

Application of the Virtual Reality Modelling Language to Computer Aided Robot Control System ROANS

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1. Introduction

Historically, virtual reality has entered into the public awareness as medial toy with equipment "helmet-glove", which was preferentially determined for wide public and the price of this system had also to correspond to this fact, so price could not be very high. As follows, the producers of virtual reality systems have aimed at developing and providing of the systems for data collecting and analysing and systems supporting economic modelling. It is obvious that, from among areas, where virtual reality systems can be most frequently used are applications based on 3D-space analysing and physical dimension visualisation. Virtual reality with ability to show data 3D and attach sounds and touch information increases

Subject review

The paper presents results of Virtual Reality Modelling Language (VRML) application to Computer Aided Robot Control (CARC) system ROANS. VRML is description language, which belongs to a field Window on World virtual reality system. VRML 2.0 is the file format for describing interactive 3D scenes and objects. It can be used in collaboration with www, can be used for 3D complex representations creating of scenes, products or virtual reality applications. VRML 2.0 enables represent static and animated objects too. CARC is a subsystem of the Computer Integrated Manufacturing system including the computer aided systems of all activities connected with realization and working of robotized workcells. Interesting application of VRML is in area of automated manufacturing systems design and presentation.

Primjena jezika za modeliranje virtualne realnosti za računalom podržan sustav upravljanja robotom ROANS

Pregledni članak

U radu su prikazani rezultati Virtual Reality Modelling Language (VRML) aplikacije za Computer Aided Robot Control (CARC) sustav ROANS. VRML je jezik za opis, koji spada u polje Window on World sustava virtualne realnosti. VRML 2.0 je format datoteke za opisivanje interaktivnih 3D objekata i scena. Može se koristiti u suradnji s www, može se koristiti za 3D prikaze stvaranja složenih scena, proizvoda ili aplikacija virtualne realnosti. VRML 2.0 omogućuje predstavljanje i statičkih i animiranih objekata. CARC je podsustav sustava računalom integrirane proizvodnje, uključujući sustave za računalno potpomognuto sve aktivnosti vezane uz realizaciju i rad robotiziranih radnih ćelija. Zanimljiva primjena VRML je u području projektiranja i predstavljanja automatiziranog proizvodnog sustav.

extraordinarily data comprehensibility. Along with increasing the number of data are increased the effects from virtual reality too.

Virtual Reality is technology for presentation of complicated information, manipulations and interactions of person with them by computer. Method of dialogue of person with computer is named interface and virtual reality is newest of row this interfaces. After applications of virtual reality in area of computer games are rise need to exercise these technologies in industry. Main areas of using of virtual projecting and prototyping are automotive and air industry in this time. Virtual projecting as very perspective method must by using in area of projecting of manufacturing systems, too [13].

2. Virtual reality

At the beginning of 1990s the development in the field of virtual reality became much more stormy and the term Virtual Reality itself became extremely popular. We can hear about Virtual Reality nearly in all sort of media, people use this term very often and they misuse it in many cases too. The reason is that this new, promising and fascinating technology captures greater interest of people than e.g., computer graphics. The consequence of this state is that nowadays the border between 3D computer graphics and Virtual Reality becomes fuzzy. Therefore in the following sections some definitions of Virtual Reality and its basic principles are presented.

Virtual Reality (VR) and Virtual Environments (VE) are used in computer community interchangeably. These terms are the most popular and most often used, but there are many other. Just to mention a few most important ones: Synthetic Experience, Virtual Worlds, Artificial Worlds or Artificial Reality. All these names mean the same [1]:

- “Real-time interactive graphics with three-dimensional models, combined with a display technology that gives the user the immersion in the model world and direct manipulation.”
- “The illusion of participation in a synthetic environment rather than external observation of such an environment. VR relies on a three-dimensional, stereoscopic head-tracker displays, hand/body tracking and binaural sound. VR is an immersive, multi-sensory experience.”
- “Computer simulations that use 3D graphics and devices such as the DataGlove to allow the user to interact with the simulation.”

Although there are some differences between these definitions, they are essentially equivalent. They all mean that VR is an interactive and immersive (with the feeling of presence) experience in a simulated (autonomous) world – and this measure we will use to determine the level of advance of VR systems [12].

After the first applications of Virtual reality (VR) in the field of flight simulators and computer game creating, arisen the need to implement the virtual technologies into industry. Product design and virtual prototyping is one of the greatest successes of VR applications in industry. The main attention in the field of VR system applications in the technical practice is given to CAD/CAM/CAE systems of higher level. It is for the cause of realisation of export in format VRML (Virtual Reality Modelling Language). The newest versions of these systems could aid both existing formats VRML 1.0 and VRML 2.0 (97). The cost of a VR system is very specific problem. The real cost of an effective system can only be assessed in relation to the benefits it brings to a company. Such hardware and

software is 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 VR format to a lower systems with aim actively utilise systems of Computer Integrated Manufacturing [2].

VR systems could be divided by ways of communication with user to such groups [1]:

1. *Window on World Systems* - for displaying the virtual world are used conventional computer monitors. 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 siluetes of human body could be displayed in 2D. User could see themselves on monitors in interaction with environment.
3. *Immersive Systems* - basic VR systems, which enables user to be in virtual environment. The feeling to be in is created by Head Mounted Displays (HMD). This HMD could be with or without limitation of moving.
4. *Telepresence* - Attached to a high - speed network, VR takes telepresence to next level. Participants can be thousand of kilometres 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.
5. *Augmented Reality (AR)* - a technology that “presents a virtual world that enriches, rather than replaces the real world”. This is achieved by means of see-through HMD that superimposes virtual three-dimensional objects on real ones. This technology was previously used to enrich fighter pilot’s view with additional flight information [15].

Distribution of virtual reality systems by hardware equipment is in these levels. Some levels are not strictly kept, mainly in virtual reality systems of higher levels.

3. Virtual Reality Modelling Language

VRML is description language, which belongs to a field Window on World System. Development of 3D graphic is connected with Silicon Graphic Corporation. This corporation creates expanded Open GL library. Under this library was proposed the format Open Inventor, which is the base for creating VRML 1.0. Official specification of VRML 1.0 was finished in 1995. In autumn 1995 arise independent expert group - VRML Architecture Group (VAG), which aim was co-ordination of other advance, to map user requirements for developing of new VRML format [7].

VRML 1.1 was only as working proposal. The new format VRML 2.0 was approved in 1996 as ISO/IEC

standard and became as international standard VRML 97. Format VRML 1.0 is the same format like Open Inventor, which is used by SGI. It is created for describing of static 3D scenes and enables connecting with URL. VRML 1.0 scene is presented by ASCII text file format. File VRML 1.0 has WRL suffix (world).

VRML 2.0 (VRML 97) is accurately new language than only expansion of VRML 1.0. Against the version VRML 1.0 has lots new abilities and simultaneously take off or make some properties from proceeding version, easier. VRML 2.0 is the file format for describing interactive 3D scenes and objects. It can be used in collaboration with www, can be used for 3D complex representations creating of scenes, products or VR applications VRML 2.0 enables represent static and animated objects too. Enables connection with sound, films, and pictures. Basic elements of VRML 2.0 correspond with usually used 3DAPI (Open GL, Direct 3D) [8].

4. Computer Aided Robot 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 to increase of products quality [10].

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 automatized 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 automatized 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 [11].

5. Application of VRML format to CARC system ROANS

Computer system ROANS is a software package on PC base created for 3D simulation and programming of automated workplaces, robots and other peripheral devices. ROANS offer to user all needed tools for robots creating and simulation. After designing of workplace subsystems and their placing in space, is able to create control program for all workplace is working in multitasking mode. For minimalization of mistakes in program and for simple programming is added program editor [9]. ROANS with help of integrated postprocessor program generates control code for specific robot language. PC hardware enables ROANS to communicate straightly with robot (reading of joint co-ordinates from encoder of robot, translating of code from postprocessor into robot controller). The sample of automated workplace with robots created in ROANS and displayed in shade regime is on Figure 1.

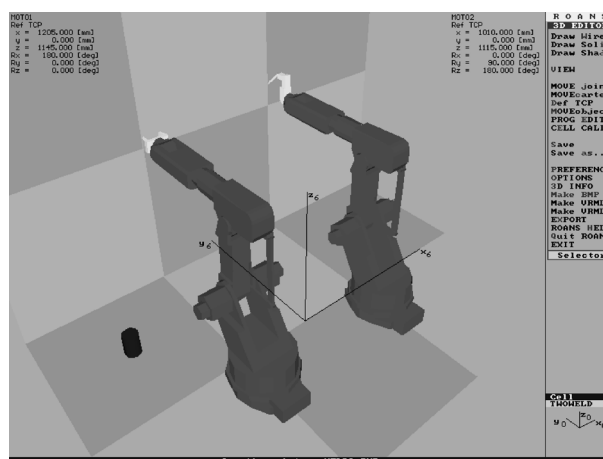


Figure 1. Robot workplace in software ROANS

Slika 1. Robotsko radno mjesto u softveru ROANS

Before initiation of VRML implementation into system ROANS is needed to identify difference between structures in ROANS system and in VRML. This difference mainly comes from used program languages.

ROANS were created in program language PASCAL. When the data are writing into the file they are indexed with rising value from number 1. VRML language was created in C++ language and data writing to file uses abilities of this language. Data are indexed with rising value from number 0. Differences in describing of points in ROANS system and VRML are in points indexing and in dimension units. Millimetres and indexing by rising value from 1, 2, 3, ... are used by ROANS. Meters and indexing by rising value from 0, 1, 2, ... are used by VRML. Differences in line defining in system ROANS and VRML are in colour indexing and indexing of points which are needed to line defining. Line colours have their own identification number in ROANS system. Identification number of a colour depends on order of colour defining in knots, which give a colour. Differences in surface defining in system ROANS and VRML are in points indexing and in order of points, which describes creating of surface. Every surface has 2 sides. Feature in which surface is drawn in one or other side of object depends on order of point defining. ROANS system uses opposite principle for point defining like VRML. That is why the program for VRML creating needs to write this indexing in opposite order like in ROANS. Adjustment of menu in ROANS is obvious from Figure 2 and Figure 3.

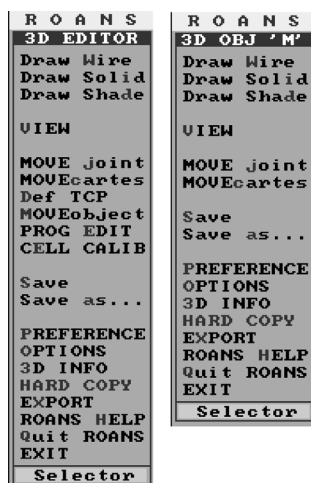


Figure 2. Original menu
Slika 2. Izvorni izbornik

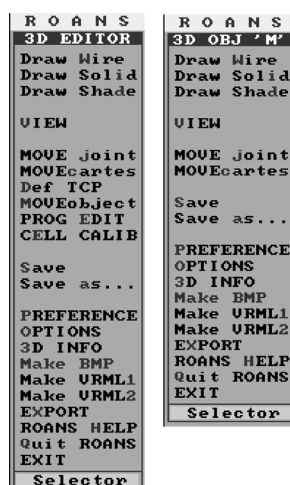


Figure 3. Adjustment menu
Slika 3. Prilagodba izbornika

The program for export ROANS data to VRML language is solved as part of ROANS system. In this case there are some changes in ROANS menu. The changes are: 3D Editor for Object structure, 3D Editor for Cell Structures, 3D Anim for Cell Structures. Created program works with data, which are saved in memory of computer. This is the reason why displaying of workplace is not needed for exporting into VRML. By activating of item MAKE VRML1 (stand with cursor on this item and than press ENTER, or right click of mouse, or pressing of hot key "1") is initialised activity of program. After this step you need to set the name of file in which will be result of export saved. It is needed to enter the name without extension, which will be automatically added. After file creating, starts export of data. First are exported header and preparatory knots (Info, BackgroundColor, ShapeHints, Material Binding, and Material). After this are exported data of points (Coordinate3) and depending on displaying regime are exported data of lines (IndexedLineSet) and surfaces (IndexedFaceSet). After ending of export is exported file closed and it is possible to work in ROANS system like before. Activity of making VRML 2.0 is similar like in VRML 1.0. It is initialised from menu by activating MAKE VRML2 item (stand with cursor on this item and than press ENTER, or right click of mouse, or pressing hot key "2"). After this procedure follows set of file name without extension WRL, which will be added automatically. After file creating, starts export of data. First are exported header and preparatory knots (WorldInfo and Background). After this, all data are exporting in dependence of displaying regime. Export of lines (Shape - for lines) and surfaces (Shape - for surfaces). In no visible shapes regime is process of points writing arranged. This is made in the case that some points are written twice and than they are marked with name "pts". When a points and surfaces are defined they are extended by name ("pts"), which were defined in lines. After ending of export is exported file closed and it is possible to work in ROANS system like before. On the Fig. 4 we can see displaying of automated workplace in VRML environment.

6. VRML and virtual engineering

Virtual engineering is currently approached in various ways. Because virtual engineering is an emerging technology, its terminology and definition are not completely established. In manufacturing, the major component of virtual engineering is virtual manufacturing. Virtual manufacturing is defined as an integrated, synthetic manufacturing environment exercised to enhance all levels of decision and control. It can be classified as design-centered, production-centered, and control-centered. Design-centered virtual manufacturing is a simulation environment for

designing and evaluating the manufacturability of a product. Production-centered virtual manufacturing is a simulation environment for generating process plans and production plans. Control-centered virtual manufacturing is a simulation environment for shop floor production activities. The most advanced current form of the Computer Aided Manufacturing is Virtual Manufacturing (VM) based on Virtual Reality (VR). VR representation techniques are widely used which means that they develop rapidly. In product manufacturing techniques and organization, virtual reality has become the basis of virtual manufacturing aimed at meeting the expectations of the users/buyers of products, also as to their low cost and lead time.

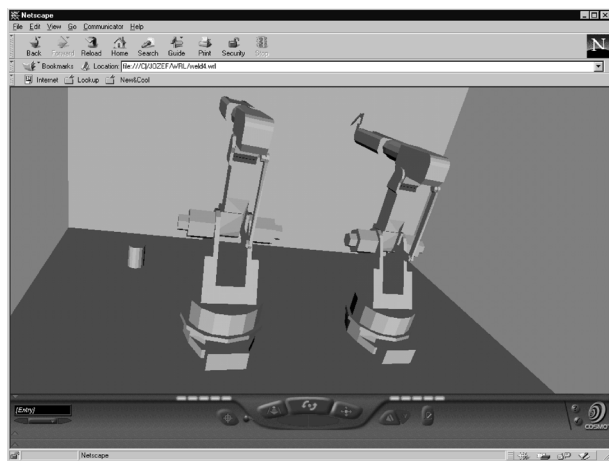


Figure 4. Automated workplace in Netscape Environment
Slika 4. Automatizirano radno mjesto u Netscape okolišu



Figure 5. Experimental application of VR in laboratory
Slika 5. Eksperimentalna primjena VR u laboratoriju

Virtual manufacturing includes the fast improvement of manufacturing processes without drawing on the machines' operating time fund. It is said that Virtual Manufacturing is the use of a desktop virtual reality system for the computer-aided design of components and processes for manufacture [16]. Example of application

of virtual reality system in laboratory of Faculty of Manufacturing Technologies in Prešov (Slovakia) is on Figure 5. It is unquestionable that virtual manufacturing aids real manufacturing processes and systems and it is perfected as the information technologies, the manufacturing systems and the business demands develop. In this context, Virtual Manufacturing should be recognized as an advanced information structure of Real Manufacturing Systems, which integrates the available information tools and the virtual environment immersiveness to achieve business-manufacturing goals [14].

7. Conclusions

After implementation of VRML maker into the ROANS system it is possible to represent all 3D automated workplaces with robot created in ROANS system by VRML browser, and it is not needed to have a license for ROANS. This enables companies, which use ROANS system, to communicate better without personal contact even they are thousand kilometres apart. This could save financial resources and expressively decreases time of workplace designing expressively. VRML maker is integrated part of ROANS and do not increase hardware even software requirements on system. It is needed to be able work in ROANS system when you want to make VRML, because created data depends on displaying mode, which is set in menu Options. It does not need to know how VRML works. Exploring of created scenes is able by individual programs (VRML browsers) or by additional programs for existing www browsers Netscape Navigator, Microsoft Internet Explorer (so called "plug in"). Introduced browsers and additional software is possible to get on Internet from web pages of its companies. Hardware and software requirements for scene exploring depend on used software.

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