Use of Augmented Reality in Assembly Process

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Abstract – Intensive research is currently underway into the concept of intelligent assembly, which integrates production processes, people, hardware and information using both real and virtual methods to achieve significant improvements in productivity, delivery time and combined market turnover. This paper describes the use of augmented reality in the assembly process at the workplace, which by integrating hardware and software equipment will enable an innovative assembly workplace for a manufacturing and development company. The assembly workplace will speed up and facilitate assembly and prevent the creation of failures and restrictions during assembly.

Keywords – Augmented reality, assembly process, technology.

1. Introduction

Virtual and augmented reality are currently evolving at a rapid and significant pace. Progress and results are reflected directly in products designed to use virtual or augmented reality, while the products can be seen directly in exhibitions, presentations of various global companies operating in the field of CAD and CAM systems on the market. The rapid development in augmented reality is the result of customer requirements, such as high-resolution requirements, high pixel density, high computing power growth, and low power consumption [1].

Over the last decade, the introduction of augmented reality technologies into technical practice has pointed to new application possibilities. With the right implementation, it is possible to simulate and streamline the already running production process, without the need to limit production. Augmented and mixed reality offer a new way of human-machine interaction. [3] The seen image in the field of view of the worker on the basis of which the analysis of the situation takes place and the subsequent decision-making has to be understood contextual. This means that everything depends on the monitored object and properly implemented virtual graphics [4]. Immediate data collection and visualization in conjunction with human decision-making skills are a benefit, especially during assembly and service operations. The application increase in the use of technology is an undeniable fact and in the future it is possible to assume an integral part for any work activities. The challenge lies in the creation of applications capable of clearly enriching the field of view of the worker in order to increase work efficiency and reduce the error rate in the monitored processes.
2. Augmented Reality in Production Process

Augmented reality is making progress in entertainment applications, but its impact on human performance is even greater in industry. Modern manufacturing involves assembling hundreds or thousands of components in the exact order, and as quickly as possible, whether it is the production of a telephone or a jet engine, each new product requires new sets of assembly procedures [9]. Most of these procedures are static and therefore obsolete. When using AR, these procedures, with appropriate technical drawings and even video recording, are taken and placed in the worker's field of view, allowing the worker both hands free [10].

Ergonomic motion analysis in a virtual environment is often used to streamline assembly procedures. In more sophisticated systems, a worker's movements are accurately mapped and transmitted to his virtual twin. By evaluating them, it is possible to optimize individual tasks, for example, based on the layout of the workplace [2]. The problem occurs with insufficient feedback, which leads to skewed data. The problem occurs with insufficient feedback and lack of realism which leads to skewed data. The main cause of these discrepancies is a weak feeling of immersion, experiencing the virtual situation as a real work action caused, for example, by an inappropriate type of equipment [5].

To use the full potential of the technology of Augmented Assembly (AA), it is necessary to combine real spatial data of the production process or the created product in the process of assembly / disassembly with enriching virtual content in a suitable way. An expanded perception of the process helps to find new possibilities for efficiency needs in the workplace [2].

2.1. Augmented Reality Systems

Augmented reality systems can be divided into two basic types according to how the user sees or perceives the world using AR. In Fig. 3 The main differences between the two basic types of AR that are used on the user's head can be seen.

![Image of Optical see-through and Video See-through system](image-url)

In the Fig. 3 above there is a system with a direct view (Optical See-Through), where a helmet with a semi-transparent display is used. Its principle is basically simple. The scene generator sends a signal to the projector, which is located in the user's helmet, and projects the image onto a semi-transparent glass which allows the user to see both the real world and the generated scene in real time [2].

The basic diagram of data flow of Optical see-through system is presented in Fig. 4.
The lower part of the Fig. 3 presents the second type of vision. This is a Video See-Through system, where instead of a semi-transparent mirror there is a display that combines the image obtained from a camera that captures the outside world, which is sent to the scene generator. The scene generator combines virtual graphic with a sensed scene, and creates and sends output data to the user's display where appears AR mixed environment (real + generated data). The principle of image processing and generation is shown in Fig. 5 [2].

![Figure 5. Basic diagram Video See-through system](image.png)

3. Use of Augmented Reality in Assembly Process

An assembly cell with AR functions was created in the experimental environment of the laboratory. The assembly cell consisted of an assembly table and a projector whose task was to project the image perpendicular to the table from the workstation. Using 3D software, a 3D animation of the components is created to facilitate their identification and to prevent their possible confusion. Subsequently animation videos were created for individual assembly procedures. The projected graphics offer a illumination of the container for the component and tool required, an assembly step animation, a 3D body preview, and a graphic mark to visualize the virtual model. The camera can detect the status of passing components and the system can make a request for replenishment in time.

The created video is played in a loop until the operator switches to the following assembly step. Virtual button was implemented to the edge of the workspace. It is provided to switch the instructions by covering a button. Environment makes it necessary to equip the working region with a camera which is mounted above the desk and whose task is to detect movement in the environment of the desk. Each time the scene is switched, a table snapshot is created, which is used to create an assembly protocol for possible control of work procedures. This design of the workplace serves to complement the see through system.

If all visual data were projected directly into the glasses, the visual field of the operator performing the assembly operations would be greatly reduced. It is possible to choose which virtual content will be projected into the glasses. The advantage of this type of assembly using AR is that the worker does not have to leave the assembly site to go verify the assembly procedure. Another advantage is the absence of real buttons or keyboards on the work table.

![Figure 6. Basic digital enriched work table setup](image.png)

![Figure 7. Assembly process using AR](image.png)
With this device, it is possible to create instructions that will accurately display step by step parts of the assembly and also their exact place where they need to be attached or stored thanks the exact setup of envirorment and sensing devices (Fig. 7). No complicated sensing of the operator's position is needed for creation of enriched graphical visualizations. Usually they are defined on the mutual position of the workspace and the head mounted unit. In this case, the virtual models of the assembled parts are drawn on the projected unique graphic marks on the table. Visualization is generated depending on the recognition of the edges of the marker and the mutual position of the imaging camera on the operator's head. The workplace can be supplemented with simple textual information sent directly to the glasses. In certain cases, it is appropriate to supplement the procedures with a spoken word.

3.1. Health Risks Resulting from the Use of Augmented Reality in Practice

In addition to the benefits, augmented reality glasses also bring several risks. They can pose health problems for the user under certain conditions. Concerns about human health stem mainly from the fact that these devices are used in new, unprecedented scenarios, which could cause new, unknown disorders and diseases.

Risky collision situations arise when a new user of the system is enthusiastic about the virtual environment, its processing and relaxes in monitoring the surrounding workplace. This problem usually disappears after a few minutes of training, getting acquainted with the new equipment. It is worse when using non-head systems in certain unsuitable designs where the individual's field of view is significantly limited, which leads to a reduction in natural peripheral vision and the formation of artificial blind spots. Limited perception of the surrounding world is very dangerous in operations with high movement of mechanisms and personnel. In extreme cases, the constant use of such equipment presupposes the occurrence of an adverse effect comparable to tunnel vision, retinal disease, which also results in loss of field of vision and photophobia.

The biggest problem that leaves users unprotected is the lack of standardization for a new type of device. Head-mounted devices require the user to focus on a small electronic display located at a very short distance from the eyes. This display is very often at the edge of the user's field of view. However, there are devices that have a transparent display. With these devices, the eye is constantly trying to focus on either virtual graphics or the real world. Frequent changes in tracking the object of interest lead to faster eye fatigue. The solution for the future can be contact lenses that can gently enrich the seen scene with appropriate virtual content [6], [7].

Great attention has also to be paid to additional functions acting on other senses. In addition to visual sensations, augmented reality can be completed with audio inputs [8]. It is necessary to bring acoustic information in the right form and intensity so that the user is not frightened or ceases to perceive the surrounding environment. Acoustic inputs and outputs have to be adapted to the environment and specific conditions. In conditions where it is not appropriate to use headphones, clog the ear canal, it is possible to apply Bone conduction technology, where the vibrations of the device affect the bones of the skull. Vibrations are transmitted to the internal structures of the ear, which interprets them as sound. Similar technology has been used with Google Glasses. However, the constant use of such an acoustic system leads to headaches, which often grow into migraines.
4. Conclusion

Augmented reality is suitable for use mainly in operations where new products are constantly being assembled or there is a frequent change of employees. The proposed solutions enables the creation of instruction sets related to assembly with use of augmented reality and can serve also for novice training. With the help of augmented reality it is possible to teach new and current workers cheaply and quickly.

Acknowledgements

This article was supported by the Ministry of education of Slovak Republic for supporting this research by the grant KEGA 004TUKE-4/2020.

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