APPLICATION OF VIRTUAL REALITY TECHNOLOGY IN SIMULATION OF AUTOMATED WORKPLACES

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With the advent of high-resolution graphics, high-speed computing, and user interaction devices, virtual reality (VR) has emerged as a major new technology in recent years. An important new concept introduced by many VR systems is immersion, which refers to the feeling of complete immersion in a three-dimensional computer-generated environment by means of user-centered perspective achieved through tracking the user. Main advantage of virtual reality application usage is the 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 whose elimination in later stage of the new workcell creation should cause great difficulties.

Keywords: automated manufacturing workplace, simulation, virtual reality technology

Primjena tehnologija virtualne stvarnosti u simulaciji automatiziranih radnih mjesta

S pojavom visoko razlučive grafike, brzog računanja, te dobre interakcije uređaja s korisnikom, tehnologija virtualne stvarnosti (VS) u posljednjih nekoliko godina je jedna od glavnih tehnologija. Važan koncept koji predstavlja VS je sustav predočavanja, koji se odnosi na osjećaj potpune uronjenosti u trodimenzijskom računalno generiranom okruženju, pomoću koje se iz korisničke perspektive uvelike olakšava praćenje. Glavna prednost korištenja virtualne stvarnosti očituje se kao mogućnost stvaranja i simuliranja novih tehnoloških jedinica prije njihove realizacije. Ovo može doprinijeti povećanju sigurnosti, povećanju ergonomije i smanjenju troškova. Virtualni model radnog mjesta mogao bi otkriti skrivene pogreške koje se eliminiraju, a koje bi u kasnijoj fazi na tom radnom mjestu mogle uzrokovati velike poteškoće.

Ključne riječi: automatizirano proizvodno radno mjesto, simulacija, virtualna tehnologija

1 Introduction

Virtual reality may be a clone of physical (real) reality or a kind of closer not defined (cyber) space that has its own rules. In both of these cases a simulation of the environment has to be done. In case of newly defined cyberspace the task is relatively easy – we can invent new laws or use simplified physics. The real challenge is to simulate the rules of physics precisely, because they are very complex phenomena: dynamics of objects, electromagnetic forces, atomic forces, etc. For the human-computer interaction purposes a subset of them has to be considered. Newton's laws are the basis when simulating movements, collisions and force-interaction between objects. The simulation, collision detection and animation of autonomous objects, may be a very complex and time-consuming task, so other approaches must be applied than in standard (i.e. non-real time) animation. The simulation process that manages the behavior of the whole environment (including interaction between different users) should be run in the "background" – decoupled from the user's interaction in order to support the full performance. The updates between these application parts are realized by means of asynchronous operations [2, 3].

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of safety and ergonomics and decreasing of economical aspects of new proposed unit. Virtual model of proposed workcell could reveal hidden errors whose elimination in later stage of new workcell creation should cause great difficulties [6, 7].

2 Creation of Virtual Automated Workplace

One of the most useful techniques for acceleration of the design process is virtual model creation. This technique resolves interface dependencies between all system components, thus enabling parallel, rather than sequential, development of hardware and software components of the system. The paper describes the creation of workshop model followed by design verification in virtual reality environment. The main goal was to verify the proposed arrangement of automated workplace design in order to test the accessibility of welding robots to workpiece and to confirm spatial set up of the whole workshop. The procedure of virtual model creation could be divided into three main steps [9, 10]:
- creation of 2D drawing,
- creation of 3D models,
- creation of workshop virtual mock-up.

First step, the 2D drawing creation was made according to input information in AutoCAD software. Output 2D drawing served as basic start point for all other activities for virtual model creation [1].

Further process consists of creation of 3D models which are based on above mentioned drawings. After model building they have to be exported in generally accepted format in the order of their following usage and import in virtual reality system. For 3D models creation was used Pro/ENGINEER Wildfire 2 (Fig. 1) and as transfer format
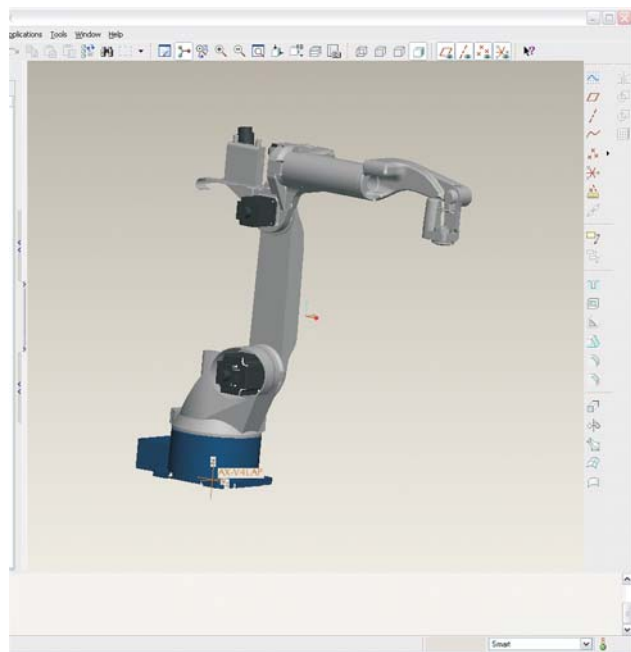
Figure 1 Model of robot created in Pro/ENGINEER

was chosen Wavefront format. Models created in this format are described with two files, and while one held information about measure and geometric characteristics of the model the second contained additional information for example about the model's material. This format was selected because of its support in virtual reality system which was used in this experiment [8] (Fig. 2).
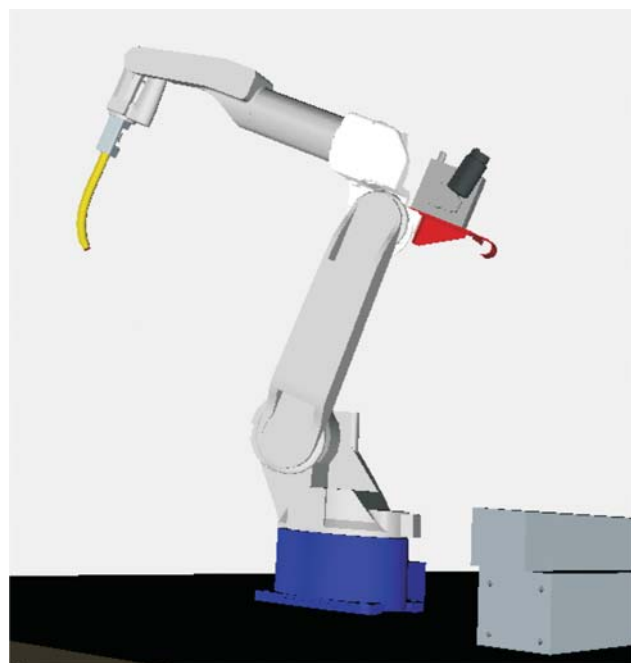

Figure 2 Virtual model in virtual reality environment

A complete VR system is a large software system, consisting of many modules. Every VR system contains an object manager, renderer, device drivers, communication module, navigation and interaction module, and, usually, physically based simulation, sound rendering, scientific visualization, application-specific modules, etc. The visual part of the virtual world is represented by a hierarchical scene graph. Everything is a node in this graph: polyhedra,

assemblies of polyhedra, LODs, light sources, viewpoint(s), the user, etc. Most of the functionality and interaction presented below will operate on the scene graph, i.e., it will, eventually, change some attribute(s) of some object(s) [4].

For the creation of virtual reality for verification purpose the following components were used:
- virtual reality environment creation system Vizard,
- head mounted display eMagin Z800 (Fig. 3).
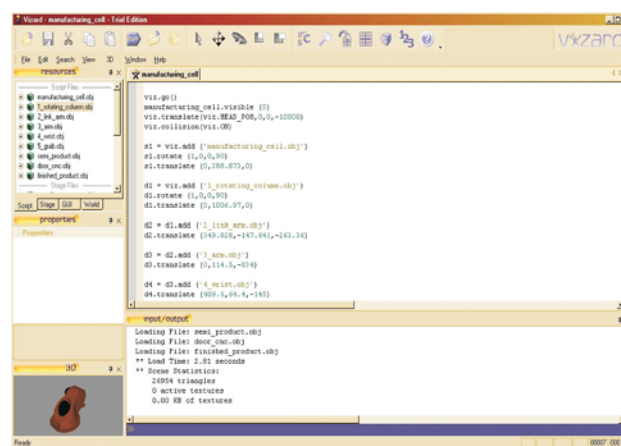

Figure 3 eMagin Z800 HMD

Figure 4 Virtual model in Vizard software environment

Vizard system (Fig. 4) for virtual environment creation is a package of high-end graphical tools designated for graphical applications creation including virtual reality, scientific visualizations, etc. Vizard uses powerful engine based on object-oriented programming which includes full usage of OpenGL and DirectX possibilities. VR environments created in Vizard environment are optimized with the usage of VizardLAXMI tools for achieving of full graphical performance. This application was selected because of its support of wide range of VR hardware and conversion formats. Output visualization was performed with HMD eMagin Z800. This HMD is equipped with OLED visualization technology with high contrast. HMD has integrated motion sensor for head position and orientation location [11].

Creation of virtual environment started with defining of new virtual environment, its parameters and behavior. This action was followed by objects importing and their allocation in virtual environment (Fig. 5). Arrangement of each object followed primary 2D drawing so the workplace virtual shape was built in 1:1 ratio to its real model. The purpose of our virtual model is the verification of design proposal with reference to robot access to workpiece during

work mode. In order to fulfill this goal it is necessary to define motion action of robot which can be controlled by user. In this way the designer can verify the correct proposal of workcell design [12, 13].

3
Experimental simulation of automated workplace

One of the main goals of using a VR system for design verification is the potentially high degree of "reality" which can be experienced when immersed in a VE. In order to achieve this, the VR system needs to be able to visualize object behavior at interactive frame rates. Other tasks of a VR system in the context of design verification are geometrical and spatial analyses. In order to check serviceability of the proposal, the VR system has to track the work space necessary for the objects to move and it has to report collisions (Fig. 6). During verification it is often necessary to simulate kinematics in order to perform a sensible design study. Real-time collision detection of polygonal objects undergoing rigid motion is of critical importance in many interactive virtual environments. In particular, simulation algorithms, utilized in virtual reality systems to enhance object behavior and properties, often need to perform several collision queries per frame. It is a fundamental problem of dynamic simulation of rigid bodies and simulation of natural interaction with objects. Simplified principle of verification of design in frame of object collision detection can be presented:

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collision detection within a visualisation loop
loop forever
move objects according to user input
check collisions
if collision detected, take appropriate actions
based on collision reports
else continue in visualisation
End of visualization
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With collisions there are two tasks to be handled: collision detection and collision handling. The former is the general problem of determining whether or not objects penetrate (i.e. "something happened"), while the latter is the problem of determining appropriate steps based on the current collision status, which is usually handled.
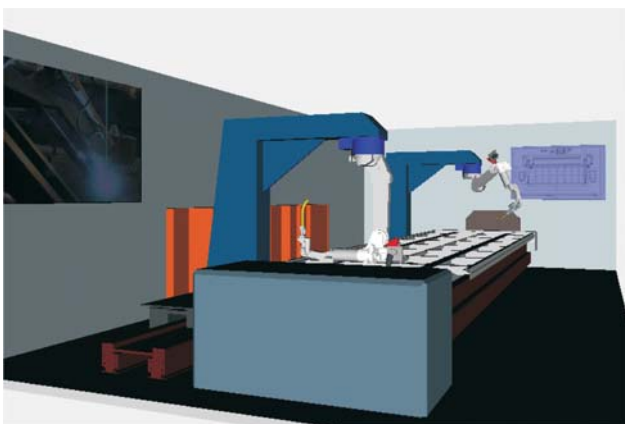

Figure 5 Virtual automated workplace

Virtual reality is one of the enabling "technologies" for all kinds of physically-based visualization in VR and other applications. Main advantage of virtual reality application usage is the possibility of creation and simulation of new
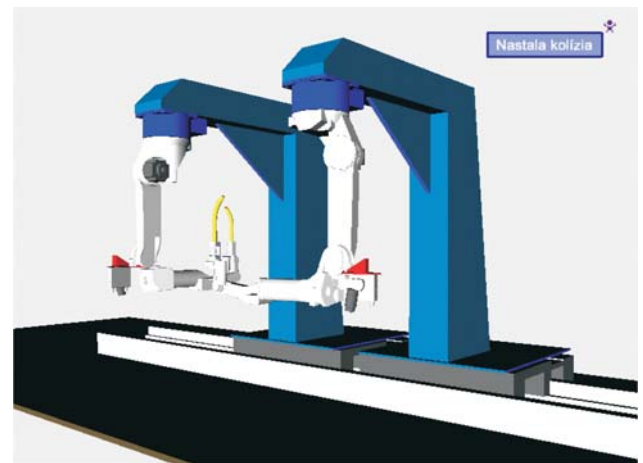

Figure 6 Example of collision error message

technological unit before its realization. Usage of virtual reality in such way as a verification tool can help to minimize errors which may occur by the creation of new workplaces. The paper presented simplified procedure of the creation of such model with the selection of software and hardware components, followed by a description of the system function principle. It presents step by step actions which have to be done in order to proceed from idea of new workplace through 2D drawing design and 3D models creation and till import of virtual models in virtual reality environment and virtual parameters set up [14].

This application allows verifying spatial arrangement of machines of newly proposed workplace and helps in revealing of hidden errors or may contribute to the creation of better alternative [5].

4
Discussion and conclusions

When a single factory may cost over a billion dollars (as is the case in the semiconductor industry), it is evident that manufacturing decision makers need tools that support good decision making about their design, deployment, and operation. However, in the case of manufacturing models, there is usually no tested one but the factory itself; development of models of manufacturing operations is very likely to disrupt factory operations while the models are being developed and tested [15].

Sophisticated computer simulations, what might be called *virtual factories,* call for a distributed, integrated, computer-based composite model of a total manufacturing environment, incorporating all the tasks and resources necessary to accomplish the operation of designing, producing, and delivering a product. With virtual factories capable of accurately simulating factory operations over time scales of months, managers would be able to explore many potential production configurations and schedules or different control and organizational schemes at significant savings of cost and time to determine how best to improve performance [16].

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References

[1] Antic, A.; Hodolic, J.; Sokovic, M. Development of a neural-networks tool-wear monitoring system for a turning process. // Strojniski vestnik-Journal of Mechanical Engineering, 52, 11(2006), pp. 763-776.

[2] Austakalnis, S.; Blatner, D. Real about Virtual Reality. Jota, Brno, 1994 (in Czech).

[3] Banerjee, P.; Zetu, D. Virtual Manufacturing. John Wiley and Sons, New York, 320 pp.

[4] Fain, N.; Kline, M.; Vukasinovic, N.; Duhovnik, J. The impact of management on creativity and knowledge transfer in an academic virtual enterprise. // Technical Gazette, 17, 3(2010), pp. 347-351.

[5] Gots, I.; Zajac, J.; Vojtko, I. Equipment for measuring the degree of wear to cutting tools. // Technisches Messen, 62, 1(1995), pp. 8-11.

[6] Kalpakjian, S.; Schmid, S. R. Manufacturing Engineering and Technology. Prentice-Hall, New Yersey, 2001, 1148 pp., ISBN 0-201-36131-0.

[7] Kocisko, M.; Janak, M. Creation Method of Visual Disassembly Procedure. // Journal CA Systems in Production Planning, 9, 1(2008), pp. 37-39, ISSN 1335-3799.

[8] Kolakovic, I.; Dovic, D. Simulation of the solar domestic hot water system operation. // Technical Gazette, 16, 1(2009), pp. 37-39, ISSN 1335-3799.

[9] Kuric, I.; Kuba, J. Dynamic classification in CAPP. In: Annals of DAAAM for 2006 & Proceedings of the 17th International DAAAM Symposium, Vienna, 2006, pp. 215-216.

[10] Marcincin, J. N.; Brazda, P.; Kuzmiakova, M.; Albeloushy, K. Simulation of Manufacturing Systems by Virtual Reality Technology. In: Proceeding of the 1st International Scientific and Expert Conference "Technics, Education, Agriculture and Management TEAM 2009", International TEAM Society, Slavonski Brod, 2009, pp. 113-117.

[11] Marcincin, J. N.; Brazda, P.; Kuzmiakova, M.; Fecova, V. Some Aspects of Manufacturing Workplaces Simulation by Virtual Reality. In: Proceedings of the International Conference on Innovative Technologies IN-TECH 2010, Praque, 2010, pp. 177-179.

[12] Marcincin, J. N.; Doliak, M.; Hloch, S.; Ergic, T. Application of the Virtual Reality Modelling Language to Computer Aided Robot Control System ROANS. // Strojarstvo: Journal for Theory and Application in Mechanical Engineering, 52, 2(2010), pp. 227-232.

[13] Mazuryk, T.; Gervautz, M. Virtual Reality: History, Applications, Technology and Future. Vienna University of Technology, Vienna, 1996.

[14] Murcinkova, Z.; Kompis, V.; Stiavnicky, M. Trefftz functions for solution of 3D problems with stress concentration. In: Proceedings of Leuven Symposium on Applied Mechanics in Engineering, Louvain, 2008, pp. 323-337.

[15] Neaga, I.; Kuric, I. Virtual Environments for Product Design and Manufacturing. In: Proceedings "CA Systems and Technologies". Zilina, 1999, pp. 60-65.

[16] Petruska, P.; Marcincin, J. N.; Doliak, M. ROANS - Intelligent simulation and programming system for robots and automated workcell. Proceedings of the IEEE International Conference on Intelligent Engineering Systems (INES 97), Budapest 1997, pp. 451-456.

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