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The application of augmented reality technologies for the improvement of occupational safety in an industrial environment

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ABSTRACT

In many branches of industry, occupational safety experts identified two main causes of worker injuries related to the usage of modern electro-mechanical machines and systems: inadequate training and insufficient work experience, and monotonicity of the tasks often performed repeatedly. In this paper, we present a system based on augmented reality (AR) technologies that can be useful in reducing these factors of risk at work and decreasing the error rate and preventing injuries. The system that is implemented on mobile devices is intended to project augmented reality instructions directly at the work place. A worker is led by the AR-system step by step through various work and safety procedures that should be performed. Each procedure consists of steps specified by a series of instructions accessed through an interactive check list. To ensure the safeness, if a confirmation is missing because of a skipped, incompletely, or wrongly performed step of a procedure, the AR-system blocks further implementation of the procedure and returns the worker to the previous step until the correct actions are carried out. At the same time, interactive work with the checklist breaks the monotonicity of the job. The system is personalized according to skills of a worker by taking into account his professional training and work experience. Depending on that it is determined the amount of data to be displayed to a worker helping even less skilled workers to perform a task.

As a case study, the proposed approach is implemented as an instructional and occupational safety system for work at a universal lathe, which is an element of many technological processes of Thermal Power Plant Ugljevik in the Republika Srpska, Bosnia and Herzegovina, where this AR-system was experimentally implemented and verified.

1. Introduction

The advent of technology and the reduction of cost of mobile hardware (smart phones, tablets, PCs) affects the development of interactive applications designed for these devices. The technology of augmented reality (AR) provides new forms of interaction on mobile devices. This technology allows the user to enrich picture of the real world as captured by the camera on the mobile device by virtual computer generated objects [1]. Augmented reality technology has been applied in various fields such as medicine [2], presentation of historic and cultural heritage [3], and education [4].

Numerous applications exploiting augmented reality technologies have been developed for industrial purposes, see for example [5] and the references therein.

According to the literature review, we can notice two categories of AR-systems aimed at application in industry, systems aimed to provide help in maintenance and training. Maintenance oriented systems usually offer virtual information by providing help in solving a particular problem or performing predefined steps in the regular checking of a machine directly at the work place. Therefore, these systems can be viewed as an improved electronic version of manuals with built-in expert knowledge. Due to this, being guided by AR-supported instruction manuals, even non-specialist can perform tasks that previously were reserved for specially trained workers.

The AR-based training systems are primarily focused on the educational component by providing virtual guidance combined with the real experience in the industry space.

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There are numerous reasons for the application of AR technologies in industry. For example, the usage of written manuals in the form of booklets is usually inconvenient at the work place, and then often avoided or neglected by workers that tend to rely on their knowledge and experience. Due to the complexity and variety of machines and different models of the same machine that often have to be handled by the same worker, some details of the expert knowledge are often missing in written manuals, or the proper manuals are wrongly distributed between co-workers.

At the same time, even well-trained and experienced workers might make mistakes caused by the monotonicity of the job, due to which some steps of the procedures are easily forgotten or intentionally omitted.

All this might cause mistakes and potentially lead to injuries if some of the procedure steps are overlooked or performed incorrectly. The audio and video information provided by the AR-based manuals combined with the request for an interactive verification of performed steps can prevent such situations.

In this paper, we present an AR-based tool intended for application in industrial processes with a twofold goal: to ensure correct implementation of all the steps in the production or maintenance procedures, and to increase the occupational safety by an interactive verification procedure.

We implemented safety instructions which are issued by the proposed AR-tool whenever necessary during the educational or work process, and have to be followed step by step by using an interactive checklist. This list is connected with the database on the server side from which the instructions are read and where the correct implementation is recorded. In the case of missed, incompletely, or wrongly performed steps, the AR-system blocks further implementation of the procedure and returns the worker to the previous step until the correct actions are carried out.

This fusion of work instructions and occupational safety instructions ensures that the tasks will be performed correctly by appreciating the occupational safety requirements. Therefore, the proposed system can be used to educate less skilled workers that are forced to answer questions in the interactive checklist. At the same time, by answering questions, experienced workers are forced to maintain their concentration and obey and strictly follow all the occupational safety measures.

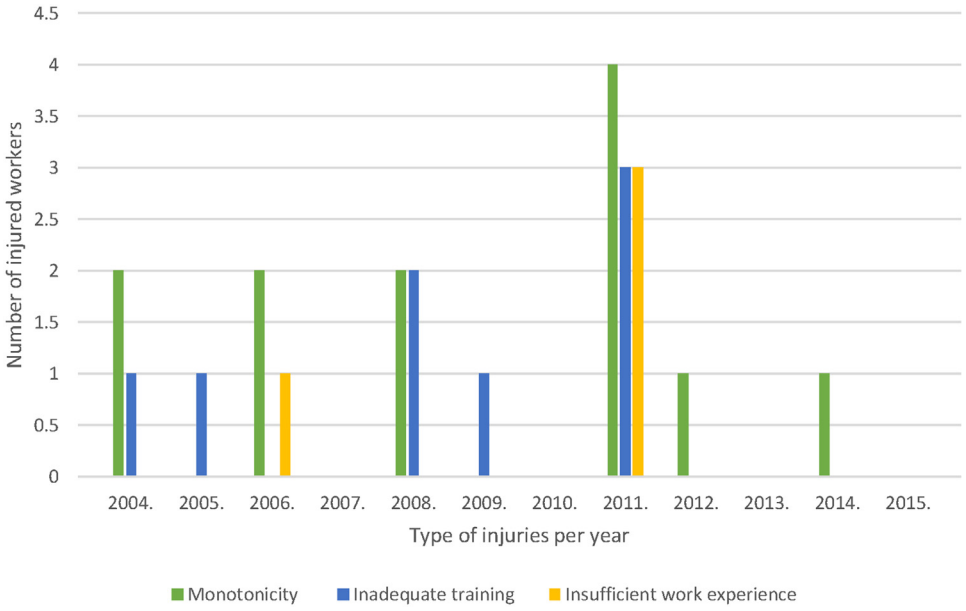
For the sake of clarity, the presentation in this paper is based on the example of the proposed AR-system implemented as a manual for the work at the universal lathe with all the required data taken from a concrete industrial site, the *Thermal Power Plant Ugljevik*, in Republika Srpska, Bosnia and Herzegovina. This, however, does not impose restrictions on the applicability of the proposed AR-system, since after a simple modification the same system can be used in different situations. The modification mainly consists of the replacement of the lists of work and maintenance instructions and lists of occupational safety measures prescribed for the concrete applications [6]. Clearly, a corresponding change in the database queries is required, while the logical structure of the system, its software elements, as well as interaction with the underlined mobile platforms and servers remain unchanged.

2. Related work

In the literature, there are many systems and projects that are related to augmented reality technology applications in industry. For example, an approach towards the integration of augmented reality tools and embedded intelligent maintenance management systems is presented in [7]. A factory environment was mixed with virtual objects in real time during maintenance activities based on the CARMMI model. A data structure was created based on this model to provide the information, using augmented reality technology to facilitate management for performing the maintenance tasks. Test cases illustrating the created structure and the concept are shown to confirm their usefulness [7].

In [8], besides different techniques of virtual reality applications for simulations and implementations in industry, the discussion is focused on the importance of respecting the order of instructions by using interactive checklist procedures. In this paper, all of the steps of the Product Lifecycle Management are followed by an immersive checklist using a VR environment and interactive simulations. Tests are applied to a real industrial environment combining the specialized interactive tools for hands free movements and gesture recognition during industrial procedures.

The paper [9] shows how augmented reality can be integrated into Building Information Modeling system (BIM) environments. The project presented in this paper concerns the Liquefied Natural



Graph 1. Number and causes of injuries per year.