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Teaching Reform and Practice of Urban Rail Transit Communication Signal Technology Course Based on Artificial Intelligence

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Abstract. In order to solve the problems of boring, long class hours and low learning efficiency of students in the traditional teaching mode of pure theory teaching, the teaching reform and practice of urban rail transit communication signal technology course based on artificial intelligence has been proposed. Firstly, the ARM chip RK3399 is used as the controller and the embedded system hardware is designed. Secondly, use 3D MAX to establish virtual teaching scenes and interactive object objects. Finally, the principle of binocular vision is used to track user interaction behavior and achieve good interactivity. In the process of system testing, the work effect of this paper is obtained. The experimental results show that the teaching system designed in this paper can support more users' access requests. When the number of visits is 500, the delay time of the system in this paper is 176.8ms, which is far less than NET platform, the available resource space for functional expansion of the system in the follow-up teaching process is larger, and the basic running performance of the system is better. Conclusion: From the perspective of system performance and system application effect, this paper verifies that the designed teaching system has good performance, enriches teaching methods and means, and fully improves the interactive teaching quality.

Keywords. Virtual Reality Technology; Interactive Teaching; Binocular Vision Principles; Railway Transportation

1. Introduction

As a professional course of urban rail transit operation management, the course of urban rail transit communication signal is mainly divided into four modules: basic signal equipment (annunciator, switch machine, relay, track circuit, axle counter system, transponder), interlocking and blocking, ATC system CBTC system is characterized by not only mastering the basic theory of each module, but also mastering the basic principle of each module through practical training, realizing equipment fault handling operation, cultivating skilled talents, and promoting students' practical application ability of knowledge [1]. The traditional teaching mode mainly focuses on theory teaching, and students cannot realize the practical application of knowledge. The signal course is too professional. For students with zero foundation in

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higher vocational education, the pure theory teaching is boring, the class hours are long, and students' learning efficiency is low [2].

With the rapid development of cloud computing, 5G network, virtual reality, augmented reality (AR) and other technologies, the reform of education mode is imminent. It requires that both teaching and learning parties can conduct real-time communication and interaction, teachers' scientific research information can be shared to the greatest extent, and the form of teaching can break the traditional constraints of time and space [3]. In terms of ways, it is required to be more diversified, expressing teaching information through pictures, text, sound, 3D video and other forms; Requirements for human-computer interaction are also critical. Real time friendly human-computer interaction can create a shocking immersion for students, thus ultimately enhancing students' real perception [4].

With the continuous promotion and application of informatization teaching, the teaching system has become the main tool to assist teachers to carry out teaching activities [5]. Among them, interactive teaching is a kind of teaching means often used by teachers in the current course teaching, through the questions and answers between teachers and students to enhance the students' attention to the content of the course teaching, strengthen the students' enthusiasm for learning, and achieve good teaching results [6]. Virtual reality technology can create a good, realistic scene, so that students are immersed in the teaching scene designed by the teacher, and interact with the objects in the scene [7]. The application of virtual reality technology in interactive teaching can fully inspire students' learning interest and enthusiasm, attract students' learning attention, and create a good teaching atmosphere [8].

2. Literature review

With the continuous improvement of the national intelligent teaching level, facilitating the epidemic of online teaching, but also makes the electronic information class teaching content more perfect [9]. Electronic information courses usually require that the teaching content has a strong operational and intuitive, so for the online teaching of such courses, the use of human-computer interactive teaching system is very appropriate, and how to further realize accurate and efficient distance learning has become the key to improve the quality of online teaching of electronic information courses [10].

In the research on human-computer interaction distance learning, some scholars have proposed a cloud classroom intelligent teaching mode, which aims to optimize teachers' teaching methods and enhance students' autonomous learning ability, thus making the distance learning mode more perfect [11]. In addition, another research team proposed a distance education system for college students' ideology and politics based on intelligent mobile devices, which effectively improved the effect of distance education of ideology and politics [12]. Some researchers have designed a set of systems to meet the needs of distance learning by applying artificial intelligence technology, which not only realizes human-computer interaction, but also significantly improves teaching efficiency [13]. These studies show that human-computer interaction system has obvious advantages in online teaching of courses with strong operability. However, a single machine control mode may lead to insufficient efficiency and accuracy of distance learning, especially in the case of higher requirements for electronic information courses.

In order to enhance the effective interaction between students and teachers in teaching, to stimulate students' learning motivation, and to improve the classroom teaching effect, the article designs an interactive teaching system based on virtual reality technology.

3. Methodology

3.1 Design of the hardware part of the interactive teaching system

In interactive teaching, both students and teachers need to interact with the teaching system through hardware devices. According to the requirements of virtual reality technology for hardware computing resources, the hardware of the designed teaching system is embedded, and the core controller is ARM chip RK3399 PRO. The chip is a heterogeneous multi-core processor with four processing cores, and the maximum main frequency of the central processing unit (CPU) can reach 2.0 GHz [14]. The system hardware is mainly composed of control module, communication module, power module, storage module, external interactive equipment (Kinect, etc.) interface unit and surrounding connection circuit. The specific hardware framework of the teaching system is shown in Figure 1.

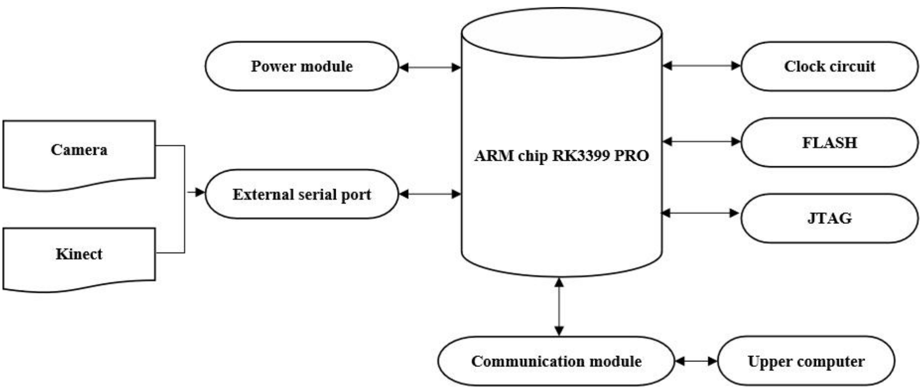

Figure1. Schematic diagram of the hardware framework of the interactive teaching system

The ARM chip has 2 GB of random access memory (RAM) and 16 GB of memory, which can cache all data and instructions during system operation [15]. The chip supports the expansion interface of multiple external devices and can receive the transmission data of external devices. In order to provide the clock signal to the core controller and communication chip, the P10 and P14 pins of the chip are externally connected with a parallel crystal oscillator and two 22 pF capacitors in series to form a clock circuit to provide the clock signal [16]. The clock frequency is set to 20 MHz, and the external interactive device sends signals to the communication serial port of the hardware part according to the set baud rate. After digital to analog conversion, the signal makes the register level in ARM change, and processes and uploads data [17].

The ARM control chip RK3399 PRO communicates with other modules through RS232C serial port, and the upper computer realizes data exchange with the hardware part through Ethernet. External Kinect and other devices are connected to the system hardware through the Universal Serial Bus (USB) 3.0. Charge Coupled Device (CCD) camera and other devices transmit data to the control core chip through Controller Area Network (CAN) transceiver. TJA1040 is selected as CAN transceiver chip, and 120 Ω resistance is connected between pin 7 and pin 6 of the chip to avoid errors in logic level conversion [18]. Connect the INPUT2 pin of the audio codec chip WM8960 to the output of RK3399, and connect the OUT1 pin of the encoder to the audio equipment to play the background sound of the virtual teaching scene.

3.2 The design of the software part based on virtual reality technology

3.2.1 Establishment of virtual reality teaching space scenarios

In this design, 3D MAX software is used to create interactive teaching scenes, and the planar teaching scene pictures are imported into the software to generate corresponding virtual teaching space scenes, and then the scene files are transferred to the user's wearing device to display the virtual scene to the user [19].

In the early modeling process of the teaching scene, Rhino software can be used to establish interactive objects such as objects in the scene for teaching [20]. In Rhino software, the interactive object is composed of multiple NURBS curves, and the surface equation composed of k * l NURBS curves.

$$M(a,b)=\frac{\sum_{i=0}^{v}\sum_{j=0}^{h}w_{ij}d_{ij}B_{i,k}(a)B_{j,l}(b)}{\sum_{i=0}^{v}\sum_{j=0}^{h}w_{ij}B_{i,k}(a)B_{j,l}(b)} \quad (1)$$

Where. $M(a,b)$ Is the space coordinate of any point on the NURBS curve; d_{ij} is the control vertex of the corresponding curve; the w_{ij} is the control weight of the curve; the B_{ik} for k B-spline basis function of sub gauge. First, modify the object surface information according to the real parameter information of the designed interactive object, import the external mapping data, and form the interactive object in the virtual reality scene. Secondly, import the interactive object generated by Rhino software into 3DMAX, and place the object position according to the designed coordinates. Finally, establish the controller in 3D MAX and set the click trigger parameters. When the user operates, the controller controls the corresponding object changes to achieve the corresponding interactive function.

3.2.2 Student interaction behavior tracking

Kinect and other external interactive devices capture users' actions in the real space. In order to display user operations in the virtual teaching scene, coordinate conversion relationships between different spaces need to be established. Set coordinate system (X_s, Y_s, Z_s) is the coordinate system of the real teaching space,the coordinate system that (X_r, Y_r, Z_r) is the user's coordinate system in the real world. The transformation relationship between the two coordinate systems is as follows.

$$\begin{pmatrix} X_r \\ Y_r \\ Z_r \end{pmatrix} = \begin{pmatrix} \boldsymbol{R} & t \\ 0^{\mathrm{T}} & 1 \end{pmatrix} \begin{pmatrix} X_s \\ Y_s \\ Z_s \\ 1 \end{pmatrix} = B \begin{pmatrix} X_s \\ Y_s \\ Z_s \\ 1 \end{pmatrix} \quad (2)$$

Where. R for 3×3 matrix reflecting the transformation variables of the user coordinate system with respect to the pedagogical space coordinate system. t is the translation component of the user coordinates with respect to the spatial coordinate system. The tracking of user coordinate changes is realized by transforming the real teaching space to the user's coordinates according to equation (2).

The Kinect external camera converts the user's behavior in the teaching space into two-dimensional images, and regenerates the three-dimensional model through modeling in the virtual scene. The conversion relationship between camera imaging coordinate system and user coordinate system is as follows.

$$Z_r \begin{pmatrix} x \\ y \\ 1 \end{pmatrix} = \begin{pmatrix} f & 0 & 0 & 0 \\ 0 & f & 0 & 0 \\ 0 & 0 & 1 & 0 \end{pmatrix} \begin{pmatrix} X_r \\ Y_r \\ Z_r \\ 1 \end{pmatrix} \quad (3)$$

Where: f is the focal length of the CCD camera. If the projection of point Q on the two-dimensional image is Q (x, y), it can be obtained from the similar proportion relationship.

$$\begin{cases} x = \frac{X_r f}{Z_r} \\ y = \frac{Y_r f}{Z_r} \end{cases} \quad (4)$$

In the teaching process, in order to ensure that the students' perspective shift has a certain sense of realism, firstly, the user's pupil change is detected and tracked. Secondly, the camera image is grayed out and set $0 \sim 160$ The grayscale value of the g_0"Use g_0 The gray value between 160 and 160 is used for OTSU segmentation of pupil imaging to obtain a new threshold g_1. Again, re-selecting the gray scale as $g_0 \sim g_1$ The adaptive threshold for pupil segmentation is obtained. Finally, after the open and close operations, the pupil image is traversed and the pupil edge changes are detected to obtain the pupil movement trajectory during the user's use of the device.

3.3 Analysis and realization of intelligent teaching system

The core algorithm model of interactive teaching intelligence system adopts artificial intelligence algorithm - RBF algorithm. This algorithm, called radial basis function, is a neural network composed of locally adjusted neurons, and generally has a five layer network model, as shown in Figure 2.

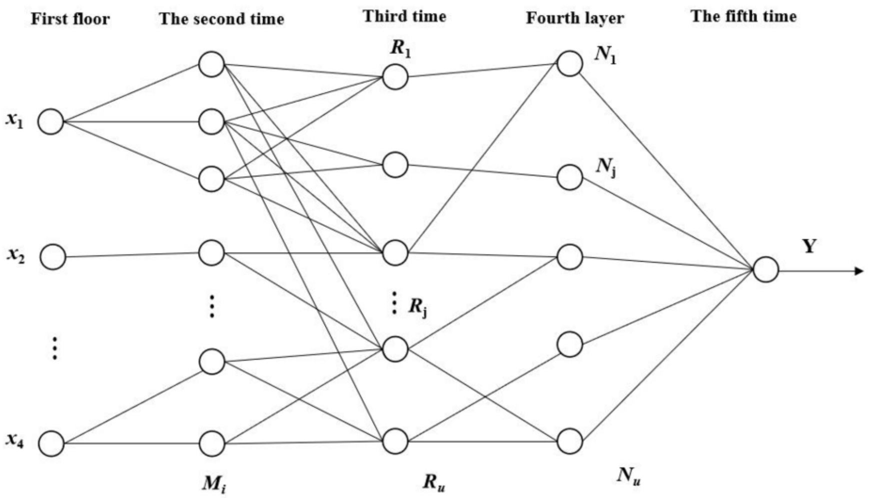

Figure2. Structure of RBF algorithm neural network

The first layer consists of case-related information factors, and these inputs can be grouped into different course program indicators and fed into the neural network structure.

The second layer is the affiliation function, whose mathematical expression, as in equation (5).

$$\mu_{ij}(x_i) = \exp\ [\frac{(x_i - c_{ij})^2}{\sigma_j^2}] \quad i = 1,2,\cdots r;\ j = 1,2,\cdots,u \tag{5}$$

The third layer describes the number of fuzzy rules, by learning the samples, try to make the least number of rules learned and the most important. The mathematical calculation of the output of the jth rule, as in equation (6).

$$\phi_j = \exp\ [-\frac{\sum_{i=1}^{r}(x_i - c_{ij})^2}{\sigma_j^2}] = \exp\ [-\frac{\|X - C_j\|^2}{\sigma_j^2}] \quad j = 1,2,\cdots,u \tag{6}$$

In the formula, the $c_j = (c_{1j},\cdots,c_{rj})$ Indicates that the first j The center of RBF units. The feature of RBF neural network is that the closer the neuron is to the center, the higher its activation degree is, which is very consistent with the teaching mode of interactive music learning influencing factors.

The fourth layer is then the normalization layer,the nodes of this layer should be consistent with the fuzzy rule nodes,it's the first j nodes N_j output, as in Eq. (7).

$$\Psi_j = \frac{\phi_j}{\sum_{k=1}^{N} \phi_k} \; j = 1,2,\cdots,u \tag{7}$$

The fifth layer is the output layer, which outputs the evaluation of each skill of the course examination. It is mainly based on the TS fuzzy model in the RBF algorithm. Its output is as shown in Formula (8).

$$y(x) = \frac{\sum_{i=1}^{u} [(a_{i0}+a_{i1}x_1+\cdots+a_{1r}x_r) \exp\,(-\frac{\|x-c_i\|^2}{\sigma_i^2})]}{\sum_{i=1}^{u} \exp\,(-\frac{\|x-c_i\|^2}{\sigma_i^2})} \tag{8}$$

w_k is on behalf of NokThe connectivity of the rules, i.e., the sum of the products of the weights of the output variables, is shown in Eq. (9).

$$y(x) = \sum_{k=1}^{u} w_k \cdot \Psi_k \tag{9}$$

4. results and discussion

In order to make the experimental data have a certain objectivity, we introduce a method based on NET platform as the reference group of this design system. Set a different number of system response requests, and collect system operation performance experiment index data through special test software. Table 1 shows the experimental index data of the operation performance of the teaching system.

Table 1. Data on experimental indicators of the operational performance of the teaching system

Number of system requests/visits	A virtual reality-based teaching and learning system		be based on. NET Platform Teaching System	
	Response delay time /ms	System resource utilization /%	Response delay time /ms	System resource utilization /%
20	87.5	7.1	98.6	11.2
50	94.2	7.6	104.8	11.8
80	98.3	8.0	110.4	12.3
100	103.7	8.9	119.5	13.4
150	113.6	10.7	128.3	20.1

200	130.4	14.5	175.9	35.9
300	149.1	21.6	234.2	44.5
500	176.8	25.2	309.7	57.6

It can be seen from Table 1 that the teaching system designed in this paper can support more users' access requests. When the number of visits is 500, the delay time of the system in this paper is 176.8ms, which is far less than NET platform, the available resource space for functional expansion of the system in the follow-up teaching process is larger, and the basic running performance of the system is better.

5. Conclusion

This paper proposes the teaching reform and practice of urban rail transit communication signal technology course based on artificial intelligence, interactive teaching system is an important part of modern informatization teaching. Through the interactive teaching system related teaching tools can assist teachers to carry out teaching, effectively expanding the form of classroom teaching. The current teaching system only utilizes multimedia technology to change the original form of displaying teaching content, and the effect of assisting interaction between teachers and students is poor. In order to realize better teaching effect, the article designs an interactive teaching system based on virtual reality technology. From the perspectives of system performance and system application effect, it verifies that the designed teaching system has good performance, enriches the teaching methods and means, and fully improves the quality of interactive teaching.

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