

Developing Virtual Residential Area using Virtual Reality Modeling Language and Virtual Reality Tools

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Abstract— Virtual reality is one of the most developing parts of computer science and engineering. It has opened the door of new possibilities in the field of computer science and engineering. It is also currently being examined for practical use in various industrial fields. One contribution of this paper is that it provides a real example of virtual reality in industrial applications which may encourage the scientists to develop virtual reality model. The paper also discusses shortly about the current use of virtual reality tools, their uses in various sectors of science and engineering and proposes theoretically an application of virtual reality system for developing residential area. One programming language, virtual reality modeling language is presented in development of computer visualization tools for the system. By using high resolution display, three dimension computer graphics, and interactive device, a virtual world can be realized in which imaginary objects created by VRML can be picked up as if they are in real world.

Keywords—Virtual Reality(VR); Virtual Reality Modeling Language ; VRML 97; Virtualization tool; 3D Object

I. INTRODUCTION

The term Virtual Reality (VR) has been defined by different researchers with many meanings [1-4]. There are some people to whom VR is a specific collection of technologies such as Head Mounted Display (HMD), Glove Input Device and Audio. Some other people stretch the term to include conventional books, movies or pure fantasy and imagination. Myron Krueger [5] defines VR's instructional value saying, "...the body can be employed as a teaching aid.... The theme is not 'learning by doing' in the Dewey sense, but instead, 'doing is learning'...". Virtual reality has opened the door of new options for science and engineering learning. It is also currently being examined for practical use on various industrial fields such as computer graphics, CAD, CAM, CIM, robotics, medical care, multimedia, games, and so on. Virtual reality consists of different techniques and tools for generation of virtual objects and scenes that simulate real system. The main feature of virtual reality programming languages is their ability to generate virtual representation of physical systems on a computer display. Virtual reality has made it possible to illustrate intricate, exclusive or hazardous system safely on a computer screen. It also made it possible to easily generate virtual model of a real system [6]. In recent years, many graphics capabilities tools have been developed, especially in

the development of virtual reality display that can be a great support in learning and experiment.

Newly came out virtual reality technology are giving scientists and engineers new ways to analyze data that is changing the direction of imagination. This new idea gives scientist a chance to gain intuition and close to the complex physical process. Virtual reality modeling language is a graphical system that creates views of three dimensional images, changes as the viewer's angle and position change [7]. It can be used to create a virtual world that appears to be realistic. It is very growing technology and widely used in games for educational application. As day by day computer technologies becoming sophisticated, virtual reality systems can allow users to perceive products in very realistic way. New products are designed with 3D-CAD system which made volume models are available throughout the complete development cycle and can be used to assemble the configuration of the products for distinguishing difference between models, to compare with different models, or to find weak points in order to serve better product. As a result virtual model often replaces physical model.

This study proposes a virtual model of a city for planning new city where objects are created by virtual reality modeling language. Before planning or development of a new city, virtual environment is necessary, because yet no method has been established to communicate among the specialists during design process, and it cannot be possible to create a city for examine. Moreover, no method has been established yet to evaluate facilities [8]. As to meet these challenges, the proposed system provide an virtual environment where specialists cooperate in city design as well as enabling citizens to experience and evaluate the virtual area . After reassemble the tools, the new model can be compares with the old one to identify the faults or weak points in different models. This paper summarizes the development of a VRML image of a virtual residential area and provides a virtual environment where specialist and citizen can interact. It also serves as a planning tool. In implementing visualization tools, VRML97 has been used that can create three dimensional solid model. Complex simulation can be made possible by creating representation of objects and defining behaviors in the scripts.

The paper is organized in five sections. The next section II discusses a brief about virtual reality modeling language and their applications. Section III presents the development of the proposed model. This section falls in two sub section, first one is developing of virtual model and the second subsection is providing a virtual environment. The summary of the work has been discussed in section IV, and finally the conclusion of the paper is presented in Section V with limitations and direction for future investigations and research.

II. THE VIRTUAL REALITY MODELING LANGUAGE (VRML)

According to Rikk carey “virtual modeling language is neither virtual reality nor a modeling language. Virtual reality generally implies an immersive 3D experience, which typically requires a head-mounted display, and 3D input devices such as digital glove” [9]. VRML mainly serves as a 3D interchange format. It is commonly found in 3D applications such as hierarchical transformations, light sources, viewpoints, animation, fog, material properties and texture mapping. Virtual reality modeling language makes available the technology to integrate 3D, 2D, text and multimedia into a coherent model. These media types combine with scripting languages and internet capabilities to produce a new type of interactive application.

The first VRML 1.0 create from “Labyrinth”, 3-D web interface, developed by Mark Peske and Tony Parisi in 1994 and In 1997, VRML 2.0 was stated as an international standard, VRML97 [10]. Finally in 1999, the web3D consortium joins the E3D as the next generation VRML2002 ISO standard that is fully compatible with VRML97 content and based on XML. It was said earlier that, VRML files describe 3D objects and worlds using a hierarchical scene graph. In the scene graph, the entities are called nodes and VRML defines 54 different node types including geometry primitives, appearance properties, multimedia objects and various types of grouping nodes. Again the nodes store their data in fields, and VRML defines 20 different types of fields that can store from a single number to an array of 3D rotations [9]. Basically VRML scene graph is a directed acyclic graph where nodes can contain other nodes and may be contained by more nodes. It is easy to create large worlds or complicated objects from subparts using this scene graph structure. Figure 1 shows very simple scene graph of one node in VRML97 that generate a red sphere [9]. Here `#VRML V3.0 utf8` is a header, `shape` is a root node which has two fields: `geometry` and

```
#VRML V2.0 utf8
shape{
  geometry sphere { radius 3.0}
  appearance Appearance {
    material Material {
      diffuseColor 1 0 0 #red
    }
  }
}
```

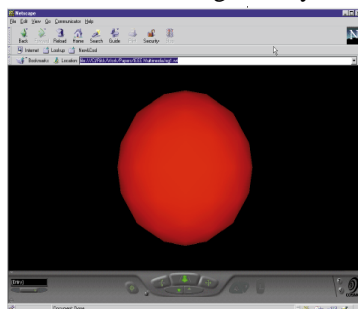


Fig. 1. Sample VRML code to generate a red sphere and screen shot of output generated by the code.

appearance. *Geometry* node *sphere* is one of the nine geometry nodes in the VRML. Again *appearance* field defines an appearance node, and was designed to add new types of appearance nodes later. It can specify several appearance properties that can be applied to the geometry node.

VRML provides a rich collection of primitives that are called nodes used for creating the worlds. Geometry nodes generate the visual appearance in VRML. There are ten geometry nodes in VRML such as *Box*, *Cone*, *Cylinder*, *ElevationGrid*, *Extrusion*, *IndexedFaceSet*, *IndexLineSet*, *PointSet*, *Sphere*, and *Text*. VRML element consists of eight grouping nodes and they define a local coordinate system for their children nodes [9]. The nodes create hierarchical views and maintain particular grouping behaviors. Again, grouping nodes, such as *Group* and *Transform* nodes allow the explanation of a collection of object that may be manipulated as one. The scale, position and orientation of component objects are set by the fields of the transform node. The *IndexedFaceSet* defines an object defining the surface of the object. The *Extrusion* node work by the similarity that, a material through a changing cross section defined by a series of points in space. The *ElevationGrid* defines a surface on a regular grid. Sensor node includes *TouchSensor*, *PlaneSensor*, *CylinderSensor*, *SphereSensor*, *ProximitySensor* and *TimeSensor*. The *TouchSensor* senses the existence of mouse. It also identified whether the mouse is over an object or if the mouse has been clicked over an object. The *PlaneSensor* follows the mouse position along a plane, used in drags and drop planar translations of objects. Again *CylinderSensor* and *SphereSensor* are also used for drag and drop rotation of objects along an axis. The *ProximitySensor* can detect user avatar within a particular area or not. *TimeSensor* can generate timing events that are used in animation [10].

Anchor characterizes *childs* as a hyperlink to a uniform resource locator and billboard automatically rotates its descendants to face the viewer. Beside VRML 97 describes a message passing mechanism which enables nodes to communicate with each other. *ROUTE* statements offer the event path between event generator and receivers. Nine sensor offer the built in user interaction primitives for VRML. *ROUTE* statement combines sensor nodes and other nodes to apparently affect a scene [9]. A *ROUTE* statement names the node and *EventOut* field which generates the event and links this to the occurrence node and *EventIn* field. Custom methods emerge in Script node, and this node may hold the state of the script. *EventIns*, which receive events from other nodes and *EventOuts* send events to other nodes. Scripts are implemented using ECMA scripts or Java classes. ECMA scripts, which are descendent from *JavaScript*, can be used to add dynamic abilities to ordinary web pages. Scripts allow the world creator to define arbitrary behaviors. Scripts nodes can be placed between event generators and event receiver. Interpolator nodes that are built on scripts, perform simple animation calculation combine with a time sensor and some node in the scene graph to make objects move or change. VRML also includes a prototyping method for encapsulating and reusing a scene graph. To define user defined nodes, the *PROTO* declaration is requires. *PROTO* consists of collection

of nodes that are part of the VRML standard, and an interface definition. Again *EXTERNPROTO* declaration permit the prototype to be defined a separate file. More over, it allows straight forward reuse of a custom defined node [10]. VRML 97 offers two primitives that cause a single VRML world definition span the World Wide Web.

A. Application of VRML in Various Sector

In education sector, VRML has wide verity of applications. Virtual solar system used by the national geography society is an example of virtual reality in science education [11]. The location of planet, relative orbits, their colors, rings and orientation, and many other features of the solar system can be visualized by the system. Anyone can view Saturn from the opposite side of its largest mood Titan. In chemistry, virtual reality can also be used in teaching. James Krieger stated “VRML (*pronounced vermal*) hold the promise for chemistry of literally ratcheting up the internet information revolution to another dimension. VRML is the three dimensional analog of HTML. And chemistry is inherently three dimensional” [12]. In biology, virtual reality modeling language can be used to represent various systems from cells to organs with animation. Tomaz Amon has constructed a virtual model “*Cell-tissue-Body Explorer*” which is educational aid for teachers and student of biology or medicine [13]. The model consists of drawing, images, and virtual reality world that enhance the understanding of biological structure. In mathematics, integration over a surface area or over a volume can be deterring in certain shapes [6]. The volume of integration can be visualized in 3D space using VRML.

In teaching robotics, virtual reality provides an impressive modeling and simulation method. Real robots are expensive where a virtual robot is inexpensive, safe, and available for experiment to several students simultaneously. Thurmond and Dezewiecki have presented that virtual reality modeling language provides an easy way for geoscientist to construct complex visualization [13]. There are also few other virtual reality systems, some of them are for commercial use and remaining for academic purposes.

III. PROPOSED MODEL

The virtual residential area presentation system is a distributed system where virtual reality can be practiced. The system consists of virtual reality workstations with a computer system based on clustered workstations interconnected through a high speed network. It provides an outline whereby developers and citizens can participate in the process of developing a virtual residential area. There are many computer based 3D graphics authoring tools that are easy to use and effective in the narrative of 3D objects. Such a tool Spazz3D [14] can be used in implementing this system. The whole working process falls into two steps:

1. Development of efficient visualization tools and
2. Providing a virtual environment where specialists and citizen can interact to develop a virtual city.

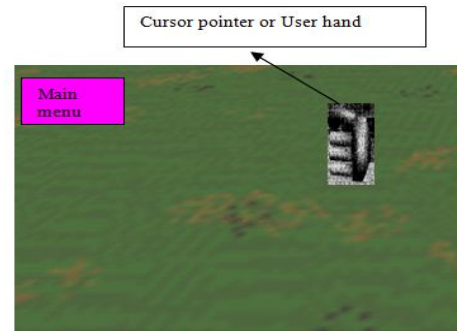


Fig. 2. Visualization screen at the opening

A. Development of Visualization Tools

To create a virtual model with direct VRML, VRML writer software can be used. A general model can be created with a VRML writer and refined by direct VRML coding. Then creation of user interface using a graphical programming language for collection of user data and its insertion into VRML file.

Operations for visualization: The visualization is designed to operate in a perceptive way. To make easy the operation, a menu hierarchy is built which gives the user to access the full functionality of the tools. There are also guidelines for user that guide the user through a command sequences. Object handlings are designed to be intuitive. It prompt the user for required input and showing the user controls when object geometries are modified. Figure 2 shows the first view when user runs the system. Here menu serves as the primary user interface. To select a menu option the user moves the cursor using data glove develop by Thomas Zimmerman [15] can be used. Menu operations include a full routing through the menu structure as well as a menu path that moves the user across the menus. User can add different object such as building, road from the menu button. Again they can also modify the structure of the object. Different objects can be added by selecting the object and selecting the place. Figure 3 shows the block diagram of organization of menu operations.

Organization of objects: To organize the objects require communication of four components such as menus, objects, arbitration, and resource allocator in the visualization. The

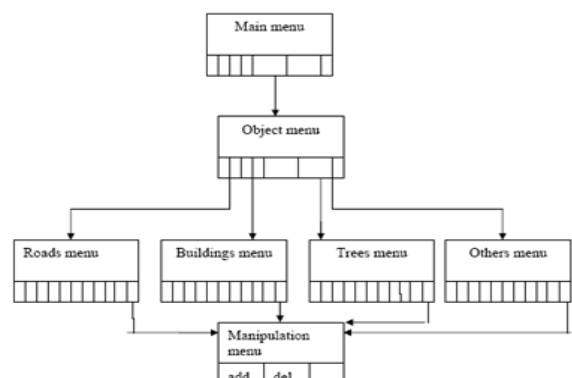


Fig. 3. Organization of menu

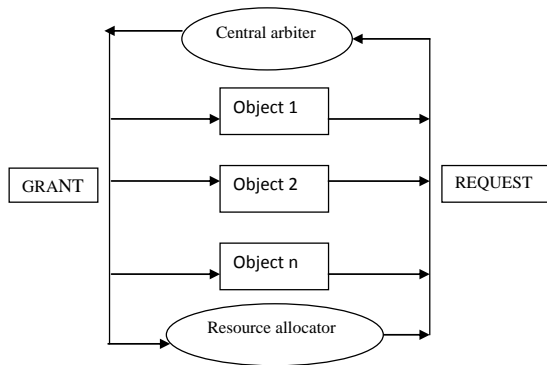


Fig. 4. Object arbitration

menu hierarchy is build from a collection of menu geometries. One menu will be visible at a time and other menus will be invisible. To accomplish the organization, every class of object is assigned in the same class identifier. As a result, when an object is selected the appropriate menu is become visible. Menu controls the visibility of the menu below it in the hierarchy. The user will able to move up the menu hierarchy through the connection between child and parent menus in the hierarchy. Object manipulations include changing position, changing direction, or may be changing geometry. At beginning, the position of the object is identified by selecting the location. After adding an object from the object menu, it can be moved to any position. The rest of the manipulations are geometry specific. Geometries can be modified only by dragging and selecting the control.

In the visualization menu, hierarchy and the editing context are shared among the objects. When resources or contexts share parallel process, then arbitration is required. In this process, each object is assigned a unique serial number. A centralized arbiter receive request from all objects and transmitted grant to all other objects. When an object is selected, it communicates along with its serial number through its request index to the central arbiter. The central arbiter first connects with the current object and frees the resource. Moreover, for effectively utilize machine resources; the objects are created dynamically which will give better performance. Figure 4 shows how objects request for resources to central arbiter. We can implement a mechanism to allocate all objects dynamically using VRML. VRML provides two methods for creating dynamic objects. For simple objects *CreateVrmlFromString* [17] method, and for complex objects *CreateVrmlFromURL* can be employed. The method consists of three arguments. The first argument is the URL for the object, second and third arguments are the nodes that receive the new object. The recipient node is a script that add object to the visualization. When object is added to the visualization, events are automatically sent to the object customizing for the initial condition. As the project will be in static visualization geometries environment and the geometry changes are simple animation, VRML 97 can be used. Because VRML 97 is quite healthy and well defined when geometry changes are simple animation.

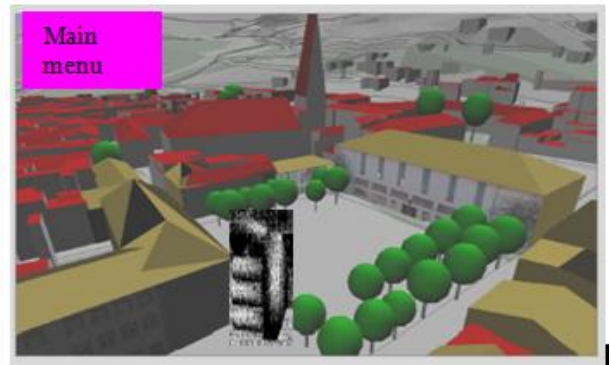


Fig. 5. Primary virtual model of the city with top view [16].

B. Providing VIRTUAL environment

To provide a virtual environment, technique stated in [6] can be followed and can also be added more features. The system includes a domed screen, six stereoscopic projector, graphics computer, liquid crystal shutter glasses and magnetic sensors. The domed screen is 6.8 m in diameter, six forward projection type projectors that present a wide view of a VR world. In the proposed model, user first built a virtual city using virtual reality tools described in the previous section. Figure 5 shows an example of top view of virtual city developed by virtual reality tools. User will see the top view or 45 degree angle from the top view. Users have option to add or delete any object. In the next step, user can see the front view just like real view. Figure 6 shows the virtual environment from the front view. In this environment, human model is invisible but pressing left, right, front and back button, user can move like car race. There are no fix positions for the user in this environment, but in a limited area user can move. The system also provides previously generated model and its components. A standard assessment is shown on the top left side of the screen. This allows user to change the model configuration through selection of the object and selecting the place.

To test different object, users are able to change the actual objects quickly. For this purpose, two cases will be applied. First case is when an object is already installed, and the users want to replace it with an alternative object. The system will find alternative of objects, if they are any, and presents them on the lefts side on the screen. To place them, the system puts

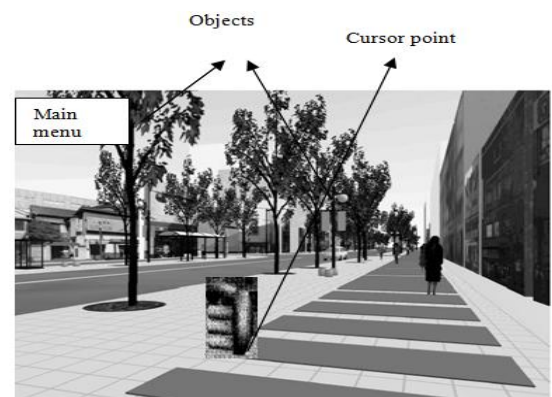


Fig. 6. Virtual environment from the front view

them in a line. If there are many alternatives, a shelf unit is used to display them. On the other hand, a conveyor belt can be used if there are too many alternatives in a shelf unit. For example, user wants to change the color of a building; he or she can change the color by selecting the building. When he selects the building, the building menu will appear in the screen and can change the color by choosing the color from the menu. The second case is, if user wants to add another component. For example, user wants to add a passenger shed; selecting the main menu, he can add an object. Due to demanding for maintaining the visualization of the objects additional information, such as the description of the objects, can be displayed in the screen so that objects can be placed in suitable places.

IV. DISCUSSION

In real world, it is very hard, or sometimes impossible to change or modify a city when it is completed. But before developing a real city, if we can visualize a virtual form of that city, we have more options to change and modify. It is impractical to produce a residential area for a test basis. To provide solution to this problem, virtual residential area based on virtual reality technology will allow creation of a virtual environment. It helps many specialists to cooperate in city design and evaluation as well as simultaneously enable citizens to experience and evaluate the virtual city. A theoretical model has been proposed here. The implementation of the model highly depends on development visualization tools and providing an environment. In development of visualization tools, different operations in visualization and how to organize the objects have been discussed here. To make easy the operation, a menu hierarchy is built in the visualization which provides user to access the full functionality of the tools. There are also guidelines that guide the user through a command sequences. User can add different objects such as building, road from the menu button. Again they can also modify the structure of the objects. Different objects can be added by selecting the objects and selecting the places.

The second step is to provide a virtual environment, where user will use a head mounted display, and data glove to interact with the environment. The virtual environment can be shown in two different view- top view and front view. The top view has shown the figure 5 and the front view has shown in figure 6. To test different object, users are able to change the actual objects quickly. The system will find alternative of objects, if there is any, and presents them on the left side on the screen. To place them, the system puts them in a line. If there are many alternatives, a shelf unit is used to display them. On the other hand a conveyor belt can be used if there are too many alternatives in a shelf unit. Due to demanding for maintaining the visualization of the objects additional information, such as the description of the objects can be displayed in the screen, so that an object can be placed in suitable place.

V. CONCLUSION

Day by day virtual reality is exploring new features for human relaxation. Education in every sector can be greatly enhance and facilitated by the use of virtual reality. A virtual model is very effective to find faults and can be modified again and again which is cost-saving. This article proposes techniques to develop a virtual model of residential area where specialists first built a model and interact with the citizen to discuss about the model; they can change or modify the model. A programming language, Virtual reality modelling language, VRML 97 has been used. VRML 97 is a programming tool that can create three dimension objects and can interact with the user commands and input to produce efficient models, and simulation of real systems. If the model is practically implemented, government, developer and the citizen will be benefited. The short coming of the proposed model is that, incapability to save every session in the visualization. Future work includes implementing tools for the visualization as well as implementing a server that will save the operations done by the different users to use in future.

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