Individual Patient Data for Simulation and Training Using Haptic Interfaces in a High Immersive Environment

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Introduction

The Surgical Research Unit OP 2000 has implemented computer, video, communication and laser technology in the clinical routine (OP is the German synonym for operating room). [Schlag98, Schlag99]. The tasks of the department of Digital Image Processing and Computer Graphics at the Virchow Medical School and the German Heart Institute Berlin are the development of software for clinical use, the enforcement of medical research projects as well as research on computer science in medical care.
The presented Virtual Reality environment facilitates men machine interaction in multi dimensional data. The essence of the underlying medical data should be available in an intelligent user adapted simulation /training environment for surgeons [Bellaire97, Bellaire98a, Bellaire98b]. Haptic interfaces are required for realistic simulations. Therefore, simulations based on individual patient data for operation planing using haptic interfaces are under development. Especially the simulation of surgical procedures like laparoscopical or endoscopical interventions shows first results integrating haptic interfaces and are projected on the OP 2000 high immersive surgical table (workbench in cooperation with BARCO, Belgium) [Kr¸ger 94].
The human visual sensor is only one of the six sensors percepting real world inputs. Especially haptic sensing is necessary for high sophisticated surgical training and is to be integrated in the surgical table. The Impulse Engine (Immersion Corp.) or the Phantom (SensAble Technology) are human / computer interface tools which accurately track a user's hand motions while applying realistic force feedback to the user's hand. Both interfaces are suitable to optimize simulations of laparoscopical interventions. Software for image segmentation and 3D reconstruction allows the generation of individual patient models based on tomographic data from CT and MRI. This serves as the input for clinical data to test force feedback devices at the surgical table.

Objectives

Virtual surgical simulation and training for optimizing tumor diagnosis and therapy.

Methods

Segmentation and Surface Model Generation

For segmentation of organs and other anatomical structures needed for surgical planning we used a software developed at our radiological department (Medical Image Editor, [Beier96a-d, Wust98]), which allows efficient object demarcation in tomographic slices by various manual and automatic methods. This includes 2D region and 3D volume growing (globally or within defined regions of interest (ROI)); geometrical shapes; various spline functions; global thresholding; automatic contour tracking; morphological image operators. If necessary, segmentation results can be interactively corrected by several drawing tools. Based on these

2D contours, 3D surface models of the different organs are created by triangulation with configurable resolution.

Simulation of Haptic sensing

The human visual sensor is only one of the six sensors percepting real world inputs. Especially haptic sensing is necessary for high sophisticated surgical training and first experiments for the integration in the work with the surgical table are started some month ago. The Impulse Engine (Immersion Corp., USA) and the Phantom (SensAble Tech., USA) are human-computer interface tools which accurately track a user's hand motions while applying realistic force feedback to the user's hand. Both interfaces are suitable to optimize simulations of laparoscopical interventions. First developments generating models of individual patient for the surgical table are finished and will be presented.
An interface between the Medical Image Editor and Phantoms Haptic Viewer and between the Medical Image Editor and VR-Wave, a VRML-Browser of the Univ. of Graz, have been implemented. Experiments of semi-automatic model generation concerning realistic visualization and interactivity using a SGI Onyx RE II have been performed. Actually two materials are realized. First experiments towards a haptic impression simulation soft tissue are started.

Surgical table

An improved surgical table has been specially developed. Two high resolution HDTV-projectors (1400x1200 pixels) are integrated. The so designed surgical table allows several configurations suitable for medicine:

- double tracked mode: simultaneously projecting (broad cast quality) two different stereoscopic views of a scenario by combination of shutter and polarization technique. Each users is tracked and wears polarized glazes that allow visibility of his corresponding projector. For stereoscopic imaging active shutter glazes are used.
- double mode: two users work on distinct data sets at same on the surgical table. For medical second opinion each user has a additional monitor. This configuration is actually under development as dual wall projection.
- stereoscopic HDTV mode: computer generated VR simulations are projected in full resolution. Live picture generated from stereoscopic HDTV image sources as 3-D HDTV camera for open surgery, 3-D HDTV surgical microscope and HDTV pathological microscope are projected (in cooperation with Ikegami (J), Leica(CH) and Zeiss(D).

Work in progress is the so-called cooperative medical workbench project (in cooperation with GMD/VSMD, St. Augustin)

Results

Patient models generated from CT/MRI-data are projected on the surgical table . Haptic interfaces are used to simulate navigation with laparoscopic tools.

Conclusion

First steps towards virtual laparoscopic interventions using high immersive environments are performed. High-resoluted imaging and haptic interfaces are required for realism. Further developments are soft tissue touch simulation for the haptic interfaces and soft tissue simulation for Computer Graphics. The prospected goal for the data presentation is a multi modal patient model (morphological and functional) optimizing tumor diagnosis and therapy.

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