Development and Application of Intelligent Connected Vehicle Teaching Software Based on Virtual Reality Technology

Yan Wang*[a], XiaoYan Huang[a], YuFei Zhang[a]

[a]CATARC Intelligent and connected technology Co.,LTd. Tianjin, China

*Corresponding author: wangyan2018@catarc.ac.cn

Abstract. The rapid development of the intelligent connected vehicle industry has led to a significant demand for talent. However, traditional teaching methods are unable to meet the requirements of actual job positions, posing challenges for vocational education institutions in cultivating intelligent connected vehicle professionals. This paper analyzes the instructional content and existing issues in the construction of intelligent connected vehicle programs in vocational education institutions. It develops an intelligent connected vehicle teaching system based on virtual reality technology and elucidates its application in terms of instructional content and functionality. The system provides a feasible and referenceable solution for the development of automotive information technology teaching in the field of intelligent connected vehicles, thereby addressing the aforementioned challenges.

Keywords: Virtual Reality; Intelligent Connected Car; Education and Teaching

1 Introduction

The advent of new-generation information technologies represented by VR/AR and artificial intelligence is exerting an unprecedented scale and speed of influence on the survival and development of traditional professions, leading to profound transformations in vocational education [1]. Integrating modern educational technologies into the teaching and training of automotive programs enables a more diversified training approach, dynamic instructional content, and efficient teaching processes. This shift empowers students to transition from passive learning to active engagement, thereby enhancing teaching techniques and talent development. The establishment of an automotive virtual simulation training center that seamlessly integrates "theory teaching - simulated training (pre-training) - practical operation" throughout the entire process is an inevitable trend in the application of new technologies in vocational education during the Information 2.0 era.

To meet the requirements of national vocational education reforms and promote instructional model innovation, as well as content and methodological renewal, it is essential to cultivate highly skilled, versatile technical professionals who are well-suited

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for the development of the intelligent connected vehicle industry. This goal represents a crucial issue that needs to be addressed in the current context.

2 Overview of VR technology

2.1 Current development status of VR technology

Virtual Reality (VR) is a novel computer technology that enables the creation and manifestation of virtual worlds [2]. VR technology is characterized by three fundamental features: immersiveness, interactivity, and imaginativeness. Immersiveness refers to the ability to place users in a computer-generated 3D virtual environment, providing them with a sense of presence. Interactivity involves utilizing sensor devices to facilitate real-time interactions within the virtual environment. Imaginativeness aims to enhance users' creative thinking and perception [3]. VR technology is a practical innovation that emerged in the 20th century. Since 2016, the Chinese government and various departments have launched numerous special initiatives and innovation plans to provide policy support for the practical application of VR technology in fields such as culture and entertainment, information and communication, education and teaching, healthcare, and more [4].

2.2 The application of VR technology in the field of teaching

With the development of technologies such as artificial intelligence and industrial internet, the application of virtual reality technology in teaching is becoming more and more widespread [5-7]. China strongly supports and encourages the application of virtual simulation in vocational education. In terms of educational resources, it is proposed to fully utilize modern information technology to develop virtual factories, virtual workshops, virtual processes, virtual experiments, and select and develop virtual simulation training systems. In terms of practical teaching, it is required to strengthen practical teaching, innovate the application mode of simulation and training resources, and improve the efficiency of use [8]. Virtual reality has been applied in various disciplines including clothing, ships, automobiles, medicine, and biology in the field of vocational education [9-11], but its application in the automotive profession is mostly focused on new energy vehicles, achieving teaching of the structure, principle, and disassembly and assembly of new energy vehicles through virtual reality technology [12-13], and there are no mature virtual reality software applications for teaching of intelligent connected vehicles yet.

3 Teaching content and characteristics of intelligent networked automobile major

3.1 Teaching content of intelligent networked automobile major

Based on the technological characteristics and professional domains of intelligent connected vehicles, the core theoretical and practical training courses for intelligent connected vehicle-related majors are shown in Table 1.

Table 1. Core theoretical courses and practical training courses for majors related to intelligent connected vehicles

	Theory Course	Training Course
1	The technical basis of intelligent networked vehicles	Intelligent traffic management and control training
2	Environmental perception technology for intelligent networked vehicles	Intelligent equipment assembly test training
3	Internet of Vehicles Technology and Application	Intelligent network environment perception training
4	Intelligent network car navigation and positioning technology	Comprehensive training of advanced driving assistance technology for intelligent networked vehicles
5	Chassis Control Technology of Intelligent Connected Vehicles	Intelligent network car navigation and positioning technology training
6	Key Technologies of Advanced Driver Assistance Systems	Smart car big data management and application training
7	Intelligent network car modification test technology	Intelligent network road application training

3.2 Teaching Features of Intelligent Connected Vehicles

In recent years, the rapid development of the intelligent connected vehicle industry has resulted in a significant demand for talent, leading to a surge in the number of educational institutions offering programs in intelligent connected vehicles. However, due to regional and institutional differences, there are several challenges in the teaching of intelligent connected vehicle programs.

3.2.1 Occupational safety

The hazardous nature of intelligent connected vehicle teaching activities is primarily evident during the retrofitting of new energy vehicles. The high-voltage systems in new energy vehicles typically operate at several hundred volts, significantly exceeding the safe voltage limit for human exposure. Failure to follow proper procedures for power disconnection and electrical testing during the retrofitting process can pose serious electrical safety risks [14].

3.2.2 Insufficient training equipment

Due to the relatively high prices of intelligent connected vehicles and associated devices, educational institutions can only acquire a limited number of vehicles for training purposes, which cannot meet the demand for hands-on training from a large number of students. Moreover, high-precision instruments such as LiDAR sensors often experience performance deviations and damage after frequent usage. b) Some schools may have acquired the necessary equipment, but limited training facilities prevent them from providing a sufficient number of training devices.

Outdated teaching methods. Most educational institutions offering intelligent connected vehicle programs rely on faculty members who come from traditional automotive repair or computer science backgrounds. Their capabilities and knowledge structures may not fully meet the requirements of teaching intelligent connected vehicle courses. The delivery of courses often relies heavily on textbooks and PowerPoint presentations, which may limit the effective demonstration of key concepts. These factors hinder students' understanding of course content and their development of practical skills, leading to a gap between the teaching outcomes and the requirements of actual job positions [15].

4 Development of intelligent networked vehicle teaching system based on VR technology

4.1 Software solution design

The VR teaching system for intelligent connected vehicles is based on the curriculum framework of intelligent connected vehicle programs. Its purpose is to virtualize and simulate complex and abstract aspects of intelligent connected vehicles, such as hardware, software, algorithms, etc. Within a virtual environment, students can learn about the structure, installation, debugging, and fault diagnosis of intelligent connected vehicles, as well as master the fundamental retrofitting operations. The software design process, as shown in Figure 1, consists of four stages: (1) login and authentication, (2) vehicle model selection, (3) learning module selection, and (4) session completion. The learning modules include the principles teaching module, installation and debugging teaching module, and fault diagnosis module.

Each module is built around key knowledge points, presenting complex structures and principles that are difficult to comprehend in a clear and engaging manner using high-definition models, animations, special effects, and other elements on VR devices. This approach greatly stimulates students' interest in learning and enhances the effectiveness of knowledge acquisition. Additionally, interactive quizzes are incorporated for each knowledge point, reinforcing the learning outcomes by combining the necessary knowledge with VR models and animations through interactive engagement.

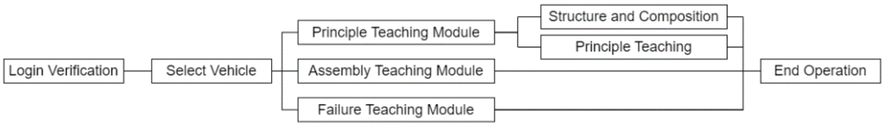

Fig. 1. Software Design Flowchart

4.2 Development Tools and Platforms

This software primarily utilizes three development tools: 3D Studio Max (referred to as 3ds Max), Adobe Photoshop (referred to as PS), and Unreal Engine 4 (referred to as UE4).

3ds Max is a powerful 3D animation software developed by AutoDesk. It enables robust character animation capabilities with low system requirements for PC-based platforms. 3ds Max is mainly used for early-stage model construction, material creation, rendering, etc. The models created include the hardware facilities within the training room, vehicle bodies, intelligent sensors, wiring harnesses, accessories, and more.

PS is an image processing software developed and distributed by Adobe Systems. It is primarily used for processing digital graphic images and possesses powerful image processing capabilities. It can be used to repair captured images and create model textures.

UE4 is the fourth version of the Unreal Engine, a game engine that offers powerful development features and open-source planning. It excels in graphics and immersive experiences compared to Unity3D, achieving AAA-level visual effects. UE4 provides various tools and resources and offers free access to source code, forming a comprehensive top-down ecosystem. Developed using C++, UE4 can run on operating systems such as Windows and Linux, as well as gaming platforms like Xbox and mobile platforms like Android. It supports packaging and deployment through multiple channels, making it popular among developers. Products developed with the UE4 engine are applied in various professional fields, including gaming, industry, healthcare, education, etc. In the development of this system, UE4 is used for scene construction and interactive actions. Finally, specific operations are implemented through Steam VR runtime environment using handheld controllers.

4.3 Process of technology development

The main development process of the virtual reality-based intelligent connected vehicle teaching software includes data collection, 3D model creation, texture mapping, and interactive scene design.

4.3.1. Data Collection.

Firstly, relevant environment images of the intelligent connected vehicle training room are collected to design the training room environment in this system. Then, actual operational steps of vehicle modification, along with images of related equipment and wiring harnesses, are captured as references for model creation.

4.3.2. 3D Model Creation

Using the polygonal modeling technique of the 3D modeling software, 3ds Max, the vehicle components are modeled. The model creation in this paper involves four main parts: creating low-polygon models for the multifunctional intelligent vehicle and its components, creating models for the training workshop's terrain, floors, walls, etc., creating models and arranging necessary equipment for the workshop training tools, and creating low-polygon models for character roles.

4.3.3. Texture Mapping.

Unwrapping the model's texture coordinates, the inherent color texture of the model is composited using Adobe Photoshop. Then, in 3ds Max, materials and textures are assigned, and texture positions are adjusted. Finally, in Unreal Engine 4 (UE4), post-processing editing of materials and textures is performed, including setting the reflection and refraction properties of materials such as water surfaces and glass, and designing visual effects for sunlight, weather, etc.

4.3.4. Interactive Scene Design.

In UE4, the user interface of the system is created, including background interface elements, interactive buttons, and background sound production. Images, videos, and other media are incorporated and linked with models and buttons for interaction. Lastly, the project files are compiled into an executable EXE file for publishing and output.

4.4 Realization of teaching function

The software serves the teaching of intelligent connected vehicle professional courses and consists of four types of functional modules: structural awareness, working principles, performance testing, and skill training. Each module allows students to operate within a fully immersive virtual environment, facilitating a seamless transition from theory and teaching aids to practical exercises. The software interface is shown in Figure 2.

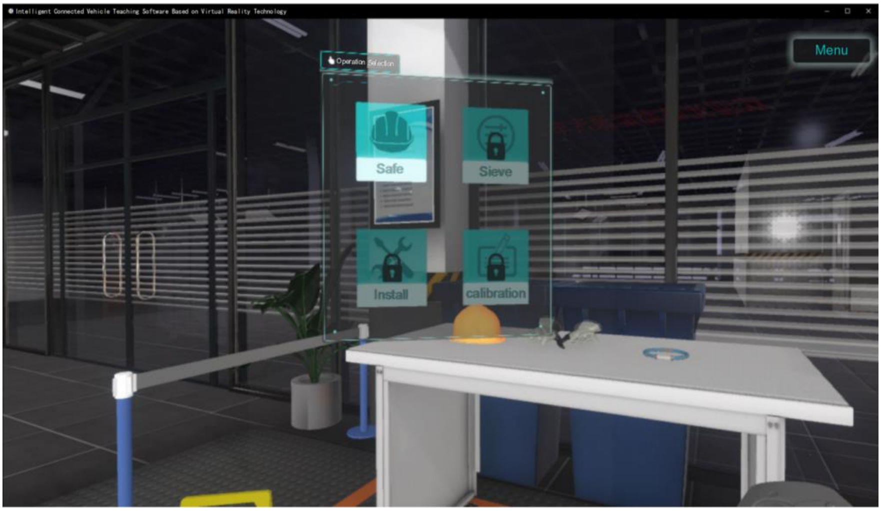

Fig. 2. Software Interface Diagram

The working principles module utilizes VR to showcase the working principles of systems or components. It does not involve interaction, and students learn by observing the scenes from a third-person perspective. The supported scenarios for the working principles module in this software include virtual simulations of environmental recognition technology, perception devices, CAN bus, control execution units, autonomous driving warning functions, autonomous driving execution functions, and vehicle chassis control system principles.

The structural awareness module primarily addresses the structural understanding of the entire vehicle, intelligent devices, and components. It presents the structures through exploded diagrams, allowing users to interact with the observed objects. For example, regarding installed sensors on vehicles such as ultrasonic probes, front cameras, millimeter-wave radars, lidars, and inertial navigation systems, the software enables directed structure decomposition, display/hide of structural components, explosion, cross-sectioning (arbitrary plane), and perspective effects. Additionally, for vehicles with installed sensors, it enables overall structural breakdown. Through immersive virtual exercises, students can experience and understand the structures, assembly positions, and other major components of intelligent connected vehicles, deepening their understanding and comprehension of theoretical teachings while enhancing safety awareness and practical skills.

The performance testing module primarily conducts performance tests on vehicles and sensors. It demonstrates the testing procedures for sensors through experiments and guides students through interactive operations. For example, performance testing of lidars, millimeter-wave radars, cameras, etc., is conducted to identify devices that can function properly.

The skill training module focuses on training in equipment installation, wiring harness connection, and sensor calibration for intelligent connected vehicles, aiming to achieve the same learning outcomes as real vehicle modifications. Students can perform virtual disassembly and assembly operations within the intelligent connected vehicle VR teaching system, simulating actual operational processes. They begin by reading relevant repair manuals within the system and then proceed to practical exercises. During these exercises, students can execute commands such as zooming in/out, rotating, and perspective adjustments to deepen their understanding of virtual vehicle components and wiring layouts.

5 The advantages of VR technology in the teaching of intelligent networked vehicles

5.1 High safety level

By leveraging virtual reality technology, the software maximizes the replication of actual operating scenarios. During training and teaching, there is no high-pressure safety risk involved. Additionally, VR training allows convenient and realistic operational exercises for all intelligent connected vehicle training projects, serving as a "pre-training" to reduce risks during actual training.

5.2 Lower training costs

VR training eliminates the cost of automotive consumables and reduces the need for excessive space utilization. Through 1:1 modeling of real components and vehicles, VR teaching simulates actual operations, reducing the probability of vehicle and equipment damage caused by improper operations due to unfamiliarity with operational standards.

5.3 Improved teaching effectiveness

VR technology enables multi-angle displays, comprehensive rotational observation, and a more interactive learning environment. It allows the dismantling of major components of intelligent connected vehicles from any angle and visualizes complex theoretical knowledge. By replicating standardized inspection processes for common faults in intelligent connected vehicles, the software helps students understand the phenomena, detection, and maintenance of common faults. With highly replicated models and standardized operating procedures, the software combines one-way theoretical teaching with interactive operations, enabling students to establish good habits of operating according to proper standards during simulated practical exercises.

6 Conclusion

The rapid development of the intelligent connected vehicle industry has brought about a significant demand for talents. Traditional teaching methods are inadequate to meet the requirements of actual job positions. For vocational colleges, modern educational technology has effectively facilitated the transformation of traditional teaching and research concepts, driving the update of teaching methods and approaches. Applying these technologies to education and teaching enhances the level of instructional techniques and talent development, serving as an important avenue for vocational education reform and development.

This paper discusses the characteristics and challenges of teaching intelligent connected vehicles based on the current situation in most vocational colleges. By designing an intelligent connected vehicle teaching system based on virtual reality technology, the application of VR technology in the content and functionality of vocational education for intelligent connected vehicles is elucidated. This system serves as a positive complement to traditional teaching methods, enabling a change in teaching mode and enhancing teaching quality. It provides a viable and referenceable solution for the development of informationized teaching in the field of intelligent connected vehicles.

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