Application of Augmented Reality for Simulation of Robotized Workcell Activity

J. Novak-Marcincin, J. Barna and M. Janak

***Abstract*—**Augmented Reality (AR) shows great promises for its usage as a tool for simulation and verification of design proposal of new technological systems. Main advantage of augmented reality application usage is possibility of creation and simulation of new technological unit before its realization. This may contribute to increasing of safety and ergonomics and decreasing of economical aspects of new proposed unit. Virtual model of proposed workcell could reveal hidden errors which elimination in later stage of new workcell creation should cause great difficulties. Paper describes process of such virtual model creation and possibilities of its simulation and verification by augmented reality tools.

***Keywords*—**Augmented reality, simulation, workcell design.

I. Introduction

SIMULATION is experimental method, in which we supply of real system by computer model. At this model is possible to accomplish a lot of experiments, to evaluate their, eventually to optimise and results to apply at real system. Existing no another method or theory, which would by enable to experiment with complicated system else before as he was putting in operation. Existing no another algorithm, which would by enable past a few minutes gamble away at computer of complicated processes which objective exist religiously weeks or months. It is ideal apparatus to support of decision at manifold distinctions of enterprise.

Simulation find exploitation in areas, as are e. g. cosmic fly, martial and military operations, urbanistic systems, computer systems, logistic and manufacturing systems, business games, financial models, economic models, ecology and protection of the environment, development of community, biosciences and in scope of these disciplines is possible use of simulation also in area of verification action of automated workcell with industrial robot.

II. Augmented Reality Theory and Applications

Augmented Reality (AR) is a growing area in virtual reality research. The world environment around us provides a wealth of information that is difficult to duplicate in a computer. This is evidenced by the worlds used in virtual environments. Either these worlds are very simplistic such as the environments created for immersive entertainment and games, or the system that can create a more realistic environment has a million dollar price tag such as flight simulators. An augmented reality system generates a composite view for the user. It is a combination of the real scene viewed by the user and a virtual scene generated by the computer that augments the scene with additional information. The application domains reveal that the augmentation can take on a number of different forms. In all those applications the augmented reality presented to the user enhances that person's performance in and perception of the world. The ultimate goal is to create a system such that the user can not tell the difference between the real world and the virtual augmentation of it. To the user of this ultimate system it would appear that he is looking at a single real scene.

Virtual reality is a technology that encompasses a broad spectrum of ideas. It defines an umbrella under which many researchers and companies express their work. The phrase was originated by Jaron Lanier the founder of VPL Research one of the original companies selling virtual reality systems. The term was defined as "a computer generated, interactive, three-dimensional environment in which a person is immersed." There are three key points in this definition. First, this virtual environment is a computer generated three-dimensional scene which requires high performance computer graphics to provide an adequate level of realism. The second point is that the virtual world is interactive. A user requires real-time response from the system to be able to interact with it in an effective manner. The last point is that the user is immersed in this virtual environment. One of the identifying marks of a virtual reality system is the head mounted display worn by users. These displays block out all external world and present to the wearer a view that is under the complete control of the computer. The user is completely immersed in an artificial world and becomes divorced from the real environment. For this immersion to appear realistic the virtual reality system must accurately sense how the user is moving and determine what effect that will have on the scene being rendered in the head mounted display [1].

The discussion above highlights the similarities and differences between virtual reality and augmented reality systems. A very visible difference between these two types of systems is the immersiveness of the system. Virtual reality strives for a totally immersive environment. The visual, and in some systems aural and proprioceptive, senses are under control of the system. In contrast, an augmented reality system is augmenting the real world scene necessitating that the user maintains a sense of presence in that world. The virtual images are merged with the real view to create the augmented display. There must be a mechanism to combine the real and virtual that is not present in other virtual reality work [2].

The computer generated virtual objects must be accurately

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registered with the real world in all dimensions. Errors in this registration will prevent the user from seeing the real and virtual images as fused. The correct registration must also be maintained while the user moves about within the real environment. Discrepancies or changes in the apparent registration will range from distracting which makes working with the augmented view more difficult, to physically disturbing for the user making the system completely unusable. An immersive virtual reality system must maintain registration so that changes in the rendered scene match with the perceptions of the user. Any errors here are conflicts between the visual system and the kinesthetic or proprioceptive systems. The phenomenon of visual capture gives the vision system a stronger influence in our perception. This will allow a user to accept or adjust to a visual stimulus overriding the discrepancies with input from sensory systems. In contrast, errors of misregistration in an augmented reality system are between two visual stimuli which we are trying to fuse to see as one scene. We are more sensitive to these errors.

III. Computer Aided Robot Workcell Control

Computer Integrated Manufacturing (CIM) represent the integration of traditional production and engineering technologies with the computer technology, which enable the automation all activities from product design to their expedition (design of products, creation of technological procedures, production planning, operative control, manufacturing of products, quality control, assembly, packaging, expedition, etc.), with goal to bring down of the material and energy pretension, to increase of work productivity, to bring down of supplies, to shorten of development and production time, to increase of time and power utilize of production devices and it increase of products quality.

The complex computer integration is not only goal or in many firms it is reality. bring down of computer components prices and increase of computer power in unite with modern software technologies, new methods of firm organisation, new progressive technologies condition orientation on modern information and communication technologies in many firms. The CIM systems in most cases are not represented by complex wholes, or they are compiled by integration of partial automated systems - CA systems (Computer Aided Systems).

Computer Aided Robot Control (CARC) is a subsystem of the system CIM including the computer aided systems of all activities connected with realization and working of robotized and automated workcells (planning of robotized workcells, off-line programming of robots and other devices, simulation of activity in robotized workcells). This stage of computer aided systems in complex CIM fluently establish on application of computer aided systems in technical (construction and technological) preparing of production and is inevitable for secure of concurrent engineering conditions.

All of the above considerations lead to the conclusion that graphic computerized process planning holds huge potential for improvements on all fronts. This is even more so considering the fact that changing a product design is almost always less costly than changing the manufacturing process. The enabling technologies for CARC emerged only in the mid-’80s. Simulation, advanced graphics, motion emulation and powerful computers to support them all matured to the extent that CARC technology could be brought into economically justifiable use.

IV. Simulation of Robot Workcell by Augmented Reality Tolls Application

Current manufacturing industries experience the dynamics of innovations. Product life cycles are shortened and diversification of the product range gets wider, all in the frame of progressive globalization. They are though short of skilled workers, who moreover present high cost. As a perfect solution for achieving both productivity and flexibility there is automation based on industrial robots. Creation of control program of industrial robotic system for a specific application is still very difficult, time-consuming, and expensive. Small enterprises can have enormous difficulties with taking advantage from robotic automation.

Programming and verification method proposed in this paper does not ask for large capital investment and tries to combine the advantages of both basic ways. It is solution of robotic workcell using the elements of augmented reality utilized as the bridge connection between programming and its simulated verification [3].

A. Hardware Configuration of the Robotized Workcell

Robotic device of experimental workplace at the Faculty of Manufacturing Technologies is robot from ABB company – compact robot IRB 140. It is the machine with 6 degrees of freedom with unique combination of great acceleration, work radius and solid load. It is the fastest robot in its class with good repeatability of position and very good trajectory accuracy (± 0.03 mm). With load 6 kg it can manipulate up to distance of 810 mm. It can be installed on the floor or on the wall. Currently it is situated on the floor stand with intention to realize sliding for easy changing of several positions.

As for the application area, the robot in this laboratory is used as a manipulator between different machining sequences. It can also used for welding, assembly realization, cutting of material, packaging tasks, batching, machine servicing, etc. Initial position of this device so far is the place, from where it can reach to working area of both machining devices. Those are didactical manufacturing devices EMCO appointed for basic operations of milling and turning. In relation to the programming method and verification of programming results we have the models of all present objects. Model of robot is in STL form downloadable on the internet, models of mill and lathe were created in CAD module of engineering system Pro/Engineer (Fig. 1).

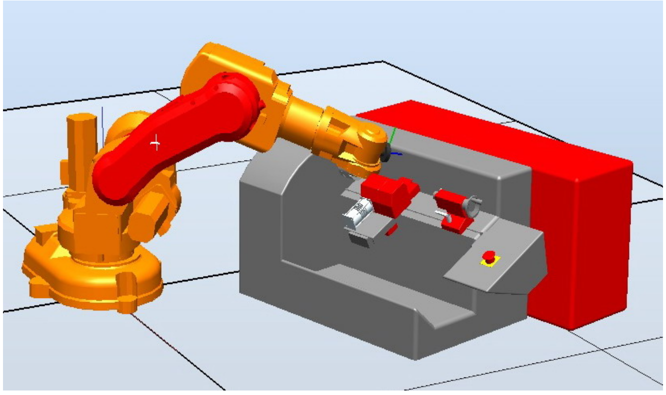

Fig. 1 Computer model of the workcell with ABB 140 robot

B. Software Characteristic of the Realized Workplace

From the viewpoint of the software, as a component of delivery there is an application called RobotStudio, which presents typical tool of online programming with integrated models of all virtual machines and devices from ABB company. After disposition of all inserted objects and harmonization of their coordinate systems, the programmer defines key positions of robot efector which serve as input of path creation for individual moves. Actions (types of movements) and operations determined are then in RobotStudio translated into program syntax suitable for robot control. Creation of programs for manufacturing devices EMCO is realized in typical way – sequences of CAD module of Pro/Engineer are with postprocessor translated into the form of final NC machining programs which run the machine under the control system Fanuc. Machines are meant especially for educational purposes and as the smallest in their class they do not have any control unit. Their control is simulated in regular Windows interface under the application called WinNC. This solution actually present the advantage from the viewpoint of easier communication and data interchange between controls of robot, mill and lathe [4].

C. Simulation and Verification of Robotized Workcell by AR

Application of the elements of AR is in many manufacturing activities realized by software implementation (overlapping) of geometries of virtual models into the real environment recorded with use of camera sensors.

This method is effective, but there is the need to watch the monitor that lies out of normal working area, what sometimes leads to the problem regarding the synchronization of working activities and moves. To fix this issue there was new visualization unit created. Its philosophy lies in creation of new mixed working environment. Thanks to the use of half-silvered surface it finally provides better interactivity of the application and increases the user comfort directly in active working environment of the programmer.

The surface of special glass is either half-silvered, or there is half-leaky foil stick on it that provides necessary reflection and in the same time allows the view to the working environment with no obstacle or decreasing of view quality. This commonly available kind of the mirror is often used in gaming, medicine or presentation business. By optical connection of two seemingly different views it creates an ideal platform for creation of realistic spatial effect.

Fig. 2 Virtual model copying the position of real device – displaying the combination of real and virtual image using the AR

Displaying is a reversed emission of the view to the reflex surface. It is provided with use of LCD monitor that is placed over the working area, out of the view angle of worker (programmer). Disadvantage of this visualization variant is making the quality and character of created view dependent on fixed watching point. Such unpleasant attribute was solved by the fact that into the application for creation of combined view running under Open Source system Blender there was a script activated for tracking of the user's face.

Another way to increase the quality of implementation of elements of AR in real working space (robotic workcell) is to use the option for audio inputs and outputs. The programmer of robotic device can obtain audio instructions and information, for example about threats of collisions detected on virtual objects, about violation of safety zone, start and end of the motion or activity of real or virtual robot, eventually about reaching or recording of desired position.

Besides receiving the information he can also give the vocal orders. By the simple activation of the microphone and with use of regular PC there is (thanks to the possibility of linking the audio input with Blender application) his voice as an interactive feature of his work that can be used for immediate and more comfortable realization of partial programming functions.

Together with the audio there is the possibility of direct text output of the information in the view displayed on the half-silvered glass plate. Different text packages (coordinates of required point, position and state of the efector, collisions, important positions, warnings) can be simply texted directly into the view field of the programmer in desired form and in real time in relation to the connections determined in Blender.

The concept of programming with use of described method is based on the creation of displaying unit and on the connection between more software environments. Displaying unit includes the construction (static frame), half-silvered glass (reflection and leakiness), LCD displaying device (emission of the image to the glass from the point out of the view field of the user), camera (detection of face motion of the programmer) and PC (synchronization of receiving and broadcasting of the image, running of Blender application itself).

Possibility of program interconnection of several software environments is partially realized, for its full functionality and thus for real online programming from behind of the imaging glass with the creation of augmented reality, it requires some additional programming corrections. It is based on the principle of mutual interaction of data coming from different software. Data from application RobotStudio must be available for main imaging and computation application running in Blender. Script from Blender has to (for example with use of RobotStudio) generate the output in the form of program with robotic syntax. Suitable improvement would mean also the availability of data from control system of machining devices for calculation purposes of Blender application, what is supported by simulated control of the mill and the lathe in the Windows environment.

Thanks to the combination of real and virtual complex data, the programmer has in his field of view the image combined from real objects, such as devices, lathe, mill, etc; and also from virtually inserted models, for example the robot, group of robots, another machine.

Fig. 3 Warning display: Collision Threat with placement shown

Advantage of such imaging lies also in possibility to use it for doing the design and disposition of robotic workplace, when the designer/constructer has the possibility to visually check (in real time) the suitability of his proposal, placing of the machines, robots, working radiuses, etc. In the workcell there is another manufacturing device inserted. The programmer can use the virtual space of Blender application for verifications where potential problems can be signalized by different colors or combined with audio signal.

On the Fig. 3 there is verification of working range of the robot related to another machining device that is not currently installed. Creation and simulation of control programs is open also in case of workplace that is not yet built, or in cases where disposition is to be changed.

V. Conclusion

This paper is focused to improvement of important features of robot workcell simulation. It concerns both design verification and simulation area. Details of research and related concept are explained on the example of experimental robotic workcell situated at the Faculty of Manufacturing Technologies TU Kosice with a seat in Presov, Slovakia.

An idea is based on utilization of newly created displaying unit that is based on the principle of half-silvered glass, fixed in frame that is situated between programmer and workcell, which reflects and simultaneously transmit the light. This means that looking to the workplace through this glass, the programmer can see real objects behind it in combination with virtual ones inserted in software environment of application created in Blender. This can be considered as new approach among the methods of robot workcell simulation.

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