The Hyper Hospital - A Virtual Reality Mediated Networked Medical System - General construction, User Reconfigurable World Design, New Cybernetic Interface, and Safety Features.

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ABSTRACT

We have been developing a novel medical care system which is constructed on an electronic or computerized information network using virtual reality as the principal human interface. The major purpose of the Hyper Hospital is to restore humane interactions between patients and various medical caretakers by making a much closer contact between them in the real medical scene than that in current conventional medical practice. In the present study, we discuss the several aspects of our development. First its general construction was discussed with respect to its system software for the creation of the virtual world. The virtual world of the Hyper Hospital is designed to allow users of various levels to modify the world construction. This can be done not only by the medical care takers, but particularly by patients. Other aspects, such as a new cybernetic interface, and a series of studies regarding the safety features are also discussed.

1. Introduction and the General Construction

In the modern hospital, the medical therapeutic procedure is regarded as paramount and quite frequently medical care is put aside. Unfortunately, in modern society, the scientific advancement of medicine paradoxically results in the tragedy that human beings or patients are treated as a collection of organs, and not as a whole organism. In this sense, the psychological or the spiritual support must be substantially stressed in the real medical scene. This is the problem of human-to-human communication, particularly related to the propagation of sympathy. The modern medicine desperately have a deficit in such aspect as the sympathetic support to the patients. We proposed in the previous studies a concept of the "Hyper Hospital" which is constructed in the computer based electronic network using an alternate reality system, namely, the virtual reality system, as the human-machine-human interfaces [Yamaguchi, et al., 1994]. The major purpose of the Hyper Hospital is to restore humane interactions between patients and various medical caretakers by making a much closer contact between them in the real medical scene than that in current conventional medical practice.

The Hyper Hospital will be built as a distributed system on the network, a node of which represents a variety of medical care facilities; for example, the out patient office, the nursing care center, the medical examination unit, the operating theater, etc (Fig.1). Above all, the Hyper Hospital space consists of the alternate reality space owned and exclusively controlled by the patient himself/herself. Most of the physical contact, such as the visit to the out patient office by the patient, is actualized by the electronic contact of the patient private space and the

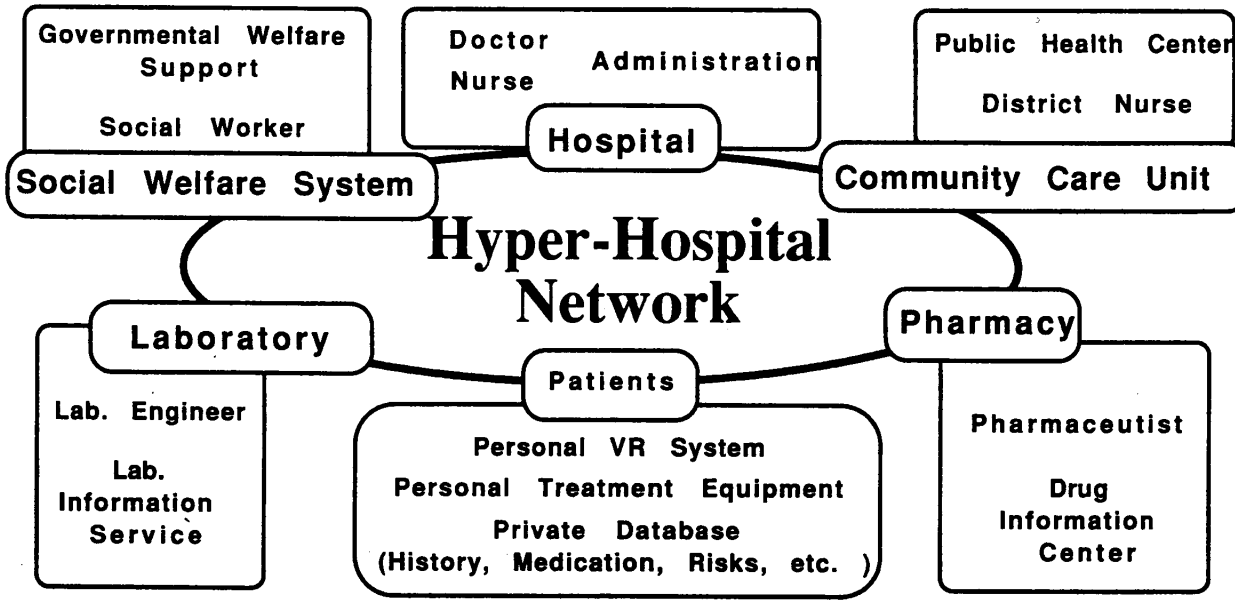

Fig. 1 A schematic diagram of the Hyper Hospital network

public space of the hospital system. Prescription of the drugs, special cares, even the administration to the ward will be integrated to the distributed electronic network as shown in Fig.2.

To actualize such system, we need to solve many conceptual and real problems. The latter, real problems should be classified into several classes, such as the research on the network oriented architecture of the alternate reality, that is, the networked reality, the development of human-machine interfaces particularly fitted to various nature of disability, the study of the behavior of the normal and diseased people, the safety features of the virtual reality technology for its use in the medical circumstances. In the present study, we will discuss these aspects of the vitural reality technology based on our own experience of the development.

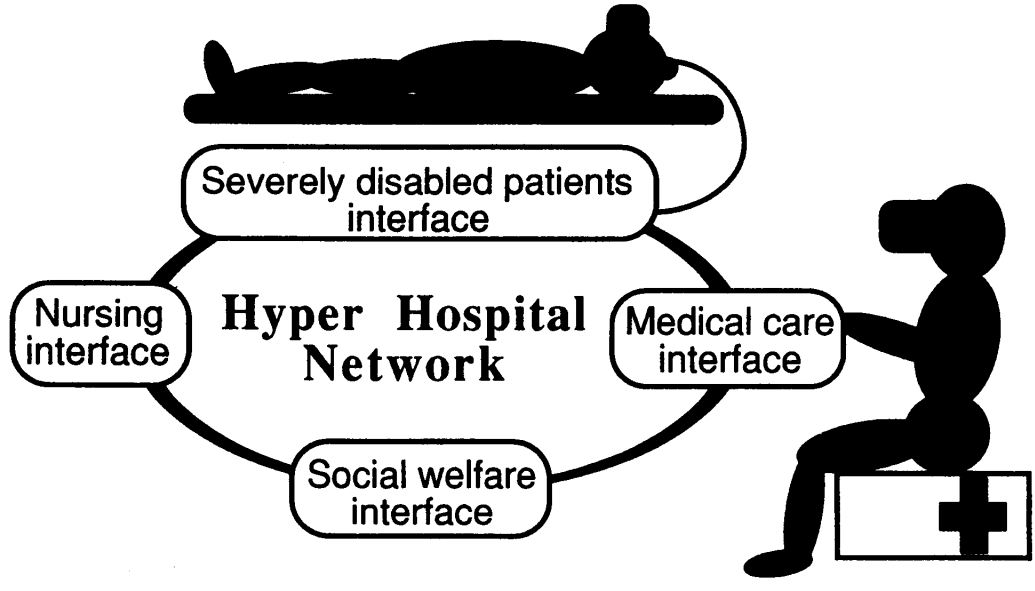

Fig. 2 A schematic diagram of the use of VR interface in the Hyper Hospital network

2. User Reconfigurable Virtual World System

In the course of the development, we devised a virtual reality world creating system which allows users to configure the world interactively [Hayasaka, et al., 1995]. The re-configuration of the virtual world was designed to be carried out without interruptions of activity and the world can continues to exist during the re-configuration process. This facility comprises an important part of our Hyper Hospital system because one of our major goals of this proposal of the Hyper Hospital is to restore maximum freedom for patients in the medical care system. To realize the user-reconfigurable world, we need to separate at least three categories of participation in the world creating system. They are, namely, the creation of the world structure, the administration of the world, and the real application utilizing the world features such as medical practice. Particularly important is the functional independence of the administration of the world itself from the medical organization. Otherwise, the medical requirement overtakes the freedom of the virtual world and results in a present problematic situation. Discussion was given in the present study with respect to the basic requirements of the system to be realized, including discussions on the permission given to the participants of different levels, and means by which to modify the structure of the virtual world. To estimate the feasibility of the idea of the user-reconfigurable virtual space, we developed small prototype of such a partial virtual world. A preliminary implementation was described following this general consideration. The developed prototype was shown to be practically suitable to the test of our virtual environment applied to realistic medical scenes (Fig. 3).

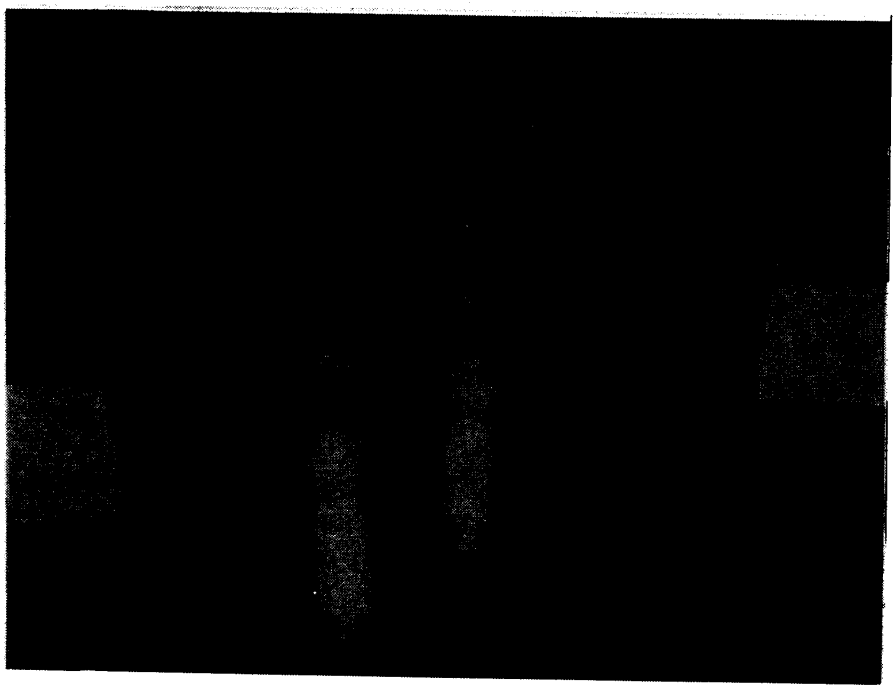

Fig. 3 An example of user configurable VR space (an out patient office)

3. New Cybernetic Interface

In order to accommodate virtual reality based medical care system to the needs of severely disabled patients, for example, a locked-in patient, we are developing a novel human-interface to the virtual reality system utilizing the Event-Related Potentials (ERPs) [Mitsutake, et al., 1993]. ERPs were recorded from healthy subjects during alphabet discrimination tasks using a CRT display. The P300 components of averaged ERP waveforms were successfully obtained

from the target trials which were chosen by the subjects in mind. It was clearly shown that the P300 component can be used to detect the attention of the subjects without any physical actions, and can be used as a human-interface to virtual reality (Fig. 4). For this purpose, the experiments demonstrated that the P300 component can be combined with an alternative or binary decision in mind such as A or B, Yes or No, etc, although a considerable amount of time was required to practically detect the decision of the patients.

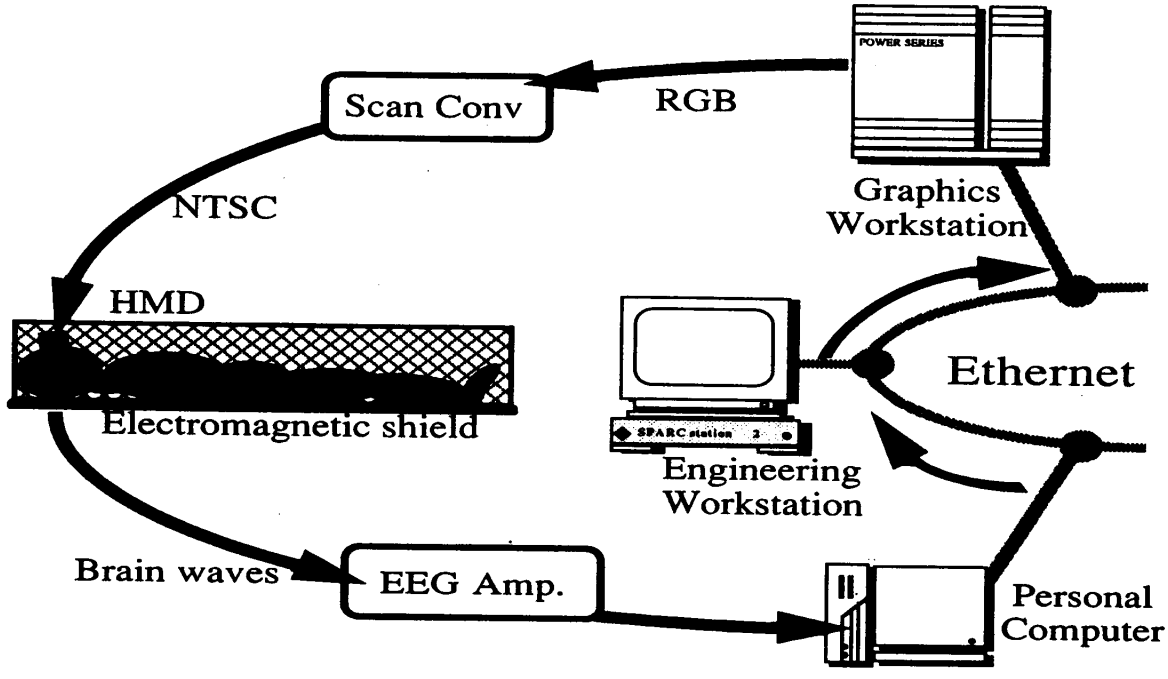

Fig. 4 Network oriented ERP detection system to navigate in the Hyper Hospital space

4. Safety Features

We examined the safety features of our own virtual reality system from the physiological, neurological and psychological viewpoints. In the first series of the experiments, 20 young male volunteers were subjected to psychological tests which was designed to apply an equal amount of mental and physical work loads [Igarashi, et al., 1994]. As measures of the physiological influences of the virtual reality system, the electrocardiogram, the blood pressure, the digital pulse wave pattern, and the respiratory movement of the thorax were continuously measured. Autonomic nerve activities were measured by the urinary release of three kinds of catecholamines, namely dopamine, epinephrine and nor-epinephrine (Fig.5). To examine the visual fatigue, the critical flicker fusion frequency was measured three times, before, during and the after the virtual reality work load. Subjective fatigue was quantitized by using a standard questionnaire and general impressions were collected by another questionnaire. In the second series of this study, we examined responses of healthy young subjects to the VR environment in comparison to control results obtained by simple video watching experiments. None of these physiological, psychological and neurological test results showed significant changes between before and after the application of the virtual reality. This suggests that the use of our virtual reality system, as long as it is applied for a shorter period, gave no serious effects on the human physical and mental health, and therefore the virtual reality technology can be applied to the diseased patients within a certain limit.

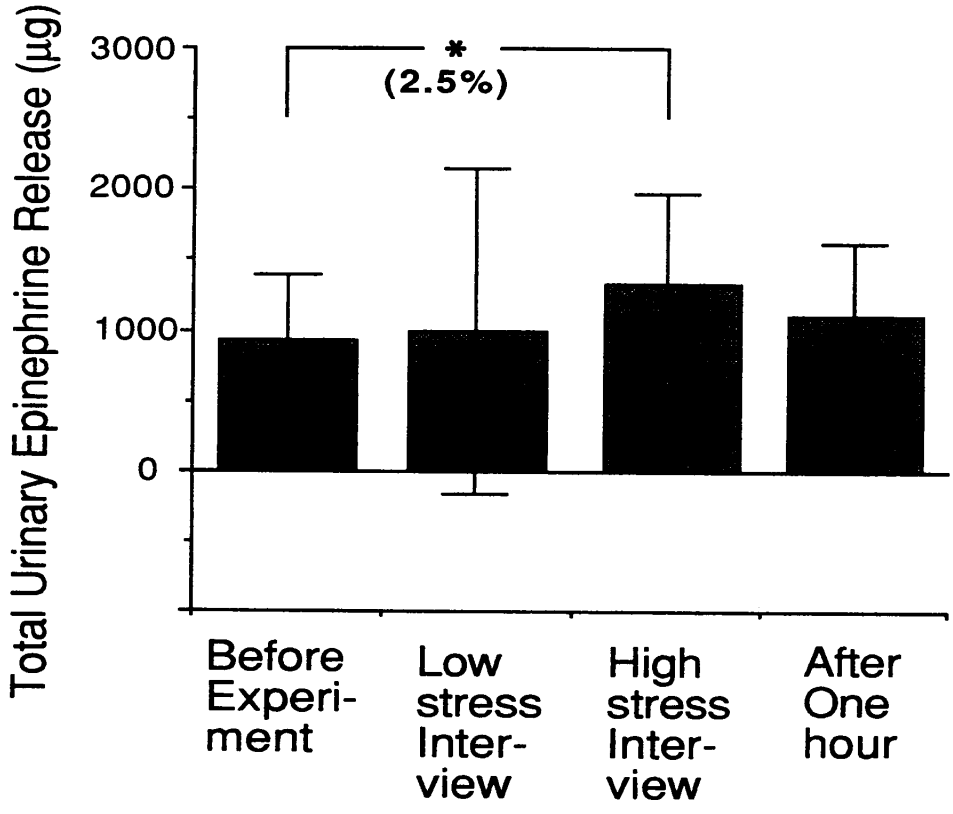

Fig. 5 Urinary catecholamine releases during the VR loading session for healthy subjects.

5. Discussion and Concluding Remarks

Most attempts at the application of virtual reality have so far been confined to game and entertainment purposes. There are not so many reported medical applications. We have been attempting to replace the current conventional medical system by the Hyper Hospital which is distributed in the computerized electronic information network for the sake of retaining humanistic principles in modern medical care. The prototype of the Hyper Hospital described in the present study showed that the user reconfigurable virtual reality world paradigm can be implemented into such a system and can be practically used for this purpose.

In almost all of previous applications of the virtual reality, the virtual world is designed to be given to a user by the system developer as a whole system, and the users are permitted to act in the given world. Implementations that have been constructed and reported deal only with constructing a virtual world easily from the view point of the world creators. To the best of our knowledge, no reports have been published with respect to the user re-configurable virtual world creating system. This implies that our concept of the combination of medical applications and a user-reconfigurable world creating system is an entirely novel one.

In the study of the safety features of our development of the virtual reality technology, we have carried out two series of studies. In the first series, twenty healthy young male subjects, and, in the second series, ten such subjects underwent the psychological interview in the virtual space using our VR system for a relatively short duration. Several measures of the physiological, biochemical, neurological and psychological fatigue were measured before, during and after the interview session. Though there was no significant changes in the measured objective parameters of fatigue, it was thought that there was subjective fatigue, particularly related with the psychological condition. No serious physical influences were found, except for the slight but not statistically significant increase of the urinary epinephrine release. This may be related to the fact that the most frequent complaints were of psychological

fatigue, since the epinephrine release is thought to show a measure of mental or neural stresses.

In conclusion, the implementation of the virtual reality technology will be a key issue to allow maximum freedom for the patients in the future medical system. The features of the user-reconfigurable virtual reality world creation as shown in the present study are thought to be very useful. The VR technology was shown to be a potentially powerful tool for the improvement of the modern medical care.

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