

“Modelling For Weld Bead In Virtual Reality”

Bharath V G¹, Dr. Rajashekar Patil²

¹Assistant Professor, Department of Mechanical Engineering, CMR University Bengaluru, Karnataka, India

²Professor & Head, Department of Mechanical Engineering, CMR University Bengaluru, Karnataka, India

Abstract— Virtual reality (VR) is an emerging computer visualization technology that allows users to experience a strong sense of reality in a computer-generated environment. VR has tremendous potential next to Human-Computer Interface (HCI) metaphor. VR technology has also been applied in manufacturing with an advantage of being potential to replace the traditional and time-consuming approach of physical modelling. The capability of simulating an actual working environment using VR has yielded another advantage for training and education.

Welding is a primary process for connecting the pipes, machinery and metal plates in nuclear power plant, automobile, and shipbuilding industries. However, because people recognize that this work is very dangerous, the shortage of skilled manpower has been brought consistently. In recent years, virtual reality-based training systems have been proposed to develop human resources. Specially, welding training systems under virtual environments support a practical training for working skills of production in manufacturing industries. To overcome this virtual reality-based metal arc welding is approached. In this present project modelling for weld bead using Autodesk 3ds Max tool and Unity 3D are used to model the weld bead in CAD model and conversion of CAD model to VR Model using Unity 3D platform. Mathematical formulation has been proposed for weld bead generation and the same is incorporated in design of weld bead. Several assets, layers are utilized in Unity 3D graphic user interface for obtaining the weld bead in virtual environment for creating immersive and interactive environment.

Keywords— *Virtual Reality; 3ds Max 2017; Unity 3d; Weld Bead; VR Model.*

1. INTRODUCTION

A- Virtual Reality

Virtual Reality (VR) involves development of a computer generated virtual environment intended to simulate the real world. It is an emerging computer visualization technology that allows users to experience a strong sense of reality in a computer-generated environment. Engineers have begun to realize the usefulness of VR as an innovative tool to visualize, manipulate, and interact with complex three-dimensional (3-D) graphical data that are difficult or even impossible to adequately understand in traditional two-dimensional (2-D) drawings or even 3-D solid models.

B- Welding

Welding is a primary process for connecting the pipes, machinery and metal plates in nuclear power plant, automobile, and shipbuilding industries. However, because people recognize that this work is very dangerous, the shortage of skilled manpower has been brought consistently. In recent years, virtual reality based training systems have been proposed to develop human resources. Specially, welding training systems under virtual environments support a practical training for working skills of production in manufacturing industries.

These technologies enable manufacturer to not only provide safe working space using virtual fume and heat, but also realize cost saving by virtual materials. Therefore, these can help to

improve trainee's skill by multiple exercises and instant evaluation using realistic visualization and precise simulation of computer generated welding situations. Moreover, teacher can present instructive guidelines by instant feedback of real-time monitoring and control.

Recently, many virtual welding simulators are introduced with the purpose of increasing technical skills of workers in the real work field. This system includes the creation and visualization of spark, fume, and darkness for real-time interactive learning. Few authors proposed a virtual welding system that can represent the bead's shape by neural network learning between welding conditions and parameters.

Aiteanu presented an augmented reality based welding guide system to overlay assembly information and technical documentations of welding in the real world using a helmet typed display [1]. The simulation process about construction of a heuristic database of spray patterns by measuring a set of real paint spray patterns with various cases. However, previous works have not provided exact representation from real experiments based on heuristic method for complex and various situation of welding.

C. Brief Literature Survey

Park et al [2] studied the design and evaluation of an augmented reality welding helmet. Development and ergonomic evaluation of an augmented reality welding helmet was described. Teeravarunyou and Poopatb [3] developed a computer-based welding training system. This system used in welding shops, and it has been developed to facilitate and to substantially enhance the basic skills in shielded metal arc welding. Ahrens and Keitel [4] studied the virtual training in GSI company depending on computer based training and communication Platform. Bornert [5] indicated the elements of the realistic education of welders to educate welders near to the practice. The decisive differences of the concept compared with other solutions are presented and their advantages are discussed. Benus and Dalto [6] considered the virtual welding training is a key to minimize the very expensive training cost.

Several technologies studies to speed the virtual welding up, to cut the training cost and enhance the training quality to give the trainer more flexibility. Rautert [7] from The Bildungszentren Rhein-Ruhr establishment in Germany studied five virtual welding systems and compared to each other within the scope of tests by different groups (apprentices, orienting measures for young people and welders' training). Hillers et al [8] used a new technologies evolve to the welding educational to support the beginner for getting started in the subject of welding. In this study, the Virtual reality (VR) system is studied with an approach of using the paradigm of Augmented Reality.

2. METHODOLOGY

The following steps is followed to satisfy the above objective and is represented in figure 1 are:

- Geometric modelling of weld bead as per the realistic weld bead model.
- Conversion of CAD model into VR model.
- Usability evaluation for weld bead model.

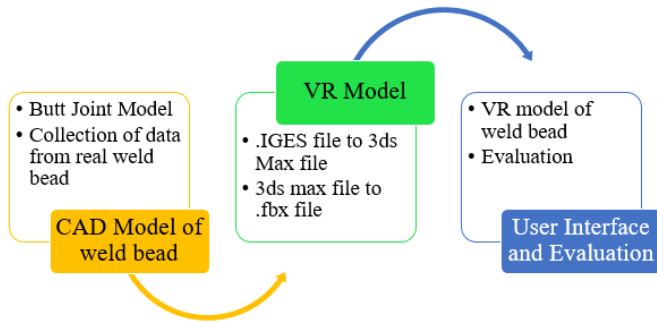


Fig. 1. Methodology of VR modelling of weld bead

2.1 3d Modelling of Weld Bead Using Cad Tool

Welding bead representation under virtual environments is capable of executing realistic expression to visualize welding elements constructed by heuristic data acquisition through real experiments. The effective representation of a bead's shape under virtual welding training contribute to maximize training effects with reflection of real situation. The bead's shape is related to the trainee's configuration and conditions of work operation such as voltage, current, travel speed, travel angle, and distance between the base metal and the electrode. Therefore, the data of the bead's shape are set by executing real operations based on conventional welding.

The key parameters for providing a strong impact on welding skill, the input datasets are length between the base metal and the electrode, welding speed, travel angle, work angle as well as current and voltage. Reflecting the shape of the base metal that is related to visualize the virtual bead's shape is the output of the weld bead representation. Figure 2 shows the actual weld bead of metal arc welding.



Fig. 2. Actual weld bead of metal arc welding.

Virtual beads take the input from the mesh data and texture images related to height information which is estimated by a section of real bead's shape. Mathematical expression of the bead's external shape such as bead width and height are considered. Certain assumptions made in constructing the weld bead in CAD tool such as weld bead seen near to hemisphere in shape and width of the weld bead is equal to radius of the hemisphere as represented in figure 3.



Fig. 3. Hemisphere shape of weld bead

- The area of semicircle of radius r is given by

$$A = \int_0^r \int_{-\sqrt{r^2-x^2}}^{\sqrt{r^2-x^2}} dx dy \tag{1}$$

$$A = 2 \int_0^r \sqrt{r^2 - x^2} dx$$

$$A = \frac{1}{2} \pi r^2 \tag{2}$$

The semicircle is the cross section of hemisphere for any plane through z-axis. The perimeter of the curved boundary is given by

$$p = \int_{-r}^r \sqrt{1+x^2} dy \tag{3}$$

With $x = \sqrt{r^2 - y^2}$ this gives $s = \pi r$ (4)

The perimeter of the semicircular lamina is given by

$$L = 2r + \pi r = r(2 + \pi) \tag{5}$$

2.2 Geometric Modelling of Weld Bead

The geometric modelling of weld bead consists of modelling of Butt Joint as shown in figure 4. Using 3DS Max tool the bead design for the butt joint is obtained as shown in figure 5.

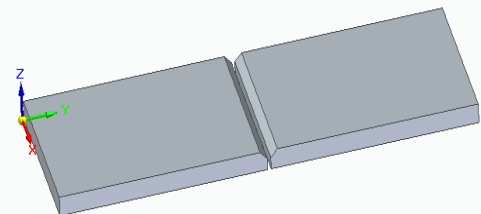


Fig. 4. 3D Model of Butt Joint

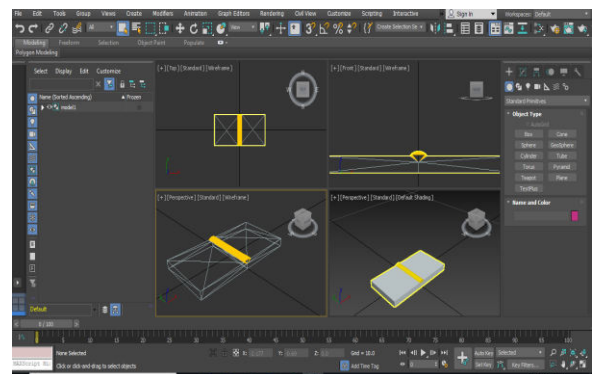


Fig. 5. 3D Model of Butt Joint with Bead

2.3. Conversion Of CAD Model To VR Model

The flow for conversion of CAD model to VR model is represented in the figure 6.

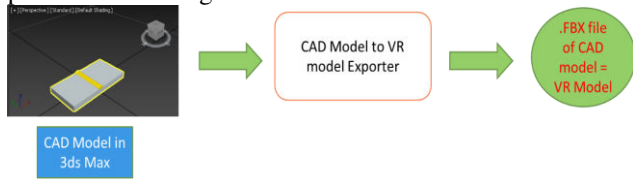


Fig. 6. Flow of conversion of CAD to VR model

The CAD model is converted to VR model using 3ds Max tool. The Initial Graphics Exchange Specification (IGES) file of the model is used as an input and Film Box (FBX) is the output. The conversion of the file is represented in figure 7.

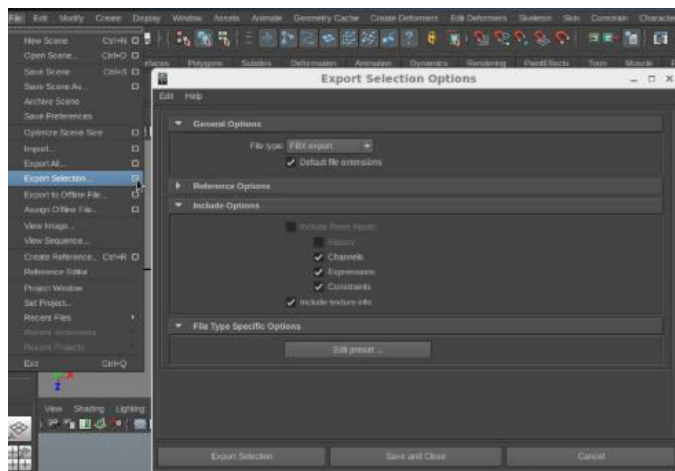


Fig. 7. Conversion of CAD model to VR Model

3. VIRTUAL WELDING SIMULATION MODEL

A Unity3D is one of the most famous virtual reality tools, it is cross-platform user interface development software, and now besides Mac OSX, Unity3D can fully support WindowsXP/Vista/7, Unity3D supports three scripting languages: JavaScript, C#, and a dialect of Python called Boo. All three are equally fast and interoperate, and can use the underlying .NET libraries which support databases, regular expressions, XML, file access and networking. Scripting is frequently thought of as limited and slow, but in Unity3D scripts are compiled to native code and run nearly as fast as C++. It is easy to get the fast iteration times and ease of use for someone who likes scripting languages. These three languages in game development projects can also be mixed-use. Unity3d also supports the Windows platform, C#, VB.net, VB6, Delphi and other programming languages. The Unity3D engine and the Unity3D development environment are tight integrated, so it provides a very powerful visual editor and language levels of the network. Assumptions made in development of virtual welding are as follows: The parameters such as voltage, current, plate preparation are required in real environment welding and not in virtual welding as the welding is practiced in virtual environment. Henceforth only modelling and weld bead generation is of priority.

In the virtual reality system, 3DS Max and other software are used to create three-dimensional models of weld bead model with butt joint features in the welding area. Three-dimensional models need to add texture and attribute information. Textures which collected through outside environment truly reflect the surface features of surrounding entities. After processing by tools such as adobe fuse, textures are imported into 3Ds Max to integrated with models. All the models are placed on the welding room, and then, combined with outside environment and attribution information to generate a complete virtual three-dimensional scene. Unity3D is used to edit and optimize the scenes in order to have a realistic environment and to achieve the best visual display by minimize the amount of data. Overall, there are two kinds of works: one is the works outside unity3D, including models, animations, textures, sounds and GUI graphics; the other is the works in unity3D, such as levels, scripts, physics, materials, shaders and GUI as represented in figure 8.

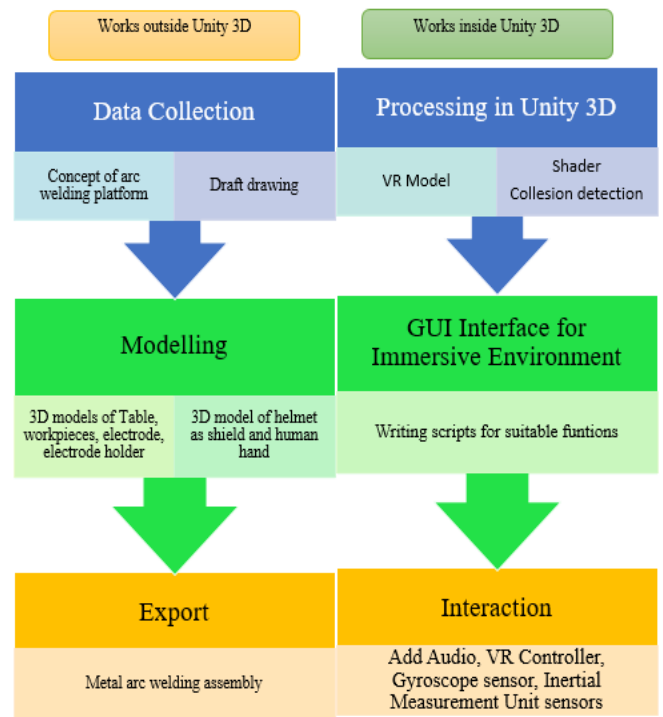


Fig. 8. Works outside and inside Unity 3D

A. Data Collection

There are two kinds of data used in design of welding platform known as spatial data and attribute data. The data collected from the sources are as follows:

- Factory layout
- Welding room area
- Texture of building, roads, human, camera setup

B. Modelling

Modelling is a crucial step of the visual reality system. The choice of modelling system dictates what type of geometry will appear in the system. For the virtual reality system to be successful, the modelling system is better to be completed and in place early in the development process. The main tools for modelling are 3Ds Max and AutoCAD. The virtual reality environment consists of welding room, table, workpieces,

electrode, electrode holder, helmet and human hand. It is essential to build fine, sophisticated models of every real object which is placed in a virtual field. The precise welding room area attribute information and models of welding equipment's are needed for achieving good quality objects of scenes.

C. Export

3D building models are important in the virtual environment. The reproduction of the real building of welding room area with welding equipment's is an important aspect of final visual effect, which impacts the authenticity of scenes. Visual modelling tools (3DS Max.) are used to modelling the welding room area with welding equipment's.

When the modeling is completed, the 3D models are saved as the format .fbx so as to compatible with Unity3D. Animations, textures, scripts, and sounds are saved in the asset file in a Unity3D project; they are added as new Game objects in the process of creating scene.

D. Shading

Unity3D comes with 40 shaders ranging from the simple (Diffuse, Glossy, etc.) to the very advanced (Self Illuminated Bumped Specular, etc.) All the built-in shaders integrate perfectly with any type of light, with cookies or without. If it is not enough, we can write our own shaders in Unity3D's powerful Shade Lab language with Cg and GLSL. In the work, besides the ordinary shaders, there are more requirements, so we write our own shaders, such as Mirror Reflection shader. It achieves a more realistic scenario results by using the shaders.

E. Programming

The most powerful editor inbuilt in Unity 3D is Visual Studio, the scenes in Unity3D is also compile with Visual Studio by adding UnityEngine.dll. The equation is used in scripting which runs at the back end of the program. The program is scripted in C# programming language

F. Collision Detection

Unity contains the full capabilities of the Ageia PhysX next—gen Physics Engine and is used in games like Unreal Tournament 2007 and Ghost Recon 3. Unity3D supports full Rigidbody physics. Rigidbodies act under forces, collide, and work in joints with no scripting required. It makes the virtual reality more true to our daily life. After writing scripts on a certain GameObject, users can press the mouse to write user name using virtual keypad, and then press keys on the icons to proceed further. The selection of helmet, electrode holder is obtained by pressing the key from VR controller. The motion of the weld bead is endowed with collision detection in the process of welding.

G. GUI Control

Selection of helmet, electrode and metal weld arc bead generation are not only having spatial information but also attribute information. To get dynamic and real-time effects, it is preferred to use GUI controls to show the attribute information. All the attribute information is stored in database—MySQL data management system. Figure 9 represents weld bead generation of butt joint.

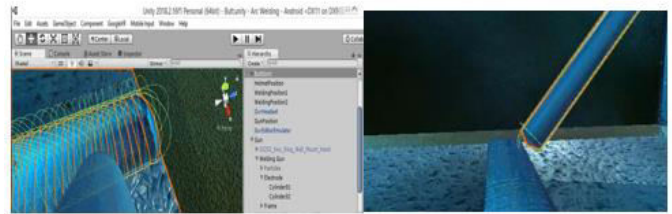


Fig. 9. weld bead generation of butt joint.

H. Interaction

Sounds, animations, videos will be added in Unity3D by Game Objects. Thus, really enhance the user's immersion in the virtual reality system.

4.CONCLUSIONS

The present work is focused on modelling of weld bead using CAD tool and conversion of CAD model to VR model using Unity 3D platform. The hierarchical approach of welding system is adopted in the present project work, and the welding room is divided into four layers: Welding table layer, Camera layer, workpiece layer and equipment layer.

Welding room is creating in the factory layout. Welding table is designed, and workpiece locality is fixed on working table for welding operation. All the models of working table, welding room, equipment's which related to different layers are converted to 3D model by CAD software. Mathematical formulation is made for generation of weld bead that resembles the real weld bead by considering the real weld bead data and its parameters. Conversion of CAD model to VR model is achieved using 3DS Max tool. The 3D models are imported into the Unity3D, and programming with C sharp language in Visual Studio is used in order to achieve Game objects and Scenes. The Scenes are integrated and published on the smartphones.

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