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Virtual Reality, Telemedicine and Beyond

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ABSTRACT

Virtual Reality (VR) is the technology that allows its users to become immersed in a computer generated virtual world. Virtual reality includes the technology for three dimensional (3-D) displays, methods for generating virtual images including 3-D modeling and techniques for orienting the user in the virtual world. Medicine is one of the major application areas for virtual reality, along with games and scientific visualisation. The medical application of VR was stimulated initially by the need of medical staff to visualise complex medical data, particularly during surgery and for surgery planning, and for medical education and training. These applications have naturally extended to include telemedicine and collaboration, involving sharing information across individual medical staff and across geographical locations. Surgery-related applications of VR fall mainly into three classes: open surgery, endoscopy, and radiosurgery. The aim of this paper is to describe some examples in these research fields.

1. INTRODUCTION

Virtual Reality (VR) has different field of applications. For example, in education (Winn, 1993, Youngblut, 1998, Sala, 2002), and in medicine. Medical education was the first area in which VR made a significant contribution. There are probably two main reasons for this. One is that education is less critical, in terms of patient survival, than is actual surgery or surgery planning. These latter two areas of application remain less developed commercially and more experimental in nature. The other reason is the established technology for applying VR to education in other fields, especially aviation. Approaches to learning to navigate within a human body have benefitted from techniques developed to train pilots to fly advanced commercial and military aircraft. There are quite strong similarities between the two application fields since both combine the need for great manual dexterity in a 3D environment with life-critical information access and decision making. Although medical "flight simulators" - based on datasets from actual bodies, both dead and alive - do not yet have the same status as those used in aviation training, it seems likely that such a time is not long off. Increased realism, especially in the simulation of body behaviours, combined with enhanced feedback and the difficulties of training these skills in other ways, seem to make this inevitable.

Another area of medical education to which VR is being applied is that of dealing with catastrophic emergencies threatening or damaging the health of large numbers of people: earthquakes, plane crashes, major fires, and so on. Here, rather general VR techniques are used to simulate a disaster scene. Trainee medical and paramedical staff use such environments to learn how to allocate resources, prioritise cases for treatment, and so on. The disaster scene can be walked through, situations are encountered and decisions made. More recently, the scope of VR applications in medicine has broadened to include physical and psychiatric rehabilitation and, to a lesser extent, diagnosis. VR is proving surprisingly powerful as a therapeutic tool for both mental and physical disabilities. The scope of this survey reflects the range of medical applications to which VR is being applied, and which is briefly outlined above.

Excluded from consideration in this survey are applications in health education for the general public (largely covered by on-line or CD-ROM-based multimedia presentations and not addressed by VR), visualisation of large-scale medical databases (i.e. medical records from large numbers of patients - although VR is being applied in this area), and the application of VR to the architectural design of medical centres. The implementation and integration of new communication technologies within organizations creates complex changes in communicative practices.

Advances in telecommunications and digital technology allow organizations to extend their boundaries beyond physical and geographic barriers. Within healthcare settings, telemedicine applications allow physicians to examine patients at remote locations via various types of telecommunications technologies. These telecommunications connections allow psychiatrists and patients to be present in a new way. This paper explores implications of this presence in the context of a psychiatric exchange. We have organized the paper as follow: section 2 introduces the concept of presence, section 3

focuses upon the Doctor and Patient Dyad, section 4 describe the Virtual Reality and its medical applications, section 5 introduces an examples for better health and therapy: the Angelo Project.

2. THE CONCEPT OF PRESENCE

The concept of presence is defined as: "...the fact or condition of being at the specified or understood place" (Kim & Biocca, 1997). Kim and Biocca (1997) suggest that the experience of presence oscillates around three senses of place: the physical environment, the virtual environment, and the imaginal environment (for example, daydreaming). In a traditional, face-to-face environment, the physical environment is relatively transparent to the interaction. Many information cues present in the physical environment can be incorporated into a communication exchange without the conscious awareness of the individuals involved. For example, a physician may notice that a patient seems to walk into an examining room in a reticent way. These nonverbal cues may aid the physician in formulating a diagnosis. When videoconferencing technology is used to bridge remote locations, a virtual environment is created. Many information cues present in the physical environment are not available in the virtual environment. This virtual environment can create a sense of telepresence. Telepresence describes the subjective sensation of being in a remote or artificial environment, but not the surrounding physical environment (Kim & Biocca, 1997). Lombard and Ditton (1997) suggest that telepresence creates an "illusion of nonmediation" where a person: "...fails to perceive or acknowledge the existence of a medium in his/her communication environment and responds as he/she would if the medium were not there." This illusion of the absence of mediation may suggest to the participants they are receiving all information cues relevant to interaction, when in fact they are not.

3. FOCUS UPON THE DOCTOR AND PATIENT DYAD

Telepsychiatry has been explored for over 40 years through a wide range of technologies. Research has compared the telepsychiatry interview to the traditional face-to-face interview across various diagnoses and conditions. Though technology has evolved dramatically, many conclusions regarding the viability of telepsychiatry over the years have remained very similar.

The first implementation of telepsychiatry was conducted by Wittson in the early 1950s at the Nebraska Psychiatric Institute (NPI), where he investigated the potential of closed-circuit television as a teaching aid (Wheeler, 1994; Wittson & Benschoter, 1972). Ten years later, the first telepsychiatry consultations were performed at NPI. The researchers involved in the trial determined that "...the isolation of the therapist from the patients had almost no effect on group sessions" (Wheeler, 1994, p. 2). Additionally, researchers found patients and relatives were very receptive to this form of communication (Wittson & Benschoter, 1972).

Similar results were found in New Hampshire where researchers explored the use of two-way-video consultations between community family physicians and psychiatrists located at Dartmouth Medical School. Dartmouth researchers argued: "...television has presented almost no difficulties as a medium for psychiatric consultation. It has not proved to be a significant barrier in establishing rapport with the patient or in perceiving emotional nuances" (Solow, Weiss, Bergen, & Sanborn, 1971, p. 1686). Telepsychiatry presented an additional benefit in that local physicians became educated in the treatment of their patients through observations of the interviews with remote psychiatrists. Local physicians reported notable changes in their use and knowledge of psychotropic drugs.

A telepsychiatry program for children that linked a medical school and an inner-city, child-health station received similar support from users, while also providing the additional benefits of improved access and decreased travel time (Straker, Mostyn, & Marshall, 1976). Findings from programs developed in the 1960s and 1970s suggest that both patients and therapists "...do not feel that televised sessions interfere with the quality of therapeutic relationships" (Maxmen, 1978, p. 452).

Another study, conducted in the 1980s, directly examined telepsychiatry, in comparison to traditional, face-to-face interviews and found no significant difference in patient and physician perceptions of the two (Dongier, Tempier, Lalinec-Michaud, & Meunier, 1986). These initial explorations suggest the technology may be adequate for diagnosis of some conditions.

A pilot study of telemedicine used for patients with obsessive-compulsive disorder showed that telemedicine resulted in near-perfect inter-rater agreement on scores on semi-structured rating scales for obsessive-compulsive, depressive, and anxiety disorders (Baer, Jenike, Leahy, O'Laughlen, & Coyle, 1995).

4. VIRTUAL REALITY AND ITS MEDICAL APPLICATIONS

What is Virtual Reality? VR is a set of computer technologies which, when combined, provide an interface to a computer-generated world, and in particular, provide such a convincing interface that the user believes he is actually in a three dimensional computer-generated world. This computer generated world may be a model of a real-world object, such as a house; it might be an abstract world that does not exist in a real sense but is understood by humans, such as a chemical molecule or a representation of a set of data; or it might be in a completely imaginary science fiction world. A key feature is that the user believes that he is actually in this different world. A second key feature of Virtual Reality is that if the human moves his head, arms or legs, the shift of visual cues must be those he would expect in a real world. In other words, besides immersion, there must be navigation and interaction. According to an assessment on current diffusion of VR in the medical sector, gathered by the Gartner Group, forecast of VR future in this area are quite promising. Within the medical application its strategic relevance will increase and gain importance. It is envisaged that by year 2000 despite possible technological barriers, virtual reality techniques will be integrated in endoscopic surgical procedures. VR will affect also the medical educational strategy for students as well as experienced practitioners, who will increasingly be involved in immersive simulated techniques. It is expected that these educational routines can become of routine by year 2005.VR has been until now widely underused, probably because of prohibitive hardware costs, nevertheless this technology is pushing forward new challenges and advances that will materialise by year 2000.

The medical use of VR will take place mainly in four domains:

- teaching: VR will reproduce environments or special conditions that will enable to educate medical personnel.
- simulation: VR will mix video and scanner images to represent and plan surgical intervention, effects of therapy.
- diagnostics: it will be possible to forecast the effects of complex combinations of healing treatments.
- therapy: A valuable exploitation of VR in the medical sector is seen with interest in the therapy of psychiatric/psychological disorders such as acrophobia, claustrophobia, nyctophobia, agoraphobia, eating disorders, etc. Therapeutic techniques will include practices that will allow the patients to reproduce and master problem environments.

5. AN EXAMPLE FOR BETTER HEALTH: THE ANGELO PROJECT

The aim of the Angelo Project is to provide a new approach to what is becoming an important social and business issue, namely quality of work for call centre employees. Market research shows that it costs roughly ten times more to acquire a new customer than to maintain an existing one. Levels of customer satisfaction depend partly on technology but largely on the operator's behaviour. It follows that happy call centre operators are likely to translate into better business performance. Angelo is based on the assumption that operators' quality of work depends on the quality of the working environment.

A high quality working environment will take into account differing individual needs, strategies and preferences thus allowing operators a significant degree of control over key environmental parameters. At the same time, it will provide operators with rapid access to quality information and an ergonomic human-machine interface. Angelo creates such an environment by integrating research results and technologies from a number of different disciplines. In particular the project will use advanced techniques in knowledge engineering and linguistic analysis to analyse customer-operator interactions and provide operators with immediate access to relevant information resources. The project will apply advanced sensor technology for measuring environmental and physiological variables, adaptive computing techniques to model and anticipate operator needs and requests as well as augmented reality tools to enhance the human-machine interface. This way, Angelo will introduce important innovations in workplace design, allowing an unprecedented degree of individual control over the working environment.

The project evaluates industry requirements and functional specifications; develop appropriate measurement system, communication equipment and human interface components; develop information management and network components; integrate, network and put in operation through volunteers taken from a user group. At the same time, disseminate the results in a user-friendly form.

Figure 1 shows the Angelo Project scheme.

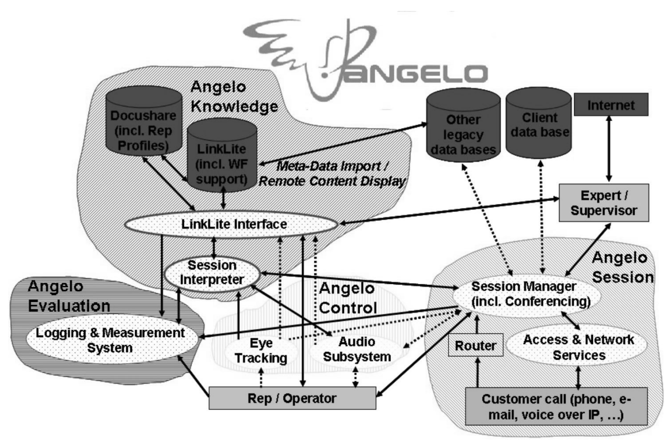
6. CONCLUSIONS

In this paper we have introduced some applications of Virtual Reality in different medical fields. There are other medical applications, for example:

- Mental and physical diagnosis and skills rehabilitation
- Complex medical data visualisation for diagnosis and surgery planning, including telemedical (remote diagnostics) applications.
- Integrated simulators for medical training

For mental and physical rehabilitation, the virtual worlds created must be believable and realistic, combining detail and fast response times. For visualising complex anatomical data, for diagnosis and surgery planning, as well as training in such operations, the needs are the same. There should also be a strong focus on user involvement and trials, from the earliest stages of needs analysis and research project planning. No department can succeed alone

Figure 1. Angelo Project scheme.



in these areas, which are by their nature multidisciplinary. Perhaps the two main weaknesses of existing applications of VR to Medicine are the relatively poor realism, and weak usability. Both of these issues could be addressed using local skills. The main research issue in Medical VR is to convey sufficiently finely-detailed 3D structures with very fast interactivity. The combination of these two factors, which tend to trade off each other, is the key to using VR in medicine for more than fairly crude simulations of relatively simple and routine activities.

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