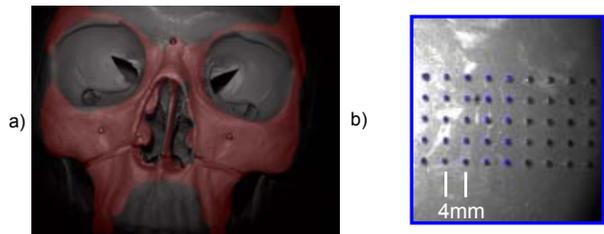


Fig.2: a) shows a microscope view of a phantom skull with the corresponding CT cut-view overlaid in red colour. b) shows a microscope view of test object consisting of a grid of spheres (diam. 1mm) with the corresponding CT cut-view overlaid in blue colour.

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: [1] Kiya N., Dureza C., Fukushima T. et al. „Computer Navigational Microscope for minimally invasive neurosurgery“. Journal Minimal Invasive Neurosurgery, Sept. 1997.

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