Application of Virtual Reality in Side Clamp Fixture Assembly

E. Raj Kumar*

Department of Design and Automation, School of mechanical Engineering (SMEC), VIT University, Vellore - 632014, Tamil Nadu, India; rajkumar.e@vit.ac.in

Abstract

Background/Objectives: The main objective of this paper is dealt with the application of virtual reality in side clamp fixture assembly. **Methods/Statistical Analysis:** The proposed methodology utilized the geometry and assembly details of side clamp assembly and makes the fixture assembly as close as possible to the real one. It includes two stages. The first stage demonstrates the procedure used for creating virtual prototype of an assembly and the second stage includes the creation of virtual fixture assembly. **Findings**: VRML coding is used to simulate virtual assembly process. Based on interference analysis errors can be rectified. Fixture assembly planning in virtual environment gives better understanding of the design engineer and the virtual assembly planning gives clear detail for virtual manufacturing. It enables intuitive assembly sequences which are then evaluated by Vizard inspector module. **Application/Improvement:** In this paper fixture assembly sequences are simulated using VIZARD software. Future research will investigate the fixture assembly plan in a complex virtual manufacturing environment.

Keywords: Computer Aided Fixture Design, Side Clamp Assembly, Virtual Assembly, Virtual Reality

1. Introduction

An important goal of designer and creators of CAE (Computer Aided Engineering) system is to integrate design and manufacturing tools. Early researches mainly focused on interactive fixture assembly. But most of the researchers concentrated on computer aided fixture design process. Virtual fixture assembly can be simulated by using virtual reality technique. It allows user to perform manipulation of fixture components in an intuitive manner. Using hand glove, user can move objects inside the virtual environment. This gives better understanding and creativity. In most of the literatures 3D manipulations can be achieved by using haptic device and virtual interface. In[1] developed modular fixture assembly relationship. Modular fixture assembly database was created based on assembly relationship and matting constraints. Matting graph gives detail about precedence relation between fixture elements. In[2] presented kinematics of fixture for virtual manufacturing environment. VJIG studio was used to simulate

fixture kinematics.In [3] discusses about virtual assembly technology. Traditionally assembly plans are generated based on product design details. Feasible assembly plans are evaluated by geometric feasibility of components. Immersive virtual applications enhance the visualization and verification of complex components in hazardous environment. In[4] developed virtual reality application for mechanical components. Automatic relationship graph used is used to represent fixture assembly model. Benefit of virtual reality was depicted by different case studies. In[5] described 3D manipulations of objects can be achieved by haptic device, snapping and geometric constraint. VR technology gives better visualization and interaction between user and virtual prototype. Automatic Relationship Graph (ARG) was used to represent fixture assembly relations. Structure view was used to represent fixture components in virtual environment. XML file format was used for data exchange in creation of virtual fixture components. In[6] described the ability to assemble virtual components not only allows the

assembly process to be planned but also prototypes to be verified. Also assembly planning tasks may be attempted much earlier in the product design cycle than usual (i.e. before any physical prototypes have been made). Thus enhancing concurrency and offering potential savings in costly prototype manufacture. In[7] utili-Goldberg algorithm to develop 3D objects. It includes horizontal, vertical and cylindrical surfaces. It is then automated by using special relationship and feature based constraint analysis. In[8] presented fastener based approach for fixture assembly sequence and the fixture assembly sequences were generated by using liaison graph.

2. Proposed Methodology

Hardware used for this research is Ascension flock of birds and virtual technologies cyber glove. The VR4 immersive display system was used to represent fixture assembly in virtual environment. Global position and orientation was implemented by Ascension flock of birds. Virtual cyber glove consists of 22 sensors, which served as an augment to represent the right hand. It is measured by bending and abduction motion of the wrist joint (2 values), four fingers and thumb (1 value). This allowed user to manipulate objects in virtual world. The proposed methodology is shown in Figure 1.

3. Virtual Assembly Procedure

The whole virtual assembly procedure is given:

Step 1: Initially, an assembly model is constructed inside a CAD system and then the assembly model is transmitted from the CAD system to the virtual environment for interactive assembly evaluation and planning.
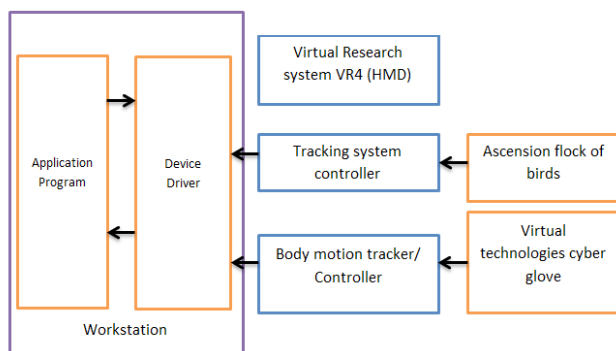

Figure 1.   Virtual reality system architecture.

Step 2: The imported assembly model in the virtual environment together with the default settings of the virtual environment describes the initial state. Here, an interface is needed to import the assembly model into the virtual environment.

Step 3: Then the assembly of a part or subassembly inevitably requires some user interactions.

Step 4: Each user operation captured by the system is an input event that changes one or more states and may cause other actions to take place, which ultimately affect the visual, aural and force outputs.

3.1 Development of Virtual Design Methodology

It is essential to create virtual prototype of fixture assembly before navigating into virtual environment.

Step 1: The initial step is to create object oriented analysis and design of the system. Creation of virtual environment consists of software and hardware implementation. Software manipulation of objects can be achieved by VRML Inspector and stereo viewing.

Step 2: Hardware configuration can be implemented by head tracking and sensors.

Step 3: Once the creation of virtual design is completed the graphical representation of objects can be imported into the VRML inputs.

Step 4: To obtain full constrained assembly, assembly constraints and the degrees of freedom of an assembly should be created. Tolerance information also incorporated in the assembly operation.

Step 5: Exact alignment of axes and planes is possible when it is converted from global coordinate into local coordinate system. This allows user to manipulate objects in 3D space. It gives provision for future interaction of an object in 3D space.

4. Implementation of Virtual Design Environment

The first prototype was created by using Computer Aided Design software (CAD). Table is created in virtual environment using VRML tool box. Cartona 3D is a virtual reality viewing software, which is used to visualize an entire fixture assembly sequence. Grasping objects within the virtual environment was accomplished by using line segment

sensors attached to the fingers. These sensors are used by Performer software module and the interactions are performed by sensors, which gives clear intersection between components. It is very difficult to measure appropriate length of line segments. It was determined by users experience and the approximate distance is 0.25 inches. This allows user to grasp objects in virtual environment. Virtual modular fixture configurations are shown in Figure 2.

5. Interaction Manager

Interaction manager is used to interact between user and the VADE (Virtual Assembly Design Environment). Output manager is used to display graphics and creating scene graph.

5.1 User Interaction in Virtual Interface

Virtual model created in 3D space was utilized by complementary systems such as CAE applications. This will help manufacturing engineer to evaluate, determine, and select more sequences to generate process plan. Interactive dialogue box in vizard used to identify collision between elements of fixture assembly. It is shown in Figure 3. Virtual environment of Side clamp assembly is shown in Figure 4.
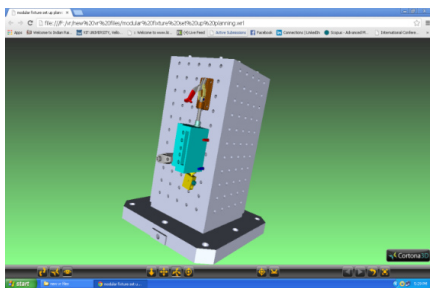

Figure 2.   Virtual modular fixture configurations.

Figure 3.   Virtual side clamp assembly.

6. Virtual Inspection of Fixture Assembly

The constraint manager is used to identify collision between parts and assembly. Hand "class" used as a sensor for collision detection. Glove "class" manages the data coming from the instrumented glove (Cyber glove). Fob "class" handles the data from the tracking device (Flock of birds). Geometric object "class" contains all the polygonal data and assembly information about a part. Collision between the parts is stored in single linked list of Geometry. Error notifications are shown in Figure 5.Virtual inspections are shown in Figure 6 to Figure 11.
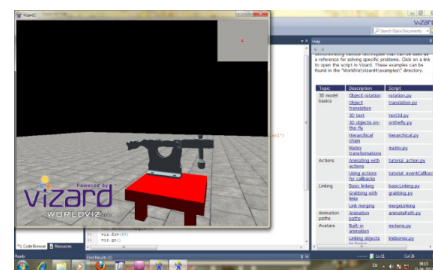

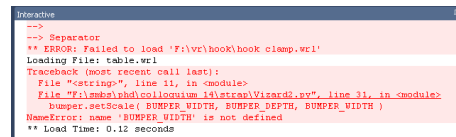**Figure 4.**   Virtual Fixture assembly manipulations in 3D space.

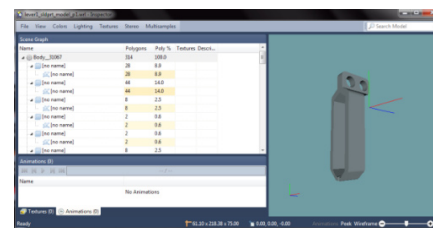**Figure 5.**   Error notifications during virtual interpretation.
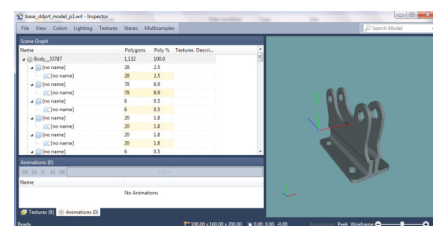

Figure 6.   Scene graph 1.
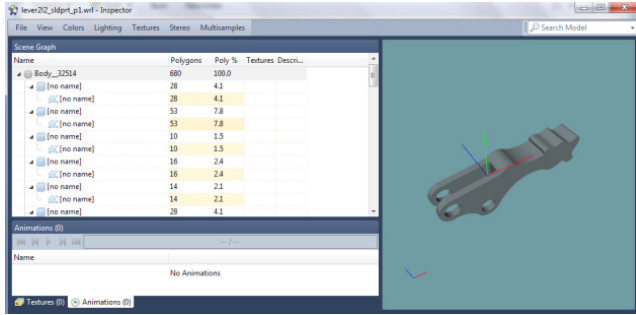

Figure 7.   Scene graph 2.

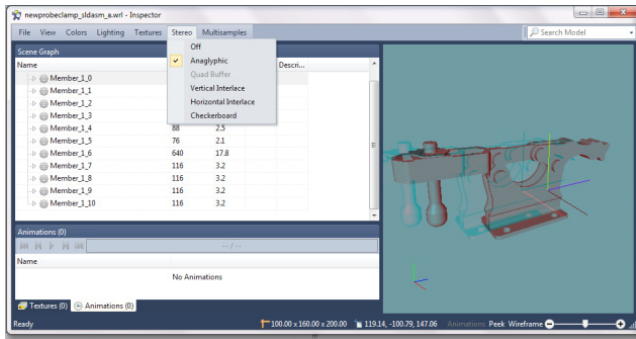**Figure 8.** Scene graph 3.
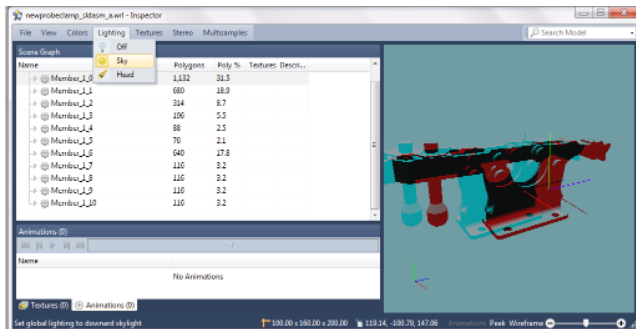

Figure 9. Scene graph 4.

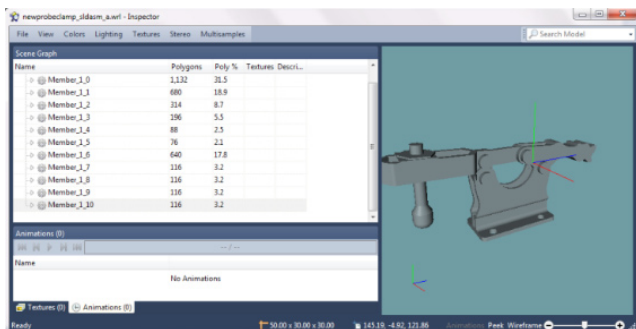**Figure 10.** Scene graph. 5 (Anaglyphic Image).

Figure 11. Scene graphs – Assembly properties.

7. Formats for Data Exchange

Data exchange formats mainly used for translating IGES (Initial Graphics Exchange System) file. Right hand coordinates system is used in VR packages. But in CAD packages, world coordinate system is used for creating part. VR (Virtual Reality) and CAD (Computer Aided Design) package differ from LOD i.e. Level of detail. Steps involved in format for data exchange is given.

Step 1: Parts created by CAD package was saved as .prt file.
Step 2: Part file is then exported as .wrl file.
Step 3: VRML file is them imported in VR package.
Step 4: Modify the global coordinate system into Local coordinate system for easy accessibility.
Step 5: Change the scale of the object into Local coordinate system.

7.1 VRML Coding

```
#Add the gallery model

gallery = viz.addChild('gallery.osgb')

part=viz.add('F:\\RAJ\\vr\\viz\\NEW PROBE CLAMP_sldasm.wrl')

part.setScale(0.004,0.004,0.004)

part.setEuler(0,360,0)

part.setPosition(-0.5,1.25,0)

viz.setMultiSample(4)

viz.fov(60)

viz.go()

BirdEyeWindow = viz.addWindow()

BirdEyeWindow.fov(60)

BirdEyeWindow.visible(0,viz.SCREEN)

#Create a collideBox for each child node rather than one encompassing the entire model

bumper.collideBox( node='Leg1', bounce = 1, friction = .00000001 )

bumper.collideBox( node='Top', bounce = 1, friction = .00000001 )

path = viz.addAnimationPath()
```

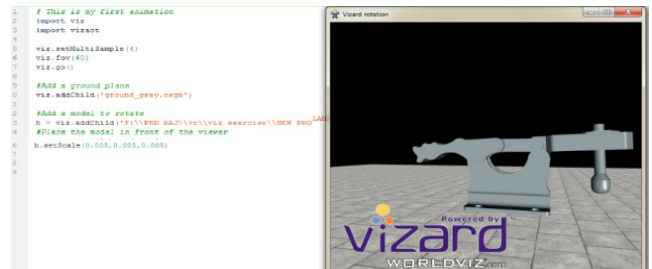Path animation program is shown in Figure 12.

Figure 12. VRML coding interface for side clamp assembly.

8. Conclusion

A real world fixture assembly operation in VADE system gives basis for virtual manufacturing and virtual assembly. Many of the assembly constraints are generated by VRML coding and it is simulated by Cartona 3D viewer. Success of VADE system (Virtual Assembly Design Environment) mainly relies on enhanced gripping ability, physics based modelling and constraint based functionality. Commercial CAD systems are at present, based on parametric and history tree. It is essential that future CAD system should incorporate built in VRML coding. Future fixture assembly sequence plan may include motion planning in a complex virtual manufacturing environment.

9. References

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