

Design and Analysis of Vehicle Operation and Maintenance Simulation Training System

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Abstract: This paper briefly introduces the basic concepts of augmented reality and virtual reality technology, sorts out the application status of the above two technologies in the automotive industry, designs and analyzes the actual teaching needs for vehicle operation and maintenance simulation training, and explores the use of augmented reality and virtual reality technology to build a simulation training system. It integrates their immersion, interaction, autonomy, multi-perception, and other characteristics into the teaching process, organizing students to conduct simulation training in vehicle application, maintenance, repair, and other aspects in a reasonable, efficient, scientific, and intensive manner. To increase the proportion of simulation training in practical training and improve the efficiency of students' practical skills, we can use virtual reality technology based on digital information to comprehensively digitize all information resources such as teaching plans, information, multimedia, practical operations, and technical data in the teaching process. So, finally, we can realize the informatization of the automobile education field to improve the intensive characteristics and management level of teaching.

1. Introduction

1.1. Basic Concepts of AR Technology

Augmented Reality (AR) integrates information from both the real and virtual worlds, blending physical elements such as visual data, sound, taste, and touch that are typically challenging to experience within specific time and space constraints. By leveraging computers and other technologies for simulation, AR overlays digital information onto the real world. This fusion is then perceived through human senses, enhancing our sensory experiences beyond what reality alone can offer.

1.2. Basic Concepts of VR Technology

The so-called VR, Virtual Reality, is a new world created by computers and electronic technology, featuring real-time dynamic three-dimensional stereoscopic images generated by computers. Through various sensor devices, users can employ human natural skills to investigate and manipulate objects in the virtual world according to their own feelings, participate in events, and at the same time, provide intuitive and realistic real-time perception such as sight, hearing, and touch, allowing participants to immerse themselves.

2. Application of AR and VR Technology in the Automotive Industry

2.1. VR Car Display and Car Selection

VR technology can help users choose cars better. Since the end of 2015, Audi brand customers have been able to wear Oculus Rift equipment to buy their cars while sitting in a car dealership.

Through the equipment, they can browse all models of all Audi series. After wearing the VR headset, users can view the vehicle configuration of their choice more intuitively and conveniently, and realize the dynamic display of car colors, configurations, lighting, and sports effects, among other features.

At the same time, VR technology can simulate the real scene of a person sitting in a car, where customers can make a variety of personalized settings, such as interior leather, color, decoration, and in-car entertainment systems. It is worth mentioning that when the user looks around while wearing the Oculus Rift, the display in front of them will show the corresponding part of the car.

Additionally, some virtual driving scenarios are integrated into the functions, such as various weather conditions and road conditions. The use of VR technology to display the interior and exterior structure of the car can simulate the real scene of the user sitting in the car. They can also use VR equipment to change the color, decoration, and other aspects. This greatly enhances the customer's car configuration purchase experience.

2.2. AR Car Manual

Traditional paper car manuals often reach 200-300 pages; buyers find it difficult to have enough time to fully review the car manual. The use of the car often relies on their own knowledge and experience, completely based on the feeling for the car. When encountering problems, they will use the manual to find a solution. This makes buyers unaware of what problems to pay attention to in daily use, how to troubleshoot simple faults, etc. Even if they encounter problems and turn to the manual, they may give up because the book is too thick.

The use of AR technology can replace paper manuals and display user guides in three dimensions, which can not only improve users' interest in reading but also help users quickly understand and solve problems. The AR version of the car manual can provide users with more intuitive guidance and suggestions, so novices no longer need to look through the manual to find the function of a button in the center console. This is shown in Figure 1.



Figure 1 AR car manual based on PAD.

2.3. AR Vehicle Repair

Vehicle maintenance workers use relevant AR equipment or apps (through mobile phones) to focus their eyes or cameras on certain parts of the vehicle, and they can see the parts that need to be repaired, the tools that need to be used, and the maintenance operations that need to be performed.

Checking the oil level, engine coolant level, battery condition, replenishing oil, replacing the battery - these apps can help you solve these issues. As soon as the camera is pointed at the vehicle, the name of the part and the relevant information are displayed on the phone screen. And by clicking on the part you want to know about, it will also display maintenance or repair information, even teach people to operate through animations. This method greatly reduces the time cost and labor cost of learning vehicle maintenance^[1].

3. Vehicle Operation and Maintenance Simulation Training System

3.1. Construction Needs

In recent years, the Ministry of Education has successively issued relevant documents pointing out that "the construction of a virtual simulation training base for vocational education is not only an urgent need to reform traditional teaching and education methods and promote the innovation of talent training models but also an important measure to strengthen the integration of teaching and learning activities such as practical training education. They can effectively make up for special difficulties such as not seeing, entering, high cost, and high danger in vocational education training" and has vigorously advocated the application of virtual simulation technology in the teaching field^[2].

The automotive operation and maintenance major is limited by factors such as location, cost, and safety. Colleges and universities generally emphasize knowledge transfer and intelligent training, with less emphasis on practice and innovation ability training. Therefore, it is considered necessary to build a virtual simulation training center for automobile operation and maintenance, integrating "teaching, learning, doing, and testing," and adding virtual simulation terminal training equipment. This can meet the school's virtual simulation course training needs and promote the improvement of students' basic professional abilities, professional core competencies, and professional behavior skills.

3.2. Construction Ideas

The construction of the virtual simulation training center for automobile application and maintenance professionals integrates the characteristics of immersive experience, 3D simulation, multi-perception, and practical operation height simulation into the teaching process. It relies on the training room and is based on the means of "Internet + simulation" to realize the innovation of teaching modes, teaching methods, and the synchronization of teaching content with reality^[3].

The VR training center can quickly create virtual scenes of cars, generate object interactions, restore non-destructive simulations of vehicle organizational structures, and simulate fault scenes that often occur during automobile maintenance. This allows students to obtain an immersive user experience, vivid human-computer interaction, and realistic simulation operations, which solves the issue of boring passive learning, deepens students' impressions, and greatly improves the teaching experience and effect.

3.3. VR Vehicle Operation and Maintenance Simulation System

The VR vehicle operation and maintenance simulation system uses virtual head display equipment to integrate its immersion, interaction, autonomy, multi-perception, and other characteristics into the teaching process. It relies on the training room and realizes the innovation of teaching mode, teaching method, teaching content, and practical training practice based on "Internet +" means. The construction of the VR vehicle operation and maintenance simulation system greatly solves the practical training of college students, and classroom teaching is connected with reality to cultivate the integration of students' basic knowledge, professional vocational skills, and practical training skills.

The VR vehicle operation and maintenance simulation system mainly includes the construction of hardware and software parts. The hardware part mainly includes the construction of VR-related equipment and VR training rooms, such as portable hosts, VR headset devices, multimedia displays, etc. The software part is the automobile application and maintenance training system. The whole simulation training system advocates the "creative concept", follows the principle of "combination of theoretical teaching and practical training" for design, combined with professional related courses, can be configured for personalized customization and upgrade, it can fully meet the requirements of the school's standardized information teaching courses.

3.4. Automotive General and Structural Learning Resources

The software platform displays the overall and various structures of the car in the form of a 3D

model simulation visualization. Each part can be displayed with BIM flexible dynamic display, and the details of each part can be touched and enlarged. The platform allows for 3D interactive interaction, and each part can be synchronized with detailed video courses, PPT courseware, and multimedia audio for a synchronous display. It also supports multi-screen interactive display and teaching with the training center, enabling students to have a comprehensive, in-depth understanding and quick mastery at their fingertips. This resource can be applied to both VR and AR platforms, with the application method determined according to the actual situation.

3.5. Vehicle Maintenance Diagnostic Resources

Vehicle maintenance is the main content of the trainees' work. They must carry out comprehensive learning and practical exercises. The software supports 3D VR simulation for diagnostic practical training questions (based on vehicle maintenance experience, a case library is set up). It allows students to immerse themselves in circuit diagnosis and exercises. Teachers can view practice results in real time on the platform, providing online timely correction and guidance. The combination of virtual and real, as well as theory and practice, enables students to quickly master circuit knowledge and diagnostic skills. Mechanical faults can be studied and operated using the simulation training platform^[4]. This is shown in Figure 2.



Figure 2 Automotive virtual simulation maintenance system.

3.6. VR Immersive Teaching Resources for Vehicle Maintenance

Using VR/AR technology with simulation training platforms, from virtual to simulated to real vehicles, from standardized practical training teaching, VR/AR virtual simulation training, virtual and real combined practical operations, to the new closed practical training teaching mode of hands-on real machine training, we break through the bottleneck of traditional teaching and practical training. Gradually, we improve students' professional and technical abilities, hands-on practical abilities, and practical training operation levels, enhance the utilization rate of practical training equipment and the efficiency of practical training teaching, reduce the risk coefficient of practical training and teaching, so we can enhance the ability generation level of vehicle maintenance professionals.

4. Conclusion

The automobile operation and maintenance simulation training system fully utilizes modern teaching methods and physical teaching methods to create an integrated classroom that combines theory and practice, enabling students to engage both their minds and hands. This approach realizes the integration of theory and practice, thereby improving their knowledge and skills simultaneously.

Through the establishment of a modern training base with high starting points and standards, students can acquire vocational skills and receive comprehensive literacy training in a real professional environment, meeting the practical training needs of vocational schools for auto repair-related majors. By employing virtual reality technology and leveraging digital information, the school's teaching, scientific research, management, and life services, among other information resources, are comprehensively digitized. Ultimately, we will realize the informatization of education and enhance the school's operational and management level.

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