



# The Role of Augmented and Virtual Reality Technologies in Developing Logistics Processes

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## Authors' contributions

*This work was carried out in collaboration among all authors. The authors contributed equally to this work. All authors read and approved the final manuscript.*

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## ABSTRACT

Nowadays, manufacturing and service companies are increasingly using new IT-based methods and solutions. Two of these areas are the use of augmented reality (AR) and virtual reality (VR). Kyrgyz National Agrarian University named after K.I. Skrybian (KNAU) and Kyrgyz State Technical University Named After Iskhak Razzakov (KSTU) established VR laboratories with the support of an European project, in which the Institute of Logistics of the University of Miskolc played a key role. In this publication, we present the basics of VR and AR technology, with the current market and research shares and lastly its application in laboratories and industrial environments.

*Keywords: Cross-border cooperation; virtual logistics center; virtual reality.*

## 1. INTRODUCTION

In recent decades, there has been a huge leap in the industry in terms of the used IT methods and

tools. Physical manufacturing and logistics are starting to reach their limits in terms of efficiency, material and energy use, so systematic thinking is becoming more and more important.

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Combination of existing technologies can be used to build automated and decision-making systems that can work more efficiently, than most human decision-making systems using large amounts of data and self-learning. These technologies include digital twin solutions, modern identification systems, autonomous manufacturing and material handling tools, robotics, smart tools, gentelligence products, augmented and virtual reality [1]. These technologies, like many, were created for military purposes, but recently started to appear in everyday life as well.

AR, but especially VR technologies are largely prevalent in the field of entertainment, in terms of video games, events and video entertainment, which account for more than 50% of the total market, as shown in the Fig. 1. To enjoy these, all we have to do is just buy a VR headset with controllers, or we can try the experience, by putting our phone in a box that costs only a few dollars and put it in front of our eyes [2]. Industrial use of these technologies have about 45% of market share, which includes mainly healthcare, engineering, real estate, commerce, military and education [3]. Healthcare and engineering tasks tend to involve AR technologies that enhance reality.

The simplest example for this is smart glasses, which is equipped with or connected to various sensors and can project, for example, a heat map of the viewed object, or display additional data from that object, by reading a 2D barcode [4]. Although most people treat VR and AR devices as optical devices, they can augment not only our vision, but also our other senses, such as hearing or touch [5]. We are currently in the age of first-generation VR-AR devices, however, some researchers say new generation devices will be coming soon, which will not focused on graphic quality but on weight reduction and sensor quantity and quality.

In this work, we present the VR devices purchased and installed in the framework of the Erasmus + ProdLog project at two universities in Kyrgyzstan: Kyrgyz National Agrarian University named after K.I.Skrybian (KNAU) and Kyrgyz State Technical University Named After Iskhaak Razzakov (KSTU). We will describe the possibilities of VR technology, their applicability in the field of logistics, and we will present these features through the VR laboratory of the Institute of Logistics of the University of Miskolc.

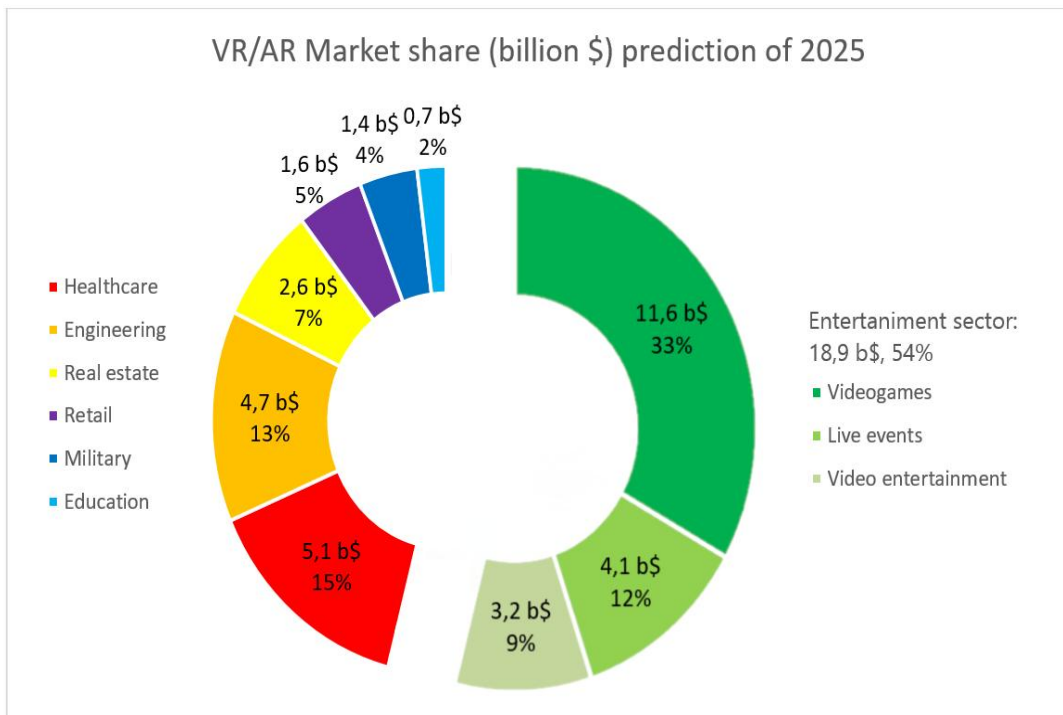


Fig. 1. VR/AR market share prediction of 2025 [3]

## 2. VR SAMPLE SYSTEM OF THE INSTITUTE OF LOGISTICS OF THE UNIVERSITY OF MISKOLC

In 2011, a logistics development environment and tool system based on VR (virtual reality) technology was introduced at the Institute of Logistics of the University of Miskolc. The system is technically based on an interactive projection system capable of stereoscopic display, and the development and running of the models is carried out with a software called "VDT-Platform" (Virtual Development and Training Platform) [6]. The toolkit was developed at the Fraunhofer Institute's headquarters in Magdeburg, and the Otto Von Guericke University of Magdeburg provided invaluable professional assistance in acquiring the knowledge needed for its use. The new tools provide an excellent opportunity to learn close about the latest types of VR technologies and to cultivate logistics-related applications at a high level. The industrial practice of recent years shows that these technologies are increasingly present in a wide range of industrial fields, for instance automotive and automotive, process modeling, process design, technical training, etc., so their knowledge and mastery is essential beyond logistics.

The following subsections describe the main hardware components of the device system and operation methods. The basic concept of the VDT-Platform development environment based on the use of these elements is also presented, which can be considered as a central element of the whole system. In addition to the main system, a so-called "holographic 3D monitor" previously manufactured by Holografika Kft. will also be introduced, which is especially suitable for unrestricted 3D display very close to reality.

### 2.1 Stereoscopic Interactive Projection System

The main device of the VR system is an interactive projection unit capable of producing a 3D stereoscopic image, which enables the realistic display of virtual environments and their real-time manipulation (Fig 2). The projector is connected to a dedicated workstation running the mentioned software called "Virtual Development and Training Platform" developed by Fraunhofer IFF in Magdeburg, which can be considered a central part of the whole system [6].

The principle of the display is based on linear polarization in different planes, which in practice means that the light beam of one projector is polarized in a plane 180 degrees different from the light beam of the other device. This is achieved by polar filters placed in front of the lenses. The lenses of the glasses worn by the user also act as a polar filter, so that both lenses transmit only one (different) beam of light, thus ensuring the user to separate the images of the projectors. The two images, of course, show the virtual environment at slightly different angles, thus coming together as a three-dimensional image when viewed through special glasses.

Another element of the VR effect, the interactivity is provided by cameras mounted on top of the projector screen (Fig 2), which use the known "motion capture" technology to detect the movement of target objects (user glasses, interaction device, general target), thus creating a connection between the movement of the user and the simulated environment. In addition to these, other devices based mainly on radio frequency connection (3D mouse, hand control, "SpaceNavigator", "WiiController") also provide additional possibilities for interaction (based on manual manipulation) [7]. It follows from the above that although the system can be used by any number of users at a time in a limited way (as an observer) with the help of glasses provided to viewers, it can only be fully used (including interaction) by the person wearing the user glasses. In addition to the projection system, 4 workstations were provided, which are basically used to create and test virtual environments. On these workstations, the same "VDT-Platform" can be run in design mode as on the main system, thus guaranteeing the immediate applicability of the designed environments.

### 2.2 Holographic 128WLD Type Holographic Display

In addition to the main systems, the Institute of Logistics of the University of Miskolc also has a special, so-called "holographic" display device, which was manufactured by Holografika Kft. in Hungary\*. The device can be seen in the Fig 3. The biggest advantage of the device (exact name of its type: HoloVizio 128WLD) is that it can display a so-called "real three-dimensional image" without the user having to wear any special equipment.



**Fig. 2. Stereoscopic display system canvas with motion tracking cameras on top**



**Fig. 3. HoloVizio 128WLD type holographic display\***

*\* This equipment was created by Holografika Kft., Hungary, <https://holografika.com/>*

The device's 32" screen size makes it ideal for desktop applications used in a typical computing environment, while its 50-degree viewing angle allows multiple users, or even a small workgroup, to work together using the display. The 3D image is created using a large number of 9.8 million pixels, but the software environment allows the use of standard 3D applications running on a PC for image generation. However, this system alone does not allow spatial interactivity, and the dimensions of the display are much smaller compared to the projection screen of the main system, so the two types of equipment can be considered as complementary to each other.

As the generation of real 3D images requires an extremely large computing capacity, this equipment also requires the use of one or more "drive" computers, which are able to produce images of various applications for the holographic monitor with the help of the target

software provided by Holografika Kft. The number of driver PCs used for your device is usually between 1 and 3, but it also depends largely on the type of applications you want to use. In our case, the goal was to create a general-purpose configuration that would meet both educational needs and the most industrial needs, so 2 workstations were set up for the display.

Together, the two devices can provide enough power to support most applications (the computational requirement for real-time, so-called computer-generated holographic display is very high). This is important because while this display cannot, by default, provide the same interaction capabilities for VR environments as the main system, it has the significant advantage of being able to connect directly to most industry-leading 3D design systems (typical CAD programs) in real time, many without the use of

an intermediate phase, for instance import of files. In other words, multiple design systems can be run in real time on the display, creating a so-called “real” 3D image in each case, which can also be a great advantage in many industrial applications. In addition, it is also very important from the point of view of education that this unique Hungarian development can be presented during operation.

### 2.3 A Virtual Development Environment Called “VDT-Platform”

Although the physical visualization of VR environments is made possible by the stereoscopic projection system described earlier, the use of a software-side development environment is, of course, essential for the operation of the entire system. This software is a development application called VDT-Platform, which has been mentioned several times before, and allows the user to create and run arbitrary VR scenarios, thus the software serves as a development and application platform at the same time.

In short, the essence of the system is that it can be used to import any 3D files and then “bring them to life” using the editing tools provided by the application. The VDT-Platform supports most of the common formats, but so far mainly VRML and FBX files have been imported.

The process begins with the import of files created using known CAD programs, which

include the objects and their associated geometry, then continues with the development of “higher-level” functions for the scenario to be implemented [8]. This process is illustrated in the Fig 4.

The system allows the implementation of different types of scenarios, ranging from quite bound (quasi-cinematic) animations to so-called “exploration mode” scenarios that allow completely free action. Their field of application can be extremely diverse, ranging from demonstrative simulations of specific products, to animations to help with practical training, to multi-level examination of complex processes. At the same time, it is common to almost all areas of use that they usually address some kind of human-centered problem, so in most cases they serve to study human-machine relationships.

The Institute of Logistics of the University of Miskolc works closely with the Department of Descriptive Geometry of the University of Miskolc in the using of industrial applications of the software. One of these cooperations is a present development of an interactive simulation of an integrated material handling system. The experience gained during this process can also greatly contribute to the implementation of many other industrial tasks, while providing extremely valuable knowledge in the fields of modern process modeling and ergonomic design. Of course, the tool also appears regularly in the practical training of the institute.

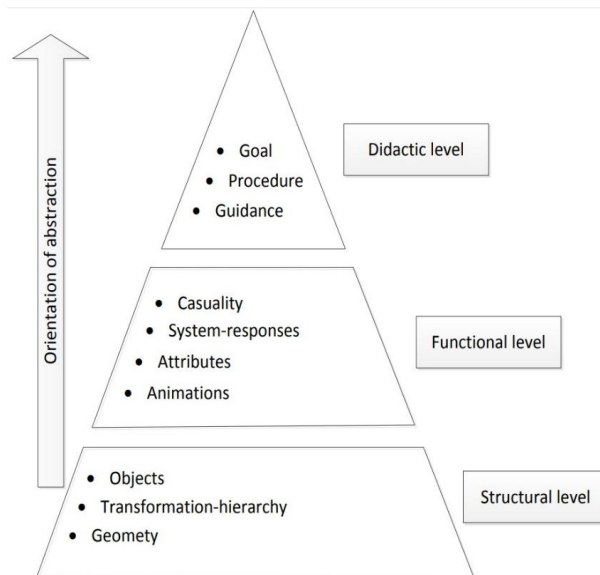


Fig. 4. Hierarchy of abstraction levels used in the “VDT-Platform” [9]

### 3. VR SYSTEMS AT KYRGYZ PARTNER UNIVERSITIES

From 2017, as part of the Erasmus + ProdLog project, colleagues from the Institute of Logistics from University of Miskolc will monitor the development of 2-2 universities in 3 countries (Russia, Kazakhstan, Kyrgyzstan) to reach an European standards in logistics together with several European universities. The aim of the project is to improve students from these universities in the field of manufacturing logistics who will later be able to stand their ground anywhere in the world in their field and with their knowledge can develop local industrial logistics in long term. The project includes:

- a review of the current training of students,
- review of current teaching material,
- developing, standardizing and bringing the missing curricula to European level,
- setting up a training structure with a European (Bologna) structure,
- encouraging the search for industrial contacts and placements,
- design laboratories to use by students and researchers.

In this publication we concentrated on the last point, which is the design and installation of laboratories. The project task of the staff of the University of Miskolc was to compile a proposed list for Asian universities on the development and procurement of their laboratories. The list included: an automatic transport vehicle; robot

and sensor programming stations; miniaturized manufacturing and logistics system, manufacturing and logistics simulation software, RFID and identification lab devices, 3D printer, VR equipment and more. Taking into account the financial budget that can be spent on laboratories, all universities have decided on and implemented their developments based on the needs of the surrounding companies. The two Kyrgyz universities (KNAU and KSTU) bought the same tools, with one software difference, and with that they were able to set up a computer, communication and VR laboratory serving 11 people with the following key building blocks:

- 11 modern PC workstations with I / O accessories,
- 1 digital tablet,
- 1 digital film projector,
- 1 projector,
- 1 3D printer with consumables,
- 3-3 licensed HACCP food safety software,
- 3 licenses for bakery technical software,
- 5 Oculus Rift VR goggles with display software,
- 5 licenses for Tara-VR-builder, a VR environment planning software,
- 1 license of AutoCAD 3D software.

As can be seen, the two Kyrgyz universities have laid the foundations in hardware and software for the construction of a VR simulation lab, which can be seen in the Fig. 5 and Fig. 6. We present the possible applications of these laboratories in the following.



Fig. 5. VR and computer laboratory of KSTU



**Fig. 6. VR equipment used by students and a working 3D printer**

#### **4. APPLICATION POSSIBILITIES OF VR AND AR**

As mentioned earlier, VR and AR systems are a continuously researched and developed area of informatics. Since the two Kyrgyz universities bought the most basic VR hardware, we can't talk about hardware development on their part, so we need to approach this from the software side. As we saw in the introduction, we can divide the applicability of VR into four major groups:

- entertainment media,
- healthcare applications,
- engineering and visual design tasks,
- education and training.

Entertainment media and healthcare [10] are not involved in the basic engineering sciences, especially not in the field of logistics, so unfortunately, we cannot make research on the largest share of the market. In engineering and visual design tasks, it is possible to conduct research with VR technologies, however, in logistics, primarily AR-type methods have a greater prevalence [11;12]. Logistics is specifically an area where a system-level thinking is needed to process a lot of data and then evaluate solution options and send it to the right management devices or people. If a person is given a task, he or she can only do it efficiently, if the person receives the necessary data and is able to process it and make fast decisions. AR technologies can help us with these tasks greatly. An example of an application is, using smart glasses in a warehouse, where it gives directions or guides the operator's vision to the location of the item as soon as it comes into the field of vision [13].

The last aspect is the possibility of education. Here, we need to think of applications that can

teach and demonstrate jobs or tasks in situations that cannot be performed in continuous operation. Such can be the maintaining, cleaning and inspecting of dangerous places [14]. In another situations, high quality education can save time and money, as the learner goes to the work area more qualified and will do the work more efficiently than if he would have to learn the basics from other people on the spot, because then not only his work will be slower, but the others as well.

#### **5. CONCLUSION**

AR and VR technologies are evolving dynamically due to their practical significance. With large hardware vendors, most university R&D centers are unable to compete, so they see their potential in software development. With the help of the Institute of Logistics of the University of Miskolc and the support of the Erasmus+ Prodlog project, VR laboratories were established at two universities in Kyrgyzstan. By using these laboratories, students can get acquainted with the latest technologies. At the same time researchers working in these laboratories are able to create an independent test environment with the help of the installed software and hardware, thus helping to develop various logistics activities and processes more efficiently.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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