The Architecture Design and Implementation of Aircraft Structural Fault Assistant Decision System Based on Data Analysis

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Abstract. That the aircraft structural damage diagnosis and prediction is very important for flight safety. In this paper, the aircraft structural damage can be predicted based on the maintenance data analysis and the structure fault diagnosis and assistant decision are realized. Thus, the maintenance management of aircraft structure damage can be developed. According to the actual service data, both the structural damage prediction and decision assistant support system are designed, which apply the micro-service architecture and Vue.Js front-end development technology. Thus, the effective container server and excellent usability are achieved.

Keywords: Maintenance; Structure; Failure; Assistant decision-making; System design.

1. Introduction
With the continuous growth of our national power, the training level of the troops has been improved, the use time of various aviation equipment is continuously increasing, and the number of flight hours has repeatedly reached new highs. In this context, the aircraft systems are in high-load operation; especially the key structures such as the fuselage, wings, and landing gear are under intensive load. Therefore, it is urgent to analyze their failures effectively to help personnel make effective decisions and make reasonable training and combat readiness planning [1-3].

Actually, it is difficult to avoid various damages to the aircraft structure during the manufacturing and use process of any measures, no matter from the aspects of materials, manufacturing, maintenance, etc. At the same time, due to the lack of comprehensive system diagnosis and structural damage prediction capabilities, the cycle of aircraft troubleshooting and average maintenance is too long. And because of the diverse types of equipment used for detection, the high frequency of maintenance, and the insufficient maintenance personnel, the structure-related guarantee costs are also getting higher. According to statistical data in recent years, the number of aircraft failures will continue to increase. To ensure that the aircraft structure does not cause catastrophic accidents due to undetected damage, predictive analysis of aircraft structure damage has become particularly important [4-6]. How to predict and reduce aircraft structural damage, improve the accuracy of equipment fault location, reduce equipment maintenance costs, and avoid waste of resources and excess maintenance, has become a problem that needs to be solved urgently in equipment fault diagnosis [7-9].

The paper combines big data analysis technology with structural health detection and management, and builds a database of aircraft structure damage report information through a big data analysis model, and conducts demand analysis with the goal of big data analysis for aircraft structure repair information.
The data collected by the demand analysis is abstracted into an information conceptual model, and according to the established model, the database is analyzed to obtain the rules, forecast results and the decision. Finally, the structure of the system's functional structure diagram, system structure diagram and database structure was constructed, and a set of aircraft fault repair information big data analysis auxiliary decision-making system was developed, according to the actual data of a certain type of aircraft fault repair.

2. Architecture Design of Decision-making Assistant System of Aircraft Structure Fault Diagnosis

![Figure 1. Aircraft structure fault diagnosis decision-making assistant system architecture.](image)

The main purpose of this system is to sort out and analyze the failure detection and maintenance support information of the aircraft structure, and then achieve the life prediction and health management of the structure. As shown in Figure 1, the use of system functions must first be authorized by the login function module; Case reporting and data analysis of structural failures are carried out in the failure case database, and key failure information is sorted and entered into the database for later use; The failure decision module can analyze various failure phenomena and give reasonable suggestions based on the prior conclusions, and the relevant personnel will make the final decision, based on the information of failure cases.

The actual failure prediction and analysis module is included in the decision module. Using the big data processing method, the development and actual growth of structural failures is predicted and analyzed, and provides information support for optimization decision-making, on the base of structural failure data cases.

The BOM (Bill of Material) management function module, through two-way communication with the database, provides data support for the big data analysis of structural failures, and also lays the foundation for the information standard of structural maintenance support.

3. System Function Realization

The system proposed in this paper is developed with Java, using Spring+SpringMVC+SpringBoot+Shiro+Mybatis framework. Vue.js is for the front-end interface, micro-service for the back-end, MySQL for the database, and IntelliJ IDEA for the development tools. The main structure of the system is shown in Figure 2:
3.1. System Login Module

Figure 3. System login interface.

Figure 3 shows the login interface of the system. In the interface, the user can enter the name and password in the corresponding dialog box, and the system will submit the data after entering the main interface to the background to complete the corresponding verification. If the user successfully logs in, the permissions of management modules such as fault case library, fault decision, spare parts management, maintenance BOM management, system management, etc will be got in the main interface, as shown in Figure 4. This interface can be directly connected to the management module platform.

3.2. Fault Case Library Module

The module can query the relevant parameters of the aircraft failure by inputting the parameter name of the sub-module, such as the unit, model, aircraft number, date of failure, engine type, engine serial number, engine number, faulty component name, faulty component type, fault Part number, defective
part manufacturer, defective part repair factory, defective part delivery date, defective part repair delivery date, number of defective parts repaired, defective part installation date, etc. Users can add aircraft fault information and modify or delete any fault case information. The interface is shown in Figure 5:

![Figure 5. Fault case library module.](image-url)

### 3.3. Fault Decision Module

The fault decision-making module can predict the development of structural failures, including a linear chart of failure prediction. The abscissa is the time year-month, and the ordinate is the times the corresponding fault damage of the corresponding model occurred in the month. The red is Original data, black is the predicted value. The interface is shown in Figure 6:

![Figure 6. Failure time prediction interface.](image-url)

### 3.4. Spare Parts and Maintenance BOM Management Module

Figure 7 shows the spare parts management page, which can separately manage various faulty parts of various models. The entry of spare parts can be completed by uploading an excel form, or manually entered information. The corresponding spare parts information items include model, aircraft number, faulty part name, faulty part type, faulty part number, faulty part manufacturer, outbound quantity, actual inventory, suggested inventory quantity, creation time and other project information. The user can perform operations such as entering, leaving or deleting the corresponding spare parts information that entered.

Monthly consumption analysis page is shown in the Figure 8 below, which can analyze and manage the monthly consumption information of various faulty parts of various models. The corresponding monthly consumption information of faulty parts is presented by a bar graph. The user can query the entered faulty parts information and get the monthly consumption of faulty parts intuitively.
The maintenance BOM module can carry out BOM management of aircraft components. The structure is model-system-component (Figure 9), which can clearly query the vertical structure of faulty parts (Figure 10 and Figure 11), and perform more detailed management of faulty parts. Users can categorize the corresponding component maintenance information that has been entered, which is convenient for management and query.

4. Summary
Aircraft structural damage is an important cause of damage to flight safety and aircraft failures. How to imply intelligent diagnosis of aircraft failures and reduce the occurrence of aircraft structural damage is an urgent requirement, and aircraft is a complex system with many components, which is difficult to measure as a whole.

In this paper, the method of big data analysis is used to predict the damage of the aircraft structure, so as to realize the fault diagnosis analysis and decision-making assistance of the aircraft structure. Based on this, aircraft structural damage and repair information is collected and digitized the cluster analysis model, time series model, and cluster analysis model are established through model fusion to predict
and analyze aircraft structural damage, and build a good development environment for structural damage big data analysis, intelligent fault diagnosis and assistant decision support.

To solve our actual problems, the paper collects a certain type of aircraft structural damage information big data analysis data, on the base of structural damage prediction and assistant decision-making, the system is developed and designed, and the micro-service architecture and the Vue.js front-end development technology framework are adopted to ensure the system efficiently provide container services, realize the efficient availability of the system, and complete the entire system.

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