

# Augmented Reality as a Support Tool in Machining Process

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**Abstract** – New innovative methods, such as augmented reality, are becoming more and more popular through the possibility of implementation the virtual elements into real-world environments. The aim of the present contribution is to link the techniques used in the educational process with the needs of real practice. The contribution points to the possibilities of usage not only of CL data for machining process, but shows possibilities comprising the use simulation data from the pre-production phase for augmented reality. Consequently a direct visualization solution for the operator is proposed, as well as an enriched information graphics environment for students to track the production process in real time.

**Keywords** – augmented reality, education process

## 1. Introduction

Augmented Reality in short AR is gaining more and more popularity because it brings elements from the virtual environment into the environment of our real world. It uses the user interface to integrate digital information in real time. Unlike virtual reality that creates a new artificial environment, AR uses an existing environment supplemented by computer-generated elements, which improves the current perception of reality. [1] Graphical elements or sounds are used very often, GPS data or touch feedback, whose main task is to improve user

experience and provide assistance in day-to-day activities. AR applications can be very simple, such as text messaging or very complicated visual instructions on how to, for example, repair complex systems or performing sophisticated surgical procedures. They can highlight certain features, improve understanding, and provide very current and relevant data. [2]

The upturn of AR has been hampered by the availability and size dimensions of hardware. With miniaturization and the gradual reduction of procurement costs, this technology is becoming increasingly popular in the world. Different start-ups and individual developers are already creating more than 52% of new applications. The AR market is growing with rocket speed and predicts enormous investment over the next decade associated with the upcoming Industrial Revolution 4.0. The use of AR features allows very fast monitoring a wide range of machines and devices without the need for searching miniature display units. The following paper points to one of the application possibilities in the machining process which does not exclude future use of technology in other manufacturing processes as well. [3]

By improving production quality combined with increasing production capacity and reducing production times, the use of monitoring systems for production processes in modern machining has increased dramatically. The monitoring system in the production process can achieve significant benefits such as maintaining the reliability of the tools used and the process quality control of the product. The monitoring process is especially needed for finishing operations in the field of hard material turning and grinding, to avoid complaints and to overhaul products.

## 2. Design of system

For a system designed to monitor the process in real-time, the essential function of the work is to collect data using inputs to regulate the data flow, including control commands running in the machine's control unit. These data are then visualized for the operator, subsequently processed and indexed for

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DOI: 10.18421/TEM91-56

<https://dx.doi.org/10.18421/TEM91-56>

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*Received: 14 January 2020.*

*Revised: 10 February 2020.*

*Accepted: 16 February 2020.*

*Published: 28 February 2020.*

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further statistical and process evaluations. At the same time, it is necessary to evaluate the data obtained before entering the database, where it is necessary to review them with intelligent real-time evaluation systems.

The monitoring systems are mostly focused on machine monitoring and diagnostics, control and monitoring of tooling, or tracking and analyzing the workplace with the worker. Downtime, extra hours, work safety and procedures are also tracked, which ultimately can have a key impact on productivity gains and the capabilities of upgrading manufacturing systems and processes. [4]

In the field of CNC machines, the most commonly used method of basic process monitoring is the display of process data through the control and visualization panel of the machine or alternatively with the use of an external computer. [5]

Practicality and simplicity are the building element that can bring peace to often hectic and complex modern systems. Progress does not necessarily mean making things complicated, but on the contrary, many emerging technologies, by their complexity, unnecessarily slow down the functional system.

In the case of a system that should be practical for an end-user, one has to take care to ensure that the solution is clear and adaptable to the rapidly changing circumstances. Based on the idea of simplicity, the machine itself was used as a place to display AR content. In emerging systems, mobile imaging units such as tablets and VR glasses are preferred. Their disadvantage is that they largely obscure worker's field of view. At the same time, they are fragile, and their battery capacity is insufficient when using all the necessary functions. From a software point of view, they require complex techniques to know where they are in 3D space and what they are looking at. Visualization based on simple graphic markers imparts advanced image recognition and edge tracking, but they can be hard to recognize during a continuous production process. [6]

An alternative solution is the use of the transparent machine cover, which is a part of the vast majority of CNC machines. For this example, the EMCO Concept Mill 55 was used. Projection of an image using a projector at an angle overlaps the view of the worker, but thanks to the contrasting settings and use of the projector's light which is projection principle; it is possible to leave the worker a view of the real working environment of the machine Fig.1. Workers do not have to monitor other panels and additional monitors, but all necessary information extended by the above-standard graphical interfaces of the

monitored production process has in its sight along with the real process. [7]

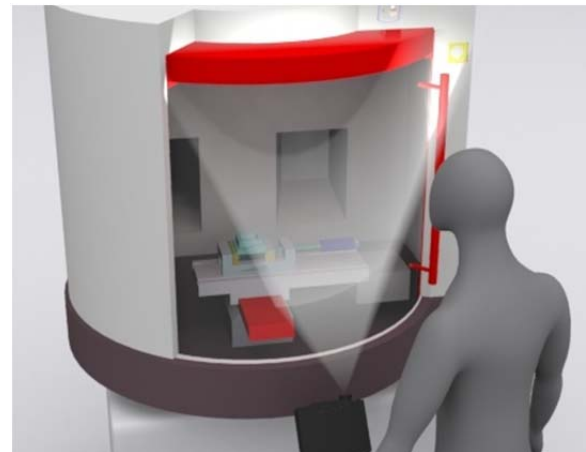


Figure 1. The concept of usage AR projection on the machine's protective glass

Digital outputs that will be projected on protective acrylic glass need a computer for real-time image distribution over the projector. The usage of a central computer unit with access to enterprise network gives better options for creating and setting up the system itself. The principles of creating visualized data that will be displayed in the form of an augmented reality directly on the machine can also be used on other mobile client display units by changing only the display principle. The creation of the project itself is therefore divided into two conceptual solutions:

- AR data displayed directly on the machine.
- AR content visualized on mobile display [8].

The order of creation which comprises individual phases is determined by the possibilities offered by the phases in terms of the process of creating the necessary data and 3D model outputs, as well as the actual implementation of AR and its calibration for correct visualization. If an image needs to be transmitted, the system needs to be complemented by a sensing camera that provides spatial detection for the purpose of applying an extended reality with the exact position of the camera relative to the workpiece being viewed Fig.2.

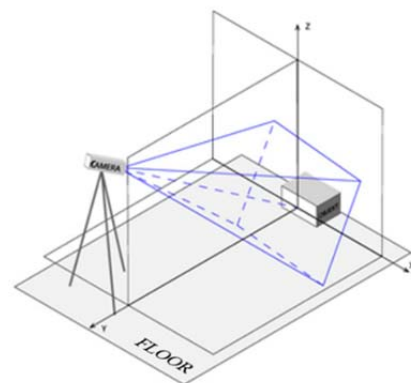


Figure 2. Position of a camera in front of monitored object

### 3. System realization and testing

All the considered data have their source, and different way how they are transmitted and visualized as well. Therefore, both hardware and software support have to be secured. According to the required conditions the solution of these specific tasks needs to be considered. These conditions lead to the use of devices that will fulfill AR monitoring objectives, and they will be created within the limits of these conditions.

The perception of objects in 3D real world is based on the projection of the image on the retina of the human eye. A man perceives the environment in perspective from nature. The principle of perspective perception of space lies in the visual illusion that an object closer to us seems to be larger than the object of the same size located in the distance. We know different ways of projecting a three-dimensional object based on the approximation of angles and edge sizes. Axonometric imaging is often used in technical practice. It is a variation of perspective that relies on space defined by planes that enclose certain well-defined angles. This fact does not distort the size of objects when they are placed in space as it is shown in Fig.3.

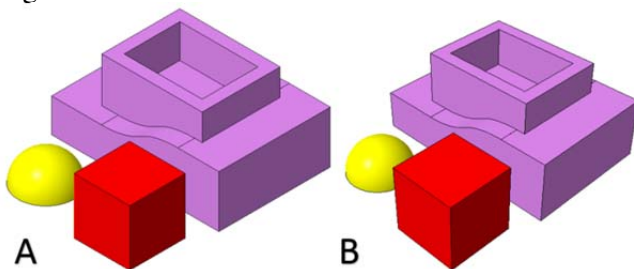


Figure 3. Visualization in A - axonometric B - perspective

Based on this knowledge, it is useful to use CAD software, which also allows perspective view of the space. Without the Visual Perspective Viewer, it would not be possible to apply augmented reality directly on to object from CAD software. Another visualization program would have to be used in order to perform this step, which is less practical. Prospective projection of virtual space is therefore an important condition for the correct representation of augmented reality. If we wanted to apply 3D models as augmented reality elements to a reality perceived by our eyes or camera lens in a non-perspective view, there would be shape mismatches, resulting in a misunderstanding of what augmented reality is trying to do, to enrich the real reality, not to disrupt it.

For creation a simulation of component manufacturing, with use of semi-product part and vice-pattern models, Creo 5.0 can display a simulation with predefined tools, tool paths and their operating parameters. These processes can be applied

in real time, additionally while displaying them as elements of an extended reality in the production process, or before its run. The worker has the opportunity to check the progress of the process, as well as to check the use of the tools or the correct clamping in the vice.

Creation of complex solutions for defined conceptual designs requires a slightly different approach to system composition, as well as for software support issues. Therefore, two solutions with small changes need to be separately created. Since the conceptual solution with the usage of a mobile output display device is based on a solution which uses graphics projection directly on a plexiglass machine. The following section will be devoted to this solution first. The design clearly shows the connection between the camera input, the computer, the streaming server, and the end user. This chain, however, needs to be developed into specific stages regarding the application of the AR in the field of monitoring. At these stages, the defined data sets are managed in different ways. Their creation and flow are provided by various specialized programs, with audiovisual real-time presentation through online stream. X-splitBroadcaster serves for the creation virtual studios for real-time video streaming over the Internet. However, its use can also be transformed into other industries and for the options offers layer creation, transformation and rotation options, layer transparency adjustment, colour-based background replacement (Chroma-key effect), and the possibility to send video output to internet streaming servers.

The scene creation by layers (Fig.4) is based on the logical way of visual preference of the layer that is on the top to appear prior to the next, depending on its transparency. The basic layer is the webcam input and the image adaptation to the selected resolution in which we want to transmit the output subsequently.

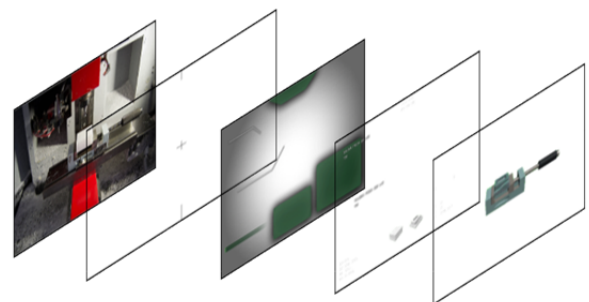


Figure 4. The scene construction with usage of layers

This layer is applied to a static cross-sectional image and its centering is connected to the previous layer. The last layer is captured from a part of the desktop in real-time, with opened Creo 5.0 environment window, in which it is necessary to set the working background to the contrasting green colour Fig.5.



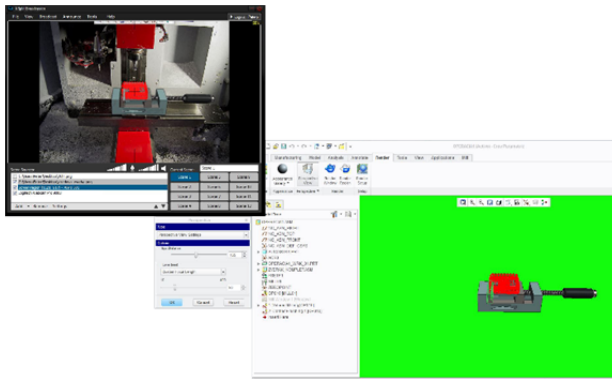


Figure 5. Sample scene preparation

The green colour is filtered by X-splitBroadcaster program in real time during the simulation running on Creo 5.0 software, and all changes will be displayed in real-time and in the created scene.

Camera centered on the subject ensures the positioning page. Therefore, it is possible to create a simple graphical superstructure based on the visual contrast background under individual data. Before the stream run the streaming program, setting has to be done. The quality of the desired output depends on the quality of the Internet connection, and on the construction of the communication channel which is transmitted in the form of a coded address that is generated by the Twitch.tv server and inserted into the streaming program. After syncing the accounts, it is possible to run a stream, with end users accessing this real-time transfer via a shared web link, and the resulting visualization can be tracked through an Internet browser or in a tablet, or smartphone application.

The created process of monitoring in the form of output to the external display unit has the advantages adjunctively presented in the previous paragraph regarding technical solution of the property that forms the basis for transformation into a conceptual design, using the projection directly on the plexiglass surface.

#### 4. Creation of visual data

The idea of projecting monitoring data directly on to the plexiglass on a machine needs changes at the input, as well as at the output. While in the most commonly used concepts the sensing task was performed by a mobile camera (previous solution), in this case the monitoring of the process is carried out at the place of its implementation, on the control computer, which allows the removal of the camera from the process. The computer sends signals to the machine where and with which speed it should move its individual parts in the form of Cutting Location data (in short CL data). This data from the pre-production simulation phase are also directly used by

the visualization subsystem and projected in real-time.

The possibilities offered by the work with AR allows the creation of computer-generated elements that can be implemented on a visual basis, which are based on the machining process and can be used as monitoring tools Fig.6. The simulation process can be monitored simultaneously with the real-world machining process; for example, by applying a different view of the component, giving a better overview of the manufacturing.

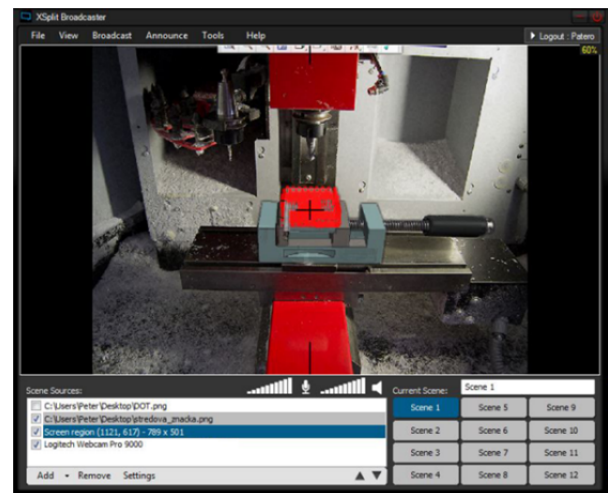


Figure 6. Visualization of tool paths with usage of AR

### 5. Completing the solution

As with the X-Split streaming program, it is important to follow a certain approach to creating a compositional scenario solution that is supposed to be an image output. When performing the scene, it is necessary to observe the aesthetic aspect of the entire processing, in addition to the functional display of the data. For this reason, it is necessary to create a graphically user-friendly interface, in short GUI.

The user interaction with the system is provided in the form of a User Interface (UI). This, in the form of text information, messages, buttons and workspaces, provides the user with tools for interaction with the system. GUI is a graphical extension of the user interface that provides better options for displaying individual aspects of the system, as well as realizing new options that are additionally user-friendly.

The entire graphical interface creation process can be performed using any graphical editor. Based on the layout of the data placement areas, simple surfaces of different transparent shapes are created, so that it is always possible to observe the real space that, in this solution, will represent the image from the webcam. The created file has to be saved in PNG format, which works with transparency based on its values and

created in a graphical editor. This file is then applied as a layer (Fig. 7) in the compiled scene of X-Split Broadcaster.

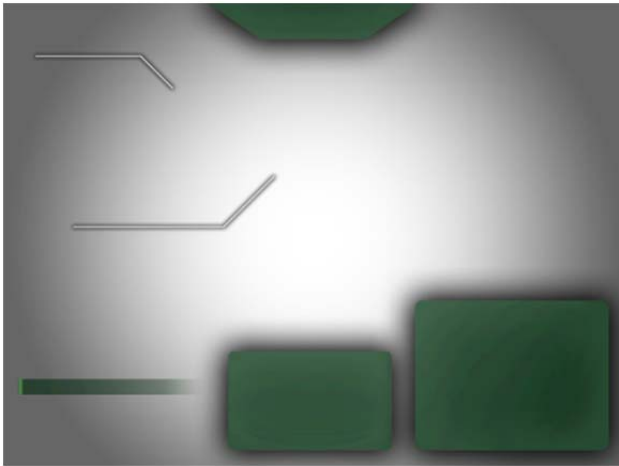


Figure 7. Layer of graphical interface

Creating a graphical user environment for application to this particular monitoring system depends on the amount and arrangement of the data within the image being shot, in order not to visually disturb the monitored process. In this case, the priority of the visual contact has a workpiece clamped in vice. The space around this image section can be used to display process data Fig.8.

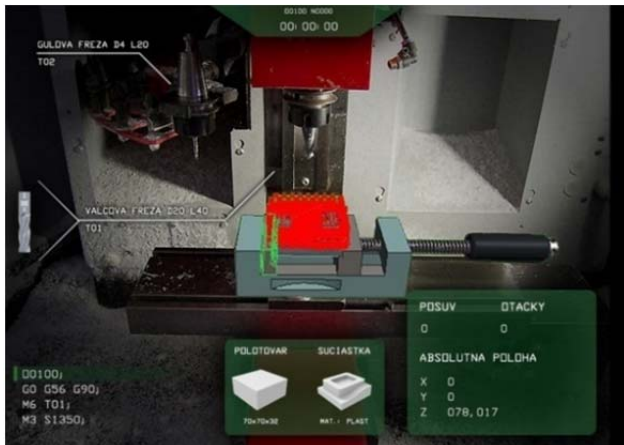


Figure 8. Output of the augmented monitoring system

## 6. Conclusion

Every newly created system carries the characteristics of its creator, available hardware and software options. The whole process, comprising creator's determination and the time that it takes to create new application, including possibilities under different conditions can be attractive for different industrial branches. Application of the presented solution can be perceived positively, especially for students and beginners while working with CNC machining centers. On the contrary, they can be perceived as unfavorable by experienced users for

whom information graphics seem to be unnecessary under the conditions that they are a piece of often-changing production. All things considered, it has its substantiation. One of the aspects is that it adds properties to the system, presenting the time which brings innovations for the current needs. Many a time, we encounter situations where breakthrough systems have lost their innovativeness shortly after they were put into service. Despite that, they have become an inspiration for new, more revolutionary solutions.

## Acknowledgment

This article was supported by the Agency to support research and development under contract number APVV - 16-0355 and VEGA 1/0026/19.

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