

Virtual Reality Technology in Computer–Aided Production Engineering

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INTRODUCTION

After applications of virtual reality (VR) in the realm of flight simulators and computer games a need to exercise these technologies in industry is rising significantly. Nowadays one of the typical domains of using a virtual reality is designing and prototyping in automotive and air industry. A practical solution for a virtual model is using a virtual reality modeling language (VRML) that supports the distribution of three-dimensional models over the Internet. Web based virtual reality technology offers possibilities for sharing virtual models for supporting collaborative work and concurrent engineering.

There are more standardized tools for virtual reality technology distributing 3D models by VRML. Another possible solution for exploiting an Internet environment through VRML is using a non-standard software package on PC basis created for 3D simulation and programming of automated workplaces, robots and other peripheral devices. The article is describing procedures for implementation of VRML 2.0 into software ROANS, which has been created in another programming language than VRML versions.

BACKGROUND

The term *virtual reality* was possibly pronounced by Jaron Lanier in 1989 and became generally accepted since 1992 together with establishing of the National Academy of Sciences/National Research Council Committee on virtual reality research and development. The second historical milestone in virtual reality acceptance was connected with creation of the VRAIS conference and the IEEE Symposium on virtual reality research and development in 1993 (Bryson, 2001).

Currently virtual reality represents broad developed technological field, which can be in generally defined as “A computer system used to create an artificial world in which the user has the impression of being in that world and the ability to navigate through the world and manipu-

late objects in the world.” (Manetta & Blade, 1995). Common alternatives to the term virtual reality include such concepts as artificial reality, simulated reality, virtual environments, virtual worlds, interactive visual simulation, cyberspace, interactive 3D, Web3D, real-time 3D, spatial visualization and others.

Virtual reality systems can be divided by ways of communication with user to the following groups:

1. **Window on world systems:** conventional computer monitors are used for displaying the virtual world. This system is also called desktop virtual reality, but usually it is called as window on world (WoW).
2. **Video mapping:** This system is modification of WoW system, where the silhouettes of human body could be displayed in 2D. User could see themselves on monitors in interaction with environment.
3. **Immersive systems:** Virtual reality systems, which enables user to be in virtual environment. The feeling of “being inside” is created by head mounted displays (HMD). This is a helmet or a face mask that holds the visual and auditory displays. The helmet may be free ranging, tethered, or it might be attached to some sort of a boom armature (Isdale, 1998)
4. **Telepresence:** Attached to a high-speed network, virtual reality takes telepresence to next level. Participants can be thousand of kilometers apart and yet feel as if they are all standing in the same virtual office or laboratory, with their product, design, or experiment right in front of them not only talking about it, but interacting with it, change it etc. This technology connects sensors, which are apart in real world. All the sensors could be placed on robot or on presented tool.
5. **Mixed reality:** Display systems in which real objects and virtual objects are displayed together (Milgram, 1994).
6. **Fish tank virtual reality:** System created in Canada. It is a combination of stereoscopic monitors and tracking system that measures position and orientation of a hand.

The main attention of virtual reality system applications in the production engineering is focused to CAD/CAM/CAE systems of higher level, which outputs are realized in format VRML. The newest versions of these systems can aid both common formats VRML 1.0 and VRML 2.0. The second version VRML 2.0 (also named as VRML97) was developed (Carson, Puk, & Carey, 1999) up to the level of international standard (ISO/IEC 14772). Using Web-based virtual reality via VRML provides an excellent tool for sharing virtual models with remote users and enables supporting collaborative work and concurrent engineering. Thus, the impact of virtual reality is dramatically increased since experience can be shared with others (Soreide, 1999).

The specific problem for utilisation of collaborative virtual environments, especially for a small company are costs concerning virtual reality software and technology tools. Such hardware and software are so expensive that only large corporations could afford to build virtual environments. One of the possible ways to solve the problem is to implement a virtual reality format to lower systems with the aim to create preconditions for active utilisation of computer integrated manufacturing systems. For this sake we investigated the use of VRML for the modeling of robot operations in a frame of design of automated workcells by virtual reality. Because robots and other automated devices can be easily modeled using VRML's capability it creates preconditions for a future Web environment where robots can be downloaded from the supplier's Web site and placed in the virtual model of a workcell.

Implementation of VR Format to Software Package ROANS

ROANS is a software package on PC basis created for 3D simulation and programming automated work cell, robots & other peripheral devices (Petruska, Marcinčin & Doliak, 1997). ROANS software offers to user all needed tools for robot's design and simulation. After designing of workcell's subsystems and their location in space, it is able to create control programs for all devices that are working in multitasking mode. This software, with help of integrated postprocessor program, generates control code for specific robot language. PC hardware enables ROANS to communicate online with robot (reading jointed coordinates from robot encoder, translating the codes from postprocessor into robot controller, etc.). Moreover, the program enables dynamic modelling of driving and mechanical components by inverse dynamics problem of the robot's motion.

The advantage of ROANS is its low requirements on hardware. This is the reason why ROANS is often used in laboratory conditions and in school laboratories. The sample

of automated workplace with robots created in ROANS software and displayed in Shade regime is shown on figure 1.

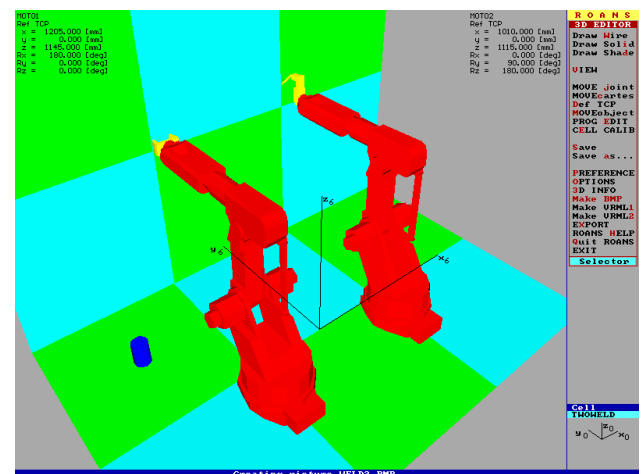
Before initiation of VRML implementation into the ROANS system, it is necessary to identify difference between structures in the ROANS system and in VRML. This difference mainly comes from program languages used. ROANS was created in program language PASCAL, where the data for writing into the file are indexed with rising value from number 1, whereas, VRML language was created in C++ language and data that are written into the file are indexed with rising value from number 0. There are also differences in the dimension units of the two systems. Millimetres are used in ROANS and meters are used by VRML. Furthermore, there are differences in indexing colours and points by which lines are defined. Colours of lines in the ROANS system are coded by their own identification number. Identification number of a colour in VRML depends on the order of a colour defined in knots.

Additional differences in defining of surfaces in the ROANS system and VRML are indexing of pints and in order of writing points for creating a surface. Setting, in which surface is drawn in one or the other side, depends on the order of point defining. ROANS system uses opposite principle for point defining than VRML.

The program for exporting ROANS data to VRML language is created as a part of ROANS system and works with data, which are stored in computer memory. This is the reason why displaying of workplace is unnecessary for exporting into VRML. If we export a ROANS file without creating any points, lines or surfaces in VRML, it will be executed but only its staple structure will be activated in a VRML file.

By activating of the item MAKE VRML1 (move cursor to this item and then press ENTER, or press the hot key "1") program is initialised. After this step it is necessary

Figure 1. Robotic workcell in ROANS environment



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