Visualisation of Jet Engine Vibration Characteristics for Novelty Detection

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Abstract

A novelty detection approach to condition monitoring and visualisation of aerospace gas-turbine engines is presented, providing a consistent framework for on- and off-line analysis, each with differing typical implementation constraints. On-line techniques are introduced for observing abnormality in engine behaviour during aircraft flights, and are shown to provide early warning of engine events in real-time, effectively communicated by dimensionality-reduction techniques. Off-line methods within the same analysis framework are shown to allow the tracking of single engines and fleets of engines from ground-based monitoring stations on a flight-by-flight basis, with a corresponding visualisation for plotting changes in engine condition.

Introduction

Early warning of potential failure is of vital importance in the operation of most high-integrity systems. Intelligent techniques for condition monitoring of such systems are required in order to provide early warning by identifying pre-cursors to system faults. This approach is being adopted by modern gas-turbine manufacturers, which allows preventative maintenance to be taken to avoid hazard and critical failure. This paper introduces a novel framework for the application of statistical pattern recognition and machine learning techniques in providing early warning of critical failure in aerospace gas-turbine engines.

Due to the complexity of typical high-integrity systems, the number of possible modes of failure is very large, the effects of which on system state are not precisely defined. Examples of abnormal behaviour in high-integrity systems are few in comparison to the quantity of examples of normal behaviour, due to the rarity of system failure. Thus, in order to facilitate early warning of this large set of ill-defined possible failures, a *novelty detection* approach is taken: high-dimensional models of normal system behaviour are constructed from "normal" data, with significant departures from the model classified as "abnormal" events. The degree of abnormality observed can provide an estimate of the confidence with which decisions are made, and can quantify the severity of the event.

For reasons of commercial sensitivity, data and system descriptions have been anonymised where necessary by not divulging absolute values of operational parameters.