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A review of intelligent equipment development and and its auto-test technology

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A review of intelligent equipment development and and its auto-test technology

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Abstract. With the development of artificial intelligence technology, the intelligent level of equipment is gradually improved, and its internal structure is becoming more and more complicated. This not only facilitates users' use, but also improves their maintenance and auto-test requirements. Taking flight simulator and other intelligent equipment as examples, this paper introduces the development history and research status of flight simulator and embedded training, and combs the development history and research status of intelligent equipment auto-test technology, which mainly involves test resource matching and fault diagnosis.

1. Introduction

With the rapid development of electronic science and artificial intelligence technology, equipment is also in the wave of intelligent development. A class of intelligent equipment represented by flight simulators has experienced years of technical accumulation and steady development, and the level of intelligence has been significantly improved. On the one hand, it effectively improves users' experience; on the other hand, with the increasing complexity of the system, its auto-test difficulty also increases day by day. Therefore, based on the analysis of the development history of intelligent equipment based on flight simulator, this paper introduces the embedded training method and the development of intelligent equipment auto-test technology.

First, the main function of flight simulator is flight training. It is a typical intelligent equipment. The following is an example of flight simulator to briefly introduce the relevant technology development of intelligent equipment.

2. Technology development and research status of intelligent equipment

2.1. Development of flight simulator related technologies

Early flight simulators were mainly used to simulate airplane and other aircraft. In the late 1920s, *Ed Link* in the United States designed and built the first flight simulator, which was used to simulate the flying experience of aircraft. This device was then formally adopted by the U.S. Army Air Corps, and achieved remarkable training results. Due to its outstanding safety and fault tolerance, as well as its ability to effectively reduce training costs and shorten training cycles, flight simulators soon became one of the necessary equipment for flight training of various aviation organizations, and realized leapfrog development relying on the progress of computer technology [1].

Electronic flight simulators appeared in the 1940s, which realized accurate digital calculation and simulation of aircraft for the first time. However, flight simulators in this period were mainly limited to mechanical operation simulation and instrument numerical change simulation, and lacked realistic flight experience. With the development of screen technology, visual simulation has gradually become a new trend. In the 1950s, visual simulation flight simulator controlled by digital computer appeared. However, limited by the technical conditions at that time, the visual effect is relatively simple and there are many problems such as clarity and pulsating sensation. Along with the development of electronic technology, flight simulator has become increasingly complicated and refinement, can simulate the whole cycle of aircraft landing from takeoff to the whole process, and also can realize simulation in military training air combat, and combined with many degrees of freedom dynamic simulation and virtual reality technology, to realize the simulation of flight simulation experience [2].

Figure 1. Visual flight simulator.

On the other hand, the flight simulator is no longer limited to flight training, but also applied to the theoretical research, prototype test, ground test and acceptance evaluation of the new generation of aircraft. The simulation objects are gradually extended to the aerospace and weapons fields. The emergence of a batch of training bombs and even intelligent equipment is the application of flight simulators in airborne weapons.

In the future, flight simulators will also provide important technical support for mankind to design subversive aircraft and march to a wider space.

On the other hand, intelligent equipment can achieve better man-machine interaction in multiple fields through embedded training, which is an important application direction of intelligent equipment. The following is an introduction to the development of embedded training related technologies.

2.2. Development of embedded training related technologies

With the development of aviation technology, flight training relies more and more on simulation equipment, and this intelligent equipment is an embedded training simulator. Embedded training refers to the realization of training functions based on the equipment itself by embedding corresponding auxiliary equipment or adding training modes to the equipment [3].

Embedded training is to achieve the training function on actual equipment by embedding it into the original system or as an additional training module of the system [3]. On the one hand, embedded training can effectively utilize existing equipment to provide more realistic training experience; On the other hand, it reduces the design difficulty of simulation training equipment and effectively reduces the support cost of equipment.

In the 1950s, the US army took the lead in flight training and combined virtual signal synthesis technology to realize the virtual target display on the radar screen, effectively improving the training efficiency and capability of the troops. With the rapid development of electronic technology, embedded training also plays a more important role in the daily training of the US military. In the late 1980s, the US Army formally defined embedded training and positioned it as the preferred training method, and continuously updated various weapons and equipment to make it have embedded training capability [4].

In embedded training, first of all, it should have good system compatibility, which requires that the original weapons and equipment should be considered at the beginning of design, which can be used for both combat and training. Secondly, it should have accurate training situation generation technology, which can accurately and quickly generate dynamic training situation in real time according to the parameter change of the surrounding environment and the original equipment. Finally, a friendly human-computer interaction experience is required. The core of training is human, and the key is how to make trainees feel and operate equipment more effectively, which requires the embedded training equipment to have friendly human-computer interaction experience.

Table 1. Classification of embedded training.

No.	CLASS
1	Fully embedded
2	Additional formula
3	Umbilical cord
4	Embedded teaching based on computer
5	Embedded task assistance

According to the degree of embedding, the embedded training equipment can be divided into the following five types :(1) fully embedded; (2) Additional formula; (3) Umbilical cord; (4) Embedded teaching based on computer; (5) Embedded task assistance. The intelligent equipment in this paper belongs to the additional embedded training equipment. By connecting with the aircraft hanger, it realizes the simulation of various types of aviation weapons and completes the task of designated training subjects [5].

3. Development and research status of intelligent equipment auto-test technology

3.1. Development of auto-test technology

How to effectively maintain and guarantee intelligent equipment and design a set of "reliable and easy to use" automatic test equipment has become an important research topic. Automatic test equipment is a set of interactive instruments that can automatically realize the function, performance parameter measurement, fault diagnosis, fault location and display of the tested object. It is of great significance in production activities, especially in the military field, and can effectively improve the production and guarantee efficiency.

In order to ensure the intact performance of equipment, it is often necessary to carry out accurate index auto-test. The equipment that can automatically complete characteristic auto-test tasks with computer as the core and controlled by the program is called automatic test system.

In the 1950s, the US army implemented SETE program to improve the maintenance and support level of military electronic equipment, which is one of the important origins of automatic test system. With the development of computer technology, automatic test system has made great progress in all sectors of society, especially in the US military, which has also developed representative general automatic test system.

The current Automatic Test system is generally composed of three parts :(1) Automatic Test Equipment (ATE); (2) Test Program Set (TPS); (3) Test assembly development tools [6]. This division mainly considers the generality and portability between platforms, which is also one of the development trends of automatic test system. And from the point of view of development, from the first generation of automatic test system through a dedicated auto-test equipment, to the second generation, represented by GPIB and RS232 bus desktop instrument building blocks type test system, and then to the third generation represented by VXI and PXI bus auto-test, as well as the standardization of the board and the case is to build up the integrated modular instrument automatic test system [6].

Figure 2. PXI test board and instrument.

In order to realize the depth auto-test of intelligent equipment, a set of useful test equipment are designed, meanwhile scientist explores and studies the test resource management method and intelligent equipment fault diagnosis method, which we summarize the research status of these two aspects as follow.

3.2. Research status of intelligent equipment auto-test technology

As the internal structure of the intelligent equipment is relatively complex, it is necessary to put forward an efficient and feasible test resource management and mapping method according to the characteristics of test resource allocation of the tested object.

In order to improve the utilization rate of test resources and realize efficient and accurate test resource management, scholars at home and abroad have carried out extensive research. Guo Yu et al. proposed to improve a signal-oriented test resource management method and provide support for cross-platform migration of test procedures [7]. Ma Leyang et al. designed a signal dynamic model based on STD standard, namely the signal COM running component, which effectively improved the efficiency of resource mapping [8]. Yang Qi et al. built a software platform of the test system based on ATML, standardized modeling of test results, and standardized the format of test information [9]. According to THE IEEE1671.1 standard, Liu Naiqiang determined the description method of test sequence information, gave the carrying mode and location, and designed the corresponding test sequence editing tool [10]. Yang Zhao et al. studied the advantages and applications of DOM based ATML test information parsing [11]. Liu Fujun et al. studied the information transmission of SERVICE-ORIENTED ATS test, proposed the INFORMATION transmission mechanism of ATS test based on SOAP, and solved the problem of information sharing between ATS platforms [12]. Luo Jin et al. proposed a service-oriented automatic test system framework and its implementation technology, and realized the joint guarantee of information system based on network and information system [13].

The above literatures put forward a variety of implementation methods for test resource management from the perspectives of instrument-oriented, signal-oriented and service-oriented, and explored and improved the resource mapping method by using intelligent algorithm and path search

algorithm. However, the auto-test of intelligent equipment is different from the traditional testing tasks, which has the characteristics of various test tasks and high resource redundancy. Therefore, it is necessary to design a set of test resource management and source mapping methods for intelligent equipment auto-test.

Due to the great difference between the internal structure of the intelligent equipment and the traditional equipment, it is necessary not only to complete the test of the simulated signal flow, but also to realize the effective fault location of some components within the intelligent equipment. Therefore, it is necessary to put forward a targeted fault diagnosis method based on the in-depth study and analysis of the fault characteristics of the tested objects.

In the existing literature, there are few special studies on intelligent equipment fault diagnosis, while there are abundant research data on bearing and other equipment fault diagnosis.

4. Conclusion

With the development of artificial intelligence technology and the promotion of its application range, more and more traditional equipment has been integrated with intelligent factors, which poses new challenges to equipment maintenance and support. Based on the above considerations, this article first analyzes the development process of intelligent equipment with a flight simulator as an example, and introduces the embedded training related technology, highlighting its intelligent application in daily teaching and training, and finally introduces the related auto-test technology of intelligent equipment.

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