Heterogeneous and dated data for optimizing operations and maintenance on aircrafts

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ABSTRACT

The goal of our work consists in integrating prognostic and health management on an aircraft system by using the largest kind of information available and associated to its missions (embedded sensors data, positioning, environmental conditions, pilot logbook...) and maintenance historic. We propose a method carrying data cubes for warehousing heterogeneous and dated data. We explore different methods of data mining and modeling for optimizing maintenance and prognostic.

1. INTRODUCTION

Most of researches in the domain of health management focus on one angle of the multiple aspects of data and information available in the aerospace domain.

In our work we will try to hang a method which will combine several types of information. By considering technical expert knowledge, reference maintenance books, maintenance planning, maintenance policy and sensors data from engine and other equipments, environmental conditions of the missions, we will try to propose a flexible model for prognostic and health management on aircrafts.

2. AEROSPACE PHM SERVICE PRINCIPLE

As part of RECORDS, a services platform introduced by the SAS 2MoRO, our work proposes to use techniques of data excavation to exploit and carry the vast amount of information associated with land vehicles or aircrafts.

RECORDS offers technical frames for monitoring use of systems. This project is made for small aircraft and complex land vehicles operator. It is developed under the agreement of Aerospace valley*. The aim is to provide services to optimize fleet management by displaying alerts and a respect of use imposed by consigns and manufactures guidelines. It's composed of an embedded system, which collects dated and geo-localized data, and a centralized secure information platform.

The collected information is characterized by its heterogeneity on typology and source. For instance, in RECORDS project, the manipulated data are:

- Human information consisting in pilots reports, and technical maintenance reports;
- Base line data equipments, like AMM (Aircraft Maintenance Manual), IPC (Illustrated Parts Catalog)…
- Environmental conditions of plane cycles, including the crossed geography, weather measurements, and atmospheres kinds;
- Embedded sensor data with different types of measurements: trajectories, pressure, temperature, engine, vibrations…;

This information is linked through positioning system like EGNOS based on GPS or GLONASS satellites and soon GALILEO.

Our work focuses on the exploitation of these elements for enhancing aircraft management by ensuring failure anticipation and optimizing maintenance operations.

3. CURRENT APPLICATIVE PHM RESEARCH

Researches in aerospace health management and prognostics have been performed in an applicative way by several teams. We propose here to resume some of the most interesting studies according to our target system.

(Fauré et al. 06) developed prevision failure system by exploiting Bayesians networks. They applied this technique on a database of operational interruptions to improve the conceptual systems stage. Along the different process iterations an expert must intervene to validate rules and Bayesian networks.

* French competitively pole concerning aerospace industrial researches in Midi Pyrénées and Aquitaine regions.

(Letourneau et al. 05) developed method to improve health systems through failure prevision on aircrafts and trains by using historic failures data. This method merges results for application of several models (decision trees through J48 and Bayesian network) to improve the final results.

The principle of the recent approach of (Le Goc et al. 07) is to combine the expert assumptions and a multi model approach to develop a dynamic system for a diagnostic task. The proposed model designs at the same abstraction level as the expert knowledge and builds four models: the theological model, which describes the process goal of the system, the structural model which describes the components structure of the system, the behavior model which describes the trend of variables across time and the functional model containing variables and functions that define their values comportments.

4. CURRENT WORK

From this status on the research undertaken in this domain, we focus our work on two different points.

The first aspect concerns the huge amount of raw data to be processed (4Go/month/plane). The aim is to find the best way to represent raw data which will allow having a decisive orientation to diagnostic. This representation will be matched with the expert knowledge's representation to smooth the monitoring and diagnostic process.

The second orientation of our work is to examine different kinds of studies to hang a limber model uses methods and algorithms of classification, clustering and others data-mining methods. This model would be able to be applied to different kinds of airplanes by adapting the first representation of acquired data and expert knowledge.

4.1 Data Cube work and discussion

One of the topics of our work is to provide a performing processing data chain. The first step is to collect and warehouse bulk information. Indeed, information must be efficiently stored to optimize its exploitation in the later process. For data warehousing, we chose data cubes. It's build through an ETL tool ("Kettle data integration"). Different representations of the bulk data was made to highlight at best complexion's information. At this step of research, we design four dimensions for the data:

- Temporal: which is composed of several time granularities; it will allow having different temporal regards of the knowledge;
- Plane dimension, with two representations: fleet oriented and manufactures oriented;
- Equipment representation which describes component's hierarchy in the vehicle;
- And environmental representation.

According to these representations we can build knowledge model by capitalizing the trends and behaviors of variables.

4.2 Data mining algorithms and expected results

In order to capitalize bulk information and describe data representation, we have to apply different data mining algorithms; this is the second step of our process chain.

The goal is to build a significant hierarchical data representation by using clustering algorithms. The main goal is to perform data organization according to variables behavior and values order. Most of the clustering algorithms must specify the number of clusters to build. We applied the K means algorithm (with k equals to 3) to dissociate the three phases of a Flight: climbing, cruise and landing. At the same order, we can build more significant clustering as follows regards on data or physical structure of the system.

The third step consists in excavating data behavior by analyzing jumping and plunging down data trends. This can be made by computing frequent elements with classical computing support algorithms (a priori). We envision investigating emerging data cubes and condensed representation of cube borders by applying probabilistic means, using ideal order and closure border to reduce execution time (Nedjar et al. 09).

3. CONCLUSION

The next goal of our work will be to enhance health maintenance and logistic of fleet aircrafts by predicting failure and dysfunctions. We hang various screws on the sensors data to build significant illustration. These representations are used to match at best raw data with expert knowledge. Next works aspire to make experimental validation of the data representation and following up the rest of the processes by matching the results with expert knowledge. Then, we have to model steady states and failure occurrence of systems in order to have an adequate view of the health systems.

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