PREGLED AKTUALNIH ISTRAŽIVANJA VIRTUALNE STVARNOSTI I NJENE PRIMJENE

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Sažetak

U ovom radu dan je pregled povijesti virtualne stvarnosti, trenutni aktualni uređaji za VR, principi rada i primjena u različitim okruženjima te mogućnosti koje nam VR pruža. Virtualna stvarnost kao tehnologija razvija se od sredine prošlog stoljeća, ali njena komercijalna upotreba nije zaživjela sve do danas kada su dostupni različiti uređaji. Kao neke vodeće uređaje možemo izdvojiti HTC Vive, Microsoft HoloLens, Oculus Rift i PlayStation VR. Jedna definicija VR kaže kako je to znanstvena i tehnička domena koja koristi računalnu znanost i bihevioralna sučelja kako bi simulirali virtualni svijet, koristeći 3D entitete koji mogu imati interakciju u realnom vremenu međusobno i sa jednim ili više korisnika u pseudo- prirodnoj imerziji kroz senzorne kanale. Postoje tri glavne karakteristike sustava za VR a to su 1. uključenost u sustav, 2. interakcija sa sustavom i 3. imaginacija. Različita su područja primjene virtualne stvarnosti a neke od njih su industrija igara, medicinska primjena i arhitektonske vizualizacije.

Ključne riječi: virtualna stvarnost, imerzija, imaginacija

OVERVIEW OF CURRENT VIRTUAL REALITY TECHNOLOGIES RESEARCH AND APPLICATIONS

Abstract

In this paper short history of virtual reality, current virtual reality devices, principles of work and applications in different fields are given. Virtual reality as technology has been developing since the middle of last century, but its commercial use has experienced an uplift with relatively cheap and accessible devices. As for leading devices we can single out HTC Vive, Microsoft Hololens, Oculus Rift and PlayStation VR. One of many definitions explains virtual reality as scientific and technical domain which uses computer science and behavioral interfaces to simulate virtual world, by using 3D entities which can have interaction in real time in-between or with one or several users in pseudo- natural immersion through sensory channels. There are three main characteristics of VR systems; immersion, interaction and imagination. Some of many different fields that virtual reality covers are gaming industry, medical application and architectural visualizations.

Keywords: virtual reality, immersion, imagination

1. Introduction

Virtual reality as a technology has been developing since the middle of last century, but its commercial use has not thrived until recent few years when a plethora of VR devices became available at relatively affordable prices. This paper comprises topics that include a short history of VR, current head mounted displays (HMD) available on market, their operating principles and possibilities that this technology provides. Also, some relevant and interesting research regarding virtual technology is included.
There are several definitions attempting to define VR and here are stated some of them. One definition stated that VR is a simulation in which computer graphics are used to create realistic environments that involve real time simulation and interaction through several sensory channels that may be visual, auditory, tactile and olfactory [1]. Another definition states that virtual reality is scientific and technical domain which uses computer science and behavioral interfaces to simulate virtual world, by using 3D entities which can have interaction in real time in-between or with one or several users in pseudo-natural immersion through sensory channels [2]. Three main characteristics that define VR systems

are immersion (explains how immersive is content for the user), interaction (explains which level of interaction user can have with the system) and imagination (can the user create and modify existing content and to what extent). Figure 1. Shows those three main VR system characteristics in Venn's diagram.

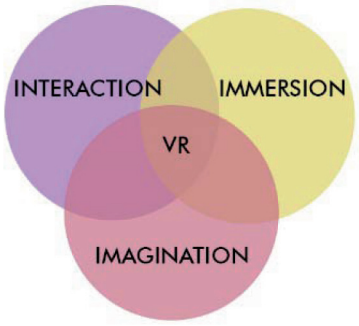

Figure 1: Three main VR system characteristics

Aforementioned three characteristics are important because they depict how users perceive different types of VR, especially immersion which has three types familiar to users [3].

a) non-immersive systems – also known as a desktop system, which consist of monitor, mouse, and keyboard and in which user is fully aware of surroundings. This system provides a lower level of presence, immersion, and interaction, but is considered as most common system today. Figure 2. a shows an image of this type of system.

b) semi immersive systems – also known as the hybrid system which includes 3D screens, polarized glasses, joystick, may include additional input such as Data Gloves. This system is a combination of real-world attributes and virtual elements. It provides a higher level of presence, immersion, and interaction. A flight simulator is one example. Figure 2. b shows an image of this type of system.

c) fully immersive systems – a system with the highest level of presence, immersion, and interaction. Users wear HMD device which tracks head position and changes position accordingly. Users may be seated in special chairs that provide a sense of movement/swinging, may have an electric fan to increase immersion and wearing gloves on hands or use controllers to interact with the virtual world. Figure 2.c shows an image of a fully immersive system.

Figure 2: a) non-immersive system b) semi-immersive system c) fully-immersive system (Google images)

2. Short history of virtual reality

In this chapter short history of virtual reality is covered, up to today's novelties in industry.

First machine that gave illusion of reality by using 3D images and videos was Sensorama. It was invented by Morton Heilig and patented in 1962. Sensorama gave illusion of reality in 3D in combination with vibration chair, sound system, smell and wind effects. It was made to fully immerse user into virtual

world. Heilig also made a few 3D movies which he played on his machine. Two parts of Sensorama were Sensorama Motion Picture Projector and Sensorama 3-D Motion Picture Camera which were essential for device to work [4]. Figure 3. shows Sensorama simulator device.

Figure 3: Sensorama simulator device (Google images)

Next major step in development of virtual reality technology was Ivan Sutherland's Ultimate Display, which implies using a head mounted display as a window for VR. Device at first used two cathode tubes which were positioned next to user's ears. That installation on human head was inappropriate due to its heaviness and pressure on head, so he installed a mechanic hand which had a grip onto system. Mechanic hand had a potentiometer to trach users head movement [5]. Today's HMD devices are much lighter and they don't use cathode tubes. This concept was named "The Ultimate Display" and device was "The Sword of Damocles". On YouTube can be seen a video of Sutherland's device while working (https://youtu.be/ISJWZpFIAlQ). Figure 4. shows "The Ultimate Display".

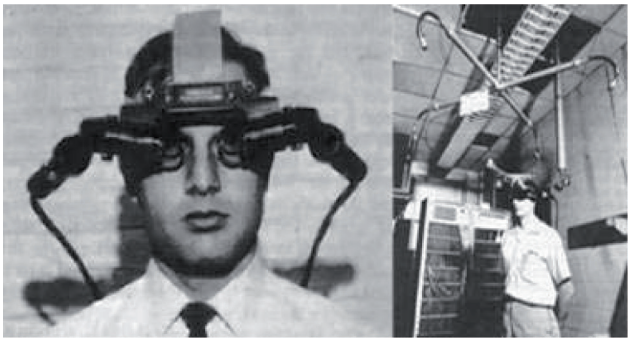

Figure 4: The Ultimate Display (Google images)

In 1987, Jaron Lanier founded the first virtual reality studio, and with Tom Zimmerman created „The data glove ", (a glove which was used as input device for interaction with VR), and „Eyephone "the HMD device with LCD display for each eye which gave depth perception in VR [6]. It is considered that Lanier introduced the term "virtual reality" which became generally accepted among researchers and general. Figure 5. Shows The data glove and Eyephone. Nintendo in 1995 manufactured a 32-bit console device named "The Virtual Boy" which had red-black screen, which gave people headaches.

Figure 5: The data glove i Eyephone (Google images)

In more recent history, more than 20 years after the Virtual Boy, a lot has changed and improved in the virtual reality technology. In this second part of VR history are descriptions and features of few most recognized devices available on the market.

Oculus Rift is one of most popular and well known device for VR. At this moment, a third version of Oculus is available, and previous to this version available were DK1 and 2 (development kit). Head mounted display uses PenTile OLED display, 1080 x 1200 px per eye, 90 Hz refresh rate and 110° field of view. As the refresh rate is higher, the better for the viewer, as it reduces the possibility for visual artefact in the image, known as screen tearing effect. This artifact occurs if we have a screen with refresh rate of 60 Hz and the content we are watching has frame rate of 75 Hz. The latest version of Oculus Rift includes a motion tracking system in physical space, which through infrared sensors monitor infrared LEDs on the device itself [7]. Oculus Rift in its latest version uses Oculus Touch motion sensors which are held in hands and they are used for interaction with virtual world, and are connected with motion tracking system.

HTC Vive is, as for now, also one of the most popular HMD device for VR. Difference between Oculus Rift and HTC Vive is that latter came from start equipped with two base stations (used for motion tracking) which are used for physical movement in space while wearing headset and two hand controllers for interaction with VR. Resolution is 1080x1200 px per eye, OLED display, 110° field of view. Field of view is important for immersion in VR, since wider FOV is one of factors which affect overall VR experience. Figure 6. Shows Oculus Rift HMD with motion controllers and Oculus Touch sensors and HTC Vive with base stations and hand controllers side by side. Besides this two specified VR devices, there are some other such as Sony PlayStation VR, Samsung Gear VR (which uses phone as display), Razer VR, Google Daydream etc. As for affordability, high end HMDs are HTC Vive (699 €), Oculus Rift (499 $) and OSVR (499 €) which are in the forefront of quality, but not in the cheap price range. As for less expensive devices available are Sony PlayStation VR (349 £), Google Daydream (79 $), Samsung Gear VR (129 $) and more (all prices mentioned are current for February 2018).

Figure 6. Oculus Rift (up) and HTC Vive (down) (Google images)

3. Some limitations and problems in VR

As is already known, in the last few years virtual reality headsets experienced revival, but still, this technology has some shortcomings. One aspect of this shortcomings are hardware solutions and other aspect are human factors. One of mayor problems that occur while being immersed in VR is cybersickness, and its connected and influenced with hardware, software and human factors. Cybersickness can be defined and explained as a result of sensory mismatch between eyes and inner ear. Cybersickness and motion sickness are connected by that sensory mismatch. Common symptoms that may occur are headache, eye strain, sweating, dryness of mouth, vertigo etc. [8]. According to Rebenitsch, there are two more theories considering cybersickness. First is postural instability which states that if one cannot remain stable with sensory input, one will surely feel ill. Second is called the rest frame theory, simply explained, that there is less chance to feel motion sickness if one anticipates movement, for e.g., driver in a car better anticipates movement with vehicle than passenger, and therefore will have fewer symptoms [9]. Related to the term of cybersickness is vection, also known as pseudo-movement or illusion of self-motion. This illusion of self-movement can be explained as sensory conflict when eyes perceive acceleration and movement but balance sense record that you are motionless [10]. Often used example is when person is in a vehicle and cars from the sides start moving, a person may be confused if he is moving backwards or other cars are moving forward. Human factors which influence cybersickness are diopter, depth perception, astigmatism, strabismus, nausea tendencies in transport vehicles or amusement parks, previous experience with virtual reality headsets, age and gender. Hardware and software factors include, but not limited to: display type, resolution, field of view, lag, framerate, latency and vertical synchronization [11], [12].

4. Research in VR

Considering many fields which use and explore possibilities of virtual reality such as gaming industry, medicine, psychology and architectural visualizations, plenty of research has been conducted over years. For subjective evaluation of motion sickness and lately cybersickness, commonly is used Simulator Sickness Questionnaire (SSQ) made by Kennedy et al., in 1993 [13]. Carnegie and Rhee in their research investigated how does dynamic depth of field blur (DoF) changes influence cybersickness. They used SSQ as subjective evaluation of cybersickness and results recorded show that dynamic DoF can reduce discomfort in virtual reality [14]. Fernandes and Feiner made similar research using dynamic field of view (FoV) change while character (i.e. person) is moving in VR. They concluded that FoV restrictors may have positive influence on initial VR experience [15]. Some research concern ways of movement in virtual environments and how speed influences cybersickness, such example is by Medeiros et.al where they researched how three different travel techniques influence sense of comfort and cybersickness in VR. They concluded that linear motion caused more physical discomfort than other two travel techniques [16]. Malinska et.al investigated heart rate variability during virtual reality immersion and 3D stereoscopic movie. They concluded that heart rate values were significantly higher in VR than ones recorded when watching 3D movie [17].

5. Conclusions

This overview gives short history, some research achievements and applications of virtual technology. It is known that this technology offers vast potential for further development in a number of industries, such as gaming industry, medicine, and architectural visualizations. Throughout recent years head-mounted displays used for VR are advancing in quality of displays, an increase of resolution, hardware weight, and computers generally have better computing power to support the system. Some problems are still occurring in overall experience of virtual reality, and most prominent one is cybersickness which some people find dissuasive enough to stop immersing themselves into the world of virtual settings. There are ways to alleviate this problem but none of them can't dissolve it to the utmost, and more research is required in the field of virtual reality.

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