Visual effects creation to improve user performance in fully immersive virtual environment of automobile engine assembly

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Abstract. Virtual reality (VR) technologies and computer-generated technologies are very useful for many industries, such as medical, education, gaming, mining, engineering, and other sectors. In engineering sector specifically for assembly department, the major problem they are facing was that traditional components of automotive engine are complex and very difficult to assemble using current method which use paper manual. The goal of this project is to create an interactive VR application such that users can quickly integrate and perform the work easily. In this work, the authors designed and developed an immersive VR application with several stages, such as 3D model creation, visual effects creation and gaming scene building. The application was built using Unreal and HTC vive headset. As this is an on-going project work, further functionality will be added to render the application immensely for users and assist the sense of pedagogy in terms of the digital method of learning.

1. Introduction
Virtual reality (VR) is currently a potentially strong tool that can transform the simple act of conventional learning through active interactions into an unforgettable experience. Most teachers believe VR has had positive effects in the learning process. A blended teaching methods program contributes to significant changes in educational outcomes [1]. VR systems can be divided into three categories such as no immersion systems, semi-immersion systems, and fully immersion systems [2] by form of display such as desktop displays [3], projection-based screens [4], and helmet displays [5].
The VR system usually consists of three elements, such as VR input device, VR application developing software, and output device. VR systems typically need at least one input device for the input device section, such as VR gloves [6], bodysuit [7], Phantom Omni [8], vive controllers [9], keyboard and mouse [10], touchscreen keyboard [11], joysticks [12], and voice recognition [13], and several other [14-15]. Major components of VR system need only one VR development software, such as Unreal, Unity 3D, Delta3D, OpenSimulator platform and many others.

Typically, there are three types of VR displays for the VR output system segment, such as desktop displays, projection-based screen, and helmet displays. VR helmet displays have also been classified into two types which are mobile headsets [16] and mobile-less headsets [17]. For adaptive production engineering, Giorgio et al. [18] performed human-machine collaboration in the virtual reality. They assembled the cubes in their application into three levels: posing, recording, and playing with built virtual ABB IRB 120 robot manipulator attached to the HTC Vive headset and controllers. They mentioned that their assembly of cubes was not intended for real practical use. They suggested technologies of virtual reality to be used for real application to be more helpful for the user.

Therefore, in this study, the authors aim to assemble virtual automobile engine components for actual functional assembly in virtual environment. In this work, we used virtual two-hand controllers with both HTC Vive headset and two vive controllers. In this project, all 3D engine components were designed by CATIA V5 software, and the immersive virtual automobile engine components assembly application was developed by using Unreal Engine and HTC vive headset. Two vive controllers were used as input devices. The development of application consists of several features such as teleportation, physics and collision, hologram set up, materials and textures, creation of animation, and building gaming scene. In future, experiments will be carried out to determine the effectiveness of developed immersive VR application compare to the traditional method using learning motivational tool of instructional materials motivation survey.

2. Materials and methods

The entire process of designing and developing virtual environment with holographic guideline was detailed in figure 1. The virtual environment was built mainly using the Unreal game engine, with CATIA V5 and Blender software being used to develop automobile engine assembly required for this module. The main aim of technical advancement was to provide an effective way to help and enhance the learning encouragement session in the challenging age of the present time.

This immersive VR technology aims at finding an alternative method of learning for assembly of engine components in tertiary education. Relative to the complexity of the parts and the difficulties of memorizing the assembly process without clear guidance, this engine components assembly scheme was selected as a tool for developing learning ability. This method for assembling automobile engine consisted of forty-four components and fort-four stages.

This VR system consists of two main items, such as a high-end laptop (Laptop ALIENWARE 15 R3) and HTC vive. The high-end laptop has been used for modeling 3D models, and for building and animating 3D elements. Five key software programs were used to create this VR application, including CATIA V5, (CAD software) for engine components modeling, Blender (a device to translate from native CAD file format (. CATProduct or .wrl) to Unreal file format (. FBX script)), Unreal for VR application creation, Steam software and Vive software have been introduced to the HTC vive for immersion in the VR. All forty-four 3D engine components were modeled using Catia V5. The models made in Catia were file format for. CATProduct or .wrl and were imported into Blender to change from . CATProduct or .wrl file to .FBX file as Unreal was incompatible with obtaining the . CATProduct or .wrl file. After that, all were exported into Unreal.

3. Development of virtual environment

In this application, many virtual components and many features were added to feel like a real workshop. We built the workshop with around two hundred and thirty virtual 3D components including automobile
engine components, tables, ceiling lamps, table lamps, drilling machine, milling machine, CNC machine, cupboards, shelves, chairs, and other several workshop appliances.

Figure 1. Process flowchart of immersive VR application development.
Much more features such as teleportation, blueprints visual scripting, hologram setup, detail setting of actors (actors are components used in this application) such as transform, static mesh, materials, physics, collision, and rendering as shown in figure 2 were also added and explained in the following sections so that the user can feel like real environment and improve user satisfaction in the virtual environment as shown in figure 3.

![Figure 2. Fully application with several features.](image2)

![Figure 3. Developed virtual reality application demonstration.](image3)
3.1. Teleportation
In VR development of Unreal, teleportation was fantastic. It could control the actor from current place to a new location. That means Blue Laser could track components of the automobile engine components (see figure 4). For teleportation and grabbing components assignment, two vive controllers were used. Trackpad was assigned for teleportation and trigger was assigned for grabbing components.

3.2. Blueprints visual scripting
In the Unreal 4.24, the framework was deployed with visual scripting of the blueprints. The visual scripting framework for the blueprints was a full scripting system based on the node-based interface model. This programming was incredibly versatile and efficient that provided designers with the ability to use the entire range of concepts. A blueprint scripting could also be used to change all the detail setting of actors.

3.3. Hologram setup
Hologram was a photographic technique that recorded the light reflected from an object in a way that appears three-dimensional, and then revealed. It helped the users to communicate more effectively with everything. An engine component was assigned by blue colour of hologram was seen in figure 5.

3.4. Transform and Static Mesh
The part of Transform section included the position, rotation, and scale of each object. In this segment, the actor's transform could be modified. Static Mesh was a piece of geometry consisting of using the
graphics card to render. 3D models produced in external modelling applications could also be imported via the Content Explorer to the Static Mesh Editor. In our application, Transform and Static Mesh setting of all forty-four virtual engine components were adjusted even though they had their different native settings.

3.5. Materials
A material was an element which can be added to a mesh to monitor the scene's visual look good. It could be coated in a color and can then made it shiny too. It could also be inputted from different images, such as textures and math expressions, into the Content. It also had the different property settings including Base Color, Metallic, Specular, and Roughness. In our application, the workshop setting of all holographic surfaces were applied with blue color.

3.6. Collision and Rendering
Collision could manipulate the actors' set-up to block one another. The Collision setting of all virtual forty-four components were adjusted the same. Rendering section was modified to enable and inactivate the actor. The Rendering feature of all virtual components were also adjusted the same.

4. Conclusions
It has profoundly affected the practices and technologies of humanity in the accelerated development of modern science and technology. This is particularly beneficial for training which needs high costs, room for training, equipment, much time consuming, and so on. As a result, the latest growth of VR technology is very useful for students to be able to learn more comfortably and quickly memorize complex assembly of engine components. This interactive virtual reality (VR) technology was therefore planned and built for the learning inspiration of the students, with the application consisting of both around three hundred virtual 3D models and many features such as teleportation, hologram setup, details of actors such as transform, static mesh, materials and textures, physics collision, lighting, rendering. This ongoing study aims to perform an experiment in the future, and to measure the efficacy of the established application on respondent satisfaction and learning motivation variable for students compared to the current existing method using learning motivational tool of instructional materials motivation survey.

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