The Overview of the Health Monitoring Management System

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Abstract

The health monitoring management system has prominent function to improve the security and dependability of the aircraft, can also shorten the maintain cycle by a large margin, improves the sortie rate at the same time. This paper has explained the concept, the development in domestic and international and the key technology of the health monitoring management system of aircraft; Construct the structure of the aircraft health monitoring management system, and has carried on analysis and research to its implementation method.

Keywords: Health Monitoring Management System; Aircraft; Built-in Test; Data Mining; Artificial Intelligence

1. Introduction

With the improvement of the attendance rate to complete mission and the serviceability rate to war preparedness required of the modern war, and with the development of the sensor technology, testing technology, signal analysis and artificial intelligence technology, the advanced weaponry has adopted the failure prognostic and health management technique in a large scope at present in order to realize “maintained Depend on the case”. This technology predicts the failure situation of system and part by state of the real-time detection system, and confirm its surplus life-span; Utilizes the multi-sensor information integration technology to diagnose the systematic failure; Utilizes language information to prompt the equip users to manage and make policy base on the available resource and the demand of using during in the maintenance. This paper explains the health monitoring management system, its application situation and key technology in the complicated system of aircraft, compare the development between the domestic and abroad, thus set up the structural model of top floor of the health monitoring system of aircraft.
2. Health monitoring system

The word “Health” come from the field of health care field at first, and it is used mainly for describing the state of the biological organism. The word “monitor” means utilize a series of means to check and record the reason of the failure take place, evolution and elimination by the way on qualitative and quantitative. Introduce the “Health Monitoring” into military equipment project field, its meaning is similar as the meaning which it represents and health care field exists, refer to finding and predicting the early failure sign before the weaponry failures the invalid incident to happen, prevent the calamitous accident from happening. The health monitoring management system of the aircraft is based on the in wireless sensor network technology, build-in-testing technology and ultra broadband communication, analysis the data resources relevant to the operation and maintain of the aircraft through the data mining technological. A real-time aircraft health monitoring systems can perceive, classify and predict the failure in time; it can reduce the run and maintain expense and optimizing the life-span of the key part of aircraft.

The health monitoring system predicts the failure situations of system and sub-system of aircraft by state of the detection system, confirm its surplus life-span; Utilize the multi-sensors information integration technology to diagnose the systematic failure, utilize the languages information to informs the users to make the manage and maintenance policy on the basis of using resources and the demand. PHM technology is the important means for realize the weaponry “maintain depend on the situation”, it has functions such as the failure predicication, failure measure, failure isolation, life-span following to the key part, failure report and life prediction, etc., it can realizes the accurate maintenance in the accurate position and at accurate time, thus reduces maintenance items effectively, saves the maintenance cost, reduces the crash rate of the weaponry, improve the rate of attendance of the weaponry. For example, USN employs make the maintain outline depend on the “maintain depend on the situation”, make the maintenance cycle lengthen 20% to maintain F-4J, engine overhaul issue extend to 2400h from 1200h; By the PHM technology, the support equipment of JSF aircraft reduces by 50%, the service engineer reduces 20%-40%, The producing rate of sortie is improved by 25%.

Health Monitoring Management System of Aircraft, is an important component of PHM technology, it is the application in the aircraft structure failures and monitors, discerns and makes a reservation of PHM technology. Because chemical corrosion, stress function, struck and tired factor of heat influences, the structural surface of aircraft or every internal system may emerge a large amount of part is damaged and little crackle. If does not measure these some structure failure in time, positioning it, form, size, and then take the essential remedy, failure and probably further expand, thus lead to the fact the structure is destroyed, even cause the serious accident.

The typical structure failures of aircraft (Such as the wing, fuselage) include the fatigue crack failure, corrosion damage in structure, contingent damage (such as overload failure against structures in the abnormal manoeuvre, including the hail, lightning, bird bump against the failure of the structure, etc.), and the comprehensive failure produced up with these factors. Apply the monitoring technology of structural health based on sensor network in the aircraft, failure and take place to carry on online monitoring and prediction with health status, possible life-span of the state of development, structure to the structure of the aircraft, have important theory meaning and actual using value to the security for guaranteeing the fly.

3. Studies the current situation both at Domestic and abroad

3.1. Foreign development

From the beginning of the eighties of the 20th century, the digital system composed of electronic hardware and software was introduced to Boeing-737, 757, 767, MD-90 and A320 aircraft. These new digital systems are challenged to the aircraft service engineers, because they can only measure and isolate the failure according to the information offered by system itself. In the face of this kind of technological challenge, the first health management standard of aircraft has emerged, that is the design and use manual
of the ARINC 604 build-in-test apparatus. This standard is researched and developed together by ARINC Company and cooperative, it indicates the aircraft enters a new stage of health management. By one or several Line Replaceable Units with the maintenance panel, offer the test and inquire systematic ability to service engineers.

Until the middle period of the eighties of the 20th century, with the introduction of the glass cockpit, the service engineers can carries on test and inquiry a lot of systems through the centralized type panel that is shared by some LRU. But these commonly panel can only report the test result of each LRU alone with panel, do not possess and point out the ability to carry on comprehensive report to a lot of LRU relevant failures, the service engineers still needs to synthesize these results artificially, otherwise they will remove and change all LRU reported the failure sign, but not change LRU really breaking down.

Boeing 747-400 has 2 CMC (Central Maintenance computer), CMC can display these result by the MCDU (Multi-Function Control Display Unit), or transmit these result to the ground satellite station during flight way, so the service engineers can make good preparations for maintaining ahead of time. This CMC offers a piece of interface of synthesis user even, benefits and carries on the test to the subsystem of all connections in ground. The CMC of Boeing 747-400 finished the failure and diagnosed synthetically through a set of complicated diagnosis based on logic equation, development and maintenance of this method is a great technological challenge, because exist more relation among these equations. This method needs to have very exhaustive understanding to all equations, so as to ensure they can have been effective all the time, and can represent the systematic behavior correctly.

The modern CMC have the following contents during the health management process to the aircraft:
- The failure measures and the isolates principle;
- The best sensor quantity and overall arrangement tactics;
- Test design and application of the build-in-test technology;
- Performance index, such as the coverage rate of failure or the rate failure isolates accuracy;
- Check, the verification of plan and procedure;
- Modeling tactics of the failure;
- The Systematic interface standard between the system and subsystem.

It is important to set up effective health management system that coordinate with the comprehensive content described above. Its final goal is to improve the testing, isolate the failure, improve systematic security and dependability and reduce the cost of life-span.

3.2. Domestic development

In the field of civil engineering, Wuhan University of science and technology, Tongji University, Southeast University of China and Dalian University of science and technology have launched the research of much structural health monitoring, especially direct against the structure of the bridge. For example installed 500 pieces of acceleration sensor, pasted a large amount of emergency slices and a set of GPS systems in Hong Kong Tsing Ma Bridge, in order to monitor the security on active service of the bridge for a long time. Mainland have many bridge install structural health monitoring system too, for instance Sutong bridge, Jiangyin bridge, etc. Jiangsu.

In the aerospace field, the Harbin polytechnical university explained the Integrated Health Management System of the aerospace craft in detail supported by the “863 projects” foundation, this project researched the Integrated Health Management System of the new aerospace craft, and the Health Management System for orbiter and ground, and analysis the main technology adopted in this project.

Xi'an Communication University “The aircraft structural health monitoring system in situ” monitor the structural health state of aircraft on line with the computer technology by the original creation “The intellectual information coat” technology. When the key or dangerous position structural of the aircraft is failure, the information intellectual coat of the relevant physical will take place great change, the airborne computer can scan and discovery these information, then it compare these information with the initial data of database, send out relevant alarm signals, thus catch all kinds of failure taking place in aircraft structure accurately in time, guarantee the flight safety, and overhaul the aircraft structure in time.
The northwest polytechnical university has proposed the networked long-range failure diagnose and healthy management scheme of the aircraft according to the correlated research on the relationship between the failure mechanism and operating personnel, aircraft and environment, and researched this scheme based on the artificial intelligence theory and method. “Research on the health monitoring management system based on virtual technique” take the wings and fuel system as example, based on the virtual technique, using the LABVIEW to construct the health monitoring management system for the wing and fuel system. This system has real-time character and warning ability, and has basically realized the measuring function.

3.3 Domestic and international contrast

Through the contrast research, we can find the “health monitoring management system of the aircraft” has already employed in some large aircrafts, and has made the good application result. China has carried on some fruitful research to explore in this respect, but has not applied in the practice yet.

4. Key technology

The health monitoring management system of the aircraft is a great complicated system, which merge many kinds of key technology, for instance the failure diagnosis, artificial intelligence, data mining, intellectual material, wireless sensor network, ultra broadband communication etc. The failure of the aircraft also has some factors such as sudden, randomness, uncertainty, etc. at the same time.

4.1 The failure diagnose expert system

The failure diagnose expert system, refers the computer gather message from the diagnose target in, use various rules (for example: the experience of the expert), carry on corresponding inference, can also call various application program at any time if necessary, after asking for essential information from the users during in the operation course, the final failure or most possible failure can be found fast, and then can be verified by users. The failure diagnose expert system is made up of database, knowledge base, man-machine interface, inference machine, etc. In The health monitoring management system aircraft, the database stores the design parameter and the state parameter of the aircraft; The knowledge base is a set of expert's field knowledge, used for storing the failure and diagnosing algorithms, inference rule, etc.; The inference machine is the management organization of the expert system, use various rules synthetically according to the information obtained, carry on the failure and diagnose, output the result of diagnosing. Set up the failure tree model on aircraft in the system, will choose the appropriate algorithm of deducing, and confirm the mechanism of deducing.

4.2 Artificial intelligence

Artificial intelligence, which is subject make the computer imitate some thought process and intellectual behavior of people, such as studying, inferencing, thinking, planning etc. Discipline, it is it to realize intelligence to last computer it last human brain the computers of the intelligences principle, manufacture mainly, enable computer to realize more high-level application.

The artificial intelligence technology is used mainly for confirming the mechanism of deducing of the failure in the system.
4.3. The data mining

The Data Mining, Obtain the non-ordinary course of the effective, novel, potential and useful, finally intelligible mode from a large number of data.

After making the believable airborne sensor information, carry on the classification of the data to the aircraft state data, carried on the modeling and assessment to the state after choosing to maintain the data, and then produced the failure predication model, produce the failure report finally.

Among The health monitoring management system aircraft, data excavate technology can record data at the one turn into the knowledge of maintaining in curriculum vitae at present, solve "the magnanimity of the data, information is scarce" Awkwardness.

4.4. Intellectual material

Intellectual material (Intelligent Material), Mean that has environment of perceiving, including internal environment and other environment) Stimulate, analyze, deal with, judge to it, take certain measure to carry on the material of the appropriate intellectual characteristic that responds.

4.5. Wireless sensor network

Wireless Sensor Networks is one kind of whole distribution system which has no nodal in the centre. Through the way of the random distribution, the nodes of numerous sensors are being disposed and controlled in the area intensively. The nodes of these sensors integrate transducer, data processing unit and communication module, and linked up through the wireless channel, forming the network system organizing. The node of the sensor measures the hot, infrared, sonar, radar and shaking signal of the surrounding environment with the aid of the built-in various informative sensors.

4.6. BIT technology

BIT means the equipment can check itself under the scheduled program. Through the build-in-test technology, the operator can locate the failure to LRU (Line Replace Unit), improves the ability of the secondary taking-off.

5. Systems form

The health monitoring management system of the aircraft is mainly made up of two parts: Airborne health monitoring subsystem (Airborne Health Monitoring Sub-system, AHMS) Diagnose the subsystem (Ground Health Diagnostic Sub-system, GHMS) with the health of ground. Kept the data circulating by the communication system in the vacant lot between AHMS and GHMS. Its structure is as shown in Fig. 1.
5.1 Airborne health monitoring subsystem

The structure of the airborne health monitoring subsystem is shown in Figure 2. The router obtained the organism or the systematic status information by the end sensor, and send to the central authorities maintain computer synthetically, the central authorities maintain computer supported by the knowledge base and database, judge experience logic, and reveal the judged result through the man-machine interface.

![Airborne health monitoring subsystem structure](image1)

Figure 2  Airborne health monitoring subsystem structure

5.2 Ground healthily diagnose subsystem

The structure of the ground health diagnose subsystem is shown in Figure 3. The expert makes decision through the CMC according to the knowledge base and the database, at the same time, collects and proves the failure model of all kinds plane and changes the data into knowledge.

![Diagnose the subsystem structure healthily on ground](image2)

Figure 3  Diagnose the subsystem structure healthily on ground

References


