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USE OF AUGMENTED AND VIRTUAL REALITY IN INDUSTRAL ENGINEERING

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Abstract: This paper describes the use of virtual and augmented reality technologies in various fields of industrial engineering. The article provides the brief description of how augmented or virtual reality contributes to the process improvement. It is also focused on the characteristic areas and the best-known areas of industrial engineering such as goods picking, design of production and logistics systems, design of assembly workplaces and visualization of procedures and ergonomics.

1 Introduction

Virtual and augmented reality as terms are well-known today and they are used in many sectors. These technologies have been used in a wide range of disciplines such as military, aviation, healthcare, but is most widely presented in the area of marketing, advertising and sales. The industry field is also not immune to progress in sophisticated information technology. Current virtual and augmented reality applications in this area get a very interesting view. The use of augmented reality in industry and manufacturing is still in the research and development phase, although the first initial projects are already underway.

2 Virtual and augmented reality within the virtual continuum

Virtual continuum is a continuous scale between a complete virtual reality and a real environment [1]. This scale includes all possible variants between the ratio of real and virtual elements. The area between these two extremes is called mixed reality. Mixed reality consists of a real environment in combination with virtual objects and interaction, according to the proportion of virtual elements in the image. Virtual Reality (VR) is an environment modelled by means of computer simulating reality. The technology of virtual reality completely pulls users into the virtual environment. The user uses a Head Mounted Display (HMD) and head-mounted device that may or may not be connected to the computer. In the virtual reality environment, the user is immersed into the virtual world, and can interact with it in a meaningful way. The virtual environment experience has a wide range of information when stimulates all the senses. Visual and sound components are the most preferred, but in more sophisticated cases the other senses, such as smell and touch, are stimulated. System that provides user´s feedback and touch interaction are called haptic system. User interaction is ensured by classic computer equipment such as keyboard and mouse, or specially tailored devices such as 3D glasses, clothing that sensing the movement and clothing that stimulates the touch, multi-channel sound, and the others. The environment created in this way can create an image of the real world [2].

3 Use of augmented and virtual reality in industrial engineering

The Department of Industrial Engineering is very intensively zealous for research in the field of using the virtual reality for industrial engineering. The main applicable areas of these new technologies include:

- **The area of goods picking, warehouse** - The proper functioning and organization of the warehouse has implications for the speed and quality of services provided to customers [3]. Picking of goods forms an irreplaceable role in the logistics chain connected with the preparation and processing of order. With increasing pressure on quality and timeliness of delivery as well as increasing diversity and number of picking items, new forms of organization are also developing and new technologies are applied to picking processes. In practice, they are starting to apply so-called free-picking systems. The advantage of these systems is mainly the replacement of the classic paper document by electronic order picking in combination with other technologies, enables to simplify, speed up and improve the process of searching and completing items into

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the picking order. An example of such a picking method is the so-called „pick-by“ systems [4]. The use of augmented reality in picking order (Figure 1) belongs to “pick-by-vision” system.

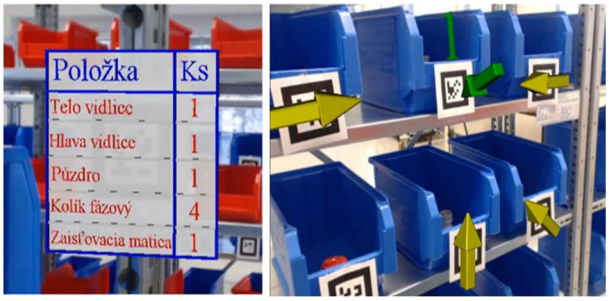

Figure 1 Pick-by-vision system using augmented reality

- **Design of production and logistics systems** - Designing production and logistics systems is another potential area for the application of augmented reality resources. Nowadays, computer technology and its possibilities are widely used in designing production systems. Augmented reality provides the designer with the advantage of creating a digital model of the manufacturing system and putting it into the real environment. The principle consists in placing markers in the production space and assigning virtual objects to individual markers. With head mounted display or stereoscopic 3D glasses, the designer can view the proposed layout. Digital designing of production and logistics systems does not replace the classical design concept, but extends the capabilities of the designer, what is enhancing the design quality of the resulting layout [5]. The design and visualization of a production and logistics system in a digital environment requires the preparation of 3D models for all components from which the proposed system will be assembled (production machines and equipment, transport and handling equipment, handling units, storage facilities, auxiliary equipment, etc.). The created digital 3D models are then the cornerstone of the digital design of production and logistics systems in a computer environment. 3D modelling of the production system gives us an environment that allows the designer to perceive this modelled environment very much like his real model without the need for major investments to build a real production system [6]. At the same time, it enables the designer to verify several variants of the solution in a short time, which ensures that the resulting production system will be effectively designed already in the preparation phase. For designing production systems, we can use virtual reality technology using Unity 3D programming environment and HTC Vive Pro (Figure 2).

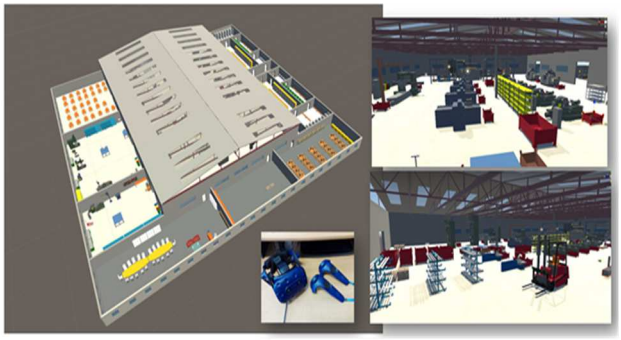

Figure 2 Design of production system in virtual reality using HTC Vive Pro and Unity 3D

For detailed design of smaller workplaces, we can use augmented reality technology and 3D objects displaying using a tablet or cell phone (Figure 3).

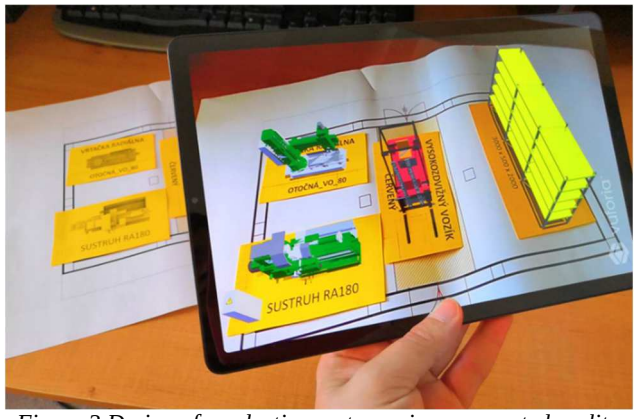

Figure 3 Design of production system using augmented reality and tablet

- **Detailed design of assembly workplaces and visualization of assembly procedures** - A related area for the design of production and logistics systems is also the area of assembly design. In the conceptual design phase, several variants of workplace design are generally created and the advantages and disadvantages of individual designs are evaluated. It is very advantageous to create variants in 3D environment because of much better imagination and possibility of complex design verification [7]. Thanks to the third dimension of the models, we are much more aware of how the individual elements of the workplace interact and limit each other. Augmented reality can work on multiple technologies to assign virtual models to the real world. In this case, it is best to use a tracking system with markers (Figure 4). This is because the easiest and the fastest to prepare and most stable to quickly place and move multiple models.

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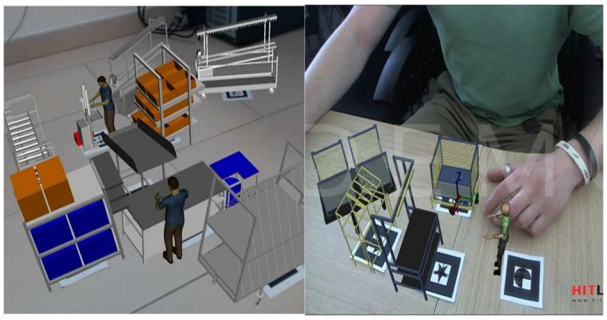

Figure 4 Detailed design of production system using augmented reality with markers [7]

Augmented reality technology can be applied in many areas. Its use is realistic especially when displaying assembly and workflows, where the main idea is to remove paper instructions and replace them with animated visualization using augmented reality. Assembly means mostly the implementation of connecting technological operations. It is characterized by high intensity of material and information flow and short operation times. The greatest time consumption is spent on the operation manipulation and on the correct positioning of the component to be assembled. Augmented reality offers a solution to reduce this time consumption by providing visual information to the worker during assembly (Figure 5).

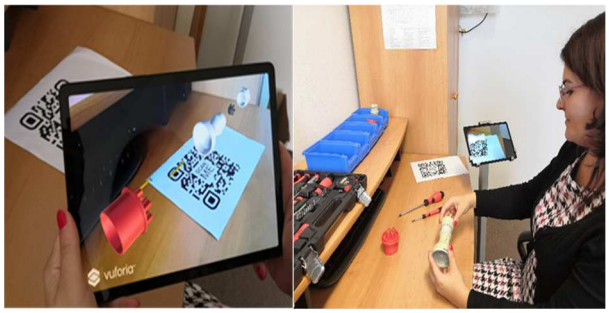

Figure 5 Assembly with augmented reality

- **Service activities and maintenance** – Use of augmented reality in maintenance and service offers a range of options, from simple visualization of disassembly (Figure 6), assembly and replacement of components to visualization of complex service activities [8].

Figure 6 Service activities with augmented reality [7]

- **Ergonomics** - Ergonomics is a scientific discipline dealing with the relationships that emerge between man and the environment that surrounds him [9]. One of the mobile tools for rapid identification and risk analysis in the field of workplace design and ergonomics is CERAA (Ceit Ergonomics Analysis Application). The idea of creating a mobile application as a screening tool came with the demand of larger companies that have hundreds of workplaces and are unable to identify risks with their own resources and tools. CERAA is a mobile application for screening evaluation of workers' spatial conditions and working positions at potentially hazardous workplaces. It is created on the basis of legislation and technical standards, on its own platform, with the support of virtual and augmented reality [10-16]. One of the biggest advantages is that the user does not need to be an expert in ergonomics, basic knowledge of ergonomics and detailed design of workplaces is sufficient. In order to use the application effectively, the customer needs a tablet, an installed application, a marker and training for the applications (Figure 7). The main objective of the CERAA assessment is to determine whether the workplace is at risk from an ergonomics perspective and whether a detailed assessment of the workplace and a proposal for remedial measures by second-level instruments are necessary, or what health risks to workers.

Figure 7 CERAA augmented reality evaluation examples [10]

- **Logistics area** - Despite the fact that the area of augmented reality in logistics, as in other areas of industrial applications, is only at the beginning of its deployment, it is a great contribution to improving logistics processes. For example, augmented reality allows logistics service providers to quickly access expected information anytime. This is highly beneficial for the prospective and accurate planning and execution of tasks, such as optimizing delivery and handling, and extremely important in delivering higher-level customer service. As with the promotion of dynamic transport, augmented reality in this case serves primarily to assist the driver in navigating to the place of delivery. In this case, the augmented reality system can not only provide basic navigation but can also serve as an additional information presentation. For example, when the augmented reality device is directed to a particular building or block of buildings, the driver will

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be provided with additional information about the building (entrance position, unloading characteristics, unloading parking options, etc.). If no public database containing information about the location of the entrance or other local facts is available for that location, the augmented reality device can be used to position its own tags and thereby create its own independent database. When the next shipment arrives at the location, the augmented reality device makes the previously collected information available.

4 Conclusion

Virtual and augmented reality technologies currently represent a very dynamically developing area of information technology applications. Their deployment in industrial practice and at the same time in university teaching processes is becoming an everyday part. The use of new technologies in industrial engineering has its merits and brings significant process improvement.

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