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Design and Application of the Virtual Simulation Teaching System for RFID Higher Education

Xiaohui Chen[1,2,a,] , Hao Zhang[2,b], Ji Fang[1,c] and Guangjun Wang[2,d,*]

[1] School of Information Technology, Anqing Vocational and Technical College, Anqing 246013, China

[2] The University Key Laboratory of Intelligent Perception and Computing of Anhui Province, Anqing Normal University, Anqing 246013, China

a. 420236663@qq.com, b. hanqianyu.zhang@qq.com, c. 351827877@qq.com, d. 734386718@qq.com

**corresponding author: Guanjgun Wang, 734386718@qq.com; Tel.: +86 13966410563*

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Abstract: Radio frequency identification (RFID) is an important technology in the Internet of Things (IoT) engineering, and there are problems of limited experimental conditions and high costs in higher education. This study designs and develops a virtual simulation teaching system for RFID based on virtual reality (VR) technology. The system includes an Augmented Reality (AR) based RFID read-write system and a VR-based Electronic Toll Collection (ETC) system. The teaching application indicates that the system is able to meet the needs of RFID courses and increase students' interest in learning.

1. Introduction

IoT engineering involves a wide and diverse range of technologies, and the representative technologies are communication technology, sensor technology, RFID technology, etc. [1]. RFID technology is an auto identification technology that uses radio frequency for non-contact, two-way data communication. RFID technology, as an important technical course in IoT engineering, has strong requirements for students' practical engineering skills [2]. However, in the current university, the practical teaching of RFID technology still has more significant problems, mainly in the following aspects: (1) RFID technology principles are more difficult, and it is difficult to let students understand intuitively. (2) RFID technology-related learning requires experimental equipment, and there is a shortage of teaching test equipment in schools, which is slow to be updated. (3) The applications involved in RFID technology are generally a complex system that does not allow students to experience and learn [3]. Therefore, it is difficult for traditional RFID technology teaching to ensure students have sufficient demand for RFID technology learning.

Virtual simulation technology can be well used in teaching by visualizing and interestingly presenting knowledge and simulating virtual environments through virtual reality and augmented reality technologies [4-5]. Sidjanin P et al. used virtual simulation technology for teaching nuclear physics in university physics education [6].M Li et al. used the concept of embedded CNC machining simulation system and contextual learning to improve learners' contextual thinking skills and innovation literacy [7]. J Chen et al. introduced the development of experimental simulation teaching for core communication courses such as microcontroller application development, embedded IoT gateway development, and mobile application development using a virtual simulation integrated experimental teaching platform for the Internet of Things [8].

We design an RFID virtual simulation teaching system to educate RFID technology in higher education. The system includes an AR-based RFID read-write system and a VR-based ETC system. The system allows for a visual and exciting display of RFID teaching content and immersive learning of typical RFID applications through VR experiences. This paper aims to introduce the system and analyze its strengths and weaknesses through teaching application.

2. Design and implementation of RFID virtual simulation teaching system

The RFID virtual simulation teaching system mainly uses various virtual reality technologies to achieve knowledge visualization, interest, and immersive experience of complex systems for RFID teaching. Through extensive course analysis and content preparation, combined with the characteristics of virtual reality technology, we choose two scenarios as examples to design and explore. They are an RFID reading and writing visualization demonstration system based on Augmented Reality technology and an ETC system based on Virtual Reality VR technology. The systems' functions are shown in Figure 1.

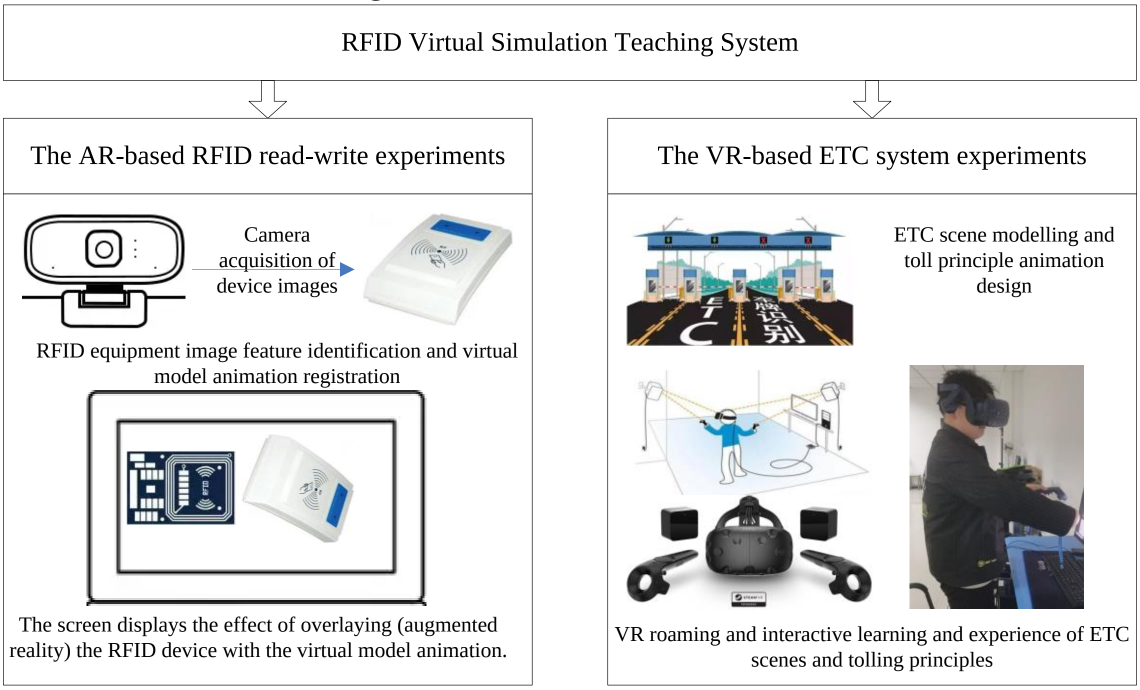


Figure 1: Overall system design.

The AR-based RFID read-write visualization demonstration system demonstrates the working principle and composition of RFID. The internal working principle and structure of RFID reading and writing cards and devices are demonstrated through 3D modeling and animation. Then a virtual animation of the internal system and working principle is superimposed on the physical object on the screen through camera identification of the physical object [9]. This approach allows students to intuitively understand the working principle of RFID reading and writing experiments and better grasp the knowledge. The effect of the AR-based RFID read-write experiment is shown in Figure 2.

Figure 2: The Effectiveness of AR-based RFID Read-Write Experiments.

The VR-based ETC system demonstrates the application of RFID in reality, where a highway ETC car can complete the application scenario of toll collection without stopping, in which ETC cars can complete payment without stopping. ETC is a typical application of RFID technology and is a more common application. By constructing a three-dimensional virtual scene of a high-speed toll gate station, VR headgear is used to allow users to view the process of ETC charging using RFID technology visually. This approach can effectively enable students to immerse themselves in a safe environment to experience the application scenarios of complex RFID systems. Figure 3 shows the effect of VR-based ETC system experiments.

Figure 3: The effect of the VR-based ETC system experiments.

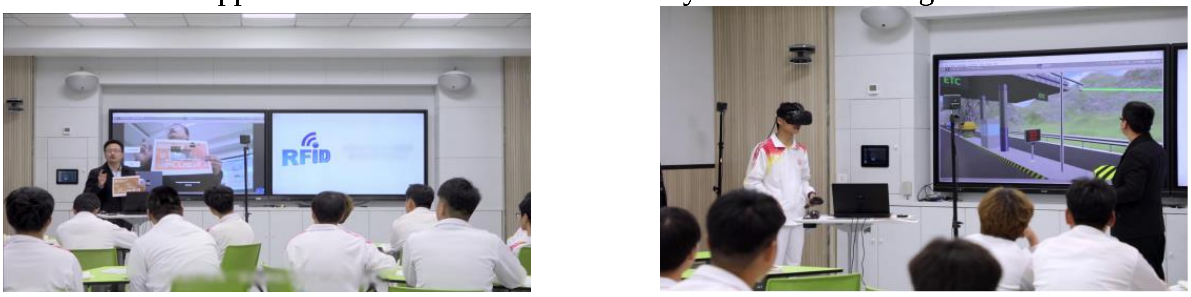
The RFID virtual simulation teaching system uses 3dsmax software for 3D modeling and virtual scene construction. Then, we develop and implement various human-computer interaction functions by Unity. Finally, an immersive learning experience is achieved through a camera or VR headset (HTC Vive).

3. Teaching applications and analysis

In order to analyze the usability of the system, we perform the virtual simulation teaching system for RFID for Higher Education applications. We recruited 40 IoT engineering students to participate in the system's learning. The experimental procedures of this course are divided into two parts. They are the AR-based RFID read-write system (experiment 1) and the VR-based ETC system (experiment 2).

In experiment 1, students need to download the APK installation package for Android, install it on their Android phones, open the application, identify the specified picture in reality, and start learning. Clicking on "Open Reader," a spherical circle of lines is observed scattering from the reader, which indicates that the built-in coil generates magnetic induction lines, and then the reader starts working. Click on the "Type" button and observe the electronic tag move towards the reader. The induction current is generated inside the electronic tag, and the signal is excited and transmitted. Continue to click "Next," and the user can observe the signal transmission step by step. At the same time, there will be relevant tips in the upper right corner of the screen. There will be a close-up frame of the lens in the lower-left corner, indicating the signal transmission to which part. Clicking on the menu button on the right side of the screen shows the original details and the related function descriptions.

In experiment 2, students were required to wear the HTC Vive as the experiment utilized virtual reality technology. Students could see various cars on the scene moving through the toll booths with the helmets on. As the ETC car passes through the toll booth, a green light can be observed connecting the body of the ETC car and the receiver of the ETC booth, indicating the transmission of signals. The electronic screen under the receiver will show the process and the toll collection status during the process. In addition, students can use the handle to observe the function of the part through the ray focus receiver and use the handle to complete the scene in different ways to move. Figure 4 shows the application of the virtual simulation system for RFID higher education.



(a) The effect of the AR-based RFID read-write experiments. (b) The effect of the VR-based ETC system experiments.

Figure 4: The Application of the Virtual Simulation System for RFID Higher Education.

Through the teaching application of the system, we found that students were very interested in the system and were eager to learn and experience the system [10]. On the one hand, the VR and AR-based interaction approaches are exciting, and on the other hand, this teaching model allows boring knowledge content to be presented in animations and data visualization, making it easier for students to appreciate and comprehend. The AR-based approach allows virtual animations of principles to be overlaid with real encapsulated equipment, which allows students to perceive the internal structure of the equipment effectively. The VR-based approach allows complex systems to be simulated, allowing students to immerse themselves in the virtual world of the system, which not only allows for a quick understanding of the system structure but is also more enjoyable.

4. Conclusion

This study explores the application of VR technology for higher education practice in RFID technology. By combining theoretical knowledge in the classroom and experiments with virtual reality technology, students are familiarised with the knowledge of RFID hardware and transmission methods. It has strengthened the students' ability to internalize engineering practice and cultivated the habit of active observation and continuous thinking. In the next step, we plan to use virtual reality technology in combination with other IoT-related technologies to make students feel the fun of learning and achieve interesting teaching.

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