Chapter 1
Haptic Interaction in Virtual Reality:
Are We Ready for the Metaverse? Neuroscientific and Behavioral Considerations

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ABSTRACT

Touch is fundamental to create our perception of reality and to allow fulfilling social experiences, such as those at the basis of metaverses. In order to be accurately reproduced, a number of scientific and technological aspects should be considered. In this chapter, the authors highlight the relevance of the tactile modality in eliciting 'presence' in virtual reality interactions. They also discuss the neuroscientific foundation of our bodily interactions and the fact that they are based on a number of receptors and neural circuits that contribute to the complexity of our perceptions. The available technological devices for the reproduction of touch in virtual environments and their limitations are also described. They suggest that virtual interactions should include more of this sensory modality and that attempts should be made to go beyond the actual approach to 'mimicking reality'. In particular, future simulations should consider the perspective of creative 'hyper-sensations' including 'hyper-touch' on the basis of our psychological and neuroscientific knowledge.

INTRODUCTION

The technological advances of the last few decades have allowed virtual and augmented reality to enter people's lives for the first time. Most recently, the term 'metaverse' (taken from the 1992 sci-fi novel "Snow Crash" by Neal Stephenson), referred to virtual worlds shared over the internet, would seem more popular than ever before and millions of dollars are invested into its development (Kye, Han, Kim, Park, & Jo, 2021; Gallace, 2022). The success of companies such as Oculus (now Meta) or HTC certainly

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testifies this growing interest in the world of virtuality. As a matter of fact, these technological devices are certainly not 'new' and virtual reality has experienced several 'waves' of popularity from the 1960s to our days. It seems almost prehistoric to think about Morton Helig's 'Sensorama', dating back to 1957, one of the first commercial attempt to simulate an hedonic/pleasant complex experience (i.e. the first flight simulators for military purposes were implemented between the 1910s and 1930s), such as driving a motorcycle. Interestingly, these early examples of virtual reality already embedded some form of tactile stimulation in the experience. That is, since the very beginning of virtual reality it was very clear that the world had to be simulated taking into account all sensory modalities that our brain can process, in order to be perceived as a fulfilling and enjoyable experience. This trend never stopped since then, even if the available technologies and scientific knowledge somehow affected its speed.

The popular way in which most people today think about virtual reality is through headsets (devices that can be worn on a person face, as a sort of heavy pair of glasses) and their hand controllers. From this perspective, the Sutherland's 'Sword of Damocles', one of the first head mounted display anchored to the ceiling due to its weight and dated back to 1968, might look now to most people as a peculiar experimental attempt to create wearable displays, from a bygone era. However, once again such device and many others not mentioned here, although still embryonic, have certainly laid the foundations for 'portable' virtual reality as we know it today. Even the interfaces developed by VPL research (the company founded by Jaron Lanier, considered one of the fathers of Virtual Reality) at the dawn of the 80s - including headsets, whole body suits and haptic gloves - were strikingly similar, at least in their basic operating principles, to those available nowadays (Lanier, 2017)! However, if the technological and theoretical systems at the foundation of VR were already well underway in the 80s, why after more than 50 years from the first studies in this field, we still don't use these technologies as an integral part of our daily activities?

Certainly part of the answer to these questions is linked to a technical/computational aspect: Moore's famous law, according to which the number of transistors in microprocessors doubles every 12 months (value then changed to 18 months) and their price is halved. In other words, the computing capabilities of electronic computers (microprocessors), such as those necessary for the interactive reproduction of complex three-dimensional graphic environments, have increased considerably since the 1980s, making computations once impossible or too slow, now possible in faster times. In fact, we should consider that the reproduction through a visual medium (e.g., a display) of an interactive three-dimensional content (e.g., an avatar or object) depends on the number of polygons (simplified geometrical structures used for 3D graphic rendering) of which it is composed. More polygons, better graphics quality, but also greater computational demands. The reader belonging to generation X (born between 1965 and 1980) could think here about the first version of 'Lara Croft', the fictional main character of the 1996 popular game 'Tomb Raider'. The features of the first versions of Lara, as well as of the remaining characters of the game, were based on a limited number of polygons, the only ones which could be managed by the Home-PC processors of the time. By contrast, the youngest readers belonging to the millennial generation, are certainly accustomed to the highest graphic quality of games such as League of Legends or Fortnight, where the characters are created by means of millions of polygons. They will certainly be horrified by the visual simplification at the basis of the early Lara's details! However, so far we have only spoken about the visual aspect of early videogames, but we might wonder about what kind of advancements (if any) were made since the 80s on the reproduction of other sensations beside the visual one. After all, the early videogame players were by no mean supposed to physically touch any element within the Tomb Raider game or any other game (just as no haptic interaction was still provided in the 2002 social