Training Simulation System of Aviation Electromechanical Specialty Based on Multimodal Information Processing

Xin Zhang(✉) and Dan Zhao

College of Aeronautical Engineering, Beijing Polytechnic, Beijing 100176, China
Jameszlx@163.com

Abstract. Traditional training simulation system has the problems of low recognition accuracy and long response time because of its poor perception effect on learning dynamic target. Therefore, this study designed a practical training simulation system based on multi-modal information processing for aviation electromechanical specialty. In the hardware part, the RS422 interface circuit is used to transmit the working state of the board, and the loopback clock circuit is used to transmit the signals of the multi-board. In the software part, after the component model library of the training simulation system is established, the learning object perception model is established through multi-modal information processing, and the multi-modal teaching information is integrated. Finally, a professional training simulation teaching module is designed to meet the various needs of training teaching. In the experiment, the system presented in this paper is compared with two traditional systems, and it is found that the system presented in this paper can effectively improve the recognition accuracy of gesture rules and speech keywords, and effectively shorten the time for the system to process user requests.

Keywords: Aviation electromechanical specialty · Simulation training · Professional training · Multimodal information · Information processing · Simulation system · Target perception

1 Introduction

With the rapid development of science and technology, science and technology is no longer a technology in a single discipline or field, but an interdisciplinary and interdisciplinary technology. With the rapid development of computer and Internet technology, many computer related technologies have been derived, including computer simulation technology with strong convenience, fidelity and interactivity. In response to the call of the Ministry of education to vigorously advocate the development of quality education and improve college students' practical ability and innovation and creativity awareness, computer simulation technology continues to develop in the field of education and teaching, and is combined with many disciplines such as mechanical dynamics, mechanical mechanics and computer display technology to produce a professional training simulation system [1].

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After investigating the characteristics and learning styles of students majoring in aviation mechanical and electrical engineering as well as the teaching characteristics and teaching styles of teachers majoring in aviation mechanical and electrical engineering, it is found that the teaching mode combining practical training system and theory and practice can achieve better learning effects. In order to meet the requirements of the aviation industry for talents, students have to carry out repeated practical training in order to achieve the effect of quantitative change to qualitative change. The training simulation system provides an economic and practical teaching means for teachers. The system can show the working dynamics of real machinery and intuitively understand the structural performance and circuit principle for students.

At present, certain research results have been obtained for the research on the training simulation system. The training simulation system first simulates the virtual environment, and then simulates the disassembly and assembly process of the actual mechanical components in the computer virtual environment. The end user performs virtual simulation operations in the virtual three-dimensional scene through the interactive device. Reference [2] proposed a training method for professional virtual simulation based on Unity3D. Use 3ds Max, Photoshop and other software for modeling and mapping, and use Unity3D, Java Script, C# and other languages to develop interactive functions for professional processes. This provides a good training platform for cultivating and improving students' innovative practical ability. Reference [3] proposed to build a teaching and training platform based on virtual reality technology that integrates teaching, multi-position collaborative training, full-scene roaming, and automatic examination and evaluation, which further enriches the practical teaching resources of related majors. The above simulation system can generate a relatively real simulation environment and has obvious advantages in immersion, interaction and real time. However, the accuracy of the learning dynamic target perception results is poor, which leads to the problems of low recognition accuracy and long response time.

Multimodal information processing can improve the perception of the training simulation system to the outside world. Because the information provided by multiple perception means is sometimes not only irrelevant or even conflicting, it is necessary to provide fusion and decision support for multimodal information, which is important different from the previous single perception [4]. Therefore, this paper designs a training simulation system for aviation Electromechanical Specialty based on multimodal information processing, and completes the training teaching of aviation electromechanical specialty through the virtual simulation of assembly operation, assembly environment and assembly process. It can enable students to carry out the assembly simulation operation of mechanical body in the virtual environment through computers or other equipment at any time and at any place without the constraints of training site, time, place and equipment, and significantly improve the efficiency of mechanical assembly training courses, so as to improve the learning effect of students.

2 Hardware Design of the Training Simulation System for Aviation Electromechanical Professional

First, design the hardware part of the aero-mechanical and electrical professional training simulation system.

The power management circuit includes three parts: a power supply circuit, a charging circuit, and a power supply control circuit. The power supply circuit is used to meet the power supply requirements of the onboard devices of the node. The charging circuit is used to charge the lithium battery. The power supply control circuit is used for node power consumption control.

The RS422 interface circuit is added to the board design. Its main purpose is to take into account that the board is used in actual projects, and it needs to communicate with other boards, control commands, or communicate with the upper computer. Some current working status of the board can be transmitted through the RS422 interface. The RS422 chip chooses the ADM3076 chip of ADI, which is a low-voltage (working voltage 3.3 V) chip with 15 kV ESD protection. It can be configured as full-duplex or half-duplex communication, conforming to TIA/EIA standards. It can connect up to 256 nodes. The RS422 interface circuit design is shown as in Fig. 1.

As the processing core of the hardware design, the logic control module needs to analyze various working condition information and receive and issue control commands to carry out fault alarms. (Digital Signal Process) DSP is a micro processor with a complete instruction system, which uses digital signals to process a large amount of data. Its biggest feature is that it has a dedicated hardware multiplier and a pipeline structure of the instruction system, which can quickly process cumbersome Digital signal. The chip includes an arithmetic module, a control module, a variety of registers, and some storage modules, etc., and an external memory can be added to the hardware circuit.

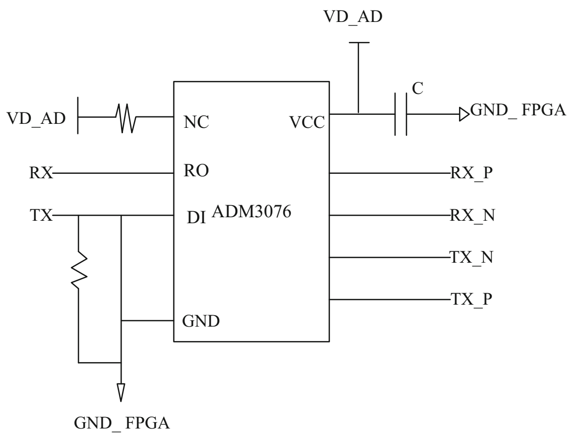

Fig. 1. RS422 serial port circuit

This text chooses TMS320F28335 chip as the logic control chip. TMS320F28335 is a 32-bit floating-point DSP with a clock frequency of 150 MHz, with 18 channels of PWM, 6 channels of HRPWM, 6 groups of enhanced capture units, 12-bit A/D converters, 3 groups of asynchronous serial ports and 88 I/Os mouth.

In order to ensure the long battery life of the node, low-voltage power supply is used to reduce the power consumption of the node. Considering the power supply range of devices on the market, 2.8 V is selected as the main power supply voltage of the node.

Affected by the discharge process, the output voltage of the lithium battery is unstable. Therefore, a voltage stabilizing circuit is set to stabilize the voltage of the lithium battery at 2.8 V. A linear power supply is used as a regulated power supply.

The onboard low dropout linear regulator (LDO) of the node is used to generate the power supply voltage required by each chip. The linear power supply is named after the triode works in the linear amplification area, and the built-in comparator uses voltage feedback to stabilize the output. The conversion efficiency of the linear power supply is not high, but the power supply ripple is very small, which is suitable for occasions with high power requirements. For synchronous signal acquisition between multiple AD acquisition and transmission boards, a synchronous acquisition clock signal source must be shared to ensure signal transmission between multiple boards. Considering that multiple signal acquisition boards do not share the same one The backplane is scattered in multiple cabinets. Therefore, in order to ensure that the clocks of multiple AD chips are the same, an appropriate clock distribution scheme must be selected. The clock design in this subject uses the loopback mode, that is, for each signal Acquisition and transmission board card, it can be used as the main acquisition board to provide acquisition clock signal source for other boards, and it can also be used as a slave board to receive the acquisition clock signal source from the main board.

3 Software Design of Training Simulation System for Aviation Electromechanical Specialty

3.1 Design and Training Simulation System Component Model Library

In order to improve the teaching quality of aviation mechanical and electrical teachers and the learning quality of students, a set of intelligent information teaching and assessment system for teaching has been specially designed for the hardware equipment of the training simulation system.

The aviation electromechanical professional training simulation system needs to simulate the aviation electromechanical automation production line, and can carry out related training and teaching. Therefore, it is necessary to establish a special 3D component model library in the 3DCreate software platform to define various physical properties of the simulation model, Freely configure the actions of the model to meet various conditions in practical applications, make the simulation effect more realistic, and complete various desired tasks. At the same time, the virtual engine also controls and manages resources such as data and peripheral devices in the entire system. Complete wireless fault settings through the network technology system, and transmit the circuit signal data of the training station to the information platform [5]; provide systematic and complete teaching curriculum standards through the multimedia teaching platform, and provide rich curriculum resources. The virtual simulation system completes the synchronization of virtual training and real training, constructs a standard maintenance process, improves equipment utilization, reduces the damage rate of real training equipment, and reduces teaching costs.

The essence of the training simulation system component model library is a general development platform based on the underlying programming language. It not only includes model drawing, retrieval, simplification, completion, and reconstruction, but also includes a variety of hardware interaction interfaces, graphics data, Function design, message response mechanism, communication interface and other functions. Through 3DCreate, users can customize the parameters of the workpiece model and the behavior of the equipment. Through the COM port and Python API, it can be completely connected with CAD and third-party data, and the simulation operation of the corresponding aviation electromechanical production line can be carried out. Teaching and assessment through the information system can better manage the quality of teaching and learning; through the networking system to connect multiple devices, connect multiple computers to the network to communicate with the training platform, and realize the simultaneous display of the teacher and the student, Improve teaching efficiency. Establish a special 3D component model library, which makes the design of the simulation system simple and fast.

The component model library structure of the training simulation system designed in this paper is shown in Fig. 2.

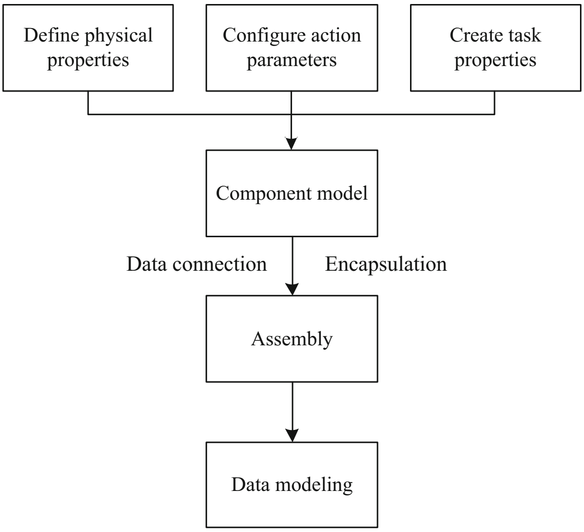

Fig. 2. Component model library structure

The virtual scene of component model library is to digitize the real-world objects in the computer, render and draw them on the display device.

In order to create an immersive learning environment for aviation electromechanical students participating in the training, this system design refers to the actual aviation electromechanical device control terminal laboratory, creates an intelligent training simulation scene based on virtual reality technology, enables it to carry out simulation calculation on the server through the communication network, and outputs three-dimensional and intuitive real-time dynamic scenes at the same time, To simulate the practical teaching contents of aviation electromechanical equipment protection and control behavior change, fault alarm, "five prevention" operation and so on. The component model library of training simulation system mainly provides supporting technical resources in the process of training simulation teaching, including maintenance technical manual, circuit schematic diagram, case technical bulletin, technical training manual and other resources. The component model library solves the problem that teachers complete the training tasks of extracurricular technical training projects, and can build a training course system according to the training project tasks.

3.2 Establish a Learning Target Perception Model Based on the Multi-Modal Information Processing Process

The simulation system is based on virtual reality, virtual simulation and network technology, and simulates teaching through simulated operation. Professional training simulation system must be used by many physical domain information of environmental perception, modal information through visual and non-visual modal information (acousto-optic electromagnetic, etc.) on the environment of different objects in space, time, motion, force, chemical, machinery and so on measure direction of perception, to better describe and describe the complex environmental information field, Therefore, it supports the intelligent subjects' abilities of autonomous judgment, autonomous learning and decision-making [6].

Every agent in the system receives information all the time, and each form of information belongs to a kind of modal information. So as to realize the strong supplement to the traditional teaching, reduce the safety risk and improve the learning timeliness and quality of practical courses. The fusion processing of multimodal information can reduce the error caused by measurement and improve the description accuracy of information, which further improves the robustness of the system [7].

In general, the organizational structure of a multimodal information network is shown in Fig. 3.

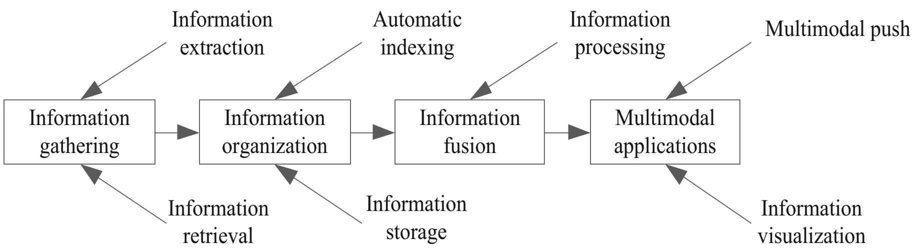

Fig. 3. Organization chart of multimodal information network

Multimodal fusion referred to in this paper is to obtain visual, auditory and tactile information in a certain period of time, and then understand the user's operation from these information. This paper decomposes the multi-modal information, including visual modal and non visual modal information, and solves the key problem of information fusion.

The information field model of non visual mode can be described as:

$$W_1 = \sum_{x=1}^{m} \varphi_m(\alpha, \alpha_x, r_x, \eta_x) \tag{1}$$

In formula (1), W_1 represents the information intensity of non-visual mode, which is used to represent the part of energy carrying information; m is the number of information modes; x is the modal number; φ_m is the single mode information field strength evaluation function; α is the equivalent quality; α_x is The equivalent mass of a specific object; r_x is the measurement of the information mode; η_x represents the direction angle of the specific object. The above model also needs to set constraints, the specific rules are as follows:

$$F(\alpha, r_x, \eta_x) - W_1 > 0 \tag{2}$$

In formula (2), F is the constraint condition of the rule.

Using virtual simulation and network teaching of multimodal information processing, one is to avoid the disadvantage of relying too much on physical venues and hardware teaching aids in traditional teaching; Second, the combination of virtual and real is realized by solidifying the standard operation process of training hardware equipment; Third, the application of network technology, students can more independently choose learning time and place. At the executive level, multimodal information perception data can provide function setting and state interface, and provide convenience and real-time guarantee for the learning objectives of aviation electromechanical specialty at a lower level [8]. The perceptual information provided at different abstract levels can be used to update or draw the learning module, and the sensor data from the perceptual module can also be directly used for practical teaching and assessment. Similarly, the information field model of visual mode can be described as:

$$W_2 = \sum_{x=1}^{m} \frac{\varphi_m \alpha \alpha_x}{(r_x + \eta_x)^2} \tag{3}$$

In formula (3), W_2 represents the information field strength of the visual mode.

The construction of multimodal information expands the perception range of multidimensional space such as time and space horizontally and vertically, uses the redundancy between information to overcome the shortcomings of multiple work blind areas in a single information, more comprehensively describes the processing object, and improves the cognitive accuracy of the processing object [9, 10]. Therefore, the first mock exam model can be expressed as:

$$Q = \gamma_1 W_1 + \gamma_2 W_2 \tag{4}$$

In formula (4), Q is the distribution of the field strength of the information field with the intelligent subject as the origin. The field strength is obtained from the non-visual modal information field component and the visual modal component information field component; γ_1 and γ_2 represent the field intensity weight coefficient.

The main data of multi-modal information perception flows into the planning and control module, and the planning algorithm is used to complete the data input [11]. The learning objectives of professional training. To realize intelligent behavior and intelligent ability, the perceiving subject must first perceive the environment. In a complex environment, different specific objects have different effects on the intelligent agent. They have different information fields. The information fields formed by specific objects are various The way affects the autonomous perception, autonomous judgment and autonomous decision-making of the intelligent agent to varying degrees.

3.3 Design Professional Training Simulation Teaching Module

The training simulation system of aviation electromechanical specialty is designed as a comprehensive information platform integrating simulation teaching system, curriculum resource system and data management system. It has modules such as simulation teaching, curriculum resource and data management. In this paper, a multimodal information fusion strategy is proposed to judge the interaction semantics under different trigger conditions by inputting the information of different channels.

The fusion strategy mesh is composed of nodes and connections between nodes. Nodes represent the user's possible intention, and the weight of directed connections represents the trigger condition of the next node. The trigger condition is composed of different modal information intersection function and information independent function. The system sets different teaching modules according to the interaction intention state under different trigger conditions. In the multimedia integrated teaching management platform system, the simulation teaching system is specially designed and supported with simulation teaching course resources. Through 3D modeling, the simulation course resource library is established for the course teaching projects such as detection and fault diagnosis that need to be carried out in the hardware system, so as to realize the online national simulation and offline grouping practice, including the fault point and troubleshooting process, and realize the consistency between simulation and reality. The use of simulation system can reduce the utilization loss rate of equipment, standardize the practical operation process, improve the practical proficiency, strengthen the students' standard awareness and safety awareness, realize the perspective observation of the engine, and solve the problem that the hardware system of the training platform can not observe the internal operation state of the engine.

In this paper, three input modes of gesture, voice and sensor are used to simulate the virtual chemistry experiment through the interaction between different modes. On this basis, an interaction framework for multi-modal fusion is proposed. Firstly, initialize, and then perceive and recognize the three modes respectively, so as to realize multi-modal fusion and complete intention understanding. Finally, it has the experimental phenomenon of voice navigation interaction, virtual reality fusion and tactile feedback. The teaching module mainly includes a full set of teaching course resources such as aviation electromechanical structure and electromechanical control system, as well as the course resources of virtual simulation system used together with the training simulation hardware system. The simulation system can be used to complete teachers' simulation teaching and students' independent simulation training and examination. As the basis of the whole framework, the intelligent chemical experiment system provides a good platform for the fusion and interaction of gesture, voice and sensors. The user inputs gesture, voice and sensor channel information respectively, and then the system judges whether the perceived and recognized information is detected.

For this reason, this study extracts the depth features of multimodal information, and normalizes the results obtained by the Relu function. The weight update form is as follows:

$$\lambda = \sum_{y=1}^{n} \lambda_y^{n-1} \vartheta + \kappa \tag{5}$$

In formula (5), λ represents the weight vector; n the current layer number; y represents the neuron number; ϑ represents the connection weight with the previous layer; κ represents the feature bias after convolution.

If it is detected, the information of different modes will be processed. If it is not detected, the modal information will be re entered. Through the multi-modal fusion interaction method, judge whether the current intention has been successfully understood. If not, it will be reinitialized. If yes, the system will output the corresponding prompt of the intention, virtual real fusion effect and professional training course phenomenon, and continuously input the modal information to present the output effect until the end of the training course. Combined with the content of hardware, the design of aviation electromechanical professional training simulation system based on multi-modal information processing is completed.

4 Experiments and Research

In order to verify the feasibility of the above designed aviation electromechanical professional training simulation system based on multimodal information processing, the following experiments are designed.

4.1 System Function Test

The training simulation system designed in this paper is actually a process of continuous interaction with the virtual model through hand gestures, voice and intelligent devices. In order to better find the problems in the system, we continue to test the system, improve, and repair the problems. It can be said that software testing is an indispensable part in the development process of the system.

With the continuous development of testing technology, there are more and more types of testing technology. Choosing a suitable testing method can allow us to better test the system. The experiment chooses to use the black box test method to test the function of the system. The application server of this article selects Tomcat server and red5 streaming media server, and the database management system is Microsoft SQL Server. The functional test cases of the system mainly include: client and background management, user interface, security and access control, and compatibility testing. After testing, the system can normally realize the related functions, that is, the system can be used according to the needs of users. And it can ensure the user-friendly interface, easy operation, and conform to the user's operating habits. Only users with system access rights can access the system. After verification, the system can run stably in different software and hardware configurations. After the system has passed the functional test, the performance of the system is further tested.

4.2 System Performance Test

Because the system needs to master certain gesture rules, voice keywords and training steps to carry out professional practice of aviation mechanical and electrical operation, for different operations to present different effects and functions. Therefore, the experiment tests the recognition accuracy of gesture rules and speech keywords.

In order to avoid the uniformity of experimental results, the system in this paper is compared with the practical training simulation system based on Unity3D (Traditional system 1) and the practical training simulation system based on virtual reality (Traditional system 2).

First, conduct experiments on the recognition of gesture rules, and the comparison results are shown in Table 1.

Table 1. Comparison of recognition results of gesture rules

Experiment several times	Recognition accuracy rate of gesture rules/%		
	System of this paper	Traditional system 1	Traditional system 2
20	97.54	93.55	93.27
40	98.23	93.08	95.25
60	96.55	90.83	93.93
80	97.22	92.43	93.51
100	98.69	92.21	94.32

According to the comparison results in Table 1, the maximum recognition accuracy of gesture rules in this system is 98.69%, while the maximum recognition accuracy of the two traditional systems is 93.55% and 95.25% respectively. Therefore, the system in this paper can accurately identify the rules and states of gestures, which is conducive to the realization of the standard demonstration of relevant teaching operation in the practical training courses of aerospace electromechanical engineering.

On this basis, the recognition accuracy of speech keywords is tested, and the comparison results are shown in Table 2.

Table 2. Comparison of recognition results of speech keywords

Experiment several times	Speech keyword recognition accuracy rate/%		
	System of this paper	Traditional system 1	Traditional system 2
20	96.14	92.27	92.57
40	96.93	91.91	92.35
60	96.35	91.35	92.45
80	97.34	92.25	93.91
100	97.22	91.16	92.62

According to the comparison results in Table 2, the maximum recognition accuracy of speech keywords in this system is 97.34%, while the maximum recognition accuracy of the two traditional systems is 92.27% and 93.91%, respectively. Therefore, the system in this paper can accurately identify the phonetic keywords in the teacher's practical training teaching. Through the demonstration and explanation of the course, students can be more integrated into the practical training scene of aviation mechanical and electrical specialty in the interaction.

4.3 System Response Time Test

On the basis of testing the system gesture rules and the accuracy of speech keyword recognition, the response time is further tested. Count the maximum response time of each system to process user requests, and the comparison results are shown in Table 3.

Table 3. Response time comparison

Experiment several times	System response time/s		
	System of this paper	Traditional system 1	Traditional system 2
20	3.2	4.2	4.9
40	3.2	4.5	4.2
60	3.0	4.4	4.2
80	3.1	4.4	4.2
100	3.5	4.6	4.0

According to the comparison results in Table 3, the maximum response time of the system in this paper is 3.5 s, while the maximum response time of the two traditional systems is 4.6 s and 4.9 s respectively. After the test, the maximum response time of the system in this paper is less to the user's request, which is in line with the expected results, and can quickly execute the user's request without causing the system crash or related abnormal phenomena.

5 Conclusion

In today's education informationization, modernization, multimedia, through it is the practical training simulation teaching system, the principle of mix, interactive virtual simulation teaching, to improve students' practical ability, knowledge, comprehensive ability and innovation spirit, also to a great extent, promote the comprehensive reform of the education career.

Based on multi-modal information processing process, a simulation system for aeronautical electromechanical training is designed in this paper. The system can improve the recognition accuracy of gesture rules and speech keywords, and shorten the maximum response time of processing user requests, and has a good application effect.

However, the research on information fusion in this paper is still insufficient, which fails to process more other modal information. Moreover, many important information will be lost if the mixed and complex information is directly processed by the neural network model. Therefore, data mining can be carried out before input into the model.

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