Chapter 29
AI and Statistical Technologies for Manufacturing and Maintenance Strategies Improvement:
Health Monitoring for Electromechanical Actuators

Susana Ferrerio Del Río
IK4-Tekniker, Spain

Iñaki Bravo-Imaz
IK4-Tekniker, Spain

Santiago Fernández
IK4-Tekniker, Spain

Egoitz Konde
IK4-Tekniker, Spain

Aitor Arnaiz Irigaray
IK4-TEKNIKER, Spain

ABSTRACT

The development and the implementation of advanced actuation systems has increased in recent years, as many factors are driving the migration from hydraulic actuators to electromechanical actuators (EMAs) in aeronautics. But not only do we have to consider the right design to customize the system from the requirements oriented to the final application, also additional functions that can provide the system with additional value, to make it more competitive in this market. This is the case of the Health Monitoring (HM) systems. The development, implementation and integration of predictive algorithms into the environment of the EMA provide the system with an additional functionality, from which it is possible to detect failures at an early stage in order to avoid catastrophic accidents and improve maintenance activities. This work shows how to develop HM algorithms based on AI and Statistical technologies to detect and predict early stages of failure in a gearbox, which can directly affect to the transmission of power in EMAs.

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1 INTRODUCTION

Nowadays, large aeronautical multinationals, aircraft Original Equipment Manufacturers (OEMs) and their suppliers are immersed in the concept called "More Electric Aircraft", which will enable the aircraft industry to improve significantly in terms of reduction in aircraft weight, fuel consumption, total life cycle costs, maintainability and reliability. This trend is accelerating in recent years and these companies are investing heavily towards this concept of more electric aircraft, in which traditional hydraulic and pneumatic systems are being replaced by electrically-driven systems.

In this context, the development and the implementation of advanced actuation systems has increased, as many factors are driving the migration from hydraulic actuators to electromechanical actuators (EMAs). EMAs provide significant advantages in complex applications because they increase the controllability of the system (shortening changeover times), provide re-configurability, maintain functionality during faults (improving the accuracy and reliability), and make it possible to carry out advanced diagnostics and prognostics for a more intelligent maintenance, furthering the increment of the aircraft availability with the long-term planning for maintenance activities. Overall, the main objective for the companies in the last few years is to save operating costs, fuel burn and environmental impact.

Due to these necessities and regarding the development of EMAs, many issues must be taken into account. Not only do we have to consider the right design to customize the system from the requirements oriented to the final application (i.e., cargo door, landing gear..), but also additional functions that can provide the system with additional value, to make it more competitive in the market. This is the case of the Health Monitoring (HM) systems. The development, implementation and integration of health monitoring algorithms into the environment of the EMA provide the system with an additional functionality, from which it is possible to detect failures at an early stage in order to avoid catastrophic accidents. Nevertheless, it is not an easy and simple task because a lot of subsystems or components are responsible for causing the fault of the EMA. A HM system must use data that already exist within the EMA and its developed algorithms, addressing all the parts of the system (i.e., electronics, sensors, motor and mechanical parts) in order to detect or predict the fault before affecting the actuator output in a critical way. In order to develop a HM system for the EMA, it is necessary to identify and define the architecture and the parameters that can be monitored from the system, and to develop the algorithms for anomaly detection and diagnostics to be implemented and integrated into the EMA finally.

Gearboxes are a common component in numerous actuation systems and EMAs in particular. They provide speed and torque conversion from the rotating power source to another mechanism, such as a screw. Direct drive mechanisms exist to take power from the source without any reduction. Nonetheless gearboxes add flexibility in design and application.

Component failures impact overall effectiveness, by means of reducing availability, reliability and safety, increasing cost of maintenance and repairs, and impacting performance. The role of gearboxes in the transmission of power makes them important in EMAs. Transmission of power in EMAs can be, therefore, affected by gear faults such as backslash, wear, or even broken tooth. As a consequence, health monitoring and assessment of this component is desirable.

A typical approach to gear health assessment focuses on direct analysis, such as threshold crossing, of sensor measurements and characteristic feature values. However, the use of statistical and computational techniques is becoming more common in order to handle uncertainty and complex decisions, and also because of their capabilities for flexible modeling and self-learning abilities.

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