APPLICATION OF THE VIRTUAL REALITY MODELLING LANGUAGE IN AUTOMATED TECHNOLOGICAL WORKPLACES DESIGN

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Summary: *Virtual Reality Modelling Language (VRML) is a description language belonging to a field of the Window of the virtual World reality system. The file, which is in VRML format, can be interpreted by the VRML explorer in three-dimensional view. VRML was created with the aim of more easily representing virtual reality on the Internet. The development of 3D graphics is connected with Silicon Graphic Corporation. VRML 2.0 is the file format for describing interactive 3D scenes and objects. It can be used in collaboration with www, and it can be used for complex 3D representations in the creation of scenes, products or VR applications. VRML 2.0 enables representative static and animated objects, too. One interesting application of VRML is in the area of automated manufacturing systems design and presentation.*

Key words: - *virtual reality*
               - *virtual reality modeling language*
               - *design of automated technological workplaces*

1. INTRODUCTION

Virtual Reality is a technology used for the presentation of complicated information, manipulations and interactions between persons and computer programs. The method of dialogue between the person and the computer is called interface and virtual reality is the newest in a series of these interfaces. Program uses of virtual reality in the area of computer games have given rise to the need to exercise these technologies in industrial applications. The main areas of using of virtual projecting and prototyping are in the automotive and air industry at this time. Virtual projecting as a very perspective method may be used in the area of the projection of manufacturing systems as well.

Historically, virtual reality entered into the public awareness as a middle-range toy with „helmet-glove" type equipment, which was preferentially determined for the broader public and the price of this system had to correspond with that fact as well, so the price could not be very high. As follows, the producers of virtual reality systems have aimed to develop and provide systems for data collection and analysis and systems supporting economic modelling. It is obvious that, of the various areas where virtual reality systems can be most frequently used, the most likely would be applications based on 3D-space analysing and physical dimension visualisation. Virtual reality with the ability of showing 3D data and attaching sounds and touch information increases data comprehensibility extraordinarily. Along with increasing the quantity of data, the effects of virtual reality are increased as well. [5].

2. VIRTUAL REALITY TECHNOLOGY

Nowadays, computer graphics are used in many domains of our life. In the 21st century, it is difficult to imagine an architect, engineer, or interior designer working without a graphics workstation. In recent years, the stormy development of microprocessor technology has introduced increasingly faster computers on the market. These machines are equipped with better and faster graphics boards and their prices have fallen rapidly. It becomes possible, even for an average user, to move into the world of computer graphics. This fascination with a new reality often starts with computer games and lasts forever. It allows us to see the surrounding world in another dimension and to experience things that are not accessible in real life or even not yet created. Moreover, the world of three-dimensional graphics has neither borders nor constraints and can be created and manipulated by ourselves as we wish – we can enhance it by a fourth dimension: the dimension of our imagination. But this is not enough: people always want more. They want to step into this world and interact with it – instead of just watching a picture on the monitor. This technology which has become overwhelmingly popular and fashionable in the current decade is called Virtual Reality (VR).

2.1. History of Virtual Reality

The very first idea of virtual reality was presented by Ivan Sutherland in 1965: "make that (virtual) world in the window look real, sound real, feel real, and respond realistically to the viewer's actions". It has been a long

time since then, a lot of research has been done and there is a status quo: "the Sutherland's challenge of the Promised Land has not been reached yet but we are at least in sight of it".

Let us have a short glimpse of the last three decades of research in VR and its highlights [1]:

- **Sensorama** – between the years 1960-1962 Morton Heilig created a multi-sensory simulator. A prerecorded film in color and stereo, was augmented by binaural sound, scent, wind and vibration experiences. This was the first approach to create a virtual reality system and it had all the features of such an environment, but it was not interactive.

- **The Ultimate Display** – in 1965 Ivan Sutherland proposed the ultimate solution of virtual reality: an artificial world construction concept that included interactive graphics, force-feedback, sound, smell and taste.

- **"The Sword of Damocles"** – the first virtual reality system realized in hardware, but not in concept. Ivan Sutherland constructs a device considered as the first Head Mounted display (HMD), with appropriate head tracking. It supported a stereo view that was updated correctly according to the user's head position and orientation.

- **VIDEOPLACE** – Artificial Reality created in 1975 by Myron Krueger. In this system, the silhouettes of the users were captured by the cameras and projected onto a large screen. The participants were able to interact with one another due to image processing techniques that determined their positions on the 2D screen's surface.

- **VIVED** – Virtual Visual Environment Display – constructed at the NASA Ames in 1984 with the off-the-shelf technology of a stereoscopic monochrome HMD.

- **VPL** – the VPL company manufactures the popular DataGlove (1985) and the Eyephone HMD (1988) – the first commercially available VR devices.

- **BOOM** – commercialized in 1989 by Fake Space Labs. BOOM is a small box containing two CRT monitors that can be viewed through the eyepiece. The user can grab the box, hold it by the eyepiece and move through the virtual world, as the mechanical arm measures the position and orientation of the box.

- **Virtual Wind Tunnel** – developed in early 1990s at the NASA Ames, it was an application that allowed the observation and investigation of flow-fields with the help of BOOM and DataGlove.

- **CAVE** – presented in 1992, CAVE (CAVE Automatic Virtual Environment) is a virtual reality and scientific visualization system. Instead of using a HMD it projects stereoscopic images onto the walls of a room (the user must wear LCD shutter glasses).

- **Augmented Reality (AR)** – a technology that "presents a virtual world that enriches, rather than replaces the real world". This is achieved by means of a transparent HMD that superimposes virtual three-dimensional objects onto real ones. This technology was previously used to enrich a fighter pilot's view with additional flight information (VCASS).

2.2. Definition and Basic Terminology in VR

In the beginning of 1990s, 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 in all sorts of media, people use this term very often and they misuse it in many cases, too. The reason for this is that this new, promising and fascinating technology captures greater interest from 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 the computer community interchangeably. These terms are the most popular and most often used, but there are many others. A few of the most important ones are: Synthetic Experience, Virtual Worlds, Artificial Worlds or Artificial Reality. All these names mean the same [2]:

- "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-tracking 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 the advancement of VR systems.

After the first applications of Virtual reality (VR) in the field of flight simulators and the creation of computer games, the need has risen to implement virtual technologies in industry. Product design and virtual prototyping is one of the greatest successes of VR applications in industry. Major attention in the field of VR system applications in technical practice is given to CAD/CAM/CAE systems of a higher level. It is used for the realisation of exporting in VRML format (Virtual Reality Modelling Language). The newest versions of these systems could aid both the existing formats VRML 1.0 and VRML 2.0 (97). The cost of a VR system is a very specific problem. The real cost of an effective system can only be assessed to be 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 of solving the problem is to implement a VR format in a lower system with the aim of actively utilising systems of Computer Integrated Manufacturing [3].

VR systems could be divided by ways of communication of the user with such groups [11]:

1. *Window on World Systems* - conventional computer monitors are used for the displaying of the virtual world. This system is also called Desktop Virtual Reality, but it is usually called Window on World (WoW).
2. *Video Mapping* - This system is a modification of the WoW system, where the silhouettes of the human body can be displayed in 2D. The user can see themselves on the monitors in interaction with environment.
3. *Immersive Systems* - basic VR systems, which enable the user to be in the virtual environment. The feeling of being in a virtual environment is created by Head Mounted Displays (HMD). This HMD could be with or without limitation of movement.
4. *Telepresence* - Attached to a high-speed network, VR takes telepresence to the 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, changing it etc.

Distribution of VR systems by hardware equipment is on these levels. Some levels are not strictly adhered to, mainly in VR systems of higher levels [6].

3. VR MODELING LANGUAGE

VRML is a description language, which belongs to the field of the Window on World System. Development of 3D graphics is connected with Silicon Graphic Corporation. This corporation created the expanded Open GL library. Under this library the format Open Inventor was proposed, which was the basis for creating VRML 1.0. The official specification of VRML 1.0 was finished in 1995. In the autumn of 1995, the independent expert group - VRML Architecture Group (VAG) - arose, with the aim of co-ordination with other advances, to map user requirements for the development of a new VRML format [8].

VRML 1.1 began only as working proposal. The new format VRML 2.0 was approved in 1996 as the ISO/IEC standard and it became the international standard VRML 97.

Format VRML 1.0 is the same format as Open Inventor, which is used by SGI. It is created for the description of static 3D scenes and it enables connection with a URL. A VRML 1.0 scene is presented in ASCII text file format. File VRML 1.0 has the WRL suffix (world).

VRML 2.0 (VRML 97) is more accurately a new language rather than merely an expansion of VRML 1.0.

In comparison with the VRML 1.0 version, it has lots of new capabilities and can simultaneously remove or acquire some properties from the proceeding version, more easily. VRML 2.0 is the file format for describing interactive 3D scenes and objects. It can be used in collaboration with www, it can be used for 3D complex representations creating of scenes, products or VR applications. VRML 2.0 enables the representation of static and animated objects, too. It enables connection with sound, films, and pictures. The basic elements of VRML 2.0 correspond with the commonly used 3DAPI (Open GL, Direct 3D) [7].

4. DESIGN OF AUTOMATED WORKPLACES IN VRML

The computer system ROANS is a PC-based software package created for 3D simulation and programming of automated workplaces, robots and other peripheral devices. ROANS offers the user all the needed tools for the simulation and creation of robots. After the designing of workplace subsystems and their spatial placements, it is possible to create a control program for all workplaces working in a multitasking mode. There is an added program editor for the minimizing of mistakes in the program and for simple programming. [9].

ROANS, with the help of an integrated postprocessor program, generates a control code for a specific robotic language. PC hardware enables ROANS to communicate directly with a robot (reading of joint co-ordinates from the encoder of the robot, translation of code from the postprocessor to the robot controller).

A sample of the automated workplace with robots created in ROANS and displayed in shade regime is seen in Fig. 1.
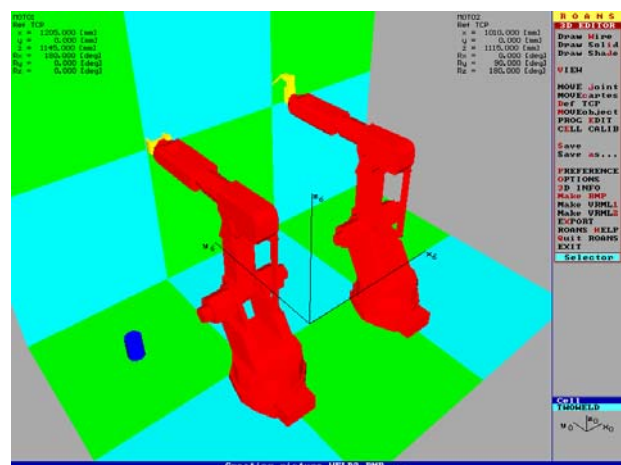

Figure 1. Robot workplace in ROANS software

Before initiation of VRML implementation into a system, ROANS is needed to identify the difference between structures in the ROANS system and in VRML. This difference mainly comes from the program languages used. ROANS was created with the program language

PASCAL. When data is written into the file, it is indexed with a rising value beginning from the number one.

VRML language was created in C++ language and data writing to file uses the abilities of this language. Data is indexed with an increasing value starting from the number zero.

Differences in the description of points in the ROANS system and in VRML are seen 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 definition in the ROANS system and VRML are seen in colour indexing and indexing of points is needed for line definition. Line colours have their own identification number in the ROANS system. The identification number of a colour depends on the order of the colour defined in knots, which gives a colour.

Differences in surface definition in the ROANS system and VRML are seen in points indexing and in the order of points, which describe the creation of a surface. Every surface has 2 sides. A feature in which the surface is drawn on one or the other side of an object depends upon the order of point definition. The ROANS system uses the opposite principle for point definition, like VRML. That is why a program for VRML creation needs to write this indexing in opposite order like in ROANS. Adjustment of the menu in ROANS is obvious from Figure 2 and Figure 3.
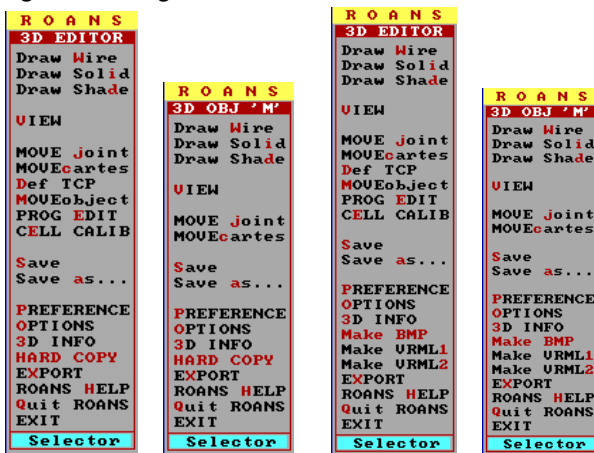

Fig 2. Original ROANS menu   Fig. 3. Adjustment menu

The program for exporting ROANS data into VRML language is solved as a part of the ROANS system. In this case, there are some changes in the ROANS menu. The changes are: 3D Editor for Object structure, 3D Editor for Cell Structures, 3D Animation for Cell Structures.

The created program works with data, which is saved in the memory of the computer. This is the reason why the displaying of the workplace is not needed for exporting into VRML.

By the activation of the item MAKE VRML1 (with cursor on this item and than press ENTER, or right click

of the mouse, or pressing of hot key "1") the program is initialized. After this step you need to set the name of file in which the result of the export will be saved. It is necessary to enter the name without an extension, which will be automatically added. After creating the file, the program starts the export of data. First, the header and preparatory knots (Info, BackgroundColor, ShapeHints, Material Binding, and Material) are exported. Following these, the data of points are exported (Coordinate3) and depending on the displaying regime there may be lines of data (IndexedLineSet) and surfaces (IndexedFaceSet) to be exported. After the export is complete, the closed file is exported and it is then possible to work in the ROANS system as before.

The activity of making VRML 2.0 is similar to VRML 1.0. It is initialised from the menu by activating the MAKE VRML2 item (with cursor on this item and than press ENTER, or with a right click of the mouse, or by pressing the hot key "2"). After this procedure follows a set of file names without the extension WRL, which will be added automatically. After file creation, the export of data starts. First, the header and preparatory knots (WorldInfo and Background) are exported. After this, all data are exported depending on the displaying regime— export of lines (Shape - for lines) or surfaces (Shape - for surfaces). The process of writing points is not arranged in a visible shapes regime. This is made in the case where some points are written twice and then are marked with name "pts". When points and surfaces are defined, they are extended by the appropriate filename extension ("pts"), which are defined in lines. After the conclusion of the export, the exported file is closed and it is then possible to work the ROANS system as before. In the Figure 4 we can see a display of the automated workplace in the VRML environment.

Figure 4. Automated workplace in the VRML environment

5. VRML AND VIRTUAL MANUFACTURING

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 the simulation of an 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 Computer Aided Manufacturing is Virtual Manufacturing (VM) based on Virtual Reality (VR). VR representation techniques are widely used, which means that they have developed rapidly. In product manufacturing techniques and organization, virtual reality has become the basis for virtual manufacturing aimed at meeting the expectations of the users/buyers of products, and also with regard to their low cost and lead time. 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 computer-aided design of components and processes for manufacture [14]. An example of an application of a virtual reality system is in the laboratory of the Faculty of Manufacturing Technologies in Prešov (Slovakia) is seen in Fig. 5.

Figure 5. Experimental use of virtual reality in laboratory

It is unquestionable whether or not virtual manufacturing aids real manufacturing processes and systems and if it is perfected as with information technology, then manufacturing systems and business demands will develop accordingly. In this context, Virtual Manufacturing should be recognized as an advanced information structure of Real Manufacturing Systems,

which integrates available information tools and virtual environment immersiveness to achieve business-manufacturing goals [12].

6. CONCLUSION

After implementation of the VRML maker into the ROANS system, it is possible to represent all 3D automated workplaces with a robot created in the ROANS system by way of a VRML browser, and it is not necessary to have a license for ROANS. This enables companies, which use ROANS system, to communicate better without personal contact even though they may be a thousand kilometres apart. This could save financial resources and extensively decrease the time of workplace designing. VRML maker is an integrated part of ROANS and does not increase the hardware or even the software requirements of the system. It is necessary to be able work in the ROANS system when one wants to work in VRML, because the created data depends on the displaying mode, which is located in the Options menu. It does not need to know how VRML works. The exploration of created scenes is enabled by individual programs (VRML browsers) or by additional programs for existing www browsers such as Netscape Navigator, and Microsoft Internet Explorer (a so-called "plug in"). Introduced browsers and additional software are possible to get on company web pages from the Internet. Hardware and software requirements for scene exploration depend on the software used. This work was conducted with the support of The Slovakian Ministry of Education, through the contract of applied research No. aAV/1107/2004.

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