Review of Virtual Reality Technology: An Ergonomic Approach and Current Challenges

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Abstract. Virtual Reality (VR) technology utilizes computer graphics to create a realistic world, in a synthetic environment which responds to the users' actions. Although transfigured, the flesh and blood user, metaphorized in the virtual environment, coordinates his/her own actions through various devices. Converting physical body movements by sensory channels (visual, auditory, tactile, kinesthetic, proprioceptive) in order the user feel as if he/she was physically present in the simulated environment. This feature, in turn, allows the user to read the context, interpret the situation and make decisions to solve problems in the physical world. As a consequence, evaluators can observe the efforts to popularize this technology in order to produce physical devices and virtual environments more ergonomically adapted, avoiding dangers, and with affordable costs. In this context, the design and development of VR products and systems still faces challenges that in some extent interfere with the quality of the user experience. That said, the present study aims to discuss VR technologies and its challenges from an ergonomic perspective, aiming to improve the quality of user experience.

Keywords: Virtual reality challenges · Ergonomics · Simulated environment

1 Introduction

In Matrix, the movie (USA/Australia, 1999, color, 136 min), directed by Wachowski brothers, Keanu Reeves plays Neo, the chosen one.

In one section of the fiction, while waiting to consult the Oracle, the avatar[1] Neo encounters a boy dressed in Buddhist vests who can bend spoons without exerting any level of physical force. In the plot, the characters talk about what would be 'the truth' on the 'Matrix':

> Boy: Do not try and bend the spoon. That's impossible. Instead, only try to realize 'the truth'.
> Neo: What truth?
> Menino: There is no spoon.

[1] Avatar: Graphical representation of the user in virtual reality. According to technology, it can range from a sophisticated 3D model to a simple image.

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Fig. 1. The avatar Neo and the Buddhist boy (Dialogue about "the truth". *Source*: https://www.youtube.com/watch?v=uAXtO5dMqEI)

Neo: There is no spoon.
Menino: Then you will see that it is not the spoon that bends. It's only yourself. (Fig. 1)
Menino: Then you will see that it is not the spoon that bends. It's only yourself.

In the plot, the spoon physically is not there. It has been metaphorically incorporated into the context: everything happens through the human mind and the neural circuits that form the basis of mental processes.

However, what seemed like a science-fiction scene takes shape in our everyday life: parallel to the development of graphic Internet, the development of Virtual Reality (VR) systems, with creative and dynamic interfaces, allowed the user to simulate fictitious and non-fictional situations based on experiences lived in the physical world [1].

This development, in turn, enabled the user to progressively feel part of this world of screens, displays and icons, in order not only to dive into an illusion but to contextually undergo the experience that lead to the sensation of physical involvement [2].

In order to provide the users engaging and realistic experiences, closer to what the user thinks, feels and desires in the physical world, the VR industry has been investing in the development and popularization of products and systems, proving to be a promising field, of significant changes in world economy.

With ever more developed interfaces to support human interaction, VR progressively began to integrate virtual worlds to metaphorized, immersed bodies, to the point where it is possible for the users to manipulate and feel virtual objects.

By the orchestration of visomotor aspects and by semiotic mediation, the active subject then constructs a perception of self and the medium that allows the senses to act in and actualize the synthetic world [1].

Given the current situation, we often wondered: would current interfaces be good enough for this purpose? What about the subjective aspect? In terms of possibilities, skills, needs, expectations and desires, how to integrate users' perspective?

The virtual environments evaluation, with sign-based interfaces and rich in metaphors, requires us to adopt an integrated perspective, in which human experience, even

if abstract, is interpreted from everything the user knows about the physical world, including his/her own corporeity [1].

Based on such considerations, the present study is anchored in the premise that the thought is the locus of metaphor, as a sociocognitive construction of the real. Despite the peculiarities inherent in digital culture, the behavior of the user In the virtual world does not differ totally from the behavior performed in the physical world [3], so that actions, emotions, expectations and user desires are similar to what is observed in the physical world.

In these terms, this study focuses on the immersion, which is related to the psychological state characterized by being involved in, included in and interacting with an environment that provides a continuous flow of stimuli [4, 5]. In this sense, the less the user perceive the physical world (see, touch or hear), the greater the VR immersion is [5, 6].

2 Immersive Technologies

These are technologies that integrate the physical world to virtual, simulated world, so that the user perceives, feels and manipulates the virtual world via a system which creates a sense of immersion.

This perception of something beyond what happens in the physical world occurs (1) through the perception of an alternative world and (2) by the perception of the context (alternative world or physical world) from another point of view [7].

Similar to a book or a picture, which transports the reader or the observer from the physical environment to that of the story or painting, VR transports the person from the physical world to an environment in which he/she is not physically present, although he/she feels like he/she was [4].

Even if it appeals to fiction, the simulation in this environment presents situations with a degree of realism that allows the user to make decisions and solve problems in the physical world [5].

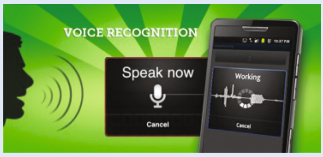
That is, in VR systems the developer expresses his/her ideas through the system, which transports the user to alternative worlds or to the representation of the physical world from another point of view, different from that of the user. The user, in turn, will be affected and respond in different ways, some of them unpredictable to the developer.

Because of its high degree of sophistication, these systems provide realistic immersive and perceptual experiences. However, in order for the system to be considered immersive, it is necessary for the devices to provide users physical immersion, since other media such as radio, book, TV and cinema allow the mental immersion, which is not enough to characterize VR.

2.1 Interaction Devices

They allow the user to interact and communicate in the virtual environment. Nowadays, two modes of VR interaction devices are observed: those that support interaction in man-machine interfaces and those that support interaction in brain-computer interfaces (Table 1).

Table 1. Devices used to support interaction

Interaction Devices	
Kind of Interaction	**Example of Technology**
BCI – Brain-Computer Interface	EEG 
HCI – Human-Computer Interface	Gesture Recognition  Speech Recognition  Omnidirectional Treadmill 

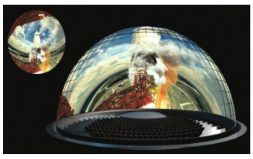
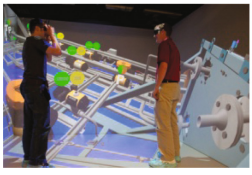
Source: Google images (adapted by the authors)

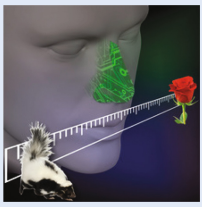
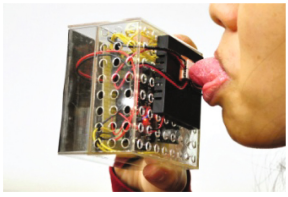
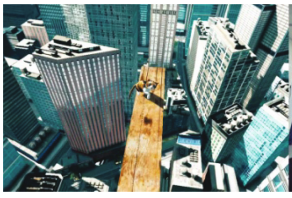
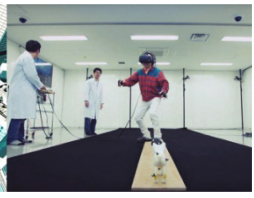
2.2 Perceptual Devices

Developed to stimulate the human senses, in order to create realistic perceptual sensations in VR users (Table 2).

Although presented as an avatar, the flesh and blood user, metaphorized in the virtual environment, coordinates his/her own actions through various devices. Converting physical body movements by sensory channels (visual, auditory, tactile, kinesthetic, proprioceptive) in order the user feel as if he/she was physically present in the simulated environment.

Table 2. VR devices used to create realistic perceptual sensations

Perceptual Devices	
Perception	**Device**
Visual	3D display
	
	Holography
	
	Head-mounted display
	 
	Fulldome
	 
	Cave
	 
Auditory	3D áudio effect
	Surround sound
	Immersive áudio

	Haptic glove
Tactile	 
	Machine olfaction
Olfative	
	Artificial flavor
Gustative	
	Body suits
Kinaesthetic	
	Platforms
Proprioceptive	 

Source: Wikipedia (https://en.wikipedia.org/wiki/Immersive_technology) and Google images (adapted by the authors)

2.3 Softwares and APPs

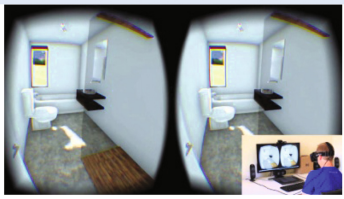
They integrate the flesh and blood users and physical devices into simulated environments (avatars, virtual environment and objects that make up the system), providing a dynamic and synchronous response.

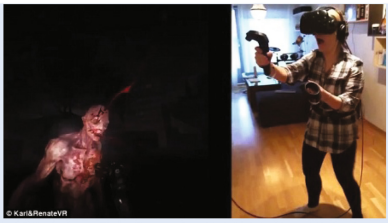
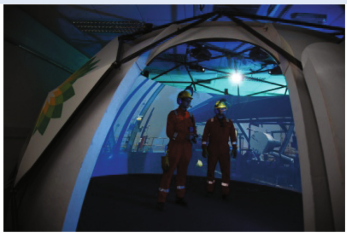
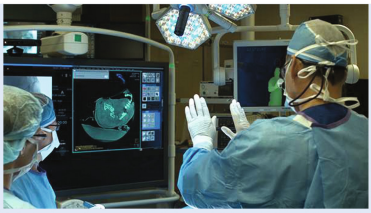
3 VR Applications

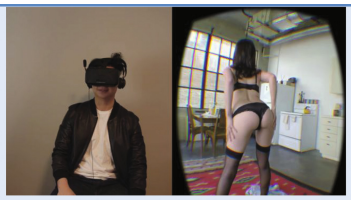
Because they are a trend, VR and its immersive technologies are increasingly gaining new spaces, and can be applied in several areas (Table 3).

Even with all the sophistication, the design and development of these technologies have the challenge of proposing devices and apps that could be used by any kind of user. So that, this context makes it necessary to investigate the usability of these technologies as well as the ergonomic constraints and risks inherent in both the physical devices and the characteristics of the virtual environment adopted by the user [8].

Table 3. VR and its immersive technologies' applications

VR Applications	
Area	**Example**
Architecture	
Art	
Aviation	

Education	
Entertainment	
Games	
Industry	
Medicine	
Military	 

Porn	
Trainning	

Source: Google images and Youtube (adapted by the authors)

4 Discussion

Despite all the advances, the production of high-fidelity VR technology still presents itself as a challenge, since it requires ergonomic criteria's of analysis that consider the perceptual aspects and the sense making in user's experience as close as possible to what is subjectively experienced in the physical world [2].

In addition to these issues, special attention in the field of design has been given to 'situational awareness', which is characterized by how we react to the world [9]. From this perspective, our senses and our ability to interpret a situation allow us to contrast the current moment with our past experiences and personality traits so that we have a set of options on how to act/respond in a given situation.

Based on these assumptions, the design of VR environments, considering the usability aspects, requires a combination of hardware, software, social networking and services, so that users' personalized actions play a central role in product analysis and development.

Users' decisions will be more and more linked to the information and simulations provided by the displays and devices that will warn us whether our diet is best suited to our performance, whether we are getting enough sleep, or the force we are employing is sufficient for the execution of a given task.

In this perspective, VR gains new contours, since, during the performance of the task, relevant data sets about ourselves and our decisions will contribute to provide indispensable information to the users experience analysis.

5 Conclusion

Despite the development of VR technology with low prices and higher simplicity, its products and systems still lacks studies that assess in depth the ergonomic constraints and risks both related to the physical devices and the virtual environment.

In such context the ergonomist must be attentive to (1) the user experience with the physical and virtual body in the use of these products and systems and (2) the users' safety, effectiveness, efficiency and satisfaction.

These conditions helps to provide a better product/system adaptation and a better user performance in order to contribute to funnier, safer, and more challenging experiences.

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