APPLICATION OF AUGMENTED REALITY FOR VERIFICATION OF REAL WORKPLACE STATE

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The article is aimed at verifying the state of a real workplace using virtual reality. In analyzing the readiness of virtual reality applications, augmented reality was selected for the following work. The most significant advantage of augmented reality is the implementation of a virtual model and the ability to deal with the analysis in a real environment, which is particularly beneficial in the case of production plants. In the first phase of the work, an analysis of the current state of the workplace was carried out, where the requirements for the design of the new workplace were specified. This was followed by the phase of design preparation in 3D modeller. At this very stage it appeared to be advantageous to use virtual reality applications; in the design process, regular approval procedures are required as for an expert team (management, design, quality, ...), which puts high qualification requirements on the readiness of this team. In this phase, the 3D design of the new workplace was inserted into the application supported by augmented reality and some options were indicated to deal with the ergonomic and risk analysis. The result of this work is, in particular, an extension of options in designing and analyzing production workplaces and machinery in multidisciplinary teams.

KEYWORDS

virtual reality, augmented reality, design of production workplace

1 INTRODUCTION

The main reason and motivation why to address this issue is the high cost of design and construction works, especially in the phase of developing and prototyping of technical object (machinery or equipment). Equally important seems to be time savings and a considerable advantage to work with a virtual model before it is implemented into production process. Within construction solutions and projects, it is possible to take advantage of virtual reality technologies in several phases. Especially in the preparatory phase of projects, industrial practice strives to reduce the time required and thus also financial demandingness in the phases of research, development, testing and production of technical object. Another very costly part of the project is the above mentioned phase of prototyping, where the virtual reality technology offers great possibilities for application in both the prototype phase and also in the phase of simulation and prototype testing [Blecha 2015].

1.1 Virtual reality

Virtual reality (VR) using computer facility enables the users to imitate a real space and human activities therein. It consists of a three-dimensional computer model of the environment; the user of virtual reality seemingly moves in this environment in a realistic manner. This is the user interface aimed as much as possible to bring the computer environment to reality as it is captured by our senses. The user should be drawn (submerged) into this environment as much as possible [Augste 2013]. Environment means the world existing only in the computer memory. It may be, for example, a model of a machine or house. This environment can be explored by a variety of methods including virtual reality.

1.1.1 Augmented reality - AR

Information from the real outside world can be combined with supplemented elements of virtual reality [Blecha 2011], [Chang 2014]. A part of the system is a camera whose position and orientation is synchronized with the movement of the user. An example is the use in military aircraft and vehicles where the outside image is captured by the camera and transmitted to the screen and immediately supplemented with significant symbols for hostile and friendly objects.

2 INDIVIDUAL STEPS FOR SOLUTION

2.1 Step 1 – first familiarization, first design

In the first phase, it is necessary to become familiar with the production process and the existing production line and to establish a procedure for designing a new workplace based on the set parameters. Discussions should also take place over the time and spatial layout of the existing and new workplace. From these input information, we would be able to create an initial 3D design of workplace.

2.2 Step 2 – team discussion, analyzing

The next step in the solution was to analyze the initial design of the newly designed workplace. During the debate, the problems arose; these could not be sufficiently solved by the existing technologies [Gomes 1999]. A designer and a multidisciplinary team could not relevantly determine the correctness of the solution. The main problem was a lack of interpretation of spatial CAD model and its predictive capability for teamwork. It was necessary to tackle the questions related to work place safety and ergonomics. The questions that arose during the discussion:

Will it be possible to implement a new workplace within the defined space?

Will this workplace interfere with another workplace?

Will the mobile parts threaten the workplace operator and other personnel?

Are all the sites accessible to the operator? (Main switches material ...)

Will the proposal meet the ergonomic standards for the job?

How will the future material flow through the workplace look like?

To solve these issues, virtual reality technology was used to achieve higher clarity and informative value.

2.3 Step 3 – import model to polygonal

In this step, it was necessary to transfer the prepared CAD model into the polygonal one due to the reasons arising from virtual reality technology. The model was subsequently stained and animations of moving parts were embedded, with texture being possibly embedded. To write the polygonal model, VRML format was chosen.

2.4 Step 4 – import model to ar

In the previous step, a prepared polygonal model was imported into the virtual reality environment. Thus prepared model can be inserted into both immersion virtual reality environments as

well as in the environment of augmented reality. For further work was chosen precisely augmented reality thanks to the benefits that it offers. Advantages and disadvantages of both solution:

2.4.1 Immersion virtual reality – general
Advantages
(Import polygonal models in VRML format, JT, FBX,
User-friendly environment, The ability to directly solve the ergonomic analysis using anthropometric human model, Display model in scale 1 : 1).
Disadvantages
(Inability display in a real environment, economically very challenging).

2.4.2 Augmented reality (AR) - general
Advantages
(The ability of viewing in real environment, integration of other modules - free programming language, import of polygonal models in VRML, X3D, economically reasonable - open source.) [Langlotz 2014]

Disadvantages
(Necessity of programmer awareness, user-unfriendly, limited view scale 1: 1).

Figure. 1. Model of production workplace (assembly) in real environment using AR technologies

In the case of application of augmented reality (Fig. 1) to solve the ergonomic analysis, the analysis of collisions [Serio 2013] and others, we have to complete this process. The actual start is programming of viewing with a camera in software Instant Reality and placing the object on the required guiding marker. On the market there are many of software application that supports AR. Including, for example Metaio, Unity with the use of mobile devices on the Android platform. Instant Reality software has been used for reasons of simpler programming language VRML against other solutions. This initial problem was solved using the instructions provided free of charge on the website [Gomes 1999]. The solution consists of a pair of files (pm and X3D). In the file extension (pm) it is written, using XMLencoding, how the guiding marker is loaded, the size of viewing window and camera distortion. The second file extension (x3d) contains the information on how the model is loaded. In the case of solved studies, it was necessary to enrich the code and supplement the collision functions between the objects. In order to adequately test the workplace, the main parameters that x3d and pm code had to meet were as follows: (the model view at the required scale, the ability to insert a model for sub-ergonomic studies, the ability to view the collisions, the ability to tackle critical points .)

Ability to insert models for sub-ergonomic studies and views of collisions
To solve this problem, a model of virtual arm has been inserted into the environment [Skrivackova 2009]. The arm was placed on a cube provided with guiding markers. The cube (Fig. 2) was selected because of its ability to view a 3D model of the arm from all sides. The virtual arm was further set up to overlap the real arm. The entire production line was placed on the other guiding marker. Among other measures to address the study of reach of upper extremities was to introduce a collision between the objects; in this case between the virtual arm and the production line. In the event of collision, the word "COLLISION" lights up on the monitor. The next step was to test this solution in real operation (Fig. 3).
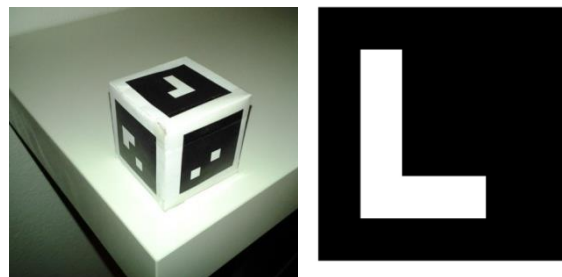

Figure2.Guidingmarkers– virtual arm, workplace

Figure3.Testing of setup of assembly workplace - coordinate systems (production workplace, virtual arm, webcam, viewing devices)

Solution for reach and critical points
To address this step, it was necessary to export the model of production line into the environment Autodesk 3D Max. In this software, animations of motions of really moving individual objects were created. This modified model was exported again to the VRML environment and thus exported model was, via the program, inserted on the guiding marker. For further continuation of the work, the virtual arm was used in points 2 and 3.
Within the ergonomic analysis (Fig.4), we solved the reaches against the starting position at the top on the left, which constitutes the mounting surface. Finding the starting position in space was solved as a touch of virtual arm on the mounting surface and the message "COLLISION" indicating a collision in the upper right corner [Tang 2014] [Tuma 2014a]. According to fig. 4, it is evident that the mounting surface is in the A reach zone (frequent and accurate motions). This was followed by monitoring of reach into the located tubes and boxes (at the top on the right and in the centre) wherefrom the operator takes the material during production as well as the maximum reach, which is indicated as collision with displayed work instructions (below) [Tuma 2014b].
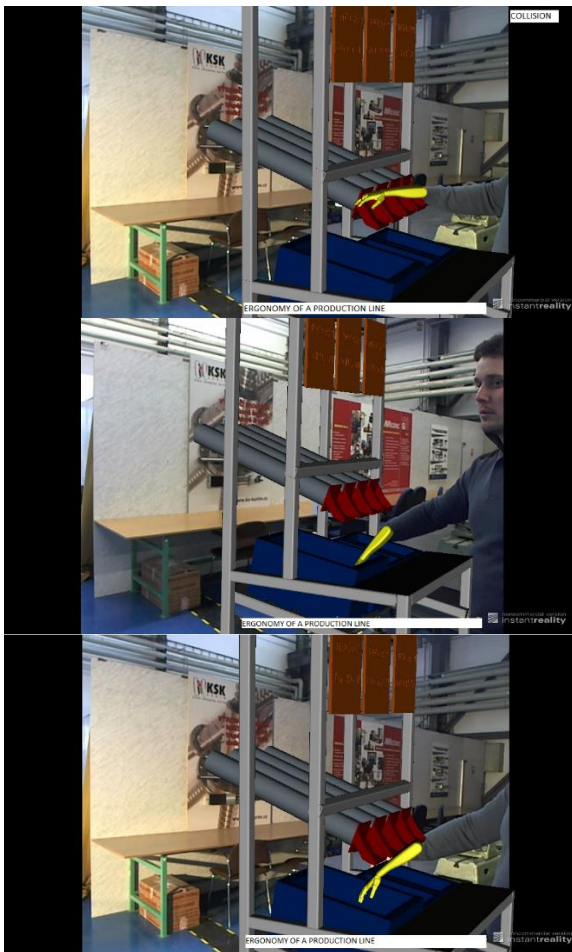
Figure4.The course of ergonomic analysis with the use of AR application viewed by webcamon the mounting table of the line for production of pneumatic components.

The next task was to examine collisions of moving parts in the workplace with operator's arm and their identification. An example is the motion of pneumatic press ram after pushing the two-handed control. In this case, the operator himself/herself is not in danger because the press is equipped with two-handed control, but it may endanger e.g. the operator of another line if he/she puts his/her arm into the pressing mandrel (Fig. 5). A stroke of pneumatic press is 50 mm, which allows you to put the arm into its workspace. One of the recommendations arising from this analysis may be to cover the pressing space.
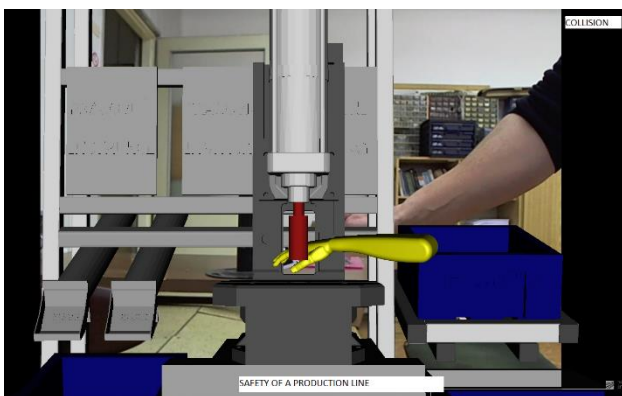

Figure. 5. Simulation of pressing with the use of augmented reality – collision state

2.5 Step 5 – Reviews, discussion

As early as in this step, it was possible to carry out a risk analysis of workplace, overall set-up and a final debate over the correctness of the selected solution. Provided that the debate revealed shortcomings, it was again followed by steps 2- 5 as part of this solution algorithm.
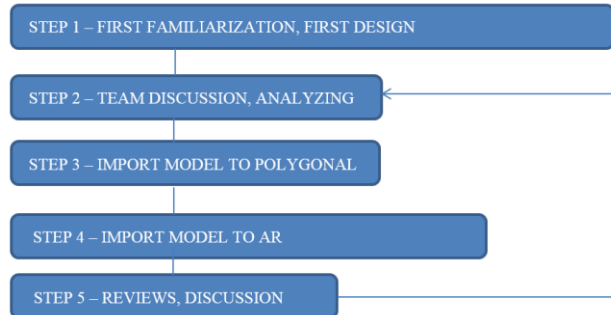
3 CONCLUSIONS

The present article has outlined a methodological procedure of the design of production workplace using virtual reality. For this work, programming environment Instant Reality was selected because it already includes solutions for augmented reality applications. This environment has been modified to be deployed in ergonomic and risk analyses, and other process analyses. Thus analyzed workplace can also be implemented without unnecessary modifications after assembly. On the basis of the final debate with the expert team from the production plant, the solution proposed in this manner was found practically applicable and interesting for future use. As the difficulties of the whole solution is unstable display object at the marker, which in this case does not restrict the work, since it uses a static camera. In the case of walking around of a marker with a camera would be preferable to use a different solution, for example, on the Android platform.

As a topic for further research, the author suggests the future use of the device Head-mounted display (Oculus-Rift, HTC Vive etc.) enriched with guiding equipment and a camera that would provide the observer with a new visual perception of the workplace without using a CAVE projection type.

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