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MODELING AND SIMULATION OF CNC LATHE AND ROBOT OF FLEXIBLE MANUFACTURING SYSTEM USING VIRTUAL REALITY MODELING LANGUAGE (VRML)

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ABSTRACT

The paper deals with the modeling and simulation of elements of Flexible manufacturing System (FMS) - CNC Lathe and Robot using Virtual Reality Modelling Language (VRML). The Elements CNC Lathe Machine and Robot, are modelled in VRML and a scene graph is created which is of static in nature and then all these elements are simulated by using a mechanism called Interpolator nodes of VRML .The Various activities such as loading, unloading, process, move, and store etc are simulated in a virtual environment

KEYWORDS: VRML, CNC, FMS

INTRODUCTION

The virtual reality (VR) technology has been advanced very rapidly in the last decade and has provided the impetus for applying VR to different engineering applications. Object interaction depends on the nature of the operation and the application being simulated [1]. The simulation can be defined as the mathematical representation of the interaction of real-world objects. Real-world objects are turned into mathematical models and their actions are simulated by executing the formulae [2]. Simulations have static and dynamic behaviours. One form of simulation based on dynamic simulation elements is interactive simulation where the user can make modifications during runtime [3].

Many Researchers have worked over the Virtual Reality methods and their applications to solve engineering problems. P. Lorenz, H. Dorwarth, K.C. Ritter and T. J. Schriber [3] describes, basic approaches toward achieving Web compliance for S&A software, specific components for potential use in an open platform independent simulation environment for the Internet or for corporate Intranets. Requirements for a Web Based Simulation Environment (WBSE) are also discussed. Robert Lipman and Kent Reed [4] describes the use of VRML in construction Industry Applications, The modeling of steel structures and construction equipment as objects for inclusion in construction-site world models was studied. The ultimate goal of this was to provide three-dimensional web-based technologies for managing, accessing, and viewing construction project information. R. Stiles, S. Tewari and M. mehta [5] relate an immersed interaction approach for interaction at a distance and directly with VRML 2.0 objects, and an implementation. Refinements or cautions for those VRML 2.0 node types that can be interpreted differently in an immersed setting are also discussed. Ulrich Klein, Thomas Schulze and Steffen Straßburger [6] describes work with distributed traffic simulation based on the High Level Architecture and the lessons learned from enhancing classic simulation and animation tools for HLA and first HLA prototypes. They also elaborates on the additional flexibility that architectures for distributed simulation offer, focussing on the dynamic integration of information relevant to the overall simulation into the dynamic event space.

METHODOLOGY

The methodology involves the modelling of CNC Lathe machine and Robot, These elements are then arranged in a suitable FMS layout so that a scene graph is created. This scene graph is static in nature i.e. the elements do no have any kind of movement. The elements of the scene graph are then provided a mechanism of communicating with each other, which results in a simulation of the various operations such as load, unload, process, move and store. The whole of the process of work is divided into the following steps:

Modelling of CNC Lathe

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The modelling of 3d Objects can be done by using different methods, such as using the dedicated 3D CAD software packages (Pro-engineer, Ideas 3D-Max, Solid – Works), Programming Language (VRML) are widely available. The author has used modelling of NC Lathe machine and Robot element of FMS using Ideas software from Structural Design and Research Center (SDRC) due to its exportability to VRML, and using VRML.

The CNC Lathe Machine consist of the following parts: (i) Head Center (ii) Tail Center (iii) Base (iv) Spindle & Chuck (vi) Cross Slide (vii) Tool Post (viii) Tool. The Head Center, Tail Center, Base, Tool and Floor are modelled using the standard CAD Package, IDEAS and then this are exported to VRML file, the VRML file is then opened in VRML browser/ Plug-in. The Spindle & Chuck, Cross Slide and Tool Post are modelled using VRML. All this parts of lathe are then assembled in VRML to form a complete Lathe machine. The Figure from 1 to 5 shows all this parts.

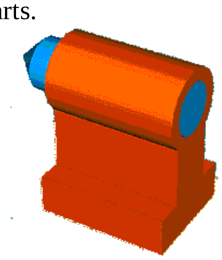

Figure 1: Lathe Tail

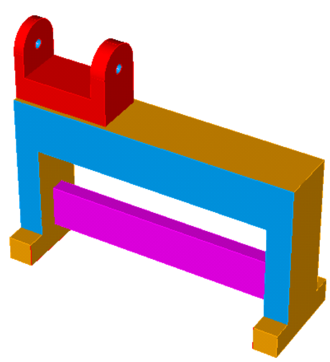

Figure 2: Lathe Base and Head Center

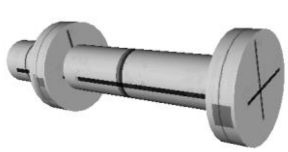

Figure 3: Lathe Spindle & Chuck

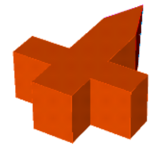

Figure 4: Tool

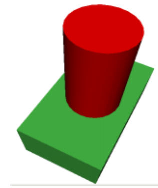

Figure 5: Cross Slide & Tool Post

A sample program for the modeling of spindle and chuck is given below.

```
#VRML V2.0 utf8
DEF T Transform {
children [Transform { rotation   0 0 1 1.57
children Shape {appearance Appearance {texture ImageTexture {url ["Image.jpg"] } material Material {diffuseColor 1 0 0 } }
geometry Cylinder {
height 0.03,
radius 0.01,
bottom TRUE,
side      TRUE    }}}
Transform {
rotation   0 0 1 1.57,
translation 0.02 0 0,
children Shape {appearance Appearance {texture ImageTexture {  url  ["Image.jpg"]       }   material Material {diffuseColor 0 1 0 }     }
geometry Cylinder {
height 0.01,
radius 0.02,
 bottom TRUE,
 side      TRUE    } } }
Transform {
rotation   0 0 1 1.57,
translation 0.06 0 0,
children Shape {appearance Appearance {texture ImageTexture { url ["Image.jpg"] } material Material {diffuseColor 0 0 1 }       }
geometry Cylinder {
height 0.1,
radius 0.01,
top TRUE,
bottom TRUE,
side TRUE    }  }  }
Transform {
rotation   0 0 1 1.57,
translation 0.107 0 0,
children Shape
{appearance Appearance {
texture ImageTexture { url [  "Image.jpg"  ] }
 material Material {
diffuseColor 0.8 0.4 0.8 } }
geometry Cylinder {
height 0.01,
radius 0.02,
```

```
bottom TRUE,
top TRUE
side TRUE } }
 } ]     }
```

MODELLING OF ROBOT

The modelling of Robot is done using VRML. The Robot consists of various parts such as Base, Joints, and Arms etc. They are modelled using the basic primitives of VRML. The basic primitives are Cylinder, Box, Cone, and Sphere etc. The program for modelling of Robot and its various parts is given below. The Figure 6 shows the Robot.

VRML PROGRAMME OF ROBOT BASE

```
#VRML V2.0 utf8
Shape {appearance Appearance {material Material {
diffuseColor 0.9 0.9 0.9 }} }
        geometry Cylinder {height 3.2
                radius 2.0
                top        TRUE
                bottom TRUE
                side       TRUE}}
DEF ARM0 Transform {translation 0 2.0 0
Children [ Shape {appearance Appearance
{material Material {diffuseColor 0.3 0.4 0.9}}
        geometry Cylinder {height 2.0
                radius 1.0
                top        TRUE
                bottom TRUE
                side       TRUE
                }} ] }
```

VRML PROGRAMME OF ROBOT ARM

```
#VRML V2.0 utf8
DEF ARM1 Transform {translation 0 3.0 0
        children[ Shape {appearance Appearance {
        material Material {diffuseColor 0.3 0.4 0.5
}}
        geometry Cylinder {height 2.0
                radius 0.8
                top        TRUE
                bottom TRUE
                side       TRUE    }  }
DEF AR1 Transform { rotation 1 0 0 1.57
translation 0 1.0 0 children [Shape {
 appearance Appearance { material              Material
{diffuseColor 0.3 0.1 0.5}}
        geometry Cylinder {height 3.0
        radius 0.9
        top        TRUE
        bottom TRUE
        side       TRUE    }} ] }  ] }
```

VRML PROGRAMME OF ROBOT

```
#VRML V2.0 utf8
Inline {  url ["Base.wrl"]  }
Inline {url["ARM1.wrl"] }
Inline {  url ["ARM2.wrl"] }
Inline {  url ["ARM3.wrl"] }
```

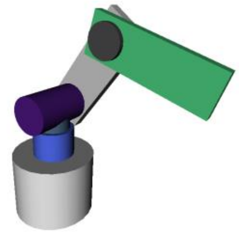

Figure 6: Robot

SIMULATION

The simulation is done to synchronise the elements. The whole of the simulation of these elements is divided into the following steps:

Creation of Scene Graph

After completing modelling of all the elements of FMS, a scene graph is created by arranging all this parts in a layout of FMS. Transformation node was used for this purpose. This scene graph is static in nature, is then converted into the dynamic nature by using communicating mechanism of VRML, which consist of Interpolator nodes, TouchSensor, TimeSensor, Script etc. The Figure 7 shows the static scene graph. The programme of creation of scene graph is also given below

```
#VRML V2.0 utf8
DEF overview Viewpoint {position  6 2 5
Description "Front" }Transform {Scale 10 10 10
children [ Inline { url [ "lathe_Head.wrl"]      }
Inline { url [ "lathe_Tail.wrl"] }
Inline { url [ "floor.wrl"] }
Transform {translation 0.7 0.26 -0.46
children Inline { url [ "Spindle.wrl"] } }
Inline { url [ "Tail_Center.wrl"] }
Transform {scale 0.03 0.03 0.03
translation 0.9 0.08 -0.3
children [ Inline { url [ "robot.wrl"] } ] }
DEF T Transform {translation 0 0 0
Children [ Inline {url [ "Tool_Assembly.wrl"] }]}
```

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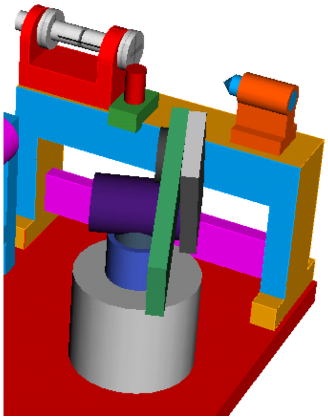

Figure 7:Scene Graph

Simulation of FMS(Lathe and Robot)

After creating the scene graph of FMS, the elements are simulated using the communication mechanism. The part is loaded on the conveyor, when user clicks on the work – piece, the conveyor moves and carries the work – piece towards the machine center, after reaching at the other end it is picked by robot by touching the robot to place it on the chuck of the lathe. When the lathe spindle is rotated, by moving the cursor nearer to the spindle and touching it, also rotating the work- piece, The tool assembly is then given the required movement. After completion of the cutting of the raw Work - piece, the finished part is taken from the chuck by stopping the rotation of the spindle, & is taken in the store of the FMS. The simulation is done using the communication mechanism of the VRML which uses, interpolator, TouchSensor, TimeSensor, etc nodes. The simulation of individual elements is considered and then is applied to whole of the FMS. The figure below shows the simulation of lathe machine and robot.

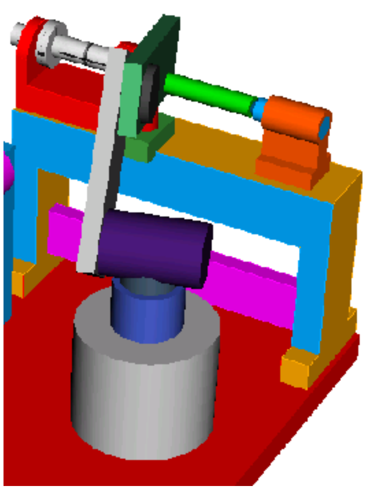

Figure 8: Simulation of loading of lathe

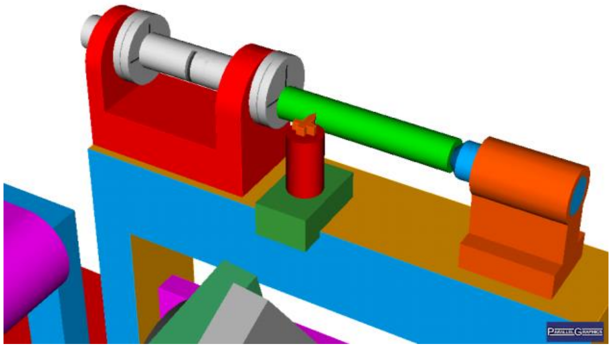

Figure 9: Simulation of Spindle and Chuck of lathe (Initial Position)

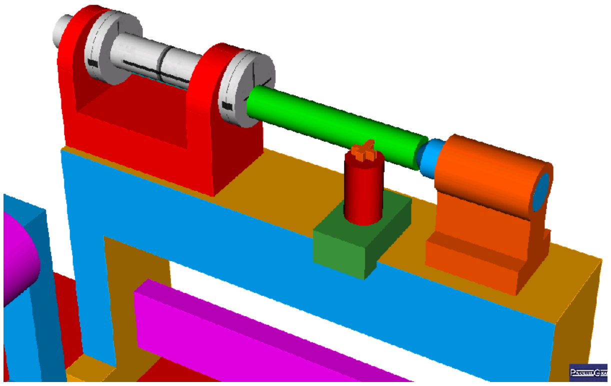

Figure 10: Simulation of Spindle and Chuck of lathe (Final Position)

CONCLUSION

Here an attempt is made to simulate the various components (CNC Lathe and Robot) of the FMS System individually and then the simulation of the whole FMS System, This simulation is manual in nature i.e. the user has to touch the elements of FMS for input to the system.

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AUTHOR BIBLIOGRAPHY

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