

mature set of HDA software for the manned lunar landing problem.

Landing hazards exist everywhere on the Moon, and many of the more desirable landing sites are near the most hazardous terrain, so HDA is needed to autonomously and safely land payloads over much of the lunar surface. The HDA requirements used in the ALHAT project are to detect hazards that are 0.3 m tall or higher and slopes that are 5° or greater. Steep slopes, rocks, cliffs, and gullies are all hazards for landing and, by computing the local slope and roughness in an elevation map, all of these hazards can be detected. The algorithm in this innovation is used to measure slope and roughness hazards. In addition

to detecting these hazards, the HDA capability also is able to find a safe landing site free of these hazards for a lunar lander with diameter ≈15 m over most of the lunar surface.

This software includes an implementation of the HDA algorithm, software for generating simulated lunar terrain maps for testing, hazard detection performance analysis tools, and associated documentation. The HDA software has been deployed to Langley Research Center and integrated into the POST II Monte Carlo simulation environment. The high-fidelity Monte Carlo simulations determine the required ground spacing between LIDAR samples (ground sample distances) and the

noise on the LIDAR range measurement. This simulation has also been used to determine the effect of viewing on hazard detection performance. The software has also been deployed to Johnson Space Center and integrated into the ALHAT real-time Hardware-in-the-Loop testbed.

This work was done by Andres Huertas, Andrew E. Johnson, Robert A. Werner, and James F. Montgomery of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

This software is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-47178.

Onboard Nonlinear Engine Sensor and Component Fault Diagnosis and Isolation Scheme

John H. Glenn Research Center, Cleveland, Ohio

A method detects and isolates in-flight sensor, actuator, and component faults for advanced propulsion systems. In sharp contrast to many conventional methods, which deal with either sensor fault or component fault, but not both, this method considers sensor fault, actuator fault, and component fault under one systemic and unified framework.

The proposed solution consists of two main components: a bank of real-time, nonlinear adaptive fault diagnostic estimators for residual generation, and a residual evaluation module that includes adaptive thresholds and a Trans-

ferable Belief Model (TBM)-based residual evaluation scheme. By employing a nonlinear adaptive learning architecture, the developed approach is capable of directly dealing with nonlinear engine models and nonlinear faults without the need of linearization. Software modules have been developed and evaluated with the NASA C-MAPSS engine model. Several typical engine-fault modes, including a subset of sensor/actuator/components faults, were tested with a mild transient operation scenario. The simulation results demonstrated that the algorithm was able to success-

fully detect and isolate all simulated faults as long as the fault magnitudes were larger than the minimum detectable/isolable sizes, and no misdiagnosis occurred.

This work was done by Liang Tang and Jonathan A. DeCastro of Impact Technologies, LLC and Xiaodong Zhang of Wright State University for Glenn Research Center.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18518-1/9-1.

Network-Capable Application Process and Wireless Intelligent Sensors for ISHM

This technology can be used for wireless sensor monitoring in vehicles, home security, system automation, and radio-frequency identification (RFID) for smart tags.

Stennis Space Center, Mississippi

Intelligent sensor technology and systems are increasingly becoming attractive means to serve as frameworks for intelligent rocket test facilities with embedded intelligent sensor elements, distributed data acquisition elements, and onboard data acquisition elements. Networked intelligent processors enable users and systems integrators to automatically configure their measurement automation

systems for analog sensors. NASA and leading sensor vendors are working together to apply the IEEE 1451 standard for adding plug-and-play capabilities for wireless analog transducers through the use of a Transducer Electronic Data Sheet (TEDS) in order to simplify sensor setup, use, and maintenance, to automatically obtain calibration data, and to eliminate manual data entry and error.

A TEDS contains the critical information needed by an instrument or measurement system to identify, characterize, interface, and properly use the signal from an analog sensor. A TEDS is deployed for a sensor in one of two ways. First, the TEDS can reside in embedded, nonvolatile memory (typically flash memory) within the intelligent processor. Second, a virtual TEDS can exist as a

separate file, downloadable from the Internet. This concept of virtual TEDS extends the benefits of the standardized TEDS to legacy sensors and applications where the embedded memory is not available. An HTML-based user interface provides a visual tool to interface with those distributed sensors that a TEDS is associated with, to automate the sensor management process.

Implementing and deploying the IEEE 1451.1-based Network-Capable Application Process (NCAP) can achieve support for intelligent process in Integrated Systems Health Management (ISHM) for the purpose of monitoring, detection of anomalies, diagnosis of causes of anomalies, prediction of future anomalies, mitigation to maintain operability, and integrated awareness of system health by the operator. It can also support local data collection and storage. This invention enables wide-area sensing and employs numerous globally

distributed sensing devices that observe the physical world through the existing sensor network. This innovation enables distributed storage, distributed processing, distributed intelligence, and the availability of DiaK (Data, Information, and Knowledge) to any element as needed. It also enables the simultaneous execution of multiple processes, and represents models that contribute to the determination of the condition and health of each element in the system.

The NCAP (intelligent process) can configure data-collection and filtering processes in reaction to sensed data, allowing it to decide when and how to adapt collection and processing with regard to sophisticated analysis of data derived from multiple sensors. The user will be able to view the sensing device network as a single unit that supports a high-level query language. Each query would be able to operate over data collected from across the global sensor net-

work just as a search query encompasses millions of Web pages.

The sensor web can preserve ubiquitous information access between the querier and the queried data. Pervasive monitoring of the physical world raises significant data and privacy concerns. This innovation enables different authorities to control portions of the sensing infrastructure, and sensor service authors may wish to compose services across authority boundaries.

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