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Segmentation für die präoperative Planung der NNH-Chirurgie

Surgical Segmentation for preoperative planning in paranasal sinus surgery

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Introduction

Sinus surgery has to be carried out in cases of chronic paranasal sinusitis. Although these interventions are frequently carried out major complications might occur. In particular relapse operations are difficult to accomplish because landmarks are often missing due to previous interventions.

Material and Methods:

Our study is based on CT- and MRI-datasets which have been acquired for surgery planning. Image analysis techniques have been applied in order to identify and delineate anatomic structures and pathologic mucosal swellings.The segmentation target structures are: optical nerve, lamina papyracea, bony ethmoid sinuses, tumor or inflammatory tissue in nasal cavity and in paranasal sinuses. Emphasis was put on the robustness of the method.
As a first step of the image analysis pipeline, a region of interest (ROI) is defined which comprises all target structures. The inflammatory tissue and the tumor as well as the optical nerve could be segmented with an edge-orientated approach based on the live-wire method. To reduce the interaction effort, this method is applied to selected slices only and combined with shape-based interpolation between the slices. The segmentation of bony ethmoid sinuses is more challenging. The following three-pass approach turned out to be

the only feasible solution in terms of interaction time. First, a rough contour which completely encloses the region of interest has to be defined in selected slices and interpolated in between to restrict the following analysis. A high-pass filter is applied to enhance image contrasts in the ROI. The enhanced ROI is used as input for the segmentation with a modified watershed transform.
All image analysis methods have been integrated in a software assistant, called RhinoVision. It is based on the ILab-library, a research platform für image analysis and visualization, developed at MeVis.
Results:

All datasets could be processed with the described image analysis methods. The average analysis time was 45 minutes. The segmentation of the ethmoid bone was the step which took most of the time.
The results of the image analysis are employed for surgery planning with the InterventionPlanner (MeVis). This tool allows the selective and interactive visualization of the relevant structures with DVR and SSD. Clipping planes and measurement tools compute for example the minimal distance between two structures. Snapshots and movies are generated for documentation. The visualization has been standardized with presets for colours and transparency values for the relevant anatomic structures.

Discussion:

A solid and efficient system for image analysis for paranasal sinus surgery was developed and introduced in a hospital. The resulting visualizations are especially useful for inexperienced surgeons and help to be aware of possible complications. However, also experienced surgeons benefit in difficult cases, for example in oncologic surgery. The documentation facilities could be used to design a case-based training facility. A combination of the preoperatively determined planning results with intraoperative navigation would further enhance sinus surgery. The demonstrated segmentation is an unalterable basic requirement to establish navigated control in paranasal sinus surgery.