National Aeronautics and Space Administration

Robotics, Automation and Control

Inductive Monitoring System

Automated monitoring techniques for complex systems

The Inductive Monitoring System (IMS) software utilizes techniques from the fields of model-based reasoning, machine learning, and data mining to build system monitoring knowledge bases from archived or simulated sensor data. Unlike some other machine learning techniques, IMS does not require examples of anomalous (failure) behavior. IMS automatically analyzes nominal system data to form general classes of expected system sensor values. This process enables the software to inductively learn and model nominal system behavior. The generated data classes are then used to build a monitoring knowledge base. In real-time, IMS performs monitoring functions, determining and displaying the degree of deviation from nominal performance. IMS trend analyses can detect conditions that may indicate a failure or required system maintenance. The development of the IMS was motivated by the difficulty of producing detailed diagnostic models of some system components due to complexity or unavailability of design information. Previous and Current IMS applications include the Hybrid Combustion Facility (HCF) advanced rocket fuel test facility, and the RASCAL UH-60 Blackhawk Helicopter.

BENEFITS

- Decreases workload required to monitor system health and to respond to anomalous behavior
- Compact health information presentation displays degree of deviation from nominal performance. Symbols encode information for quick interpretation
- Automated Diagnosis System – IMS-detected anomalies can be sent to a diagnostic software module for diagnosis

technology solution

THE TECHNOLOGY

The Inductive Monitoring System (IMS) software provides a method of building an efficient system health monitoring software module by examining data covering the range of nominal system behavior in advance and using parameters derived from that data for the monitoring task. This software module also has the capability to adapt to the specific system being monitored by augmenting its monitoring database with initially suspect system parameter sets encountered during monitoring operations, which are later verified as nominal. While the system is offline, IMS learns nominal system behavior from archived system data sets collected from the monitored system or from accurate simulations of the system. This training phase automatically builds a "model" of nominal operations, and stores it in a knowledge base. The basic data structure of the IMS software algorithm is a vector of parameter values. Each vector is an ordered list of parameters collected from the monitored system by a data acquisition process. IMS then processes select data sets by formatting the data into a predefined vector format and building a knowledge base containing clusters of related value ranges for the vector parameters. In real time, IMS then monitors and displays information on the degree of deviation from nominal performance. The values collected from the monitored system for a given vector are compared to the clusters in the knowledge base. If all the values fall into or near the parameter ranges defined by one of these clusters it is assumed to be nominal data since it matches previously observed nominal behavior. The IMS knowledge base can also be used for offline analysis of archived data.

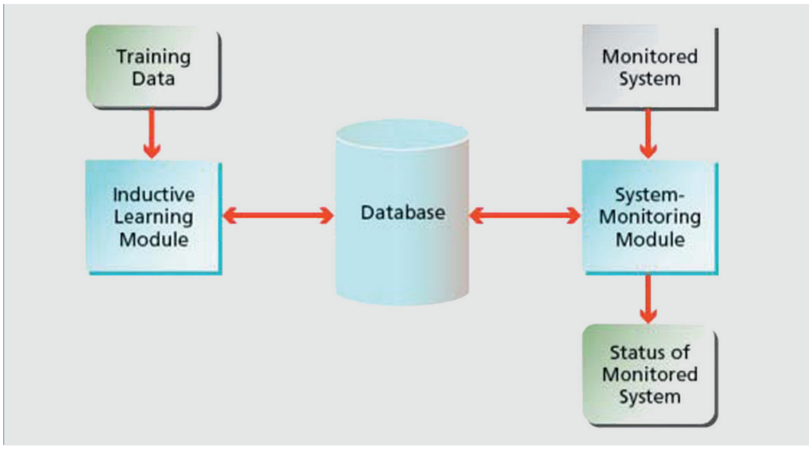

FIGURE 1 – IMS Conceptual Overview

APPLICATIONS

The technology has several potential applications:

- Aeronautics
- Space (on-board or mission control center)
- Surface transportation
- Medicine
- Research Facilities and Data
- Infrastructure
- Manufacturing/Process monitoring
- Military/Security

PUBLICATIONS

ARC-15058-1

More Information

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