New Path of Civil Aircraft Maintenance Under the Support of Big Data Technology

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Abstract. The civil aviation industry develops rapidly and produces a large number of aviation data. The collection, analysis and utilization of these data are of positive significance for guiding the development of civil aviation industry and civil aircraft maintenance. The characteristics of the current data era are more obvious, and big data technology also facilitates the integration and utilization of civil aviation data. Therefore, it is necessary to integrate and utilize civil aviation data based on big data technology to guide civil aircraft maintenance and civil aviation operation. This work chose the civil aircraft maintenance supported by big data technology as the research subject, discussed civil aircraft data classification in detail, explored the effective application of data in civil aircraft maintenance, and expounded the application path of QAR data in civil aircraft maintenance, expecting to provide guidance and reference for the integration and utilization of data in civil aircraft maintenance, and accumulate experience for the play of data application value.

1. Introduction

In the data era, the data value is more prominent, which also objectively requires people to do a good job in the integration and application of data. For the operation and management of civil aviation, some valuable data can guide the maintenance of civil aircraft, so the airlines also start to build their own data platforms and databases, hoping to play the data value with big data technology, and bring a more ideal civil aircraft maintenance and management effect. According to the data, by the end of 2020, more than 300 airlines in the world have conducted data utilization analysis based on big data technology, formulated effective solutions for civil aircraft fault handling based on effective data, and formulated civil aircraft health management system, so as to maximize the value of data in the field of civil aircraft maintenance [1].

2. Overview and Classification of Civil Aircraft Data

2.1. Overview of civil aircraft data

A large amount of data will be generated during the operation of civil aircraft. According to the type of application system, civil aircraft data mainly includes design documents, maintenance related manuals, operation data, maintenance management data, etc. Among them, the design documents include system design documents, maintenance analysis documents, system interface control documents, data communication specification documents, etc. Maintenance related manuals include aircraft fault isolation manual, aircraft maintenance manual, system diagram manual, parts catalog diagram manual, line construction manual, structural repair manual, maintenance plan, etc. Operation data refers to the airborne data generated and recorded by the aircraft including audio and video data. Maintenance management data include various maintenance records, navigation material management, maintenance plan and control data [2].

2.2. Civil aircraft data classification

According to the data type, civil **aircraft** data can be divided into three categories.

2.2.1. Structured data

Structured data, stored in a relational or object-oriented database, can be logically expressed with a two-dimensional table structure. The data model usually takes the form of two-dimensional tables, which needs to define the data structure before defining the data. The structured data in civil aircraft operation data mainly includes ACARS data, QAR data, etc.

2.2.2. Unstructured data

Compared to structured data, data unsuitable for storage in a two-dimensional logical relational database is usually unstructured. Usually the data comes first, then the data structure or data model. For example, all document text in Word and PDF format, pictures in various formats, reports in various formats, and audio and video data in various formats are unstructured data types. In civil aircraft operation data, various maintenance manuals and some maintenance records are usually unstructured data.

2.2.3. Semi-structured data

Semi-structured data refers to the data type between structured and unstructured data. Usually, documents in formats like HTML and XLM are semi-structured data, and generally. In general, semi-structured data, data structure and content are coupled together and cannot be clearly distinguished. Semi-structured data of civil aircraft operation data mainly includes reliability data, part of maintenance record data, etc.

3. Application of Data in Civil Aircraft Maintenance

3.1. Data quality management

The data collected by the big data platform of civil aircraft operation may not be completely clean and effective, and data quality management is required. Cleaning, conversion, and standardized processing of large amounts of data through ETL tools is the basis of big data analysis. The key link of ETL is data transformation, mainly including null value processing, data format standardization, data correctness verification, data replacement, Primary and foreign key constraints and other conversion methods. The data can be preprocessed through the standardized process of data quality management, which can ensure that the civil aircraft running big data platform obtains a preset defined high quality data set.

3.2. Data mining analysis

In order to improve the data analysis capability of the civil aircraft operation big data platform, it is necessary to introduce data mining analysis algorithms, which can not only cope with large capacity of data, but also have the ability of fast data processing. Data mining methods and techniques include induction learning methods, classification and clustering techniques, sequential data pattern mining techniques, statistical analysis methods, fuzzy mathematical methods, artificial intelligence, and machine learning [3]. Generally, civil aircraft operation database is taken as the research object, and data mining methods and techniques are constructed and applied in aviation data analysis. Mahout is often used as a data mining tool in the big data platform of civil aircraft operation.

3.3. Visual analysis

Data visualization is a graphical way to clearly show data information, so as to achieve efficient communication effect. Whether data analysis experts or ordinary users, data visualization analysis can visually show the data, so that users can see the results intuitively. The big data analysis platform supports the rapid query of data in massive data and supports the visual report presentation of data. The platform can provide various data display tools, such as run chart, bode ploys, polar diagram and spectrum map, which can facilitate the formulation of user customized data reports and support the automatic output of reports.

3.4. Predictive analysis

Data mining algorithm and data visualization make the information carried by data be digested faster and better understood. With technical support, the accuracy of judgment can be improved. Predictive analysis allows data analysts to make some failure predictive analysis based on the results of data visualization analysis and data mining. Predictive analysis is mainly applied in the field of civil aircraft PHM. It can support the fault diagnosis, fault prediction analysis and equipment health management of key parts of civil aircraft, and provide reference for subsequent maintenance decisions.

4. Application Path of QAR Data in Civil Aircraft Maintenance

4.1. Monitor aircraft operation status

Wireless QAR data application process diagram, as shown in Figure 1, shows that QAR data of aircraft can accurately reflect the operating status of each system component during the use of aircraft. Through relevant monitoring and analysis of the data, airlines and maintenance units can more accurately and timely understand the working status of the aircraft, so as to carry out maintenance according to the situation. The amount of aircraft QAR data is huge. Taking China Southern Airlines as an example, according to the existing fleet size and route distribution of the company, there are about 180 million structured data automatically generated during the flight and can be collected and used every year, and the unstructured data (QAR data) is about 4 - 5TB, and this scale is still growing rapidly [3]. The huge amount of data has undoubtedly become a "gold mine" for the industry. At present, QAR data is widely used in the monitoring of aircraft operating status. The application in oil pressure monitoring is taken as an example. By design, when certain conditions are reached, the oil pressure sensor on the A330's Turbulent 700 engine converts the oil pressure signal into a wave signal. This signal input to EVMU can lead to air parking in severe cases. The general practice is to periodically decode the QAR data of each engine and replay its oil pressure and related flight parameters. If fluctuating data is found to be about to appear, the sensor will be replaced in advance. However, this processing method is extremely workload and prone to errors and leaks. By building a background of automatic decoding analysis, the scientific mathematical method of scientific calculation can be built. When the plane lands, WQAR completes data transmission, and the background automatically gives the power spectrum of oil pressure fluctuation. If the set threshold is reached, the engineer will receive a warning from the system to monitor the operation of the plane.

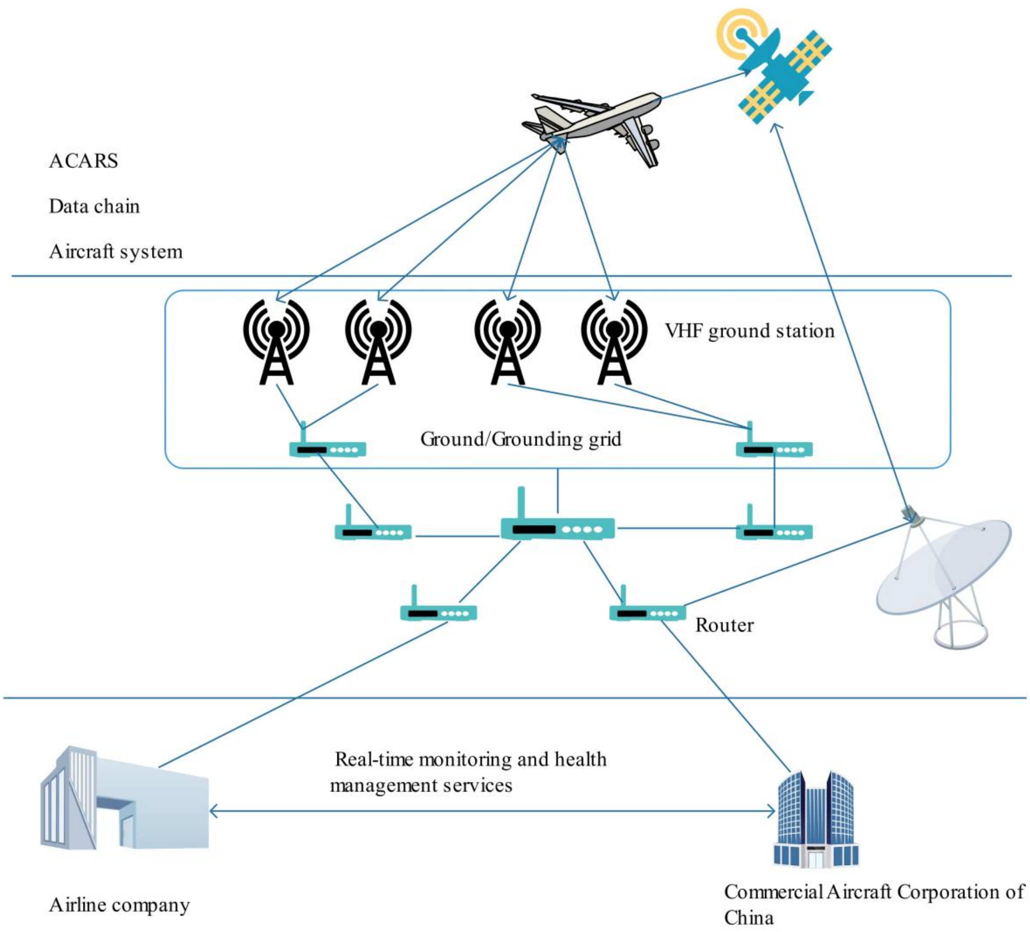

Figure 1. Process diagram of wireless QAR data application

4.2. Assist aircraft maintenance and troubleshooting

The aircraft system structure is complex, so it is necessary to comprehensively refer to various situations during the troubleshooting of the aircraft, including the response of the unit to the fault condition, the whole route troubleshooting process and the results of analysis by engineers using QAR data, and then determine the cause of the fault based on the principle of the system itself and the detection results. During the whole troubleshooting process, QAR data can be used to quickly locate faults, accelerate troubleshooting speed and improve maintenance efficiency. Take a troubleshooting case of an airline as an example, the crew reported that the transition light of the flab on THE P2 panel of a Boeing 737-800 aircraft was on after take-off, and the transition light was still on according to QRH, then the plane returned and landed for inspection. After a series of exhaust work, the plane was released normally on the next day. However, after taking off, the crew found that the transition light of the leading edge flaperon was still bright, so the crew decided to turn back again. The two turns back brought a certain economic loss to the airline. After the accident, relevant engineers made an emergency investigation. According to the QAR data, it was found that after the first flight began to show the leading edge slat signal, slat 4, 5 and 7 were retractable normally, and slat 2 was also retractable after a long time, but the QAR data corresponding to the leading edge retractable was always in conversion. After the second flight showed the leading edge retraction signal, all the QAR data corresponding to the leading edge retraction was always in conversion [5]. Based on the integration of the feedback information of the unit and the analysis results of QAR data, it is preliminarily believed that the reason for the leading edge flagging transition light is that the leading edge flagging does not receive the position, and the possibility of indicating system failure is ruled out. Further reasonable troubleshooting suggestions are given. The final accident investigation results found that the lapel retracting fault was caused by the damage of the sealing ring in the leading edge flaperon actuator cylinder, which led to excessive leakage in the actuator cylinder.

5. Conclusions

With the advent of the era of big data, data application becomes inevitable and the development of civil aviation is no exception. Based on this, it is necessary to attach importance to the innovative application of big data, deep mining and extraction of data based on big data technology, so as to guide the development of civil aircraft maintenance work, realize dynamic monitoring of civil aircraft operating state, and support troubleshooting. In the future, the application of data in civil aircraft maintenance will be developed towards intelligent risk prediction, remote monitoring and operation guidance, and the application of data in civil aircraft maintenance will achieve a more ideal application effect. The most urgent task is to do a good job in this topic study and explore the diversified path of data application in the field of civil aircraft maintenance.

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