

# Preface

Today's information and communication technologies (ICT) dominate most economic, cultural, and social practices of our world and have perhaps forever changed the ways how we work together, communicate with each other, or spend our leisure time. These digital technologies play an essential part in our daily life by now, and we cannot imagine living and working without computers, cell phones, email, instant messaging, or the Internet. As a matter of fact, the digital revolution has transferred many of our real-world activities to the virtual world. Examples include, but are not limited to communication, shopping, learning, fabrication, gaming, and even finding friends or life partners. As a result, humans often tend to spend more time in digital virtual worlds than in the real world; with a tendency to rise [1]. Popular examples of such virtual worlds are interactive computer games, which particularly attract the generation of *digital natives*—the generation of humans, which are fluent in the *digital* communication with computers, video games and the Internet [2]. Today, 97 % of average college grads in the US play video games and have spent more than 10,000 h playing games (not to mention 20,000 h watching TV). It is not surprising that sales of games are significantly growing. The US game industry brings in nearly \$15 billion a year [3]. A major turning point in pop culture history was reached in September 2013 when the fourteenth installment of Grand Theft Auto sold 800 million copies worldwide in only a single day. According to [3] that was the biggest launch day ever for any piece of entertainment at all. Nowadays, the video game industry is a multibillion dollar industry that not only rivals film and music industry sales but has already outperformed them. There are many reasons why video games have become so successful. One major reason is that the virtual environments (VEs) displayed in such games provide the means to immerse players into a computer-mediated reality in which they can experience numerous forms of adventures, tensions, action, or controlled stress [4]. Virtual reality (VR) technology pushes the idea to immerse someone into a VE to the next level [5, 6]. For instance, with head-mounted displays (HMDs) combined with tracking systems, it becomes possible to fully immerse a user into a VE and decouple her perception from the real world. In such scenarios a user only perceives the visual and auditory VE, which is displayed, for instance on an HMD, while all

her movements in the real world such as walking or head movements are transferred to corresponding motions in the virtual world providing an updated virtual view [6]. Since the purchase of Oculus VR in March 2014 by Facebook people around the world wonder and try to figure out what they can do with VR. Mark Zuckerberg wrote in his post announcing the purchase<sup>1</sup>:

*The incredible thing about the technology is that you feel like you're actually present in another place with other people. People who try it say it's different from anything they've ever experienced in their lives.*

—Mark Zuckerberg

The term “virtual reality” itself was initially popularized by American computer scientist Jaron Lanier in the end of the 1980s.<sup>2</sup> From a linguistic perspective, *virtual reality* seems to be an oxymoron due to the apparent contradiction between the adjective *virtual* and the noun *reality*. As denoted by Nicholas Negroponte,<sup>3</sup> VR has the potential to make the *artificial* as *realistic* as the *real* [7]. In this interpretation, virtual and reality are considered as equal halves and the term *virtual reality* is becoming a pleonasm for a new understanding of *reality*.

In popular media, VR has often been used in a misleading way and interchangeably with other terms such as *cyberworld* or *virtual world*. In this context, these terms often refer to virtual online games such as Second Life<sup>4</sup> or World of Warcraft.<sup>5</sup> And even in research, there is a constant debate about a common definition of VR. For the scope of this book, we will follow a definition of Frederick Brooks<sup>6</sup>:

**Virtual Reality (VR)** requires three *real* features: (i) *real*-time rendering with viewpoint changes as head moves, (ii) *real* space, i.e., either concrete or abstract 3D virtual environments, and (iii) *real* interaction, i.e., possible direct manipulation of virtual objects.

This definition is helpful since it distinguishes VR from other forms of interactive VEs as described above. In particular, the first aspect of head-coupled perspective rendering provides an immersive or semi-immersive experience. Such immersive virtual environments (IVEs) seek to invoke a *place illusion*, i.e., having

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<sup>1</sup><https://www.facebook.com/zuck/posts/10101319050523971>.

<sup>2</sup>Jaron Zepel Lanier is an American computer scientist and a pioneer in the field of VR. He was the co-founder of VPL Research, Inc., which was one of the first companies selling VR technology.

<sup>3</sup>Nicholas Negroponte is a Greek-American architect with an early research focus on computer-aided design. He founded the Massachusetts Institute of Technology's (MIT) Media Lab in 1985, and also founded the nonprofit organization “One Laptop per Child”, which deployed \$1 billion of laptops for primary education in the developing world.

<sup>4</sup><http://secondlife.com>.

<sup>5</sup><http://www.warcraft.com>.

<sup>6</sup>Frederick Phillips Brooks, Jr. is an American computer scientist, who founded the computer science department at the University of North Carolina at Chapel Hill in 1965. Dr. Brooks has received many awards, including the National Medal of Technology in 1985 and the Turing Award in 1999. I feel very honored that he served as a member of my habilitation committee in 2010.

the impression of being in a real place, as well as *plausibility illusion*, i.e., having the sensation that the scenario being depicted is actually occurring [5, 8]. Those illusions occur despite the fact that the user is aware that the VE is only a simulation [5, 9]. Furthermore, the combination of place and plausibility illusions often induces physical reactions. For instance, people tend to show increased heart rate or nervous sweating when they experience stressful situations in the VE [10].

The notion of an IVE, which is indistinguishable from the real world, has been addressed repeatedly in science fiction arts, literature, and films ranging from Plato's Allegory of the Cave from the ancient world to several science fiction movies from the modern era like "The Matrix", "Surrogates", "Avatar", or "World on a Wire". These are just some prominent examples of fictional works, which play with this perceptual ambiguity, and constantly question whether our perceptions of reality are real or not.

Until very recently, IVEs were only used by experts in very specific application domains such as research, training or simulation, or by participants during scientific experiments [6, 11]. Furthermore, these systems have been used only during short sessions, typically ranging from 30 min to a maximum of approximately 3 h [12]. With current VR display and interface technology such as Sony's PlayStation VR,<sup>7</sup> HTC Vive headset,<sup>8</sup> Samsung GEAR VR,<sup>9</sup> the Oculus Rift HMD<sup>10</sup> as well as the Microsoft Kinect,<sup>11</sup> Intel RealSense<sup>12</sup> or Leap Motion tracking devices, it becomes obvious that soon more and more people will spend a significant amount of their time particularly for communication and entertainment in IVEs. As a consequence, the traditional interaction metaphors as we know them, for example, from graphical user interfaces (GUIs) will become less important and rarely used, and finally will disappear from the set of standard user interfaces for interaction with computers. Hence, like the transition from command line interfaces (CLIs) to GUIs, we will observe another transition to natural user interfaces (NUI) or even magical or super-natural user interfaces [13]. Actually, we can already observe and experience this transition right now.

During the last decade, I gave several talks and presentations about the topic of VR and 3D user interfaces. The audience was often fascinated by these topics, but skeptical and reserved at the same time. Typical questions by people from the audience were about my expectations about the time frame it would take until we would observe VR at our living rooms, about the effects of immersion on presence, or how to include other modalities in a VR-based simulation. Sometimes lively debates were held about the question how such a virtual world would change the way we live as humans in a digital world. Science fiction literature and films

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<sup>7</sup><https://www.playstation.com/en-us/explore/playstation-vr/>.

<sup>8</sup><https://www.htcvr.com/>.

<sup>9</sup><https://www.oculus.com/en-us/gear-vr/>.

<sup>10</sup><https://www.oculus.com>.

<sup>11</sup><https://dev.windows.com/en-us/kinect>.

<sup>12</sup><https://software.intel.com/de-de/realsense/home>.

envision dystopic telepresence systems in which humans live their lives with a VR-based user interface, for instance, by resting on a high-tech chair, while they are immersed into a virtual or remote location [14, 15]. There are numerous challenging questions involved when such a novel paradigm of human–computer interaction would become reality: virtual environments and/or virtual objects, which get indistinguishable from the real world, and in which we as human beings will spend a significant amount of our time:

- How will VR systems and technology evolve within the next 15 years?
- What will be the challenges for VR in the next 15 years?
- How far are we away from computer-mediated realities, which are indistinguishable from our real world?
- Would we spend essential parts of our life in a computer-mediated reality?
- What are the benefits and potentials of those VR experiences?
- What are the limitations and possible dangers of VR?
- Which technological, anthropological and sociological challenges do we have to address?
- How would such a virtual revolution alter our society?

As pointed out above, with the development and widespread use of VR, there are several moral and ethical questions involved. This book will examine these futuristic visions of VR and provide an in-depth look into as well as a critical discussion of these questions based on our current understanding of IVEs.

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