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„Interactive Simulations in OP 2000“

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INTRODUCTION

OP 2000 designs, develops and implements modules for the operating room of the future by combined use of computer-, video-, communication- and laser technology in the clinical routine of surgery and surgical oncology. Goal is to achieve more precise, optimized tumor diagnosis and therapy [Schlag1999], [Graschew 2000].

Especially important for the precision of surgical interventions is the initial education of students and continuous training of surgeons. In a high-immersive training environment the perception of the surgeon is supported optimally by computer-assisted simulation and visualisation. It consists mainly of the *Surgical Table*, which is an enhanced, high immersive workbench projection, haptic feedback devices (work in progress) and voice control as a working interface suited for the operating room. Moreover by using interactive tools the surgeon can actively take part in the training and work collaboratively.

The combination of this kind of technologies enables realistic simulations of surgical investigations (Fig. 1). Briefly: a surgeon supervises a surgical training of one of his medical students. Therefore a three-dimensional reconstruction of radiological patient data is being projected onto the workbench. The student manipulates the model, rotates and moves it on the workbench. He may touch bones or cut through some skin or tissue with a virtual tool. While doing so he watches his actions in 3-D and feels matching haptic sensations. At the same time the surgeon is able to observe his student's actions and he can give guidance as he is able to point at structures (e.g. a tumor), to talk to the student or to demonstrate an intervention (telementoring). During such a training session it is also possible to have virtual windows showing additional information, movies, or video conferences with other experts or participants [Bellaire 1999], [Neskakis1999].

MATERIAL AND METHODS

The Surgical Table (design and development in cooperation with BARCO, Belgium, and the Virtual Environments Group of the Institute for Media Communications of the GMD, Sankt Augustin, Germany) consists of two high-resolution HDTV-projectors (1600 x 1200 pixels) integrated in a mobile unit, where virtual objects and control tools are projected on a real workbench.

Fig. 1: Realistic simulations of surgical procedures with haptic feedback (work in progress).

These projective display systems are the state of the art in high-end virtual reality environments. They free the user from the heavy load and inconvenience related to head mounted displays and enable virtual reality for routine applications (Fig. 2). The size of the unit is comparable with an operating table (90 x 120 cm projection, 200 x 140 x 75 cm size).

Both users are individually tracked with the electromagnetic multi-channel Polhemus Fastrak system (sensors on the glasses and the stylus) and wear polarized glasses that only allow visibility of their corresponding image. For stereoscopic imaging active shutter glasses (Crystal Eyes) are used. The *Impulse Engine* (Immersion Corp.) and the *Phantom* (SensAble Techn.) are modules with human-computer interface tools for realistic force feedback to the user's hand.

RESULTS

Working on the Surgical Table the users are tracked and can observe according to their positions the correct perspective of the simulation. The users wear special glasses which through a combination of polarization filters and active shutter glasses allow visibility of their corresponding picture in stereoscopic quality. Thus the simultaneous projection of two different stereoscopic views of a single computer-generated virtual scenario is possible.

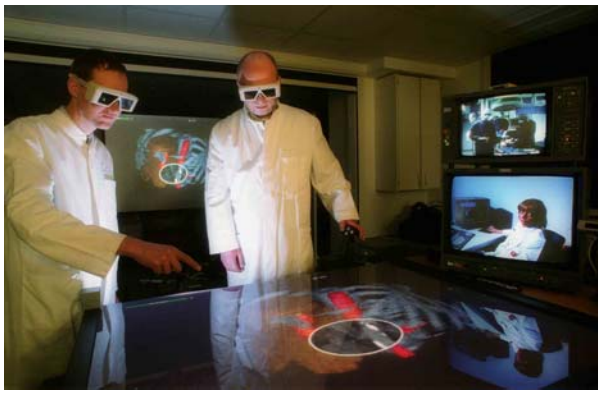

Fig. 2: Surgical Table: a special Cooperative Medical Workbench (CMW) for surgical training. Here: BERTA software module (3-D reconstructions of real radiological patient data), combined with live video conferencing for teleradiological consultation

The Surgical Table allows for several working modes:

- ***Double-tracked mode:***
  Simultaneous projection (in broadcast quality) of two different stereoscopic views of a virtual scenario. Both users can work independently with the various virtual manipulation tools (e.g. magnification, rotation, translation of the data set, as well as removal of selected anatomical structures). In this mode, collaborative simulations for two users *positioned on opposite sides of the surgical table* are possible, as is the situation during real surgery (see Fig. 3).

- ***Double mode:***
  This mode enables two users to work simultaneously on the Surgical Table, each on their distinct data set For medical second opinion each user has an additional monitor.

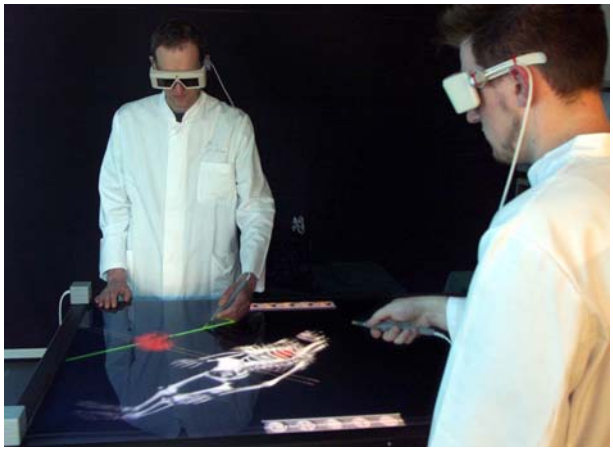

Fig. 3: Surgical Table: Simultaneous display of two different tracked views of the same data set (double-tracked mode)

- ***Stereoscopic HDTV-mode:***
  Projection of stereoscopic, full resolution HDTV. Sources for the displayed scenarios are computer-generated, three-dimensional models, computer-based movies, as well as live pictures from stereoscopic HDTV cameras. In OP 2000 there are various 3-D HDTV camera systems available: 3-D HDTV camera for open surgery, a 3-D HDTV surgical microscope and a HDTV pathological microscope.

CONCLUSIONS

The described high immersive visualization and simulation environment of the Surgical Table is optimized on the surgeons needs [Bellaire1997]. The ability to simulate procedures with two tracked users on opposite sides of the operating table is transferred from the clinical routine, where usually surgeon and assistant surgeon are operating cooperatively. Beyond that, the Surgical Table represents one of the rare possibilities to view stereoscopic video in HDTV quality (high resolution).

Work in progress involves, amongst others, the implementation of haptic feedback devices. Combined with the high immersive 3-D visualization of the Surgical Table, both modules are suited to optimize simulations of surgical interventions. In this way, an even improved simulation and visualization environment for surgical training will emerge, which can contribute significantly to a better qualification and training of surgeons.

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