Evaluation of a virtual reality system for medicine

Hiroshi Oyama1), Fumihiko Wakao2)
1) Chief of MedVR Projects, Head of Neurosurgery, Dept. of Neurosurgery,
2) Dept. of Diagnostic Radiology, National Cancer Center Hospital,
5-1-1, Tsukiji, Chuo-ku, 104 Tokyo, Japan.
Tel:+81-3-3542-2511, Fax: +81-3-3542-1724,
E-mail: hoyama@ncc.go.jp.

Abstract

We are currently developing a virtual reality system for cancer diagnosis and treatment. The new technology of virtual reality will be applied to a surgical simulation system, a new diagnostic system, a palliative care support system and an informed consent support system. In the research and development of this virtual reality system, we need a method to evaluate it for practical use. For evaluating a medical virtual reality system, we propose the equation S (S: System factor = Sp: presentation factor, Sm: measurement and control factor, So: operation system factor)= $\alpha \cdot A/H$ (A: Application factor, H: Human factor, α : a coefficient). We think that the human factor is the most important consideration for the development of a medical virtual reality system.

Keywords: virtual reality system, methodology, equation, medicine, surgery.

1 Introduction

Research on the application of virtual reality (VR) to medical treatment began in the National Cancer Center in 1993. Five sub-projects on medical VR are currently underway. Three prototype applications for surgical support, medical education and informed consent being developed.[1,2] Thus, it is important to establish an objective method for evaluating such systems. In the present paper, we report a method for evaluating a VR system for medical treatment based on an analysis of the comments of medical students after they had experienced a surgical simulation system for removing a brain tumor. The purpose of this application was to teach an operation plan to medical students.

2 Method

Subjects: Eleven 3rd-year medical students who had not previously experienced VR participated in this study (8 men and 3 women). Outline of the study. Date: March 15, 1996. Place: National Cancer Center VR Development Room. System name: Surgical simulation support system. Application name: Brain tumor removal surgical simulation. Presentation system (Sp: presentation factor): The subject used a Head-Mounted Display (HMD). Shape data of the brain were displayed in virtual space using three-dimensional texture mapping by real-time rendering. The amount of data in virtual space was less than about 15000 polygons per frame, and more than seven or eight frames were displayed per second. The tactile system was not used. The auditory system presented the sound of both a skin incision and a drill used in the operation. The vestibule system and the system used to present the applied force were not used. The systems for olfaction, nociperception, and temperature were also not used. Measurement and control system (Sm: measurement and control factor): The Polhemus sense system was used to track position. The eye-, tactile- and force-measurement systems were not used. Operation system (So: operation factor): Command instruction method: A pen-type stylus was used to provide commands. VR session: All of the subjects were given a simple 10-min explanation concerning the use of the VR system for medical treatment at the National Cancer Center VR Development Room. In addition, all of the subjects were also given a brief overview of the equipment and about a 5-min explanation on the use of the stylus. The subjects were divided into two groups and briefly instructed how to select objects in virtual space; e.g., a virtual surgical knife and a drill. Each subject spent about 10 minutes in virtual space. The subject sat in a chair and wore an HMD. With the HMD in the see-through mode, a data glove was placed on the left hand, and a stylus was placed in the right hand. The subject was then instructed to look at the ceiling in the virtual world, then at the virtual floor, and finally at objects to the right and to the left. The purpose of this procedure was to orient the subject in the virtual world. The left hand with the data glove appeared in the virtual world, and opening and closing of the virtual hand in the virtual world could be seen with the HMD. (Photograph) Thereafter, a virtual surgical simulation was experienced. Afterwards, the subject completed a questionnaire.

Photograph: VR surgical simulation environment and demonstration scene.

3. Evaluation

We evaluated the VR system for medical treatment using three indices: a human factor, a system factor, and an application factor. The subject's understanding of VR technology, computer literacy, and the content of the education were used as an index of the human factor. The subject evaluated both the experience of using the system and the value of its application.

4. Results

All of the subjects were familiar with the term "virtual reality" before experiencing this system; 73% had learned about it from television and 45% had learned about it from magazines. Only 27% knew that VR technology has been applied to medical treatment, and most of these had learned of this from more senior students who had experienced VR at the National Cancer Center the previous year. Evaluation of the subjects' level of education: The subjects had completed the phase of their instruction which involved lectures concerning basic and clinical medicine. They had not yet received training in a hospital ward or in an outpatient clinic, and had never seen an actual surgery. Evaluation of the system by the subjects: Presentation system: Visual system: Resolution is insufficient: 45%. The systems tires the eyes: 18%. The septum of the HMD is disturbing: 18%. The image does not appear to be three-dimensional: 36%. The difference between the right and left images is disturbing: 18%. Tactile system: The illusion of reality is impaired because the sense of touch is not experienced: 64%. Auditory system: (not evaluated). Position system: There is no sense of distance: 9%. Vestibule system: (not evaluated). Force system: The illusion of reality is impaired because force is not experienced: 55%. Olfaction system: (not evaluated). Temperature and nociperception system:(not evaluated). Measurement and control system: Visual system: The HMD is heavy and tires the neck: 18%. It is not easy to focus: 73%. The difference between movement in the virtual world and movement in reality is disturbing: 27%. Both responses and movement are slow in virtual space. Operation system: Command instruction method using a stylus: It is difficult to select a menu item: 36%. The arm becomes tired when the stylus is used for a long time (about 15 minutes in this study): 27%. It is difficult to select a menu item in the virtual world: 9%. Overview of the subjects' responses: The subjects noted that while this technology has the potential to revolutionize the field of medical training and treatment, the current state of the art, particularly with regard to the surgical simulation, does not provide either an adequate sense of reality, due in part to inadequate resolution, or adequate information to be a stand-alone system. Many students noted that the system's value could have been enhanced if their experience had been associated with a conventional lecture or a live demonstration of the surgical technique. However, even with its current limitations, some of the subjects thought that the system could be very useful for studying anatomy, and could be immediately used for patient education/ entertainment. Subjects recommended that the system be more portable, for use outside of the Development Room, and that costs could be kept down by using a pen-type pointing device. The subjects also recommended that training aids could be superimposed on the virtual image; e.g., navigation aids could be used to identify the location of an incision. Evaluation of the system's potential usefulness in the field of medicine: Operation simulation: 100%. Medical education: 91%. Radiation diagnosis study: 64%. Remote medical treatment: 45%. Relaxation: 36%. Patient support system (education/ entertainment): 36%, Rehabilitation: 27%. Radiation treatment plan support: 27%. Treatment of nervous disorders: 9%. Home medical treatment: 9%.

5. Summary

We think that VR is an important technology for the resolution of various problems in the medical field. Unfortunately, there is currently no established method for evaluating medical VR systems. In the present study, we analyzed our medical VR system by considering three levels: (subject level (Human factor: H factor), system level (System factor: S factor) and application level (Application factor: A factor)) by using our medical VR system. The medical VR system consists of three subsystems: a virtual-space presentation system: Sp ; a measurement and control system: Sm ; and an operation system: So. We developed the following formula as an evaluation tool: S (S: System factor = Sp: presentation factor, Sm: measurement and control factor, So: operation system factor)= $\alpha \cdot A/H$ (A: Application factor, H: Human factor, α : a coefficient).

The subject's computer literacy plays an important role in using VR technology, even though it is believed that VR currently represents the ultimate human/computer interface. In the present study, although all of the subjects had heard of the term "virtual reality", few knew that it has been applied to the field of medical training and treatment. As this technology matures, it will become increasingly important to evaluate medical VR systems in terms of a) the subject's experience of the system's ability to deal with measurement and control in the presentation, b) the subject's personal background, and c) the subject's experience of the operation system. Moreover, in the future it will be important to be able to recognize problems with VR technology in terms of the subject's VR experience. We are developing an improved medical VR system using this approach.

Acknowledgments: We are grateful to the students of the Hokkaido University Department of Medicine for their cooperation in this research during a training period at the National Cancer Center Hospital.

References:

[1] Oyama H., et al.: VR medical support system for cancer patients. Cancer edutainment VR theater (CEVRT)and psychooncological VR therapy (POVRT). Interactive Technology and Healthcare, 433-438: Edited by R. M. Satava et al., IOS Press and Ohmsha,1995.

[2] Oyama H., et al.: Surgical simulation support system. Interactive Technology and Healthcare, 439-444: Edited by R. M. Satava et al., IOS Press and Ohmsha,1995.