Research on Virtual Assembly Technology of Automobile

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Abstract. The conventional training for automobile assembly and disassembly has such weak points as need of ample space, lack of teachers, heavy loss of instruments, low efficiency and unsatisfactory training results. This article puts forward a kind of automobile assembly technology based on virtual reality (shortened as VR). With the help of HTC VIVE helmet display and handle as the input and output media, the interactive connection between the user and the virtual scene is established. Lead the structured automobile model into the Unity 3D development engine, and write the script using the object-oriented programming method of C# language, to realize automobile virtual assembly processes, which includes such major functions as main scene design, component recognition, assembly demonstration, virtual assembly and simulated driving. This technology, featuring rich content, short cycle, low cost, flexible and easy use, strong user experience, low risk, lead and play, and strong expansibility, etc., has good practical significance for current automobile assembly.

Keywords. Virtual Assembly, Automobile, Unity 3D

1 Introduction

Virtual reality technology is an important orientation of emulation technology, and the collection of emulation technology with multi-technologies, such as computer graphics, human-machine interface technology, multimedia technology, sensing technology, and network technology [1, 2]. In USA, many risky high-cost trainings are first simulated in VR, and then put into real drilling, for instance, the flight simulation training for pilots, and the virtual combat training for special task forces [3]. People are made to experience real scenes repeatedly in a virtual environment, and make corresponding reactions. Therefore, this technology can be applied in a lot of fields and industries, to greatly reduce costs and risks.

The rapid development of virtual reality technology has made virtual assembly a reality, and virtual assembly has then been widely applied in many fields such as aerospace, rail transport, automobile, education, and medical treatment. Many researchers have completed virtual assembly (shortened as VA) and virtual maintenance (shortened as VM). At present, the research on virtual assembly technology is mainly focused on product assembly information modeling, interactive operation methods, and tooling modeling [4]. Liu Shufeng et al [5] have proposed the model of teaching for assembly and disassembly of automobile engines， which has enhanced the effect of disassembly and assembly and reduced the costs. Wang Jianhua et al [6] have proposed the virtual disassembly and assembly practical training teaching platform oriented to automobile structure teaching, which displays the flow of engine disassembly and assembly. To address the issue of model verification in the process of automobile development, Ma Dengzhe et al [7] have used the distributed parallel virtual environment to realize co-operative assembly operation and information exchange on an automobile model by the designers in different geographical locations. Hu Yanjuan et al [8] have built the feature models for the automobile gears of the cylindrical type and those of the bevel type, on the basis of gears' manufacturing characteristics, and did manufacturability analysis. Fan Xiumin et al [9] have proposed a virtual product assembly process planning environment under the real and virtual mapping process of a mechanical system. This article proposes the realization of a complete vehicle assembly using the virtual reality technology, covering four functions, such as recognition of basic components, animated demonstration of assembly, practice of virtual assembly and experience of simulated driving, to make the users more deeply understand the functions and locations of different components on an automobile, and enhance their feeling of experience and improve the efficiency simultaneously.

2 Research Objectives

2.1 System architecture

To ensure the systematicness and integrity of platform development, pre-design of the system architecture for the VR scene was done as shown in Figure 1, thus to help control of the overall development and design, which were basically divided into the tooling layer, model layer, development layer, application layer, interaction layer and equipment layer.

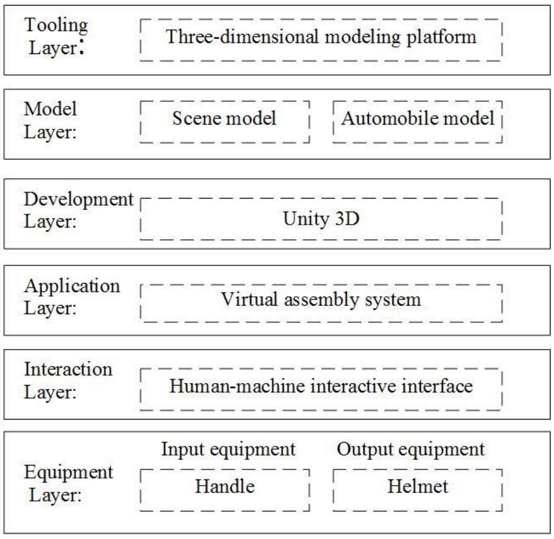


Fig. 1. System Architecture Design

The virtual assembly technology is realized on the basis of software integration, which includes modeling rendering and development. Various software are used in modeling, such as Delmia, Solidwork, Pro/E, Flexsim, 3DS MAX, and UG. UG and 3DS MAX modeling software, which are used to complete the building of an overall vehicle model, patch optimization, and rendering, are guided into Unity 3D virtual reality development engine in the format of FBX. Object-oriented programming method of C# language is used to write the script, which includes scene effect setting, scene change, sequence planning of automobile assembly and disassembly, collision detection with rays, and interactive update, so as to accomplish human-machine interactive experience with outside input and output equipment.

2.2 System design

This system has five scenes in all. The main scene is the scene of teaching mode, and the four sub-scenes realize four modes respectively; they are component recognition, assembly demonstration, virtual assembly, and simulated driving. Simulated driving is so provided as to reflect integrity and embodiment of the system. As shown in Figure 2, its major flowchart starts from entering a virtual automobile assembly scene, with the voice prompt to instruct the user in teaching basic operation. Upon completion of this scene, the user can choose any of the four sub-scenes at his/her option. Among these scenes, the scene of component recognition is for learning the names and functions of the basic automobile components; the scene of assembly demonstration demonstrates in animation how to assemble automobile components so that the user understand the flow processes of virtual assembly; the scene of virtual assembly allows the user to assemble automobile components as he/she has just been instructed so as to reach the goal of virtual practice; and the scene of simulated driving provides the experience of simulated drive of an automobile, to add amusement to the system.

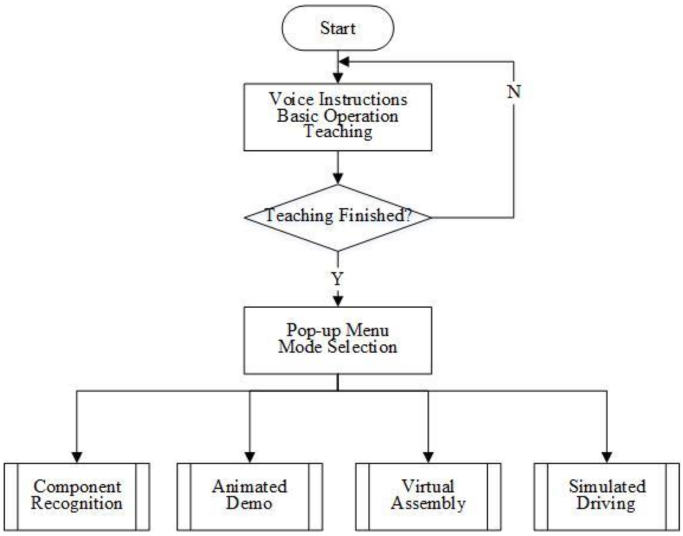


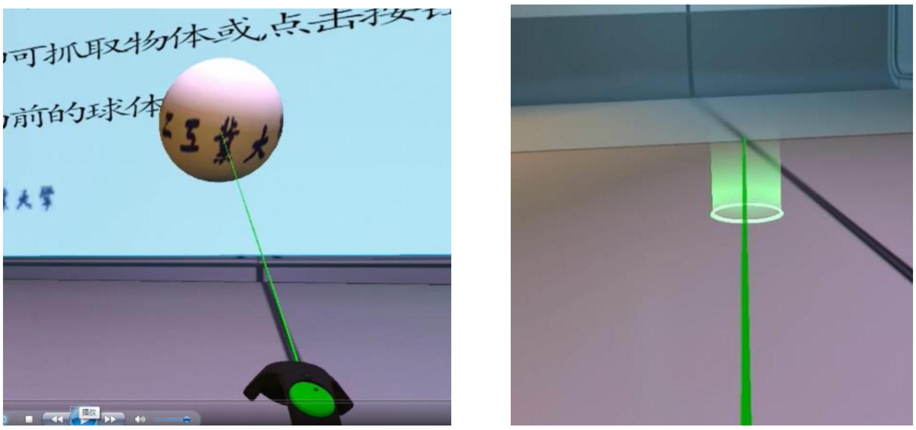
Fig. 2. System Flowchart

3 Software Design

3.1 Design of main scene

When entering the virtual assembly environment, the first requirement for the user is to familiarize him/herself with the human-machine interactive basic operation, which mainly includes the following:

a) Emission of handle rays. Use simple pointer in VRTK.
b) Grab of objects, as shown in Figure 3 (a). Use the method of pressing the Trigger Key to grab the object when the ray is selected. This makes use of Setup Interactable Object in VRTK. The Is Grabbable attribute judges whether the object can be grabbed; the Hold Button To Grab attribute tells whether it is necessary to hold the button to grab the object.
c) Laboratory roaming. Use the Teleport Plug-in in VRTK, as shown in Figure 3 (b).
d) The way of main menu call-out. The main menu can be called out when pressing the menu key on the handle, to change the scenes. The UI of the main menu needs to be a sub-object of the helmet component, and adjusts the current position, so that the menu can move with the helmet.



(a) Grab of object (b) Scene roaming

Fig. 3. Main Scene Design

3.2 Design of component recognition scene

In this scene, the trainees have a chance to take a close look of the names and functions of each component of an automobile.

Press the Pad Key on the handle to emit a ray. Aim the ray to the component. The UI on the handle can display the relevant information of the component for the user to learn and recognize automobile components. To save computer resources, a Collider Box of the same size of each component is set up, using the OnTriggerEnter function in SteamVR. When the ray stops on the component, the component information is dispalyed with the text.show function. In addition, there is also the OnTriggerExit function.

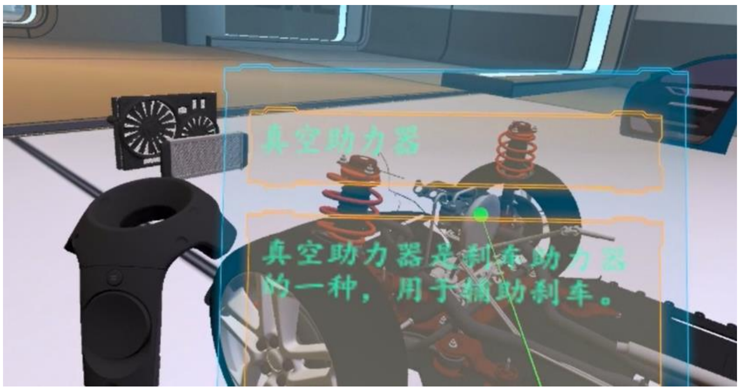


Fig. 4. Component recognition scene

3.3 Design of assembly demonstration scene

In this scene, the user can see the sequence and process of automatic assembly from the best angle. The demonstration is mainly performed by the animation system of Unity 3D, as shown in Figure 5. The move starts from the initial position to the position where the assembly is to be done. In Unity 3D, the positions x, y and z can be set and the route of move can then be adjusted. With the animation system, a complete assembly process can be animated for the trainers to learn.

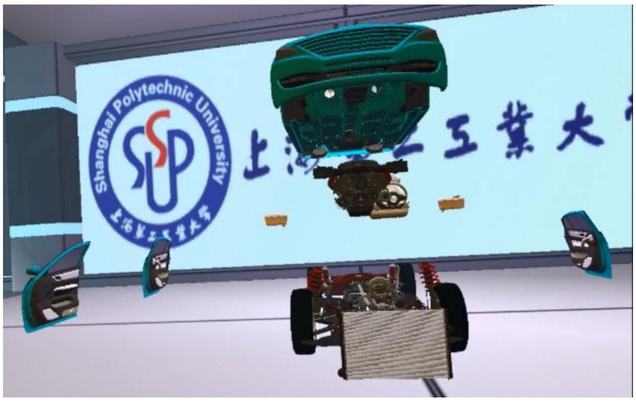


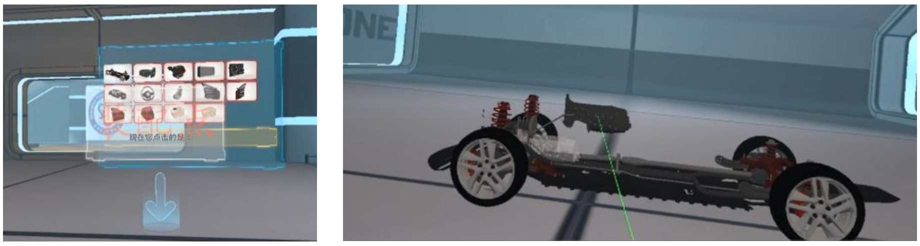
Fig. 5. Component recognition scene

3.4 Design of virtual assembly scene

In this scene, optimum assembly points are provided for the users, as shown in Figure 6 (a). Click on a component displayed in the UI in front of the user and move the component to the assembly position, where there is a translucent component to indicate the position where it should be installed. When installation is correct, the translucent component will be highlighted to show it is installed in position. On the UI, the installed component cannot be clicked again to prompt the correct installation sequence.

In this scene, a translucent material identical to the real object is created, and a car using this translucent material is led in, and placed in the installation position. Based on the user-clicked UI key, the Visible attribute in the script to set the translucent car is triggered, as shown in Figure 6 (b).

The UI is designed with the design system contained in Unity 3D. The controls of major applications are buttons and panels.



(a) Assembly points and UI interface (b) Translucent automobile component trigger display

Fig. 6. Virtual assembly scene

3.5 Design of simulated driving scene

In this scene, the user can drive the car assembled by him/herself. He/she can change the color of the car to his/her own preference, and then operate the handle to start simulated driving. To realize this function, the following methods are used:

a) Two cameras CameraRig are created, which are used to shift cameras when car color is selected.

b) Write the script. Use the Trigger key on right-hand control as the acceleration key, and the Pad key on the right-hand to turn the car right; use the Trigger key on the left-hand as the deceleration key, and the Pad key on the left-hand to turn the car left.

c) Create the scene. This scene is mostly used as the laboratory scene and the outdoor scene. The laboratory scene exists as a garage, in which, car color can be changed. The outdoor scene is used to experience driving, either on the urban roads or on the round-city superhighways. During the driving, other cars running on the roads can be met.

d) Teaching guidance. Before entering this mode, a voice promt will be provided, and on the handles the operation methods will be instructed accordingly.

Fig. 7. Simulated driving experience

4 Conclution

This article, which proposes the use of the virtual reality technology to perform virtual automobile assembly teaching and experiencing, with the aim at the weak points, such as need of ample space, lack of teachers, heavy loss of instruments, low efficiency and unsatisfactory training results, in conventional automobile disassembly and assembly training, has good practical significance. This technology, commencing from system architecture and development design, performs the platform construction, model rendering, human-machine interaction, logic computation and application release for the system, taking full consideration of integrity and implementability of the system, featuring good reusability and experiencing effects, successfully avoids such issues as equipment losses and parts missing encountered in real automobile disassembly and assembly. The system can enter the virtual assembly environment again by simply restarting the application programs, with avoidance of unnecessary assembly risks and improvement of safety. Experiencing this system helps the user to have a preliminary command of automobile disassembly and assembly techniques and assembly processes, and improve the user's recognition and practical operation skills of automobiles. This system can be oriented to such aspects as assembly and maintenance training, process design and process test in the enterprises in automobile-related industries, oriented to teaching of automobile courses in some special universities, and can be expanded to cover different types of vehicles, and it can also be oriented to the society for automobile science popularization education, thus wining wide applauses from the users.

Although VR equipment is not yet perfect in hardware development – when one wears it for a long time, he/she still will feel dizzy – its advantages in convenience, verisimilitude and high resource utilization are in line with the development of the times. This technology will certainly bring about new breakthroughs and changes in the future. Virtual manufacturing will be implementation and come into reality.

Acknowledgments

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