Virtual Reality Laboratory in the Help of Research and Education

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***Abstract*—In 2020 a new Virtual Reality Laboratory was developed and equipped at Óbuda University Alba Regia Technical Faculty. The new laboratory consists of high performance PCs, VR Head Mounted Devices (HMD), complex depth cameras, projectors for the education and research in the field of virtual, augmented, and mixed reality. This laboratory helps the newly accredited Mobile Application and Game Development Specialization of the IT Engineer MSc course, the Mechanical Engineer BSc. and Mechatronic Engineer MSc. courses. Furthermore, it makes possible some educational projects, and research projects that are listed in this article.**

Keywords—Virtual Reality, Augmented Reality, education, Spatial vision

I. INTRODUCTION

Virtual reality, augmented reality and mixed reality have become part of our everyday lives. Historically publications on virtual reality have appeared in the scientific world since the 1960s. Then, at an increasing pace, the enhancement of related hardware tools, software tools and development environments took place. The developed systems can be of great interest in almost all segments of industry and society, highlighting healthcare and education as already successful applications[1]–[11].

Figure 1 shows the prevalence of VR and related concepts in scientific vocabulary. The two basic terms associated with it are Virtual and Augmented Reality. Virtual Reality: "A high-end user interface that involves real-time simulation and interaction through multiple sensorial channels (vision, sound, touch, smell, taste)" or "A computer-generated, immersive, multi-sensory information program which tracks a user in real time"

Augmented VR: the idea of taking what is real and adding to it in some way so that user obtains more information from their environment.

The number of publications containing the term VR in the title, based on Google Scholar search, grew rapidly between 2000 and 2010 and today the number of publications exceeded the 1,000,000. The number of publications containing augmented reality in the title

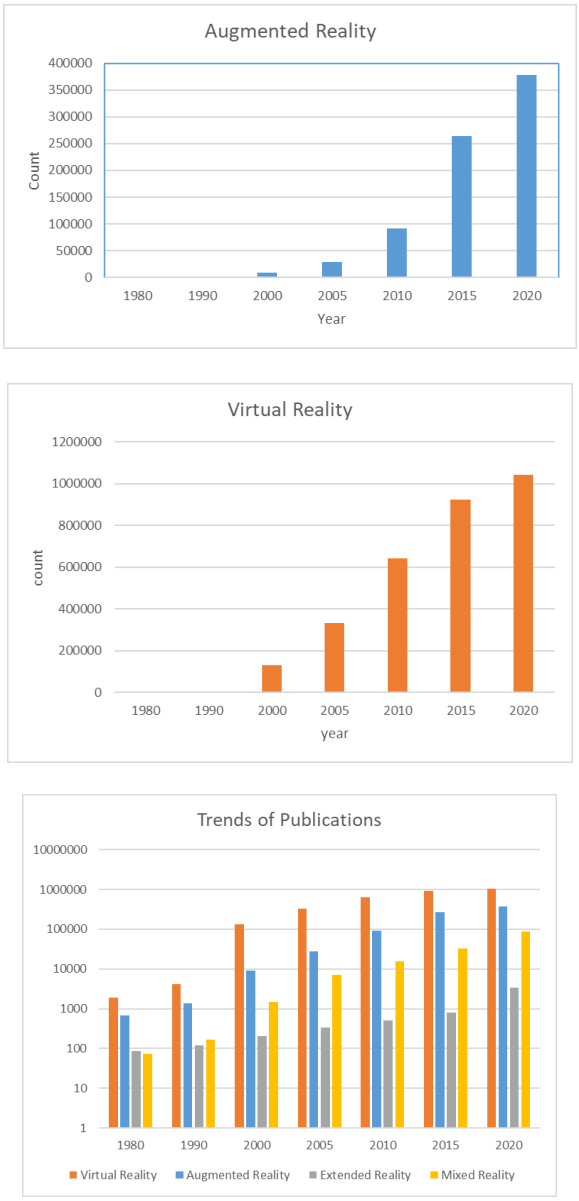

Figure 1 Number of VR related publications

increased rapidly after 2010 and till now reached hundreds of thousands. It is easy to see that this amount of publication unfortunately does not allow to follow the topic in every detail. Complementary concepts, mixed and augmented reality are also popular. The background of the large number of publications is that however the basic concepts and principles were laid down in the previous century, but the implementation struggles with many difficulties and childhood diseases, both in terms of hardware and software. However, the areas of application are very promising in the light of psychological studies. With the connection of COVID-19 pandemics, the impact of VR in distant education and in business communication has increased [6][11][1].It can be stated that there are currently no suitable tools and software that allow continuous (full-time) learning or work in a VR environment. We can expect a change in this regard in the future, as the tools will become easier and more convenient due to the ever-evolving technology. The psychological study of virtual reality is also intensive. This includes testing immersion, examining the psychological impact of activities in VR systems, and analyzing the health effects of VR devices to reduce adverse effects. VR is an explosively growing market segment around the world and its role in IT training became more central. In this article, we will present the construction process and results of the VR laboratory established at the Alba Regia Technical Faculty of Óbuda University, and evaluate the usability of the tools in education, as well as formulate research projects related to VR.

II. Composition of a VR Laboratory

In the spring of 2020, a new virtual reality laboratory was installed at the Alba Regia Technical Faculty of Óbuda University [12][13][5][7].

Two newly purchased PCs which are suitable for 3D design and computer graphics and related VR MR devices have been acquired. Laboratory equipment is listed in Table 1.

TABLE 1. VIRTUAL REALITY AND GAME DEVELOPMENT DEVICES

Devices	Attributes
PC	PCT Blade Base Intel Intel Core i7-8700 3400MHz 8MB LGA1151 8GB DDR4 memory module 256GB 2,5" SSD SATA 2TB 3,5" HDD DVD inner writer Windows Pro 10 32/64
VR device	Oculus Quest VR Headset 128GB+Handheld Controller
MR device	MS HoloLens2 (under acquisition)
Depth sensors	Kinect for Xbox One Kinect for Xbox 360
Game platform	Xbox One

These devices complemented the existing PCs from previous purchases, Xbox One devices + Kinect for Xbox One sensors and Kinect for Xbox 360 depth sensors. Currently, the VR lab has a capacity of 10 people. In the future, the PCs are planned to equipped with suitable graphics cards, as well as to purchase additional sensors (Kinect for Azure, Orbbec).

An important aspect of the laboratory equipment was that it could be conveniently used for project-based education as well as research projects.

The installed software configuration enables computer graphics, 3D modeling, 3D sensing, and their use in software development and testing. We managed to create a test environment in which the software execution process of VR devices by a user can be objectively evaluated. The image seen in the device can be projected and recorded along with the interactions of the user.

Figure 2 Oculus Quest and HoloLens2

III. Methods

The following methods were used during the design of the system.

Depth sensor

The MS Kinect SDK was installed and applied to query the Kinect Depth Sensor.

Database

The data containing the movements were saved in a MongoDB database [10]. An MLP neural network was used to analyze the movements.

Implementing virtual reality

The Unity game engine provides easy integration with virtual reality devices, including Oculus devices, in this case by installing an Oculus SDK that can be easily integrated into the project.

Assets and VR development

The Oculus Quest development team has developed an integration package for the Unity game engine that includes a stable interface that allows the engine to

communicate with the virtual reality device and provide ready-made solutions to take full advantage of the device's features. This package is called "Oculus Integration" which is available through the Unity Asset Store. During the development of the source code, using the pre-made model in this package, the "prefrab" model, which provide the ability to move the player, called "OVRPlayerController". This model was created, which includes the usability of the HMD (Head Mounted Devices), provides different controller models and the player's real-time virtual spatial tracking.
The image of the Oculus VR headset was projected onto the projector with the SideQuest 3rd party software[14].

IV. PROPOSALS

The newly established research site can serve as a location for educational and research projects.

A. Educational projects

From the 2019/20 academic year, we managed to start the specialization called Mobile Application and Game Development in the master's degree in IT engineering with the John von Neumann Faculty of Informatics of Óbuda University. The Software Tools of Game Development and Multiplatform Game Development subjects taught in the specialization are based on this lab. The laboratory is suitable for the implementation of the course entitled Project Work, furthermore it can be used in the robotics engineering education by the implementation of robot simulation tasks. The topic of many dissertations is VR and AR, which can be realized by this laboratory.

A. Research projects

Within the framework of the intelligent data analysis research group of Alba Regia Technical Faculty of Óbuda University, we formulated projects that fit the research of the working group. Our main objectives are applications of 3D data visualization and data analysis.

Our primary goal is to visualize tabular data in an augmented and mixed reality environment. Our goal is to visually link the data extracted from the database or received from different data sources with the corresponding data source object to assist in the exploratory data analysis. Our second important project is the quantitative analysis of human behavior in the VR environment. During the investigation the movements of the user during the VR software execution are measured and then analyzed. The system developed in this way will be suitable for examining many basic research issues in quantitative psychology, sociology and pedagogy. In addition, it will be used for applied industrial research and for monitoring and supervising practical educational and industrial design or optimisation projects.

V. RESULTS

In the previously developed system, real-time recording and storage of human movements in a MongoDB database and high-precision classification of some basic forms of movement with an MLP neural network were accomplished[10]. Three games have been developed to make tests in the developed VR system. To test spatial orientation and navigation, we developed a software that generates a spatial maze in which the user aim is spatial orientation and finding the exit of the maze. Our second test application is a motion coordination application that is a VR implementation of a Darts game. The third application is suitable for examining a complex issue.

Figure 3 3D shape connection game with lowpoly design. The user gets different complexity 3D prism generated by the software according to the defined complexity level. The user has to rotate it to the appropriate orientation and fit into the keyhole.

Figure 4: Darts game with realistic design The user can play a classic darts game alone or with a different level computer player.

It is a 3D object matching game, in which the 3D prism generated by the game must be rotated into the appropriate orientation by the player to fit in a given scheme. The software makes possible to examine the hand movements implemented in the VR environment as well as the user's spatial vision. Measurements of the three test programs have begun. The following is a detailed re-measurement of the three test applications as well as an evaluation of the measurement results. In the future, it is worth further developing the tool system by solving the following tasks. By using several depth cameras at the same time, it is possible to examine a larger area or a group consist of more

than six people. By calibrating the depth cameras, it is possible to characterize the movements of the examined person in the real metric system and with spatial coordinates, as well as to measure them with the movements in the virtual space units. The next goal is to create test applications in which the subject can perform tasks in cyberspace without using a handheld controller.

Figure 5 VR Labyrinth test game in cyberpunk style. The user has to direct a small virtual machine to find the exit from the two layered 3D labyrinth.

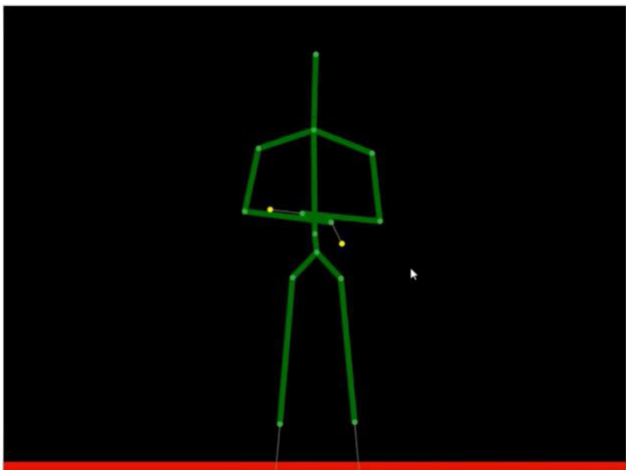

Figure 6 Skeleton picture by the detected 20 joints of a standing person.

VI. Conclusion

Virtual reality has become widespread worldwide and has become a technology gaining serious use in more and more areas. Alba Regia Technical Faculty of Óbuda University wanted to join this process. The method was to develop the appropriate tools and to set the related educational and research goals. In the article the development process was presented, tools, the purpose of the development and the usability of the developed laboratory for the educational and research purposes of the University of Óbuda Virtual Reality Laboratory was showed. The completed laboratory can be used in almost all training programs, in addition, in project-based education, development projects, dissertations and diploma theses can be applied to it. In the field of research projects, the intelligent data analysis research group can be primarily connected to the research and they want to use the tools in the future in data analysis and data visualization projects. The formulated and planned VR system will also be applicable in basic research, applied research and R&D projects cooperation with industrial companies.

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