The Virtual Reality challenges in the health care area: a panoramic view

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ABSTRACT

This paper presents a general view of computational applications in the health area, highlighting the use of Virtual Reality technology resources in Brazil and other countries. From this initial survey, suggestions for improvements in this area were presented along with the relevant research needed to make these improvements and overcome the current obstacles.

Categories and Subject Descriptors
J.3 [Computer Applications]: Life and Medical Sciences-health;
A.1 [Introductory and Survey]: Miscellaneous;

General Terms
Experimentation, Security, Human Factors.

Keywords
Virtual reality, sbc challenges, medical applications

1. INTRODUCTION

Recently, the Brazilian Computer Society (SBC) held a workshop, which discussed the grand challenges in Computer Science research in Brazil, inspired in similar initiatives, that occurred in other countries around the world, such as the “Grand Challenges in Computer Research”, held in the USA and England [9].

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This paper offers a survey of VR work related to the health area, by drawing the perspectives and needs for overcoming the Grand Challenges applied in this domain.

2. VIRTUAL REALITY

VR includes advanced interface technologies, immersing the user in environments that can be actively interacted with and explored. The user can also accomplish navigation and interaction in a three-dimensional (3D) synthetic environment generated by computer, using multisensorial channels.

In this case, diverse kinds of stimuli can be transmitted by specific devices and perceived by one or more of the user’s senses.

There are three fundamental ideas involved in VR: immersion, interaction and presence. Immersion can be achieved by the use of head mounted display (HMD), trackers and electronic datagloves that support user navigation and interaction, aiding the exploration of the environment and the manipulation of objects in an easy way. Interaction means communication between the user and the virtual world. Presence is a very subjective sense, but fundamental to all VR applications, in which the user is physically inside of the virtual environment, participating in it[4].

2.1 VR in health area

The initiative to use the computer and associated technologies in applications of the health area are many and present an increase in relation to the amount, extension and objectives to be reached.

The essential characteristics for the medical 3D applications in order to generate presence sensations are: three-dimensional objects - the content of the virtual environment must dispose of the images similar to actual objects, in relation to the colors, volumes, textures, activities and behaviors; and realistic control of the interaction - the actions in the environments must consider the physical behavior of objects and people.

In many of these applications, interaction and reaction to the user actions are implemented by means of common equipment in VR applications. In the health area, the most used are datagloves, haptic equipment - that can supply the force feedback, and eyeglasses, which generates stereoscopic images.

3. 3D APPLICATIONS IN HEALTH CARE AREA

3.1. Medical education and training

Currently, the medical community faces diverse challenges, both in the biological sciences and in the technological area. The constant evolution of clinical procedures demands a continuous update of the health area professionals. In this context it is essential to expand and to strengthen some routes of permanent education.

The training procedures in this area are traditionally carried through with support from text books, atlas of anatomy, guinea-pigs and corpses. The use of guinea-pigs and cadavers makes it possible to train in the object of interest, using dissection techniques [11]. In many cases the use of cadavers exposes the student to the real situation in relation to the anatomy, but it leaves some gaps in relation to the physiology, and also, presents high maintenance costs, beside diverse ethical problems.

The 3D simulation procedures in health area have been object of research around the world. It aims at substitute, in a near future, the current methods of training and planning, through technological alternatives [14]. The advantages of simulation based learning are many. The learning is interactive and occurs in realistic environments. Learners can make mistakes and appreciate their consequences without causing harm to patients [25].

Medical procedures training

The procedure trainings, mainly surgical, are perhaps the most used in the associated literature about virtual applications for training in health area. Gorman et al. [7] described a lumbar puncture simulator for training, Tendick et al. [26] presented a system to allow the training of abilities in laparoscopic surgeries. Webster et al. [29] presented a simulator of sutures composed by components that deform the skin and the material of suture in real time. Rodrigues et al. [23] described a system for training and planning of orthodontics treatments.

Brain surgeries are delicate procedures, which demand high precision and medical skills. The perception of the potential of VR technology for this kind of activity is not recent. Henn et al. [12] considered that the interactive simulation of cerebral structures, with stereoscopic projection, needed a high degree of realism and could be used in the education and training of neurosurgeons. Savata [24] stresses the potential of the VR to support the accurate identification of cerebral structures during brain surgeries. Miller et al. [18] developed a 3D brain model exploring a Nonlinear Finite Elements, where the geometric information was gotten through magnetic resonance. Hansen et al. [10] created a 3D brain model based on Finite Elements for the surgical training. For the interaction they used a specific spatula to manipulate the cerebral tissue and the 3D model was carried through an equipment of force feedback, exploring a collision control method. Lima et al. [16] presented a simulation prototype for training the puncture of breast. It is a non immersive Virtual Reality environment that explores a conventional platform. The interface shows two mammographic images and synthetic objects, which are represented by a breast and a syringe (Figure 1).

Figure 1 – Breast puncture prototype [16]
Virtual Atlas

In general, the Atlas for anatomy studies present drawings and photos that do not have an integrated vision of organs and systems. In a virtual human it is possible to observe the organs in functioning, decreasing errors, risks and adverse psychological effects generated by the contact with a real cadaver.

The Visible Human Project [28] created a three-dimensional representation of feminine and masculine bodies, gotten from detailed data set of human bodies cross-sectional photographs. The AnatomI [19] is a digital atlas of free use. It allows, in an interactive way, the manipulation and the study of three-dimensional human body structures. With the objective of facilitating the study of anatomy and physiopathology of the breast cancer, Ramos and Nunes [21] presented a virtual atlas, where users could get information about the body structures during navigation in the 3D environment. This application simulates the growth of malignant tumors, as it can be seen in Figure 2.

3.2. Rehabilitation

The VR has also been explored to support the treatment of different motor and cognitive impairments, caused by cerebral damages. Virtual Environments have been especially successful in terms of making a rich association not possible with other man-machine interfaces, due to the multi-sensorial and spatial qualities of these environments.

Figure 2 - Example of a breast cancer simulation developing in different stages[21].

If a person suffers some brain damage, one or more motor or cognitive functions may become deficient. To recover some of the functions it is necessary to undertake specific therapeutical strategies for each kind of detected deficiency.

Adamovich et al. [1] developed a VR system to train finger movements of people who suffered a stroke. According to authors, an essential variable to induce the neuroplasticity is an intensive and highly repetitive sensory-motor stimulation. We can reach this level of tasks through virtual environments that offer simple games and diverse actions, as well as to motivate the user participation in the activities. An environment that is specific to treat the phobia of driving was presented by Paiva et al. [20]. In the neuropsychiatric area, Costa and Carvalho [4] discussed some results of a cognitive rehabilitation program for patients with schizophrenia and mental insufficiency. In this environment, the activities stimulate attention and memory.

Experiments with virtual 3D environments to train the accomplishment of daily activities to people with attention and perception impairments caused by stroke are presented by [3]. The patients accepted work with the virtual environment with enthusiasm and the results showed a significant recovery of the attention and concentration levels in the daily activities.

Telerehabilitation

Telerehabilitation is the provision of rehabilitation services at a distance by a therapist at a remote location. Integration with VR is a relatively new addition to this field. Deutsch et al. [5] described the technical and patient performance of a telerehabilitation application by using a remote console that is integrated with a VR system. The patients used a robot to interact with two VR simulations, while the therapist was in the same room during the first three weeks or in another room during the fourth week. Technical and patient performances were assessed in the transition from the third to the fourth week of training.

Holden et al. [13] developed a system to telerehabilitation. The environment allows the therapist to lead interactive sessions for the treatment of people with motor problems in their hands. In this case, the therapist remains in his house, far from the patients.

Although there is a significant increase in VR research applied to the health area, new challenges arrive and must be overcome as there are advances in both the technological and medical areas. Some of these challenges are argued in the next section.

4. CHALLENGES FOR THE AREA

From the exposed subjects, it is possible to verify that, in fact, the development of VR applications for health area still needs to transpose some obstacles that in many cases permeate the 5 Grand Challenges proposed from SBC. A transverse topic for all these challenges applied to health area is the interdisciplinarity, which nowadays is considered as fundamental for science advance. The narrowing of interdisciplinarity consolidates partnerships among professionals from different areas and allows production of suitable applications, that satisfy their final users and considers ethical and quality criteria.

• Challenge 1

The Challenge number 1 is related to large volume of information in distributed environment. The goal of a distributed virtual environment is to join users that are scattered geographically and give them capacity to use the system [22].

With the amplification of initiatives of telemedicine and mobile medical systems, it is necessary to develop techniques to support the user navigation and control the process involved in transmission and presentation of 3D scenes. New specific protocols for 3D environments presentation have been developed, as well as the Virtual Reality Transfer Protocol [2] and the Multi-user 3D Protocol [6]. However, each one of them has limitations that hinder their adoption as a standard model. Therefore, it is necessary the creation of a pattern that can be used by distributed VR applications and considers particularities of this technology combined with the demands in the health area: image quality with high rate of information transmission.
- Challenge 2
In general, the modeling of environments for the health area requires more than 3D images with high quality and simulations of the objects behavior similar to real ones. It demands the integration of several domains, as physics and mathematics. For example, a 3D simulation of a procedure that uses a needle or a bistoury requires that these instruments can react perfectly when in contact with a human organ. It is not possible for the user to feel himself immersed in a virtual environment if the objects do not have reactions recognized by him. Lamb et al. [15] stated that it is necessary to understand the cognition model in order to find an answer to this challenge. The cognitive science is built on psychology, philosophy, linguistics, neuroscience, anthropology, computer science and artificial intelligence concepts. Models and systems that have as objective to shape the man-machine interaction with efficiency, adaptability and usability must consider cognitivos aspects. These aspects were contemplated, mainly, in the Tsai et al. [27] and Webster et al.[30] works.

- Challenge 3
The ubiquitous and pervasive 3D applications, mainly those that explore Augmented Reality techniques, need advances on new communication technologies allied to mobile technologies. The Applications require minimalist hardware models without lose graphics processing capacity. In this way, the challenge 3 is a motivating topic for orienting the research in the area, since we do not find in literature works that discuss the problems related to this challenge, considering the perspective of 3D application in health care area.

- Challenge 4
3D virtual environments can approach the common citizen in scientific or historical knowledge. When an application reconstitutes some object or scene that does not exist anymore, by using 3D virtual environment, it opens a new perspective for accessing information. The universal access to the knowledge demands an infrastructure capable of transmitting and presenting images and graphic contents. The high speed networks and the increase in diffusion of personal computers, associated to creation of new products as the virtual human atlas ([17] and [21]) will amplifies the possibility of access to a larger number of people. Another example of innovative applications is the Visible Human project [28] that offers means of accurate visualization of human body structures.

However, to overcome this challenge it will be necessary to integrate efforts together from enterprises, government and academy because hardware and software are still expensive and the amplification of technological diffusion depends on more global political decisions.

- Challenge 5
The building and use of 3D applications in the health area include the technological aspects as much as the human aspects. The technological questions are centered in the technical questions related mainly to the performance of programs that control the medical procedures, the definition and implementation of data storage structures, the communication medias, the logical structure and methodologies and quality patterns of development process. The human questions concern the program’s impact on users, verification of program in solving the desired problem in a correct manner, or still, exposure of the professional or the patient herself to some risk or discomfort.

The improvement of the evaluation process is intimately related to participation of professionals from health area during all the development and evaluation processes, by supplying technical knowledge, opinions and subsidies as medical images and characteristics of procedures. The integration of projects and the experience exchange between different groups of professionals can aid this challenge. In addition, related to two previous aspects, the ethical question, that must orientate any technology development in the health area.

5. CONCLUSIONS
This paper presented an overview of the VR applications to the health care area. Considering the SBC challenges, we outlined the new perspectives for the VR applications in this domain, with a special regard to Brazil.

One of the important aspects observed in this study is that when we compare the VR applications in health in Brazil, with those developed in other countries, we perceive that while in Brazil the majority of the projects test a small number of people, in other countries, this number is already significant.

Another aspect that is stressed in this work is the lack of investments in the development of the specific hardware, which hinders a bigger diffusion of applications for training in different health domains. In the same way, the development of low cost packages of software to assist the creation and maintenance of virtual environment, as well as tools to support the interaction with good usability must be considered. Some initiatives are already perceived in the Brazilian’s groups of research, but there are still a great amount of work to be made. The modeling of objects that simulate virtual patients, human organs and instruments used in training is a task that exceeds the ability of the professionals from Science Computer area.

Therefore, another challenge may be approached and achieved: the adequate formation of human resources to explore the potential of the interdisciplinarity, generated by the joint work of different professionals. To extend the access to tools that can aid the learning process, Brazil’s government has a service that offers learning object repositories in the Internet [17]. However, there is limitation on the size of each learning application in this site. This limitation hinders the inclusion of VR environments. Therefore, it is fundamental to open more space for applications that work with 3D visualization. Beyond the governmental financial support, the industry investments in this area are essential for its progress. The VR products have a high potential of practical use in the health care area and they could create markets with high level of returning investments.

Finally, we consider that this study has highlighted the VR integration to health care main challenges. We concluded that further research and application of VR in the health care area is necessary and will benefit from a well-developed and appropriated working paradigm for integrating good health practices, technologies and man.
REFERENCES