

Virtual Robot: Virtual Becomes Reality

N. Mohamad¹, S. A. M. Yusof² and R. C. Mat²

¹ *Virtual Reality Innovation Centre (VRIC), School of Information Technology
Universiti Utara Malaysia, 06010 Sintok, Kedah, Malaysia*

² *School of Information Technology,
Universiti Utara Malaysia, 06010 Sintok, Kedah, Malaysia*

Abstract - One of the benefits that education reaps from Virtual Reality (VR) is the ability to visualize, simulate and interact with virtual objects. This ability allows the students to have the trial and error session before actually practicing it on real things. Here comes to the point where the idea of having virtual robot in assisting students learning emerged. Instead of studying the physical robot in class, students can study the virtual robot on computer at home prior to class or even in the class itself. Students can immerse themselves in this digitized world; experience the sense of moving and becoming part of the robot system. This paper presents the methodology for the whole-robot 3D graphics design, integration between the object modeling to VR, and the construction of real-time behavior and interactivity modification to accommodate changes in the virtual environment.

Keywords: Education, Virtual Reality, Virtual Robot.

1. INTRODUCTION

With the advent of the 21st century, robots have come of age. Though initially and most commonly used in the automotive industry, robots are also at work elsewhere, performing such tasks as material handling, spot welding, arc welding and coating applications. Hundreds of thousands of robotic work cells are now in operation worldwide. As application of robots extend to everyday human life, new approaches to simulating interactions between them and their environment are emerging at the intersection of physical and virtual worlds. -Virtual Robot

The capabilities of virtual robot represent a significant contribution to the virtual world. For example, visualization and interaction to the dynamic simulation of virtual robot provides special insight into the real-world behaviors of a physical robot system hence producing potential applications for virtual prototyping, animation, surgery, robotics, cooperative design and education.

The challenge with today's education system is to provide a better education environment hence to produce better students' performance. New emergence 3D technology provides an alternative tool in assisting our education system. VR, declared as the next step technologies after multimedia is believed to give a great impact in educational system as it provides

alternative tools for teaching. With it enhances features it could be a turning point where it gives a new interesting and exciting environment that could motivate students' learning and interest in particular subjects.

The term 'virtual reality' is used to describe a technology that enables interactive real-time viewing, makes the world on the window look real, sound real, feel real [1]. It is a human-computer interface where the computer and its devices create a sensory environment that is dynamically controlled by the actions of the individual so that the environment appears real to the participant [2]. VR lets you navigate and view a world of three dimensions (3D) in real time, with six degrees of freedom (d.o.f). In essence, a virtual reality is clone of physical reality [3]. VR, in many ways has created an opportunity towards assisting and enhancing the educational process and techniques. One of the characteristics that VR provides is *constructivism* hence enables to create 'learning by doing atmosphere' [4].

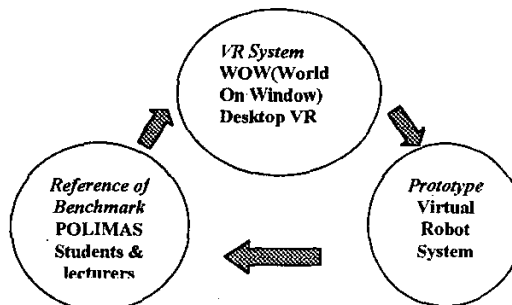


Fig. 1. Scope of the research summarized in a diagram.

The scope of the research is shown in Figure 1. This research will put forward the idea of using VR as a teaching and training tool in robotics, by first building the prototype of visual robot arm by using the Virtual Reality Modeling Language or VRML and finally to evaluate the outcome as a means to facilitate robotics courses. The project will use an affordable, non-immersive VR system. It allows user to navigate and interact with a 3D computer-generated display by using a conventional desktop system. Further in this research, the test on user performance and the cognitive effect by POLIMAS (Politeknik Sultan Abdul Halim Muadzam Shah, Jitra) students and

lecturers after using the virtual robot system will be analyzed.

2. METHODOLOGY

2.1 Model Creation

The objective of 3D graphical design is to produce a real representation of the physical robot system in a virtual environment. The object to be modeled in this research is the PanaRobo KSV20 robot. The software used to model the virtual robot was 3D Studio MAX. The development process starts from building the shape from standard primitives solids, mapping suitable texture to the object and modifying the standard shape by using the modifying tools available in the command panels and toolbar. The figure shown below is the rendered 3D model generated in 3D Studio MAX (Refer Fig.2).

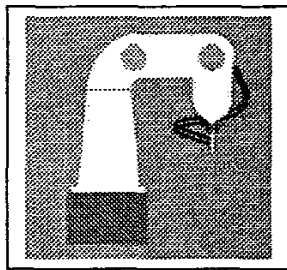


Fig. 2. PanaRobo KSV20 in 3D Studio MAX.

Primitive solids – simple objects like spheres, cylinders and boxes together with texture maps were used to build the 3D robot. The texture of the 3D robot is mapped from the original texture of PanaRobo KSV20 robot.

Modifying – In order to get the exact shape to mimic the physical robot, operations like Boolean, Mesh, Taper and Bend were applied to the primitive shapes.

Virtual environment was built by first identifying objects that have well defined roles and identities in the interface. It involves identifying potential objects mentioned in the interface description and distinguishing between virtual and physical objects. Virtual objects are those entities that need to be modeled and generated by the computer. In the virtual robot system, the data element involved is 3D presentation of the robot link and the end effector.

Before designing the virtual environment for virtual robot system, the data elements were identified. Data elements function as an enabler communication between VR interface and entities that are external to the VR system. The goal is to identify data inflows coming into the VR interface.

The interface receives data from three sources;

- a) User,
- b) Physical devices and

c) Other VR system.

The user is referred to the students and physical devices referred to the mouse and keyboard. Other VR systems were the external file inserted in the main virtual environment.

2.2 Integration

After the model of virtual PanaRobo KSV20 was constructed, the 3D model is exported into the VRML 2.0 file format. This task is made possible by 3D Studio MAX as it has the capability to export MAX file to WRL file. It also has the capability to import WRL file to MAX file. In order to view the WRL file, the user need to install VRML browser. For this research, Cosmo Player 2.1 plug in was used to read and render the VRML file.

The current process of translating from 3D Studio MAX into VR is normally a two-way process shown in the diagram below (Refer Fig.3). Before exporting the model into VR, camera target was added to the model so that it is visible to the user when rendered in Cosmo Player.

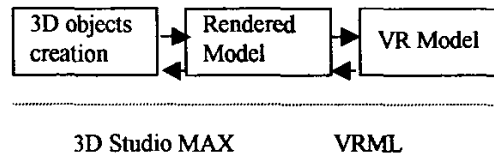


Fig.3. The current process from 3D Studio MAX to VR is a two-way process.

The virtual robot was then viewed in Cosmo Player. Inside the virtual world, the virtual robot seems to have problems with smoothness of the shape. To make it smoother, more polygons were added on the model modified in 3D Studio MAX. When this was done, it was rendered again and this time the rendering takes a longer time than the previous one because more polygons have to be counted. In order to get a better rendering time, fewer polygons were used.

2.3 Interactivity & Behavior

Inserting interactivity and behavior to the virtual robot will add more realism to the virtual environment. These features were the values of VR that extends from text and picture display only. The steps taken to create behavior to the virtual robot were:

- a) Identifying behaviors from the description of the physical robot
 - The PanaRobo KSV20 movement was recorded by a digital camera upon the visit to POLIMAS. The movements involved rotary motion by the robot link and the pick and place behavior by end effector.
- b) Classifying the behaviors into simple and composite categories
 - Simple behavior is categorized as the basic kinematics for robotics motion which is the forward and inverse kinematics of the robot links.

c) Composite behavior, specify sequences in which simple behaviors are to be combined for producing the composite behavior.

- The task of this robot is to pick and place object. It combines kinematics motion plus grip and place action by the end effector.

After the 3D model of PanaRobo KSV20 is converted into WRL file, it was then opened in Cosmo World editor for the scene to be edited and for the interaction and behavior to be added to the 3D robot. VRML pad editor was also used to add or edit behavior/interaction to the virtual robot.

The first behavior added to the virtual robot is the Planar motion of the robot base. Adding PlaneSensor node to the robot base gave the appropriate motion. It allows the robot to be moved in a straight path in 3 dimensions. Then each link is added with CylinderSensor node for the link to move in rotary motion.

The user through a simple mouse interface can interact with the robot inside the virtual environment. Dragging one part of the robots arm moves the appropriate joint. In general, the user was guiding the robot in 'Joint Space' [5]. Taking the hand you can move the tip of the robot link in any Cartesian and any orientation in its workspace. Robotics people call this 'Motion in Cartesian Space' [5]. The problem during Cartesian motion is to make all joints follow in the right manner. This is solved by calculating the Inverse Kinematics, which is implemented in the virtual robot system using vrmlexport.

Example of VRMLSCRIPT:

```
...url "vrmlexport: function
set_multimode(value){multimode=value;}function
pos2mat(thispos){
mat[0]=0;mat[1]=0;mat[2]=0;mat[3]=thispos[0];...
```

3. RESULTS & DISCUSSION

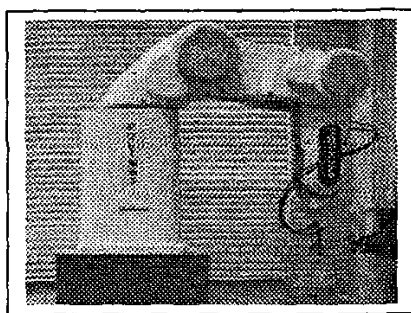


Fig. 4. PanaRobo KSV20 Robot (Courtesy ; POLIMAS)

The Figure 4 shown above is the PanaRobo KSV20 Robot picture taken at POLIMAS, Jitra. This robot was used to teach the Mechanical Engineering students in Introduction to Robotics course.

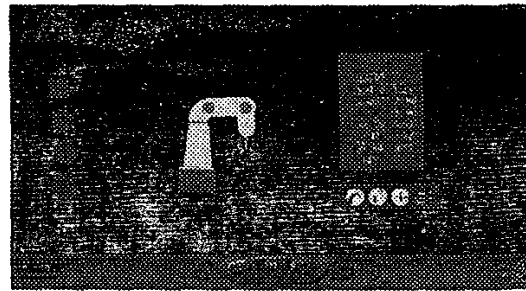


Fig.5. Virtual PanaRobo KSV20 robot.

The virtual robot developed using the VR utilities were shown above (Refer Fig.5). The interaction panel in the virtual environment functions as below (Refer Fig.6):

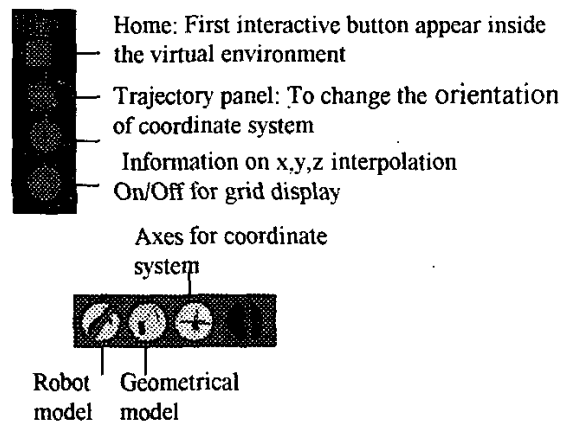


Fig.6. Interaction panel inside the virtual robot system.

The interaction of the individual components and the information flow within the virtual robot system were described in a diagram (Refer Fig.7):

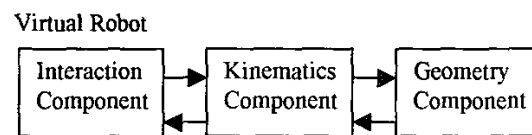


Fig.7. Flow within the virtual robot system.

Geometry component- Contains the diagram of the robot at the display.

Kinetics component- Completes the calculation of the forward and inverse kinematics. Data in Cartesian space.

Interaction component- Receives the interaction between user and the model.

The Cosmo Player plug in also manages some user interaction on their browser. On the dashboard panel, the user can select between different modes of movement (Refer Fig. 8). The movements were described as below:

Go - To move in any direction

Slide - To slide straight up and down or left to right

Tilt – To look up and down or from side to side
 Seek – To move closer to an object
 Redo/Undo Move – To retrace steps
 Control – To switch from one set of controls to another
 Straighten – To straighten the environment

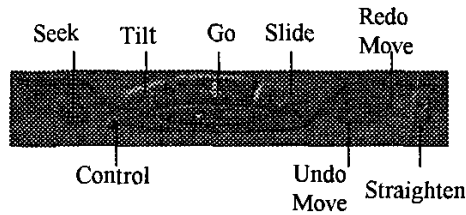


Fig. 8. Cosmo Player dashboard

The virtual and actual PanaRobo KSV20 robot can be compared. In terms of graphics display, the texture mapped on the 3D model did not exactly look like the actual color of the robot. This is due to the stretching of the color pixel to cater the robot model. Other than that, the robot models were in sharp edges and did not look smooth enough like the actual robot. The virtual robot cannot 100% mimic the actual robot but in terms of interaction and real-time behavior, it is a real success for immersing user inside the virtual environment. The sense of moving in planar, cylindrical and rotary motion gives the user experience of the robot system. In this digitized world, users can feel like they were the robot link doing the movement and walking around the environment. The ability to view in 6 d.o.f gives the freedom for the user to view the virtual robot in real-time as if they were dealing with actual objects.

For interaction to seem realistic to a user, the virtual object should exhibit the same simulated physical properties as the real object, including the dynamic of rigid and articulated bodies, along with such mutual influences as those created by the impact forces during contact. Inside the virtual environment of the virtual robot system, user interacts by using the mouse and keyboard button to move the robot in virtual environment. When the link is moved, the information panel will show the position of the X, Y, Z coordinates of the system in 3D space (Refer Fig.9). The user is also able to conduct the behavior of the robot end effector to make it pick and place object by dragging the robot link.

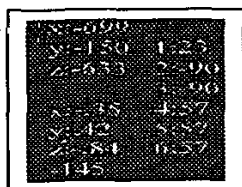


Fig.9. X,Y Z position and angles in 3D space.

User navigation in 3D space is not a simple task. Users may easily loose orientation, either by stepping 'into' an object (e.g. diving into the ground or ending up between two sides of a wall) thus making the reset-to-original-viewpoint the most frequently used one [6].

A more realistic feeling of the scenes can be implemented by adding several levels of collision detection, which affect the camera path and thus meet the user's intuitive expectation of solid objects. In the virtual robot system, collision detection was added to avoid the robot link from stepping into each other links' when the users interact with the virtual robot.

5. CONCLUSION

The virtual robot has been successfully implemented by using VR utilities. The software used for the 3D modeler: 3D Studio MAX, VRML editor: COSMO World and VRML pad make it feasible for the process of developing virtual robot. The virtual robot developed in this research can be enhances with the programming features used for controlling the robot. It could then be integrated with the physical robot and by interfacing; we could control the physical robot from the virtual robot. VR has yet to prove that it can be used to describe objects, places and event in an interesting, interactive and more realistic manner rather than the conventional way where only text and pictures were displayed. Further research on VR in robotics system is relevance in near future to enhance and fully utilize VR application in robotics system.

6. ACKNOWLEDGEMENTS

I would like to thank the School of Information Technology and University Utara Malaysia for their assistance and support, to my colleagues who have the same interest in VR, the Virtual Reality Innovation Centre (VRIC) group.

7. REFERENCES

- [1] Sutherland, I.E. Citing Internet Sources URL http://www.cc.gatech.edu/classes/cs751_97_fall/projects/abowd.E.Sutherland 1963
- [2] Latta, N.John. "Beyond The Vision and The Technology, Research, & Business of VR", in *Proceedings of Virtual Reality '91*, 4th Wave Inc. 1991, pp 112- 133
- [3] Schweber, E.V. "Virtually Here". *PC Magazine*. March 14 (2). 1995
- [4] Youngblut, C. "Educational Uses of Virtual Reality Technology", Institute for Defense Analyses (IDA). 1998
- [5] Rohrmeier, M., Vogel, J. & Hirzinger, G. "VRML 2.0 Robot", Diploma Thesis, Institute of Robotics and Mechatronics, Robotics Systems, German Aerospace Center, German. 1998
- [6] Jucknath, O. & Fellner, D. "MRTSpace- Multi User Environments using VRML". *Proceedings of WebNet96*. 1996