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ASSEMBLY CONFIGURATION AND APPEARANCE CHANGES IN VRML ENVIRONMENT

Anton Jezernik, Gorazd Hren and Borut Golob

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1. Introduction

CAD systems could be addressed as basic systems in today design process. Due to development process they have developed into very sophisticated tool for modelling 3D objects, highly parameterised and powerful in presentations, analyses and simulations. However, many problems still remain unsolved. CAD is primarily oriented in detail design and 2D drafting output. Visualisation capability of CAD systems is limited and they cannot satisfy the user requirements. They are not providing support in the early design stage although that stage is recognised as the most important for product development with great impact on development and production costs. The old paradigm of using 2D design interfaces for modelling 3D objects is still applied. In the today global market and concurrent engineering domain the data exchange over the Web between participants in the design or in CAPP, CAM process represents another deficiency. Due different user preferences and different algorithms used in CAD systems the incompatibility will continue to exist. The standard exchange formats (STEP, VDA, etc.) do not support the transfer of all functionalities available in CAD systems and moving data between CAD systems remains to be a problem. The problems of global cooperation over Web are reduced with more or less specialised viewers [Mahoney 1999]. With new user-computer interface, Virtual Reality (VR), CAD users and researchers are starting to incorporate new techniques to overcome mentioned weaknesses. The VR techniques enable the performance of functionality tests and verifications in advance what CAD cannot do. The multimedia techniques are supporting the user-computer interaction as well as the dialogue among the users. The VR techniques are used in many applications from different fields [Gomes de Sa 1999][Stjepanovic 1998][Beier 2000].

VR emerged to be a popular technology enhancing a user-friendly human-computer interface in product design fields. With several unsolved problems as representation speed vs. reality outlook, it still presents potential for further development of user-friendly interfaces. The Virtual Reality term is manly used for immersive systems using special IO devices as: CAVE, HMD, BOOM with full-scale stereoscopic viewing of computer generated virtual worlds. The realistic navigation and real-time interactions for manipulation and virtual environment control are provided. The feeling or illusion to be fully immersed in virtual world is fairly realistic. Beside full immersive systems, the semi-immersive systems have been developed based manly on screen projection (virtual tables, CyberSphere). The low level of VR systems are desktop systems using only monitor based viewing of virtual objects. The production of quality virtual worlds requires a considerable amount of design and programming time. Expertise is required in device handling, user interface design, network programming, graphics programming and interaction techniques.

3D CAD models provide a natural way of sharing design information among designers. Unfortunately, in order to share a CAD model among two or more people, traditionally each person is required to have access to a CAD workstation. This is reasonable if everyone involved is working at the same

company and more preferably, if they work at the same or related departments. In practice however, the situation is often different.
Over the past few years the Web or the Internet has been making a big impact on almost all fields of human life all over the globe. Virtual Reality Modelling Language (VRML) is a tool specifically designed for creating 3D virtual worlds on the Web. These synthetic worlds give us the ability to visualize objects on the computer screen almost as if they were in the real world and also view them from all possible angles and directions.
Traditionally, VR systems are separated from CAD systems, and CAD systems outputs geometric data into VR system, that is used as a separated visualisation tool. This forces the use of one-directional data-flow, and makes it hard to feedback some modifications to CAD systems. The integration of CAD and VR system enables interactive modifications in VR system product model improving evaluation while reducing costly physical prototypes.
The research about including VR techniques into design process is heading in two directions: including VR into CAD and including VR after CAD. Following the first, researchers are trying to develop tools to create, modify and manipulate models inside CAD systems with 3D interfaces based on VR techniques and using VE as visualisation and analysing environment as in [Bimber 2000][Gao 2000]. In the second approach, models are created in CAD system and than converted to VR system to improve visualisation and functional analyses of the part or the assembly. The models are converted from CAD and enriched with additional information into 3D virtual environment, but user cannot directly modify a CAD model in the VE. For any modification, user have to make the changes in CAD system, and convert the model into VE again, what leads to very unproductive and time consuming repetitive loop. The description of many such examples could be found over the Web [Beier 200][Beazley 2002].

2. Proposed approach

2.1 Definition of the problem

VR techniques require a significant computer power to provide basic requirements, as viewing and interactions with real-time response. Large companies lack the time and small companies lack the resources required to implement the technology and automation needed to compete in the market place. Desktop non-immersive VR systems features are far from possibilities of immersive VR technologies, but a key advantage in desktop systems are that standardised IT techniques could be used.
In order to integrate the virtual world heterogeneous data sources should be composed. If we go to the system level, that means the association or connection of CAD parts and assemblies for generation of the virtual environment components. If we go to the data level it means converting and processing different data formats. That part of the process is very important and intensive. The process needs to raise precision of appearance and illustration, to raise presentation performance and to reduce the information loss. It has to be pointed out that virtual models are manly-tessellated CAD models, because only a polygonal representation allows fast rendering in a real-time. There are available many standard independent exchange formats for geometry data but only STEP offers standardised way to propagate other product data, beside geometry. The VR systems use different dataflow for manipulating virtual models in real time and converting data into the VR format is maintained differently from the system to the system, manly depending on application [Beazley 2002]. With other words, the conversion is not standardised, and proposals do not exist in this direction, since in applications virtual environments vary severely.
The VR techniques enable interactive evaluation of virtual prototypes in computer world. Due modularity many times in VE only the few changes, sometimes only texture, have to be changed for evaluation. Very often different configurations are performed; one element is swapped with another at the same position in assembly offering the same or slightly different functional behaviour. For such part exchange in the assembly different VE have to be configured and prepared. Creating virtual worlds is still a cumbersome and tedious process and VE should allow the user to experiment and play interactively within virtual world.

2.2 Proposed computer model

The goal of presented research work is to develop and implement a computer model to handle viewing and examination of assemblies in low-level VE, to manipulate with different appearances of the parts and to enable the possibility of changing parts with other parts simultaneously.

Due to the possibilities to exchange the models over the Web and considering other limitations a model has been developed schematically presented in Figure 1. Only standard free-ware tools are used: VRML as standard data transfer and Web browser as virtual model viewer, XML as configuration carrier and Java as programming language.

Virtual models are exported from CAD system via VRML as standard geometry data transfer. The quality and applicability of transferred data differs a lot from CAD system to CAD system. In general, the VRML model is defined in the file in the regular ASCII text format and standard syntax. VRML models have 3D polygonal presentation enriched with functionality and dynamic behaviour that could be interactively controlled by the user. With converting CAD model into VRML the crucial step is performed since that conversion is irreversible. As the VRML representation of a part is a polygonal approximation of the original CAD model it cannot replace the CAD model. The viewing of VRML models is possible through free-ware plug-ins for Web browser. VRML is full of elements for immresive data representation in 3D space, but very short for streaming and multi-user elements.

Models in VRML syntax are optimised and additional entities are included, defining materials, sensors, interpolators, scripts and routes. The combination of VRML and JavaScript creates a very strong tool for developing dynamic virtual worlds and on-line presentation of objects [Turgut 2002]. All VRML models are in VRML models database, the appearance data, scripts, sounds and light definitions are kept in database separately. The configuration of assemblies is defined in separate database in XML files using XML schema technology.

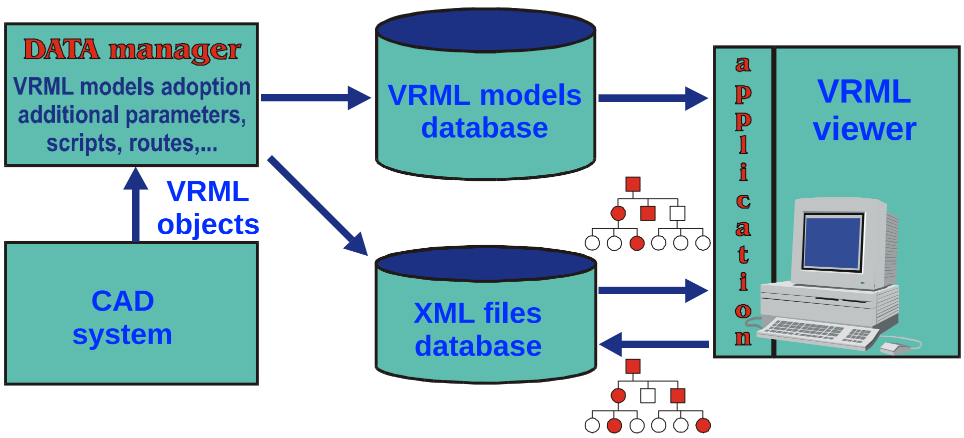

Figure 1. Computer model schema

XML is a Web standard format to define and exchange structured data. XML defines the content and not the presentation of data. Documents are in ASCII code that is easy to define; they basically have a tree-like structure and may contain references. It is constrained to be syntactically well formatted and validated. The main benefit is in a hierarchical structure that is easier to search or rearrange and is very useful for application programming. XML enables the separation of the semantic and presentation of the data. The parsers are easy to obtain and is well suited for data exchange over the Web and for producing output user interfaces in different formats. The assembly configuration and parts, including appearance and behaviour, are very clearly specified as attributes of parts. Typical XML using in application is [Rezayat 2000].

The application written in Java reads the configuration data from XML files database, search for appropriate parts and scripts in VRML database and present it in the VRML viewer (IE browser with Cosmos Plug-in is used), where could be examined. In the application the configuration is presented from XML file through DOM parser as tree using Java Swing coding.

With Java DOM Parser it is possible to read the input file in XML, check formatting and semantic

validity and built and presents a complex hierarchical object structure in few lines of code.
The structure of an assembly is well defined in XML file, including references to parts geometry, appearances and functional behaviour as attributes. The user has the possibility to change attributes or replace parts with others from the limited selection defined in configuration file. The limited selection assures consistency with CAD system database. Changed assembly is rewritten and reviewed simultaneously. New configuration is saved in XML database.

2.3 Working example

As working example a small assembly from ADRIA Mobil Ltd. is presented. ADRIA Mobil Ltd. is one of the leading European producers of motorhomes and caravans. Every market has its own technical regulations, different customer fancies and needs that significantly increase the number of variations of produced models. The competition on the market is very demanding and consequently the companies are forced to improve the quality of the products very often by adding new features or refresh the outlook and the interior design. The evaluation of design properties and geometry in accordance with manufacturing and assembly process is usually possible only with physical prototype production. The optimal arrangement of interior should be achieved due to very limited space and comfort requirements. The main problems of producing prototypes are that require time consuming and expensive work and more important, the production of physical prototype moves the design from computer domain into physical world. After analyses and evaluations are performed the modifications need to be transferred back to computer environment.
In Figure 2, a representative piece of XML file that is created as configuration file for the part of motorhome interior is presented. Every part is described as leaf node consists of three tags: ID definition with adequate attributes, position tag and appearance tag. Attributes in ID definition comprehend the reference to geometry and optionally references to scripts, routes, sensors that are needed for functional description of the part. In the position tag the translation and rotation in main coordinate system is defined. It seems that this tag is redundant and is unnecessary, but it is needed in further development of the application. In appearance tag the reference to material definition is defined. The assembly consist of more subassemblies and parts that are clearly defined in XML file as hierarchical tree definition. It is one more thing that is unusual in our XML file definition. It is possible to notice one more tag ***choice*** with exactly one attribute **c**. That tag means that inside that tag is possible to choose between different elements. It is easiest to explain on appearance tag in the last part described in Figure 2. We have ***choice*** tag with a value of ***c*** attribute equals to 1. That means that between next tags at the equivalent level first is used as reference for material definition. The same system is used for others elements. The tag at the beginning of file extraction defines that in assembly ***Omara*** the third subassembly is selected. That assembly is shown at Figure 3. In VRML models database three different cabinets exist, that could be on the same position: with no doors (Omara0v), with single door (Omara1v) and with two doors (Omara2v). If the value of ***c*** attribute is 3, the cabinet with two doors is included in VRML model file with all definitions: geometry, scripts, and appearance. In two screen snapshots the appearance of elements is clearly different, the lamps and cabinet are different as well including functionality (door opening). The lamps switch is the same in both variants.
We have complete description of the assembly configuration with all possible variations defined in single XML file. In other applications using XML technology the contents of file is rearranged from input XML file, processed with DOM parser to tree structure, with the application the new tree structure is arranged and written to output XML file [Johnson 1999]. We use single XML file, where only the selected elements are. Application enables to change the configuration and properties of the virtual environment and perform analyses and evaluation simultaneously. Objects properties (appearance, material) and assembly configuration is possible to modify via limited selection of exchangeable parts and subassemblies including their functional behaviour (simulations, sound, etc.). The limited selections of exchangeable parts are necessary due consistency of databases.

```
    ...
 - <Omara>
   - <choice c="3">
     - <Omara0v>
     ...
       </Omara0v>
     - <Omara1v>
     ...
       </Omara1v>
     - <Omara2v>
       ...
       - <VrataD GEO="GEO_Vrata.txt" SCR="CS_VrataD.txt" ROUTE="R_VrataD.txt">
       - <Poz>
           <translation x="500.0" y="1557.0" z="-687.0"/>
           <rotation x="0.0" y="0.0" z="0.0" ang="0.0"/>
         </Poz>
       - <App>
         - <choice c="1">
           <plast.blue file="PLASTBLUE.txt"/>
           <plast.red file="PLASTRED.txt"/>
           <wood.sen file="WOODSEN.txt"/>
           <wood.ash file="WOODASH.txt"/>
           </choice >
         </App>
       </VrataD>
   - <Omara2v GEO="GEO_Omara2v.txt">
     - <Poz>
         <translation x="465.1" y="1381.0" z="-744.0"/>
         <rotation x="0.0" y="0.0" z="0.0" ang="0.0"/>
       </Poz>
     - <App>
       - <choice c="1">
         <plast.red file="PLASTRED.txt"/>
         <wood.ash file="WOODASH.txt"/>
         </choice >
       </App>
     </Omara2v>
   </izbira>
 </Omara>
```

Figure 2. An extract of XML configuration file

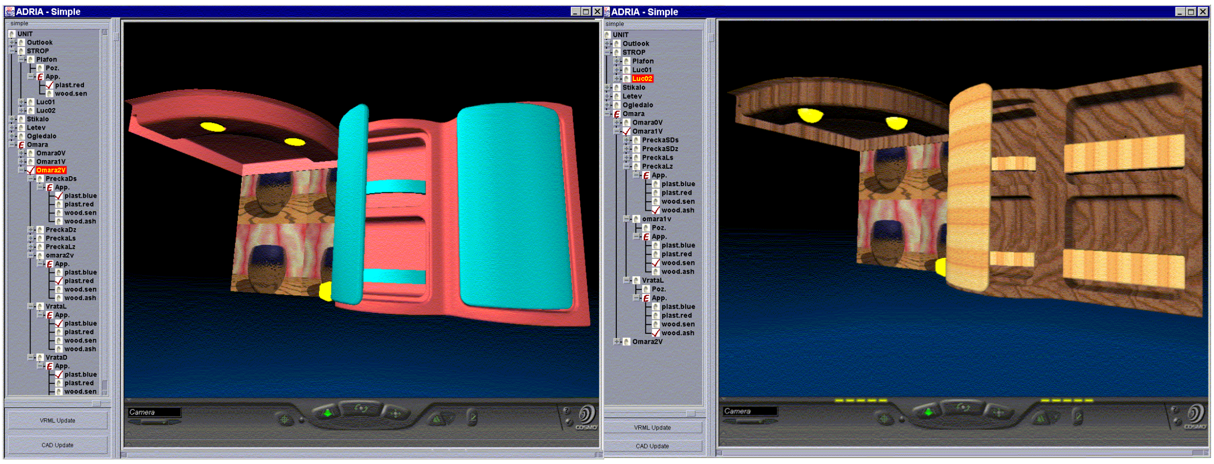

Figure 3. Screen snapshots of two different configurations from single XML file

3. Conclusions

Because of competitiveness and cost reduction the time and resources needed for developing a new product are nowadays essential in industry. For that purpose the computer models of user ideas about design objects are created and outlined in CAD systems. Before the manufacturing process a design object should be verified that all construction constrains are obeyed, what could be very easy or time consuming and expensive process depending on the object. As an alternative for physical prototyping and testing more and more a computer techniques are used to present ant test the functionality of the object. VR is recognised as technology at the moment that can offer to the user to see and explore new products or concepts before they exist in reality in more realistic manner. The costs involved in Virtual Prototyping are often essentially smaller than doing a similar test with real prototypes.

The main benefit of using XML technology is in a hierarchical structure that is easier to search or rearrange and is very useful for application programming. The model enables generation of virtual environment for viewing and evaluation of the functionality in standard VRML browser. The application reads the configuration from XML file, generates virtual environment for evaluation, and enables the change of the configuration from limited selection of options. The problem is to find the balance between different program languages, as VRML is event driven and Java procedural. The adequate control of the scene and events is crucial for the application speed and efficiency. The time driven events and scene maintain are easier controlled in VRML, programming the access to database is in program languages domain.

The paper presents first part of ongoing research where same further progress is soon expected. That research is going in two directions, transfer of the application to Web (server side) and propagate changes from virtual environment to CAD system.

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Prof. Dr. Anton JEZERNIK
University of Maribor, Faculty of Mechanical Engineering
Smetanova 17, 2000 Maribor, Slovenia
Phone: ++386 2 2207690, Fax: ++386 2 2207994
Email: anton.jezernik@uni-mb.si