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REVIEW ARTICLE

DESIGN AND IMPLEMENTATION OF AN INTERACTIVE VIRTUAL ASSEMBLY SYSTEM FOR SLR CAMERAS BASED ON VR

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ABSTRACT

To promote the construction and deepening of the "New Engineering" education, innovate teaching methods and means based on students' interests, and using VR technology, a virtual assembly system for SLR cameras was designed and implemented. Students can learn and understand the overall structure of the SLR camera in a virtual reality environment, and conduct assembly training through interactive operation of the virtual reality device. By applying virtual reality technology in SLR camera assembly training, it has played a role in cost saving, quality improvement and efficiency enhancement.

KEYWORDS

VR; SLR camera; virtual assembly; system design

1. INTRODUCTION

Aiming at the complex assembly process, precise components, and high cost of SLR cameras, a virtual assembly process was simulated based on the actual assembly principles of SLR cameras. This visualization of the assembly process can solve the problems of high cost and low applicability of virtual assembly systems. A virtual assembly system for SLR cameras was established based on VRP-Builder and presented in a game-like manner. This system is mainly used for school teaching and introduces parts and assembly functions to provide a platform for cultivating students' learning abilities. Students can become proficient in the understanding of the SLR camera's component structure and basic virtual assembly operations training.

1.1 Overall Design of Virtual Reality Assembly System for SLR Cameras

The virtual assembly system based on VRP-Builder creates a more realistic environment and a more rigorous simulated assembly process (Wang et al., 2017). It provides students with a virtual laboratory to deepen their understanding of the component structure and assembly relationships of SLR cameras. Additionally, assessment and testing can be conducted based on virtual assembly time, optimizing learning methods, simplifying laboratory processes, and transforming on-site assembly into virtual assembly. This not only reduces equipment costs but also improves teaching efficiency. The design and implementation of the entire system includes core module components such as three-dimensional solid modeling, virtual assembly, and interactive practical training.

1.2 3D Solid Modeling of Parts

Core components of an SLR camera include the shutter unit, reflex mirror assembly, lens assembly, image sensor assembly, image processor assembly, front mirror body assembly, and rear mirror body assembly. Some of the 3D modeling results are shown in Figure 1.

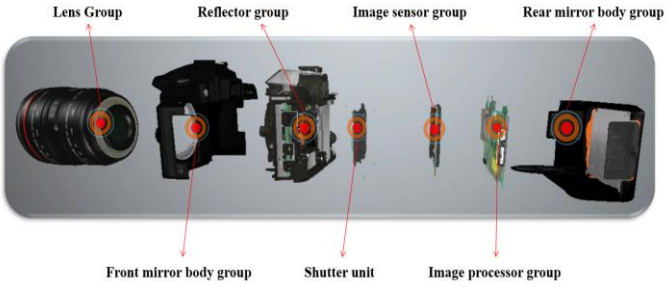

Figure 1: Parts of a SLR camera

Different modeling techniques were chosen based on the characteristics of different types of models to improve modeling efficiency and visual effects. Firstly, the SLR camera components were surveyed, and for some parts that were difficult to measure, 3D models were created based on design drawings to ensure the authenticity of the parts. UG modeling software was used to create 3D models at a 1:1 scale. To improve the texture and realism of the mechanical parts, the models were imported into 3Dmax software for surface mapping and baking of the part textures, so as to maintain the authenticity of the SLR camera parts as much as possible (Nie & Zhao,2022).

2. VIRTUAL ASSEMBLY SYSTEM

Virtual assembly technology can be used in teaching to visualize the product training assembly process for complex product design and manufacturing processes, and it has the advantage of being immediately usable. Using the VRP-Builder engine and the HTC VIVE head-mounted display, a virtual assembly system for SLR cameras was designed and implemented. The system includes three learning and training modules: a

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parts list, virtual assembly process, and assembly simulation animation. In the parts list scene, the component structure of the SLR camera is explained and understood through simple operations. In the assembly process scene, virtual assembly and disassembly are performed, and in the installation animation scene, the assembly and disassembly of the parts are automatically demonstrated. In the interactive training scene, students can operate and train, forming an integrated education-training-skill system.

2.1 Part List

According to the learning rules of skill training, before virtual assembly of an SLR camera, it is necessary to understand the components of the SLR camera, such as the function of each component group, the components that make up each group, and their position in the whole machine. This cognitive learning is accomplished through the parts list module. Taking the lens assembly as an example shown in Figure 2, the cognitive learning of the parts list module is introduced.

Figure 2: Parts list of the lens assembly

The shutter unit components include the shutter blade bracket, spacers (3 pieces), lower curtain, upper curtain, and shutter blade positioning bracket. The reflex mirror assembly components include the viewfinder LCD and pentaprism assembly, reflex mirror assembly, aperture assembly, shutter unit, camera bracket, and triangular fixing bracket. The image sensor assembly components include the CMOS image sensor, low-pass filter, and fixed bracket. The image processor assembly components include the digital board and shield. The front mirror body assembly components include the eyepiece support bracket, top cover, hand grip shell, front shell, lens fixing bayonet, and logo shell. The rear mirror body assembly components include the LCD display, carbon ink button assembly, button board cable, slot cover, bottom cover, and button and display screen fixing bracket. The lens assembly components include the lens barrel, fixed outer frame, bayonet, eyepiece retaining ring, zoom mechanism, zoom ring, objective lens, and eyepiece.

2.2 Assembly Simulation Animation

The VRP-Builder engine allows for the creation of buttons, insertion of audio and video, addition of timeline animations, support for special effects, and embedding of IE and network online browsing, among other functions. Students can interact with objects or properties in various ways within the 3D scene using the mouse, keyboard, event triggering, timed triggering, and script flow (Huang, 2021). The assembly simulation animation aims to familiarize students with the assembly process of each component of the SLR camera according to the assembly sequence and working principle, after they have learned the parts through cognitive learning. By creating timeline animations for each component and adding event-triggered scripts, students can use the created buttons to control the automatic playback of the assembly simulation animation for each component and the whole camera assembly. The specific assembly process is shown in Figure 3.

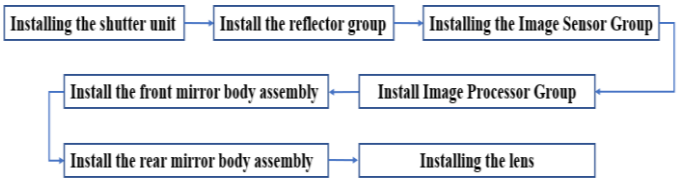

Figure 3: Simulation animation process for SLR camera assembly

2.3 Virtual Assembly Process

This system is designed based on the working principle of the SLR camera, and the assembly of the shutter unit, reflex mirror assembly, image sensor assembly, and lens assembly is the most critical part of the entire device.

Taking virtual assembly of the shutter unit as an example, the shutter unit is an important component of the camera for controlling the exposure time of the photosensitive element. To protect the photosensitive element inside the camera from exposure, the shutter is always closed. During shooting, the shutter speed is adjusted, and the photo button is pressed. In the gap between the opening and closing of the shutter, the light from the camera lens allows the photosensitive element inside the camera to achieve the correct exposure. The light passes through the shutter and enters the photosensitive element, and then is written to the storage card. The process of interlocking and coordinating the various parts is complex, and the requirements for part assembly are high. To virtually assemble the components of the shutter unit, first, timeline animations are added for each part separately. Then, assembly buttons for each part are created, and corresponding event-triggered scripts, such as timeline, audio explanations, camera and text displays, are added. The interactive control of assembling parts is achieved in sequence according to the assembly relationship and order (Chen & Sheng, 2023; Du, 2022; Han et al., 2023). The virtual assembly process of the shutter unit is shown in Figure 4.

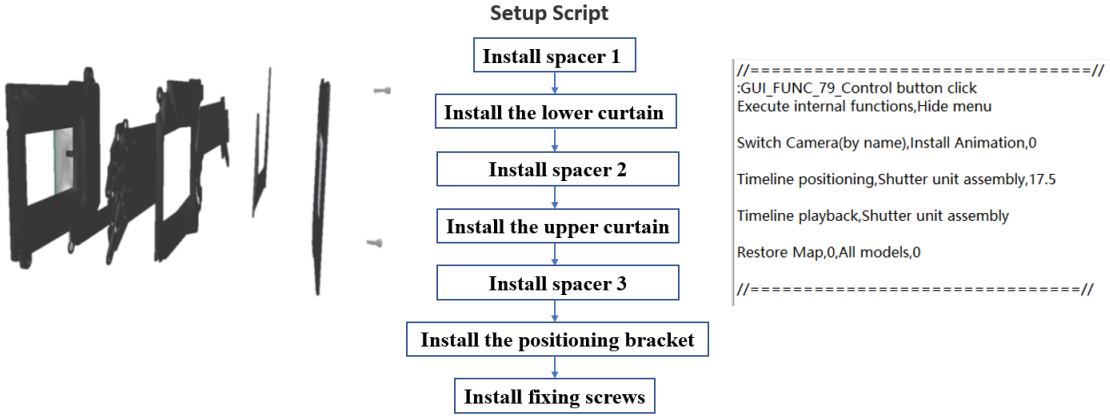

Figure 4: Process of virtual assembly of shutter unit

3. Interactive Training

Students wear a head-mounted display, such as the HTC VIVE, to interact with the virtual scene. They use the grab button to pick up the SLR camera parts that need to be assembled. When grabbing the parts, they do not need to hold the grab button continuously. Pressing the button once will pick up the part, and pressing it again will release it. They can move the parts forward, backward, left or right by touching different directions on the touchpad, and then assemble the parts in the correct position. In the interactive training module, points are awarded for correct operations, and the system resets to the initial state for any incorrect operations. If three incorrect operations are detected, the system will return to the parts list for relearning. After completing the learning of the parts list, installation simulation animation, and virtual assembly process, students can retake the interactive training test (Liu, 2017; Xu, 2019).

4. Conclusion

The design and implementation of this system saves teaching and experimental training resources while providing an immersive and feature-rich virtual assembly training for SLR camera. It also plays an indispensable role in training employees in certain production processes.

Through simple and easy game-like training, the system includes an automatic scoring and evaluation system, which enables students to master the basic assembly skills of SLR cameras. The development of the system has also significantly improved the teaching and research level of the teachers. In the next step, VR technology will continue to be used to develop an intelligent evaluation system to replace manual evaluation, which will provide more objective evaluations of students' practical training operations. This will contribute to the construction of information-based practical teaching and the cultivation of high-quality technical talent.

Fund Project

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