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ANOMALY DETECTION OF LIQUID PROPELLANT ROCKET ENGINE USING SYSTEM INVARIANT ANALYSIS TECHNOLOGY

Abstract

Health monitoring of rocket engines is one of the key technologies to enhance safety and survivability of launch vehicles. A large amount of data for engine condition monitoring, such as pressures, temperatures, flow rates, and so on, can be collected from distributed sensors to analyze engine system behavior. If we can interpret the collected data effectively, a foretaste of engine failure can be detected and the engine can be shut down safely before a catastrophic failure for avoiding the loss of vehicle.

In order to detect a foretaste of failure of liquid propellant rocket engines from a large amount of engine condition monitoring data, the System Invariant Analysis Technology (SIAT) is applied. The SIAT is a kind of analysis methods to handle big data for automatic system management, developed by NEC. In this method, a concept of flow intensity is introduced, and a large, dynamic, and complex system is modeled as aggregate of relationships between flow intensities measured at various points across the system. Auto Regressive models with eXogenous inputs (ARX) is used to learn linear relationship between two flow intensities from the measurement data. If the modeled relationships hold all the time, they are regarded as invariants of the system. By tracking any change of those invariants, the operational status of system can be detected in real time. In addition, the component that causes a failure can be identified by extracting the broken invariants.

In the present paper, the SIAT was applied to detect anomaly behavior of a liquid propellant rocket engine. The numerical verification was conducted with use of existing firing test data of Reusable Sounding Rocket (RSR) engine. This paper shows the latest results of numerical verifications. It shows that the SIAT can detect anomaly behavior such as foretaste of engine failure including sensor trouble and would be a useful tool for the health monitoring of rocket engines.