National Aeronautics and Space Administration

Health Monitoring for Complex Systems

NASA has developed a health monitoring system tool that uses data-mining techniques to analyze operations data collected from a system and automatically builds a multivariate nominal operations model for that system. Automatic system health monitoring can significantly benefit from comparison of system sensor data to an accurate characterization or model of expected system behavior. 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. IMS is a general purpose, data-driven system health monitoring software tool that has been successfully applied to several aerospace applications. The Outlier Detection Via Estimating Clusters (ODVEC) software, an extension of IMS, provides an efficient method for real-time or offline analysis of multivariate sensor data for use in anomaly detection, fault detection, and system health monitoring. It employs novel techniques to efficiently calculate the degree of deviation of current system behavior from a range of previous, similar nominal operations.

These inventions are available for licensing from NASA's space program to benefit U.S. industry.

Patent

This technology is protected by U. S. Patent No. 7,383,238 and a pending U.S. Non-Provisional Patent Application.
(Reference No. ARC-15058-1; ARC-16467-1)

Benefits

- Uses data clustering
- Increased analysis speed
- Annotates each cluster
- Efficient search technique
- Real-time queries analysis
- Efficient at analyzing full data sets
- Number and size of clusters can be adjusted
- Software re-use
- Automatic and efficient system
- Intuitive interpretation of anomalies
- Inductive learning

Technology Details

Health monitoring of complex systems is achieved with the Inductive Monitoring System (IMS), the Outlier Detection Via Estimating Clusters (ODVEC), the Parameter Selection and Weighting Tools for Distance-Based Anomaly Detection (PSWT) in conjunction with a graphical user interface (IMS GUI). IMS provides efficient software for system health monitoring. It automatically analyzes nominal data to form general classes of expected sensor values, enabling the software to inductively learn and model nominal behavior. These classes are used to build a monitoring knowledge base. IMS performs real-time monitoring functions, determining and displaying degree-of-deviation from nominal performance. ODVEC, an augmentation of IMS, uses models automatically derived from archived data to identify unusual data samples (outliers) and calculates the degree of deviation (a numerical score) of current behavior from a range of similar nominal operations. ODVEC re-uses and augments code from the IMS monitoring module. It uses clusters built by the IMS learn-clustering algorithm, but can also use input from other clustering algorithms. PSWT uses innovative correlation techniques to determine behavioral relationships between parameters in a representative data set.

Nuclear Power Plant

Commercial Applications

- Space/ Aeronautics
- Automotive
- Medicine
- Military / Security
- Research and Data facilities
- Manufacturing/Process/ Energy monitoring

Contact the Ames Technology Partnerships Office at 1-855-627-2249 or ARC-TechTransfer@mail.nasa.gov