

**VIRTUE: A Navigated Virtual Endoscopy System for
Maxillo-Facial and Neurosurgery**

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Abstract

The combination of minimally-invasive endoscopic methods of surgery with techniques from virtual endoscopy and image-guided navigation promises a significant improvement of the three-dimensional spatial orientation during surgical procedures. In particular the better representation of risk structures like blood vessels or nerve fibers enables a better planning, and hence reduces the risk of serious complications of an intervention.

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1 Introduction

The virtual endoscopy system VIVENDI has been developed over the past years by the working group for “Visual Computing in Medicine” at the WSI/GRIS, in collaboration with the departments of neuroradiology and neurosurgery of the University of Tübingen. VIVENDI is an interactive system which can be used for the visual simulation of endoscopic examination. Furthermore, it enables a truly three-dimensional representation of the respective organ systems.

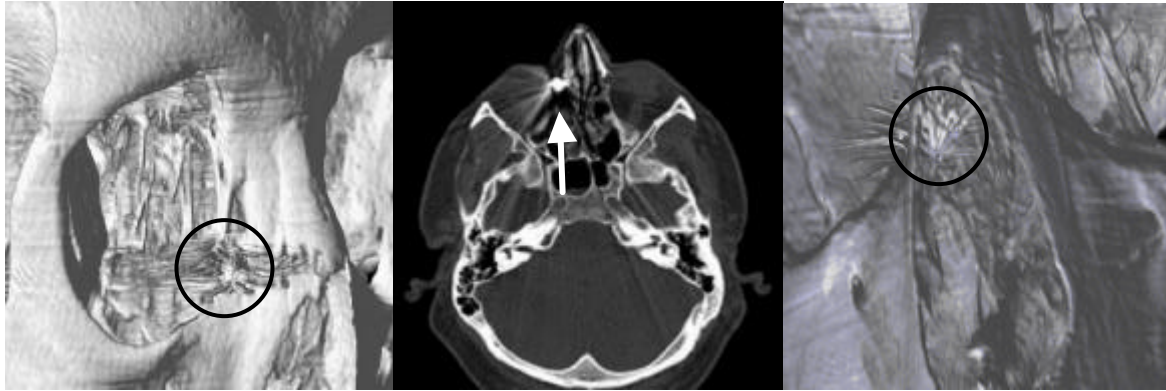


Figure 1: Bullet of an air rifle in the ethmoid on the right side. Using image-based navigation, it could be removed by nasal endoscopy, while an extensive bicoronal approach could be avoided. Left: View on the right facial skull (bullet is marked); middle: Slice from multi-slice CT with bullet (arrow); right: view through nose skeleton on bullet (marked).

Currently, VIVENDI is in a pre-clinical test phase, where it is used mainly for the planning of the actual intervention. Furthermore, it can be used for measurements of anatomical structures and for the volumetric evaluation of various cavities. In this context, VIVENDI has been used for the examination of the colon [6], of the ventricular system of the brain [1,5], as well as for the vascular systems of the heart [3] and the cerebral nervous system [2].

Systems and techniques of image-based navigation have been used at the University Hospital of Tübingen for quite some time. In particular, it has been used in the departments of neurosurgery [4,5] and in the maxillo-facial surgery [7]. During the intervention, the position and orientation of the referenced optical endoscope are mapped into a pre-operative acquired stack of images (volume dataset) of a medical 3D-canner (i.e., CT or MRI). Navigated optical endoscopy are used for diagnostic and therapeutical interventions, i.e., in the area of the cerebral ventricular system [4,5], the treatment of fracture reduction and osteosynthesis of the zygomatic bone [7], or for the navigation-based removal of foreign bodies (see Fig. 1). Catheter-based interventions are also performed in interventional neuroradiology, however no truly three-dimensional spatial representation of anatomical cavities are provided for interventions of this kind. Furthermore, the influence of the brain shift is largely ignored, since it either has only a limited impact, or the focus of the orientation is on the bone structures that are not affected by it.

The goal of this project is the efficient combination of virtual, and navigated-optical endoscopy for the clinical application for neuro- and maxillo-facial surgical intervention. This combination enables the three-dimensional visual representation of the organ system – based on the pre-operative 3D-scan of the patient –, coupled with the respective optical representation through the endoscope. In case a minor bleeding reduced the optical visibility, we keep the spatial orientation of the OR situ. Therefore, the virtual representation (Fig. 2) can still ensure the safe retraction of the endoscope. With the integration of multi-modal data from CT, MRI, or 3D rotational angiography, additional information can be overlaid on the virtual representation (Fig. 2), i.e., blood vessels or nerve fibres. Serious complications, such as an injury of major blood vessels – which are usually not visible through optical endoscopy –, can be avoided using this information. Furthermore, if an unusual anatomy, or an pathological variation increase the difficulties of orientation or identification of structures, a

virtual endoscopic examination can access these areas which are not accessible for the optical endoscope.

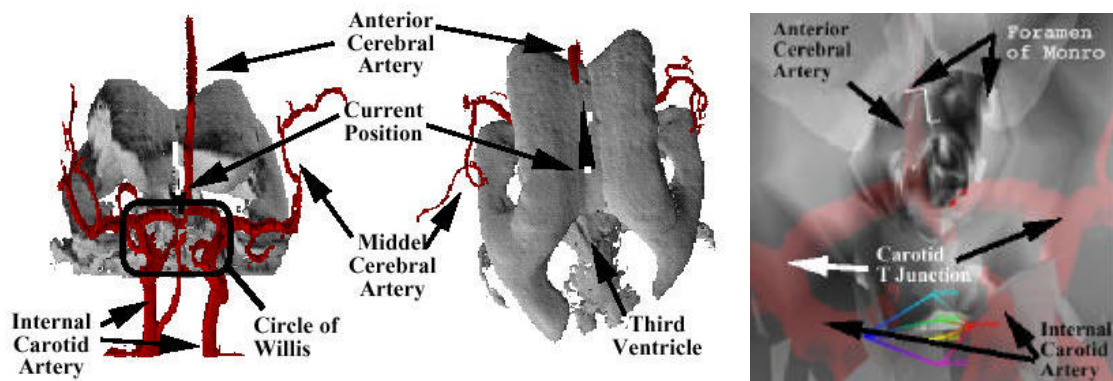


Figure 2: Multi-modal representation of the cerebral ventricular system with participating arterial blood vessels. Left: Front and top overview representation; right: virtual-endoscopic representation of the third ventricle.

2 Material and Methods

Figure 3 shows an overview of the project architecture. The VIVENDI-based planning of the intervention is based on a volume dataset of the patient (MRI in this example). Initially, the optical endoscope is referenced to the volume dataset, which enables the current 2D navigated imaging through the navigation system. This system provides the orientation and position data of the navigated endoscope to VIVENDI, which uses the information to synchronize the virtual view with the optical view. With this synchronized view, the surgeon can guide the endoscope to the target.

To achieve this goal, various problems need to be addressed. The combination of navigation and virtual endoscopy requires the real-time representation of the respective organ structures. VIVENDI uses a visibility driven rendering, which removes currently non-visible parts of the geometric representation of the organs. Other problems include the smoothing of jitter in the data transfer of the orientation- and position information, segmentation tasks, and the registration of the various datasets. A special focus is also the integration of the roll of the endoscope, which is not detected by the navigation system. Finally, the improvements of recent scanner technology requires new data management strategies to cope with the increased size of the data. In particular, data compression and out-of-core methods can be used to address these problems.

Diskussion

In summary, the combined representation of navigated, optical endoscopy with virtual endoscopy can significantly increase the share of useful information. This in turn reduces the risks of serious complications. Furthermore, the improved planning and navigation possibilities increase the range of potential endoscopic interventions.

Acknowledgements

This project is financed by DFG CatTrain, DFG VIRTUE, and the EU IST programme.

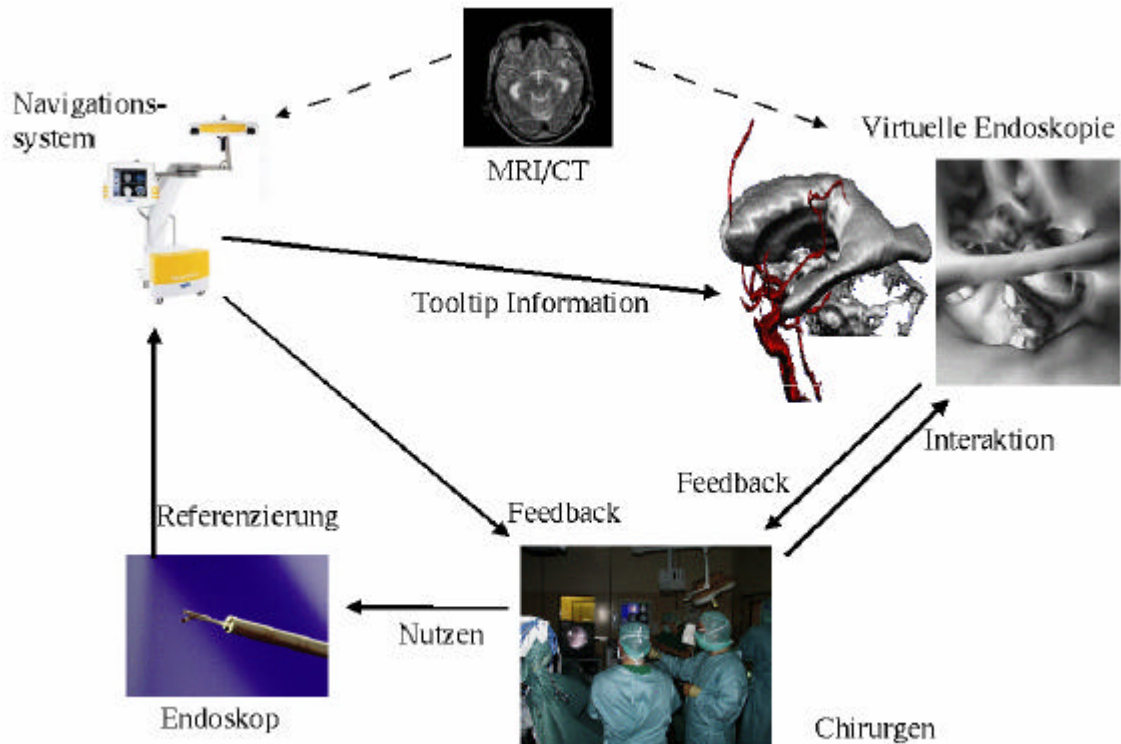


Figure 3: Overview of the architecture of the integration of virtual and navigated endoscopy.

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