Chapter 2
The Science and Fiction of the Ultimate Display

We certainly had the dreams before, but the computing just wasn't good enough.

—Tom Furness

2.1 The Ultimate Display

In 1965, Ivan Edward Sutherland,[1] who is one of the godfathers of computer graphics and creator of the groundbreaking computer graphical user interface *Sketchpad*, wrote his wonderful essay about what he termed the *Ultimate Display*. In this famous essay, he describes his vision of a futuristic display, which allows users to immerse themselves into computer-generated environments via novel types of multimodal input and output devices. He concludes his essay with the following sentences:

> *The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming such a display could literally be the Wonderland into which Alice walked.*
>
> — Ivan Sutherland

Already in 1968 (several years before the invention of the personal computer), Ivan Sutherland demonstrated with support from ARPA an extremely preliminary, but surprisingly advanced iteration of his vision of the ultimate display [1]. More than 50 years ago, Sutherland took a crucial step toward the implementation of his vision of the ultimate display by creating one of the first HMDs. Further details about this device are explained in Sect. 2.3.3.

As described by Sutherland the ultimate display is a computer-mediated reality, which would be indistinguishable from the real world. This notion of a VR, which

[1] American computer scientist Ivan Edward Sutherland was born in 1938. For his pioneering work in computer graphics he received the Turing Award from the Association for Computing Machinery in 1988.

© Springer International Publishing Switzerland 2016

F. Steinicke, *Being Really Virtual*, DOI 10.1007/978-3-319-43078-2_2

is indistinguishable from the real world, has been addressed repeatedly in science fiction arts, literature and films, and is often used to question whether our perceptions of reality are real or not. Prominent examples like Plato's Allegory of the Cave from the ancient world, and several science fiction movies from the modern era like "The Matrix," "Surrogates," "Avatar," or "World on a Wire" (see Fig. 2.1) play with this perceptual ambiguity. These fictional works often show different forms of VR-enabled world-building or cosmos construction that serve as a means of making sense of our own world. Such relations, which have arguably, patently links to religions, are discussed in more detail in Rachel Wagner's book [2].

2.2 The Fiction of VR

VR and 3D user interfaces are common themes in cyberpunk movies or science fiction literature. Directors and authors of this genre use VR to illustrate their visions of the future of human–machine communication and human–computer interaction. When we consider current and past VR installations, we will observe that some of these visions have already been implemented and evaluated in laboratory environments. However, some have been used successfully, others have been proven to be very inefficient in a real use case. Indeed, VR science and fiction seem to be closely related, and there is enormous potential for common visions and perspectives at the intersection of technology and fiction. In the following, we consider some of the most essential pieces of science fiction literature and cinematography in the area of VR, which are often cited and referred to in scientific presentations about VR research.

2.2.1 Plato: Allegory of the Cave, 360 BC

The *Allegory of the Cave* was described by the Greek philosopher Plato at the beginning of his famous book *BookVII* of the "The Republic." In a dialogue between Plato's mentor Socrates and his brother Glaucon, the former describes a dark scene in an underground cave, where a group of prisoners sit chained while they face the wall in front of them. Being in that position since birth, they can only see shadows that are projected on the wall. In addition to the chained prisoners, there are further people, which Plato called the "puppeteers." These puppeteers are located behind the prisoners and cause the shadows by handling and interacting with objects in front of a fire. However, for the prisoners, who are unable to see puppeteers, these shadows would become reality. The allegory points out that the prisoners' conception of reality is based on the limited view, which shows only an imperfect projection of the real world, defined by the puppeteers. Similarly, in his treatise "Meditations on First Philosophy" from 1641 Descartes hypothesized the possibility of a so-called evil genius, who creates and presents a complete illusion of an simulated reality by controlling all our senses.

2.2.2 Daniel F. Galouye: Simulacron 3, 1964

The novel *Simulacron-3* (also published as Counterfeit World) by Daniel F. Galouye describes the story of a simulation of a virtual city, which is used for marketing research. Scientists have developed this simulation in order to replace opinion polls. Although the virtual agents populating the simulated city have their own consciousness, they are unaware of the fact that they are only agents simulated in a computer. The protagonist, Douglas Hall, who is a specialist in developing self-conscious computer programs discovers that even his own world is not real, but a computer-generated simulation. In the novel, Simulacron refers to the VR simulator. The term is a closely derivative of "simulacrum," which denotes an imitation of an original. The number 3 refers to the novel's (at least) three levels of computer-generated simulation.

Galouye's novel has been adapted several times into other media such as the two-part German television film "World on a Wire" (see Sect. 2.2.3) directed by Rainer Werner Fassbinder and "The Thirteenth Floor" directed by Josef Rusnak in 1999 (see Fig. 2.2a).

2.2.3 Rainer W. Fassbinder: World on a Wire, 1973

In *World on a Wire*, Fassbinder describes the story of the Simulacron, which is a VR simulation populated by so-called identity units being unaware that their world is just a simulation (see Fig. 2.1). Upon suicide of one of the identity units the protagonist Fred Stiller investigates the case. Therefore, he approaches the contact unit of the simulated world, which is the only identity unit that knows about the simulation. The contact unit persuades Stiller that the real world in which Stiller lives in is a simulation as well; i.e., this simulation is arranged one level higher than Simulacron. Now, Stiller searches for another contact unit, who can connect his world with the real world one level above his world. Finally, using a mind switch technique, the simulated Stiller gets exchanged back to the real world.

2.2.4 William Gibson: Neuromancer, 1984

In the cyberpunk novel *Neuromancer*, William Gibson describes the story of the out-of-work computer hacker Case. After he stole from one of his employers, Cases's nervous system was damaged so that he cannot access the cyberspace anymore. In order to get his nervous system repaired, he participates in a series of data thefts along with his team. For their first job they need to steal an electronic copy of the mind of a brilliant hacker, who was a mentor of Case. The group's second job is to hack into the powerful artificial intelligence Wintermute. However, as it turns out Wintermute

Fig. 2.1 Scene from the 1973 science fiction film "World on a Wire" (German: "Welt am Draht") directed by Rainer Werner Fassbinder, which contains the first TV appearance of an early literary description of VR. Dr. Fred Stiller (played by Klaus Löwitsch) gets immersed into the simulation program, which includes an artificial world. The film is based on the science fiction novel "Simulacron-3" from 1964 (also published as "Counterfeit World") by Daniel F. Galouye [3]

itself was the driving force behind the malicious scheme. Wintermute was using the team to break regulations, which have been enforced by the Government in order to control artificial intelligences. In the end, Wintermute merges with another AI called Neuromancer, and both become a new, more powerful digital being.

2.2.5 Brett Leonard: The Lawnmower Man, 1992

The science fiction horror movie *The Lawnmower Man* was directed by Brett Leonard in 1992. The story is about the scientist Dr. Lawrence Angelo, who works for Virtual Space Industries on experiments with the goal to increase the intelligence of chimpanzees using VR in combination with drugs. Dr. Angelo realizes that he would need human subjects to continue his work, when he spots his young neighbor on the lawnmower Jobe Smith. Dr. Angelo invites him to play some VR games, and later convinces him to participate in his experiments. Jobe, who is a local greenskeeper with an intellectual disability, agrees to participate in the program with the goal to

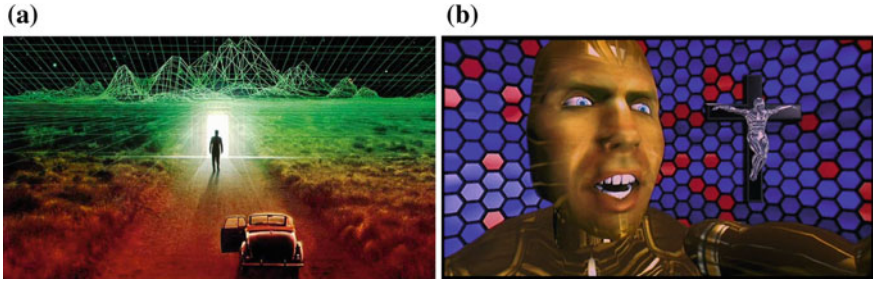

Fig. 2.2 Images from **a** Josef Rusnak's "The Thirteenth Floor" and **b** Brett Leonard's "The Lawnmower Man"

get smarter. With the beginning of the program, he becomes more intelligent, gets telepathic abilities, but also perceives hallucinations. His abilities further continue to grow, but the VR exposures affect his mental stability. Jobe is convinced that his final stage of evolution is to become pure energy in the mainframe computer. At the end he is able to enter the mainframe computer by abandoning his body and finally becoming a virtual godhood (see Fig. 2.2b).

2.2.6 Neal Stephenson: Snow Crash, 1992

In his third novel *Snow Crash*,[2] Neal Stephenson describes a dystopic vision of the twenty-first century in which the federal government has assigned almost all power and estates to private organizations. People try to escape from violence and suppression by the mafia in the real world by immersing themselves into the Metaverse. The Metaverse is the successor to the Internet, which is a shared VR-based massively multiplayer online game populated by avatars representing its players. The main protagonist Hiro finds a new narcotic called snow crash, which is offered at an exclusive nightclub inside the Metaverse. One of Hiro's friends falls victim to the effects of the drug, which can be experienced in the Metaverse and also in the real world. Hiro uses his skills to uncover the mystery of the narcotic. Together with the streetwise 15-year-old girl Y.T. he learns that snow crash is actually a computer virus capable of infecting the machines of unwise hackers in the Metaverse and also a real-world virus crippling the central nervous system.

[2] As explained by Stephenson in his essay "In the Beginning. . . was the Command Line" from 1999, the term Snow Crash refers to a particular software failure on early Apple Macintosh computers.

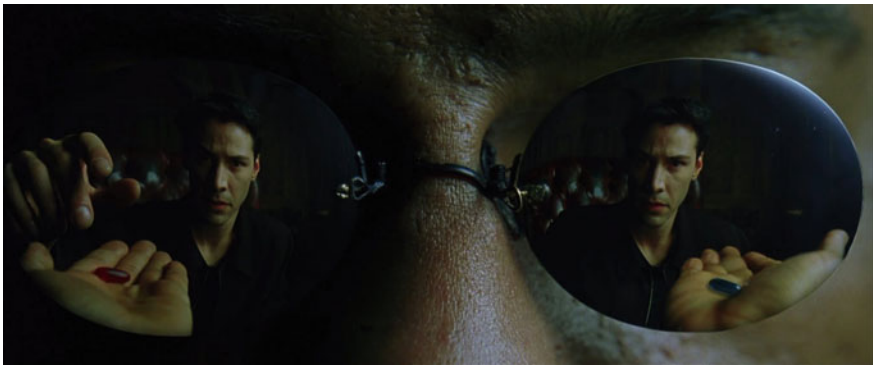

Fig. 2.3 Scene from *The Matrix* directed by the Wachowski siblings in which Morpheus offers the red pill to Neo, which allows to escape the matrix

2.2.7 The Wachowski Brothers: The Matrix, 1999

The Wachowskis, i.e., Lana Wachowski and her brother Andrew P. Wachowski, directed the science fiction action film *The Matrix*. The movie depicts a dystopic future in which machines subdue the human population by simulating a VR, called the matrix, which is perceived by almost all humans as their reality. However, their bodies are used as energy source for the machines, while they are connected with all senses to the matrix. The protagonist computer programmer Thomas Anderson (whose hacker alias is Neo) learns about this truth after one of the leaders of the rebels called Morpheus offered him to swallow a red pill (see Fig. 2.3). Morpheus and his crew hack into the matrix and unplug enslaved humans in order to recruit them as rebels. Since the rebels know about the true nature of the simulated reality, they are able to bend physical laws resulting in superhuman abilities.

2.2.8 Vernor Vinge: Rainbows End, 2006

Vernor Vinge's science fiction novel *Rainbows End* from 2006 describes a futuristic vision of 2025 from the view of two different persons: Professor Emeritus Robert Gu and his granddaughter Miri. Thanks to technological advances, the technophobic protagonist Professor Gu recovers from Alzheimer's disease after 20 years. However, Robert must adapt to a world, which is totally different from the world he remembers. Almost all humans and objects are connected and computer-mediated realities are commonplace. The people, in particular, children can create overlays over the real world in such a way that their view can be extended by computer-generated content, for example, for playing games. Since the use of search engines in combination with such technology has become such fundamental capability that no more knowledge

needs to be taught at school, but the teaching focus has entirely shifted to handling of knowledge, creativity, and cooperation.

2.2.9 Ernest Cline: Ready Player One, 2011

Ernest Cline's novel *Ready Player One* describes a dystopic view of the year 2044, in which the only pleasure of living can be achieved in the virtual utopia known as the OASIS. OASIS functions as a massive multiplayer online role playing game as well as as a virtual society. Upon the death of the creator of the OASIS a contest was launched with the goal to find a hidden Easter Egg inside OASIS. The person who solves the Egg Hunt first would receive control over the OASIS, and hence would become the most powerful person in the world. However, even after years of hunting, no one even ever completed the first stage in the contest. Therefore, the public interest in the contest diminished until the protagonist Wade Watts solved the first stage. Other players want to take the ultimate prize as well, and are willing to kill. In order to survive Wade must win the contest, but also has to compete against the global communications conglomerate Innovative Online Industries, which provides access to OASIS.

2.3 The Science of VR

Some people argue that the birth of VR dates back to rudimentary Victorian *stereoscopes*, which were the devices for displaying separate images depicting left-eye and right-eye views of the same scene [4]. However, to most people working in this area, VR as we know it today was created by a handful of pioneers in the 1960s. A detailed chronological review of the development of VR as a science and industry through the 1990s is given in Ben Delaney's book: *Sex, Drugs and Tesselation—The Truth about Virtual Reality*. In this section, we will provide a broader review of some of the milestones including research as well as industrial developments beginning already in the 1950s and 1960s.

2.3.1 Morton Heilig: Sensorama, 1962

The first idea of an HMD was patented by Thelma McCollum already in 1943 [5] (see Fig. 2.4a). This display was intended for noninteractive films supporting only visual display without any motion tracking. To my knowledge, this device was never build, however, using a similar approach, Luxembourgish-American inventor Hugo Gernsback demonstrated a prototype of television goggles (see Fig. 2.4b). Cinematographer and filmmaker Morton Heilig was one of the pioneers of VR, who extended these

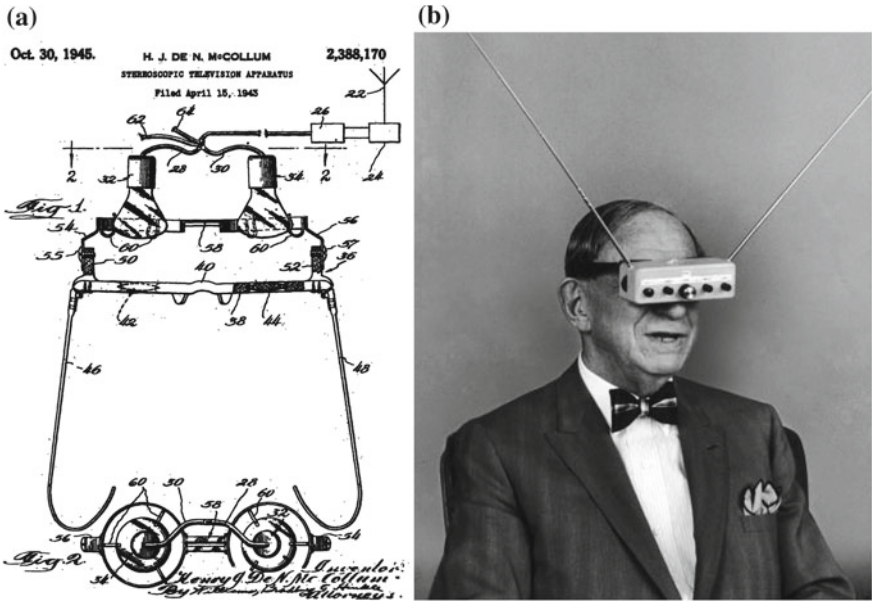

Fig. 2.4 First display goggles: **a** McCollum's stereoscopic television apparatus (image taken from US2388170), and **b** Gernsback demonstrating his television goggles for Life magazine (copyright by Life magazine)

ideas by introducing the first true multisensory VR system. During the 1950s he had the vision that the future of the cinema would allow immersing the audience in a fabricated world that engaged all human senses. Morton's Telesphere Mask (see Fig. 2.5) was patented in 1960 and was intended to provide stereoscopic television and sound. However, his vision was that despite viewing and hearing a film, users

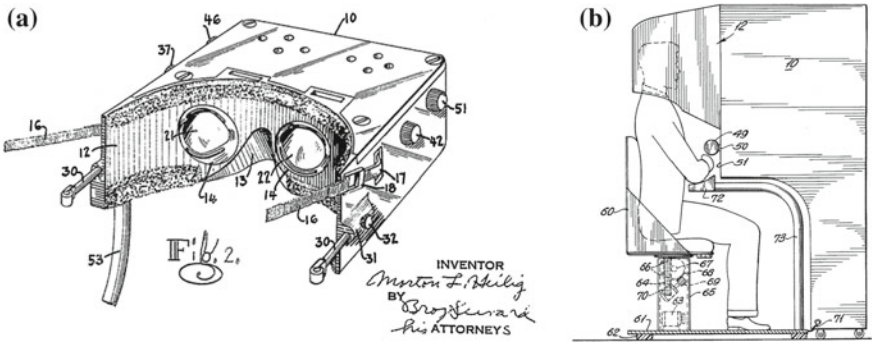

Fig. 2.5 Images from early VR systems of Morton Heilig's patents: **a** Telesphere Mask (image taken from US2955156) and **b** Sensorama simulator (image taken from US3050870)

should be able to simultaneously experience, for example, corresponding vibrations, scents, and wind. In 1962, after years of work he was able to patent and built his *Sensorama machine* (see Fig. 2.5b). The Sensorama is an arcade-style cabinet with a 3D display with wide field of view, sound, vibrating seat, and scent producer. It catapulted viewers, for example, into a multisensory motorcycle excursion through the streets of Brooklyn. Heilig developed it as one in a line of products for the cinema of the future, but unfortunately was never able to commercialize his visionary prototype. In a later interview he stated that "The Sensorama may have been too revolutionary for its time." Later, the cinema and entertainment industry revived his ideas with 4D/5D cinema experiences.

2.3.2 Charles Comeau and James Bryan: Headsight, 1961

Finally in 1961, two Philco Corporation engineers Charles Comeau and James Bryan developed the *Headsight*, which was the first actually fabricated HMD as we know these displays today [6]. The Headsight incorporated a single CRT element for each eye and a magnetic motion tracking system to determine the direction of the head (see Fig. 2.6a). The setup was intended to be used for telepresence setups for remotely viewing dangerous situations by the military. Head movements would move a remote camera, allowing the user to naturally look around in order to explore a remote location. While the development of Headsight was the first step in the evolution of the HMDs, it lacked integration of computer and image generation.

2.3.3 Ivan Sutherland: Sword of Damocles, 1968

In 1968, Ivan Sutherland, alongside his student Bob Sproull, demonstrated what is widely considered to be the first HMD system. As illustrated in Fig. 2.6b the so-called *Sword of Damocles* was a periscope-like helmet shaped apparatus, which displayed output from a computer program in 3D stereoscopic display. It was designed to immerse the viewer in a visually simulated 3D environment, which consisted only of wireframe 3D models. The computer-generated wireframe models augmented the view to the real world, and the user could change the position and see different views. Hence, the Sword of Damocles was actually the first AR display. More than 50 years ago, Sutherland took a crucial step toward the implementation of his vision of the ultimate display by creating one of the first HMDs as we know them today.

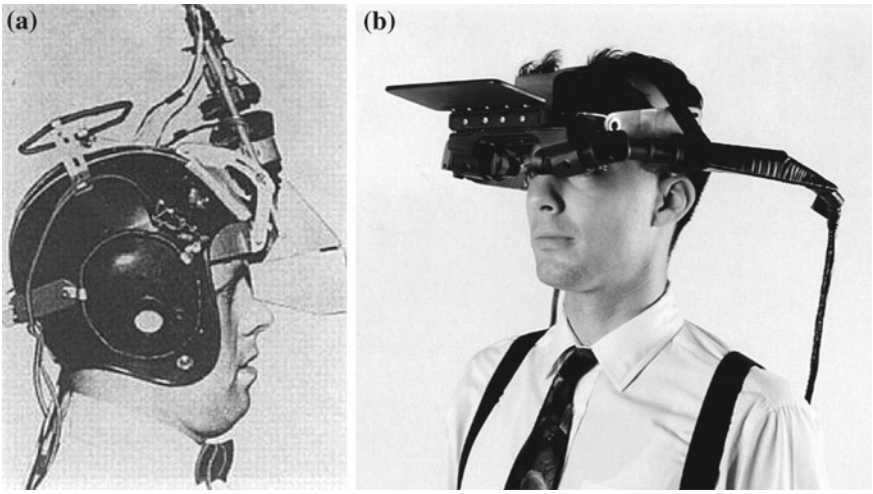

Fig. 2.6 Images from first HMDs: **a** Headsight [6], and **b** Ivan Sutherland's "Sword of Damocles" (copyright by Harvard University)

2.3.4 Thomas A. Furness III: Super-Cockpit, 1968

Around the same time, Thomas A. Furness III introduced VR technology to the U.S. Air Force. He designed and built visual display systems for the cockpits of fighter aircraft and developed some of the first VR-based prototypes of flight simulators. For two decades, he worked on the goal to improve cockpit technology for pilots. He orchestrated the development of several configurations of HMDs with motion tracking, 3D sound, and speech as well as gestures for user input. During the 1980s, this project eventually became the hallmark program known as the Super Cockpit (see Fig. 2.7a). As being one of the pioneers in the field of VR, he has earned the title of "grandfather of VR" [4]. Thomas Furness founded the HIT Lab[3] in 1989 with the aim to develop a laboratory, which is dedicated to empowering people by building interfaces to advanced machines.

2.3.5 Myron Krueger: Artificial Reality, 1969

Computer artist Myron Krueger is one of the early pioneers, who combined interactive art and VR. Beginning in 1969, he developed a series of interactive experiences, which he termed *artificial reality* [7]. These computer-mediated environments displayed virtual content on projection walls and responded to movements and gestures

[3]The Human Interface Technology Lab (HITLab) is a multidisciplinary research and development lab focussed around human interface technology.

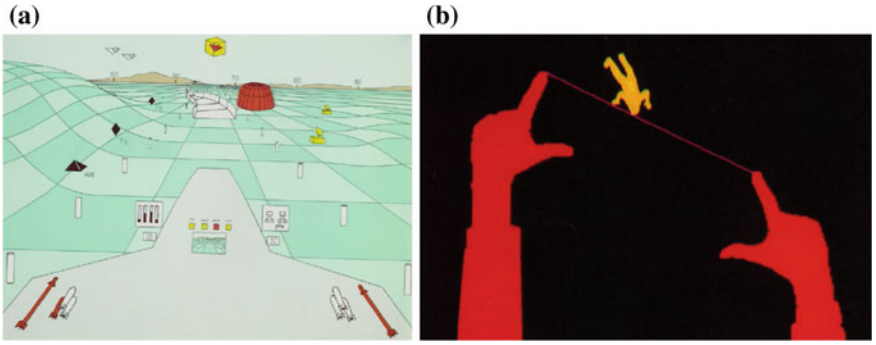

Fig. 2.7 Images from the **a** Super-Cockpit project [9] and **b** VideoPlace [8]

of the user through a combination of video cameras, sensing floors, and graphic tables. His most famous installation at that time was the "VideoPlace" technology from 1985. This vision-based system tracked the hands and enabled multiple fingers, hands, and people to interact using a rich set of gestures. Using VideoPlace users could explore interactive experiences in an unencumbered way with full-body interaction [8].

2.3.6 Jaron Lanier: Virtual Reality and VPL Research, 1985

The above-described achievements were enormous developments in the area of VR, in particular, regarding the fact that most of them had been made several years before the invention of the personal computer. However, so far, the technology and the applications were not referred to *virtual reality*. This changed when Jaron Lanier, cofounder of the visual programming lab (VPL), coined and, in particular, popularized the term in media. Now, the research area got a name, which further popularized research and commercialization in this area. As already described in Sect. 2.1, VPL research developed a range of VR devices and was the first company to sell VR goggles including several models of the EyePhone HMD and the Dataglove [4].

2.3.7 Jonathan D. Waldern: Virtuality, 1991

In the early 1990s, the interest in VR was enormous, and significant mainstream press coverage caught the public's attention. Pioneering companies such British company W Industries founded by Jonathan D. Waldern launched and produced the first VR games, and the public got access to VR. W Industries (renamed *Virtuality Group PLC*) produced already all principal components required for a typical VR

experience in their *Virtuality* gaming machines. Using these machines players wore a set of VR goggles and played on gaming machines with real-time stereoscopic rendering, joysticks, and with other players in networked units. The Virtuality Group became one of the best-known makers of VR entertainment in the 1990s [4].

2.3.8 Gunpei Yokoi: Virtual Boy, 1995

Nintendo's *Virtual Boy* (codename VR32) was the first ever portable 3D gaming console launched in 1995. The Virtual Boy could display stereoscopic 3D graphics based on red LED eyepiece display technology. Since the middle of the 1980s, Reflection Technology, Inc., had developed this technology. Although, it allowed only single-color display (games were in red and black), the general manager of Nintendo's R&D Gunpei Yokoi, decided to enter an exclusive agreement with Reflection Technology, Inc.. Gunpei Yokoi was already very successful with the development of the Game Boy and the design of the D-pad (sometimes referred to as the cross pad) nowadays available in most video game controllers. However, despite the low price of $180 and further price drops, the Virtual Boy was a commercial failure and one of Nintendo's lowest selling platforms. Obviously, the lack of colors in the graphics was a problem, but people were also complaining about missing software support and suboptimal ergonomics [4]. As a consequence, Nintendo discontinued the production and sale of the Virtual Boy in the following year.

2.3.9 Classic Readings in VR

Of course, there are several other people and companies, who have paved the way to VR as we know it today. Unfortunately, there is not enough space in this book to credit them all. Luckily, many of them are still very active in the field and will further advance the field of VR and AR in the next years. For the interested reader, I collected a small list of classic readings in the field of VR, which I use for teaching:

- Sutherland, I.E. (1965): The Ultimate Display, Proceedings of IFIPS Congress, Vol. 2, pp. 506–508.
- Sutherland, I.E. (1968): A Head-Mounted Three Dimensional Display, Proceedings of the Fall Joint Computer Conference, AFIPS Press, pp. 757–764.
- Furness, T. (1986). The super cockpit and its human factors challenges. Proceedings of the Human Factors Society, 30, pp. 48–52.
- Krueger, M.W. (1983): Artificial Reality. Reading, Mass., Addison Wesley.
- Raab, F., Blood, E., Steiner, T., Jones, H. (1979): Magnetic position and orientation tracking system, IEEE Transactions on Aerospace and Electronic Systems, Vol. 15, No. 5, pp. 709–718.

• Roberts, L.G. (1966): The Lincoln Wand, Proceedings of the Fall Joint Computer Conference, AFIPS Press, pp. 223–227.

2.4 2016: The Year of Virtual Reality

The first 15 years of the twenty-first century have shown exponential advancements in the field of VR. Computers, in particular, mobile technologies, have dominated our lives because of their power, relatively low costs and small form factor. The raise and ubiquity of smartphones have enabled a generation of lightweight and practical VR devices and have led to a resurgence of the interest in VR. Today's principal main components of smartphones such as high-density display panels, gyroscopes, or accelerometers are built in most devices. This is one of the main reasons that VR technology costs only a fraction of the price of Virtuality machines in the early 1990s. Moreover, the video game industry has continued to drive the development of consumer VR. Depth sensing cameras, motion controllers and natural user interfaces are on the edge of becoming the standard way of modern computer interfaces.

Regarding these advancements, it seems clear that 2016 will be a key year in the VR industry. Some high-end VR headsets and multiple other consumer devices for input/output will come to market. Among them, there is the first consumer Oculus Rift developed by Oculus VR. Palmer Freeman Luckey, the founder of Oculus VR, worked as an engineer at MxR as part of a design team for cost-effective VR. Luckey developed a series of different HMD prototypes and posted regular updates on his work on a VR enthusiast forum-based website.[4] One of the latest units was named the *Rift*, which was intended to be sold as a do-it-yourself kit on the Kickstarter crowdfunding website. Oculus VR was started in order to facilitate the Kickstarter campaign. During its period as an independent company, Oculus VR raised US$2.4 million for the development of the Rift. On March 25, 2014, social media giant Facebook bought Oculus VR for US$2.3 billion. Certainly, this is an incredible vote of confidence, which underlines the global interest in this immersive VR technology. When the Oculus Rift was released in 2016 it was already competing with products from Valve corporation and HTC, Microsoft, as well as Sony Computer Entertainment. But other companies like Google and Samsung have released VR products essentially based on smartphones such as Google Cardboard or Samsung's Gear VR, which are do-it-yourself and mass produced headsets, respectively, that use a smartphone as VR device. Many other enterprises will follow these new VR heavyweights.

In numerous media appearance, 2016 is referred to as "the year of virtual reality" [10]. Many of the VR enthusiasts are confident that this time the technology will answer the unfulfilled promises made in the 1990s.

[4] http://www.mtbs3d.com/.

References

1. Sutherland, I.: A head-mounted three dimensional display. Proc. AFIPS Fall Joint Comput. Conf. **33**, 757–764 (1968)
2. Wagner, R.: Godwired: Religion, Ritual and Virtual Reality (Media, Religion and Culture). Taylor & Francis (2011)
3. Galouye, D.F.: Simulacron-3. Bantam Books (1964)
4. Delaney, B.: Sex, Drugs and Tessellation: The Truth About Virtual Reality, as Revealed in the Pages of CyberEdge Journal. CyberEdge Information Services (2014)
5. McCollum, T.: Stereoscopic television apparatus. US 2388170 A (1945)
6. Comeau, C., Bryan, J.: Headsight television system provides remote surveillance. Electronics **10**(34), 86–90 (1961)
7. Krueger, M.: Artificial Reality. Addison-Wesley Professional (1991)
8. Krueger, M., Gionfriddo, T., Hinrichsen, K.: Videoplace—an artificial reality. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 35–40 (1985)
9. Furness, T.: The super cockpit and its human factors challenges. In: Proceedings of the Human Factors and Ergonomics Society Annual Meeting, vol. 30 (1986)
10. Morris, C.: Is 2016 the year of virtual reality? http://fortune.com/2015/12/04/2016-the-year-of-virtual-reality/ (2015)

Springer

http://www.springer.com/978-3-319-43076-8

Being Really Virtual
Immersive Natives and the Future of Virtual Reality
Steinicke, F.
2016, XVIII, 166 p. 51 illus., 40 illus. in color., Hardcover
ISBN: 978-3-319-43076-8