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Guest Editorial

# Virtual Reality and Disability

## 1. Introduction

The AAATE conference was held in Lille, France, in September 2005. Each time, we feel that certain orientations of technological research developments in the field of assistive technology should dominate. The subtitle of the last 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 potential offered by the technology of Virtual Reality as applied to the field of assistance to handicapped people.

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

A plenary session, led by Albert Rizzo, concerned a survey on the potentialities which offer virtual reality according to the 'types' of handicap.

This technology is approaching a state of maturity today. The different types of software which manage 3D images are available and adaptable towards all kinds of application. The hardware is also available: powerful personal computers, with reduced computing times, systems ensuring immersion (visual feedback, sound feedback, haptic feedback . . . ) and actuators for interaction in real time (data glove, speech processing . . . ): These technologies make it possible to obtain a satisfying realism, now sufficient to make some new applications possible. This paper presents an overview of the potentialities opened up by virtual reality and suggests some ideas of applying them to assisting 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 they are confronted with are really "there", that they are "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 for promoting significant advances in the field of Behavioral Sciences. It is particularly 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 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.

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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 [5,6]. 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 also involves 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 the necessary starting point for any rehabilitation program is the objective accurate assessment of a patient's functional capabilities (or disabilities). It is also necessary to make sure this assessment relates to the patient's 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 definitive solution. However, its flexibility and controllability certainly help 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 on both 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, be 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 easily be adapted to a given patient. It is fundamental to acknowledge the role of the clinician, acting like a "Wizard of Oz", monitoring the patient's behavior in real time and adjusting the level of difficulty of a task (in sensori-motor as well as in cognitive challenging terms). Note that this type of interaction between the therapist and the patient can be conducted remotely, 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's 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 enable the clinician to adjust the context to the patient precisely (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 remains.

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 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 agood chance of being able to use a wheelchair. Note that this is a multi-sided problem, in which spatial and motor skills can be assessed. Secondly, 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 presented papers were scanned in order to determine those best belonging 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: we hope that other researchers will follow in order to bring to handicap rehabilitation all the power of 21st century tools.

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