Virtual Reality and Disability

1. Introduction

In September 2005, was held in Lille, France, the AAATE conference. As each time, we felt that certain orientations of technological research developments in the field of assistive technology, dominate. The subtitle of the last edition conference was " Assistive Technology : From Virtuality to Reality " which aimed to stress two particular points :

- the difficulty in passing from a research or an idea towards a real, continuous and financially acceptable use;
- to connect in the same expression the words "Virtuality" and “Reality" in order to suggest the potentialities offered by the technology of Virtual Reality applied to the field of the assistance to the handicapped people.

All over the conference interventions, several papers have referred to this technology either in an explicit or an implicit way through interactive systems of simulation.

A plenary session, animated by Albert Rizzo, concerned a survey on the potentialities which offers virtual reality according to the ‘types’ of handicap.

This technology approaches a state of maturity today. The different softwares which managed 3D images are available and adaptable towards all kinds of application. The hardware also is available : personal computers, powerful, large with reduced computing times, the systems ensuring the immersion (visual feedback, sound feedback, haptic feedback…) and actuators for the interaction in real time (data glove, speech processing…). These technologies make it possible to obtain a satisfying realism or rather sufficient to make now possible certain applications. This paper presents an overview of the potentialities offering virtual reality and suggest some ideas of opening applications towards assistance to the people with specific needs.

2. Virtual reality as a multidisciplinary convergence domain

Virtual Reality (VR) technology is basically defined as a computerized system, enabling one (or several) person(s) to visualize complex and/or massive data while interacting with a versatile virtual environment [1]. Two major aspects of VR capture attention. First, visualization is immersive, since the goal is to give the user the sensation that the environment and/or the objects that she/he is confronted with are really "there", that he/she is "inside" the virtual world. Secondly, the operator is able to interact in "real-time" with this environment.

These objectives are attained by using various interfaces that enable "real-time" updating of multi-modal sensorial information as a function of the actions and movements of the user in the virtual world. From our point of view, this emerging technology is rather susceptible to promote significant advances in the field of Behavioral Sciences. It is in particular remarkable that VR systems enable researchers to generate controllable complex sensorial stimulation patterns, and to measure precise spatial and temporal aspects of human behavior in the presence of such stimulation. Manipulations of real-time interactions between the actor's behavior and the sensorial stimulation finally give the researcher the unique opportunity to "penetrate" the perception-action loop, in order to better understand the sensori-motor transformations and cognitive processing occurring in the central nervous system. In this sense VR techniques act as a "virtual electrode" (as a functional analogy to electrophysiology). Such parametric manipulations address classical problems, such as the nature of the sensorial information involved in a given task, or spatio-temporal aspects of motor coordination in skilled behaviors. This has strong implications for clinical applications of VR, as we will see below.

In return, Behavioral Neuroscience might contribute to bring new insight, hence favor technical advances, to "ill-posed" problems and "ill-defined" concepts, such as the role of immersion, the functional consequences of a sensation of presence in VR, or the behavioral meaning of "real-time" coupling in virtual world experiences [6] [5]. We suggest that Virtual Reality thus acts as a convergence domain, interdisciplinary by essence, between Life Sciences and Technological/Computer Sciences, having potential and actual positive outcomes in assistive technologies. The development of VR systems, while promoting new research in Behavioral Neuroscience, will logically depend on new data and models of sensori-motor coordination originating from this research. It is also clear that the definition of an "efficient" immersive and interactive VR system will result from a satisfying compromise between the subject's task, the neuro-psycho-sensorimotor determinants of human behavior and the available technological solutions.

3. Implications for disability and rehabilitation

Research on disability assessment and rehabilitation clearly involves also a multidisciplinary approach, merging behavioral sciences (Psychology, Physiology, Neuroscience and Medical Sciences) and Technological Sciences. It is thus a practical domain in which Virtual Reality is slowly and strongly making its contribution. More precisely, virtual reality systems, using real-time interactive fully controllable environments enable clinicians to measure, improve and transfer a given patient's performance to the "real world" (for recent reviews, see [2], [3]).

Without going into detailed research description, we can first say that the objective accurate assessment of a patient functional capabilities (or disabilities) is the necessary starting point for any rehabilitation program. It is also necessary to make sure this assessment relates to the patients' actual skills in real life. This is certainly a difficult task. We can also assume that this task is even more acute when the clinician tries to assess cognitive functions, as compared to sensorial and motor capacities. In this respect, Virtual Reality (VR) is certainly not the definite solution. However, its flexibility and controllability certainly helps build powerful interactive assessment tools, which can be adapted by the clinician to a particular individual. Moreover, the constant search for "ecological validity" of laboratory assessment is a leitmotiv of VR, since, from its cinematographic origins, VR technology is in itself a quest to bring reality into virtual experiences. Within evident limitations (which depend on the technology as well as on current understanding of human psychophysiology), VR environments enable the clinician to confront the patient with "realistic" everyday situations, without the correlative danger (imagine making coffee in the kitchen). We can also note that VR technology enables control both on the user interface and the sensorial feedback, such that a virtual environment can easily be adapted to a given pattern of impairment, in order to facilitate cognitive assessment, for instance.

Another key aspect of the interest of VR in rehabilitation is its motivational side. Without going into physiological details (such as the role of practice and feedback in brain plasticity, see [2]), we can agree that a reduction of arousal and interaction with the physical environment is often linked to a functional impairment (being it physical or neurological, or both…). Even if VR applications are sometimes compared to video games, it is clear that, because they are interactive and deliver real-time feedback, they appear to motivate a patient. Here again a particular application can be easily adapted to a given patient. It is there fundamental to acknowledge the role of the clinician, acting like a "wizard of oz", monitoring in real time the patient's behavior and adjusting the level of difficulty of a task (in sensori-motor as well as cognitive challenging terms). Note that this type of interaction between the therapist and the patient can be remotely conducted, opening the road to "telerehabilitation" [4].

From this motivational advantage, training itself naturally benefits from VR applications. Like in assessment, the powerful tools of VR (realism, complex multi-sensorial feedback, sophisticated and versatile interfaces) help define training environments matching a given patient needs. Such environments can, at the same time, be close enough to real situations and adapted to a patient's functional cognitive and functional repertoire, at a given time in the rehabilitation process. Once again, real-time or off-line analysis of complex aspects of the patient's behavior (in functional and physiological terms) certainly helps the clinician design the training process. However, because VR precisely enable the clinician to adjust the context to the patient (for instance in terms of control modes for a given disability), the problem of the transfer of skills learned (or re-learned) in VR to the real-world always remain.

Finally, VR is increasingly used not only in rehabilitation per se, but also in handicap. For instance, there are a number of laboratories, worldwide, using wheelchair simulators [2]. This approach is interesting, considering that VR is somehow the evolution of flight and car simulators. Following this, it seems that a "design for all" approach is here active in the field of VR. In other terms, simulators become accessible to handicapped populations. More seriously, a "wheelchair" simulator has numerous potential advantages. First, it enables the therapist to judge, in objective terms, whether a patient has good chances to be able to use a wheelchair. Note that this is a multi-side problem, in which spatial and motor skills can be assessed. Second, it enables the therapist to adapt a device to the capacities of an individual. Finally, it can act as a "simple" simulator, a training device.

At the end of the conference, a meeting was held in Lille, and the presented papers were scanned in order to determine those belonging best to the scope of VR. It appeared to the committee that nine papers were worthy to be picked up and they are presented in this edition of Technology and Disability once the necessary adaptation had been made.

The field is now open; may other researchers follow in order to bring to handicap rehabilitation all the power of the 21st century tools.

4. References

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