Application of advanced virtual reality and 3D computer assisted technologies in tele-3D-computer assisted surgery in rhinology

Klapan, Ivica; Vranješ, Željko; Prgomet, Drago; Lukinović, Juraj

Coll. Antropol. **32** (2008) 1: 217–219
Original scientific paper

Application of Advanced Virtual Reality and 3D Computer Assisted Technologies in Tele-3D-Computer Assisted Surgery in Rhinology

Ivica Klapan[1,2], Željko Vranješ[2,3], Drago Prgomet[1] and Juraj Lukinović[1,2]

[1] University Department of ENT, Head and Neck Surgery, University Hospital Center »Zagreb«, Zagreb, Croatia
[2] Reference Center for Computer Aided Surgery and Telesurgery, Ministry of Health and Social Welfare of the Republic of Croatia, Zagreb, Croatia
[3] University Department of ENT, Head and Neck Surgery, University Hospital »Osijek«, Osijek, Croatia

A B S T R A C T

The real-time requirement means that the simulation should be able to follow the actions of the user that may be moving in the virtual environment. The computer system should also store in its memory a three-dimensional (3D) model of the virtual environment. In that case a real-time virtual reality system will update the 3D graphic visualization as the user moves, so that up-to-date visualization is always shown on the computer screen. Upon completion of the tele-operation, the surgeon compares the preoperative and postoperative images and models of the operative field, and studies video records of the procedure itself. Using intraoperative records, animated images of the real tele-procedure performed can be designed. Virtual surgery offers the possibility of preoperative planning in rhinology. The intraoperative use of computer in real time requires development of appropriate hardware and software to connect medical instrumentarium with the computer and to operate the computer by thus connected instrumentarium and sophisticated multimedia interfaces.

Key words: *telemedicine, virtual reality, computer assisted surgery, rhinology*

Introduction

In otorhinolaryngology, research in the area of two-dimensional (2-D)[1,2] and three-dimensional (3-D) image analysis, visualization, tissue modeling and human-machine interfaces provides scientific expertise necessary for developing successful 3D-CAS (computer assisted surgery), Tele-3D-CAS and virtual reality (VR) applications. Such an impression of immersion can be realized in any medical institution using advanced computers and computer networks that are required for interaction between a person and a remote environment, with the goal of realizing tele-presence[3]. The basic requirement in otorhinolaryngology, resulting from the above mentioned needs, refers to the use of a computer system for visualization of anatomic 3D-structures and integral operative field to be operated on[4]. To understand the idea of 3D-CAS/VR it is necessary to recognize that the perception of the surrounding world created in our brain is based on information coming from human senses and with the help of the knowledge that is stored in our brain. The usual definition says that the impression of being present in a virtual environment, such as virtual endoscopy (VE) of the patient's head that does not exist in reality is called VR (Figure 1). The user/physician has an impression of presence in the virtual world and can navigate through it and manipulate virtual objects. A 3D-CAS/VR system may be designed in such a way that the user/physician is completely immersed in the virtual environment[5].

Materials and Methods

Preoperative preparation

The computer system has to store in its memory a 3-D model of the virtual environment. In that case the real-time VR system will update the 3-D graphic visualization

Received for publication June 12, 2007

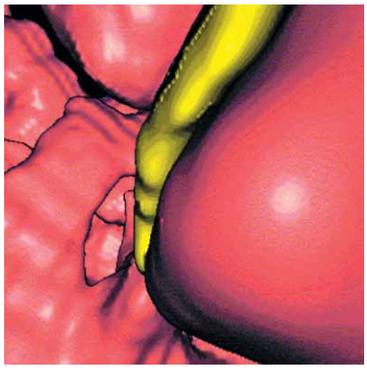

Fig. 1. Visualization of anatomical structures, an virtual endoscopy of individual patient anatomy.

Fig. 2. Virtual endoscopy and tele-virtual endoscopy overcomes some difficulties of conventional endoscopy. In classical endoscopy an endoscope is inserted into the patient to examine the internal organs or spaces. The physician uses an optical system to view interior of the body.

as the user moves, so that up-to-date visualization is always shown on the computer screen[6] (Figure 2). Such a preoperative preparation can be applied in a variety of program systems that can be transmitted to distant collaborating radiological and surgical work sites for preoperative consultation as well as during the operative procedure in real time[6].

During our tele-3D-CA-surgeries, the modeling was done by use of the VolVis, Volpack/Vprender, GL Ware programs on a DEC Station 3100 computer[8]. With the advent of the 3D Viewnix V1.0 software, we started using this program, and then the 3D Viewnix V1.1 system, AnalyzeAVW system, T-Vox system and OmniPro 2 system on Silicon Graphics O2, Origin200 and Origin2000 computers.

Computer assisted diagnosis and surgery

3D-CAS systems can be used to aid delivery of surgical procedures[7]. The system fuses computer-generated images with endoscopic image in real time. Surgical instruments have 3-D tracking sensors and the instrument position is superimposed on the video image and CT image of the patient head[8,9]. The system also provides guidance according to the surgically planned trajectory. The advantages of the system include reduced time for the procedure, reduced training time, higher accuracy, and reduced trauma for the patient[10]. The use of 3D spatial model of the operative field during the surgery has also pointed to the need of positioning the tip of the instrument (endoscope, forceps, etc.) within the computer model[11].

Results and Discussion

Tele-operation is a special case of tele-presence where in addition to the illusion of presence at a remote location the operator also has the ability to perform certain actions or manipulations at the remote site. In this way, it is possible to perform various actions at distance locations, where it is not possible to go due to danger, prohib-

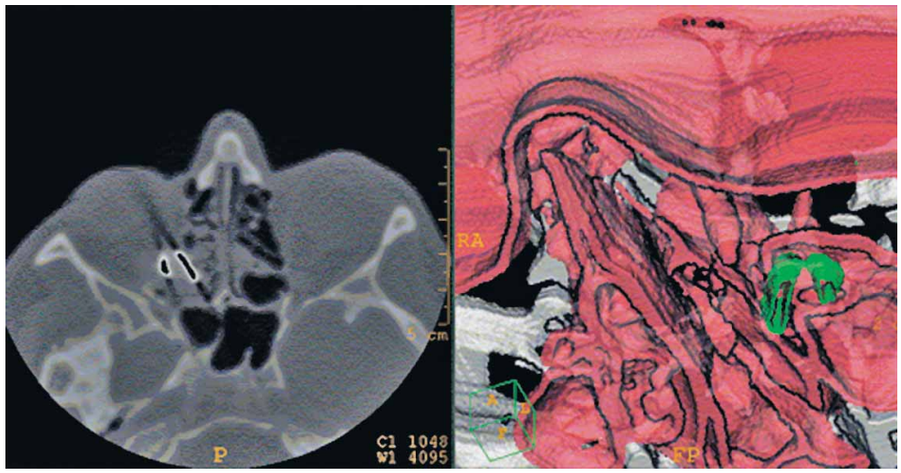

Fig. 3. An example of 3D computer-assisted surgery of the nose and paranasal sinuses (3D-C-FESS) with simulation and planning of the course of operation.

itive price, or great distance. Realization of VR systems requires software (design of VE) for running VR applications in real-time. Computer technologies allow for computer assisted surgery to be performed at distance. The basic form of telesurgery can be realized by using audio and video consultations during the procedure (Figure 3).

The establishment of complex computer networks of diagnostic systems across the country offers another significant application of computer networks in medicine, i.e. telemedicine (distant medical consultation in the diagnosis and treatment). Current computer networks using ATM technology allow for very fast and simultaneous communication among a number of physicians for joint diagnostic or therapeutic consultation. Textual, image, audio and video communication as well as exchange of operative field spatial models are thus enabled[12].

In 1992, a scientific research rhinosurgical team in Zagreb, Croatia, developed a completely new idea of a novel approach in head surgery. This computer aided functional endoscopic sinus microsurgery has been named 3D-C-FESS. The first 3D-C-FESS operation in Croatia was carried out in May 1994, when a blind 12-year-old child was inflicted a gunshot wound in the left eye region[1,7]. In 1998, and on several occasions thereafter, the team conducted a number of first tele-3D-computer assisted operations as unique procedures of the type not only in Croatia but also worldwide (www.mef.hr/MODERNRHINOLOGY)[13].

Conclusion

Some recent studies show that physicians are more likely to make errors during their first several to few dozen surgical procedures. Advantages of computer simulations are that the procedures can be repeated many times with no damage to virtual body, virtual body does not have to be dead, i.e. many functions of living body can be simulated for realistic visualizations and organs can be made transparent and modeled. The trainee may be warned of any mistakes in the surgical procedure using a multimedia-based context-sensitive help. Using the computer recorded co-ordinate shifts of 3D digitalizer during the telesurgery procedure, an animated image of the course of surgery can be created in the form of navigation, i.e. the real patient operative field fly-through, as it was done from the very beginning (from 1998) in our telesurgeries [6,12].

REFERENCES

1. MLADINA R, HAT J, KLAPAN I, HEINZEL B, Am J Otolaryngol, 16 (1995) 276. — 2. RIŠAVI R, KLAPAN I, HANDŽIĆ-ĆUK J, BARČAN T, Int J Pediatric Otolaryngol, 43 (1998) 271. — 3. ELOLF E, TATAGIBA M, SAMII M, Comput Aided Surg, 3 (1998) 89. — 4. HOLTEL MR, BURGESS LP, JONES SB, Otolaryngol Head Neck Surg, 121 (1999) 181. — 5. KLAPAN I, ŠIMIČIĆ Lj, RIŠAVI R, BEŠENSKI N, BUMBER Ž, STIGLMAJER N, Orbit, 20 (2001) 35. — 6. KLAPAN I, ŠIMIČIĆ Lj, PASARIĆ K, VLAHUŠIĆ A, RIŠAVI R, SRUK V, SCHWARZ D, BARIŠIĆ J, J Telemed Telecare, 8 (2002) 125. — 7. KLAPAN I, ŠIMIČIĆ Lj, BEŠENSKI N, BUMBER Ž, JANJANIN S, RIŠAVI R, MLADINA R, Am J Otolaryngol, 23 (2002) 27. — 8. KLIMEK L, MOSGESM, SCHLONDORFF G, MANN W, Comput Aided Surg, 3 (1998) 194. — 9. MANN W, KLIMEK L, Comput Aided Surg, 3 (1998) 202. — 10. ANON J, Laryngoscope, 108 (1998) 949. — 11. OLSON G, CITARDI M, Otolaryngol Head Neck Surg, 123 (2000) 188. — 12. KLAPAN I, ŠIMIČIĆ Lj, RIŠAVI R, BEŠENSKI N, PASARIĆ K, GORTAN D, JANJANIN S, PAVIĆ D, Otolaryngol Head Neck Surg, 127 (2002) 549. — 13. KLAPAN I, VRANJEŠ Ž, RIŠAVI R, ŠIMIČIĆ Lj, PRGOMET D, GLUŠAC B, Ear Nose Throat J, 85 (2006) 318.

I. Klapan

Department of Otorhinolaryngology, Zagreb University School of Medicine, Kišpatićeva 12, HR-10000 Zagreb, Croatia
e-mail: telmed@mef.hr

UPOTREBA NAPREDNE PRIVIDNE STVARNOSTI I 3D-RAČUNALOM POTPOMOGNUTIH TEHNOLOGIJA U TELE-3D-RAČUNALOM POTPOMOGNUTOJ RINOLOŠKOJ KIRURGIJI

SAŽETAK

Zahtjev »u stvarnom vremenu« znači da simulacija mora pratiti radnje korisnika koji se kreće u prividnoj stvarnosti. Računalni sustav također mora pohranjivati u memoriji trodimenzionalni (3D) model prividne stvarnosti. U tom slučaju sustav za prividnu stvarnost u stvarnom vremenu će obnavljati trodimenzionalnu grafičku vizualizaciju kako se korisnik kreće, tako da je na zaslonu uvijek prikaz radnje koja se odvija istovremeno. Na kraju tele-operacije kirurg uspoređuje preoperativne i postoperativne snimke i modele operativnog polja i proučava videosnimke samog zahvata. Korištenjem intraoperatvnih snimaka se mogu dizajnirati animirani zapisi stvarnog tele-zahvata. Virtualna kirurgija (VS) nudi mogućnost preoperativnog planiranja u rinologiji. Upotreba računala tijekom operacije u stvarnom vremenu zahtijeva razvitak hardvera i softvera za spajanje medicinskih instrumenata sa računalom te za upravljanje računalom sa tako spojenim instrumentima i sofisticiranim multimedijskim sučeljima.