

ADFS corrects for piston estimation error terms, which appear in the fitted phase term when processing a DFS signal. The results of the Monte-Carlo type simulations clearly validate the analytical work to prove a correlation exists between calibration-induced piston estimation errors and the algorithm fitted phase.

At the time of this reporting, ADFS is being integrated with the DFS algorithm

improvement called Multi-Trace. Multi-Trace is currently the baseline for the dispersed Hartman sensor (DHS) used on-flight for coarse segment alignment of the James Webb Space Telescope (JWST). Because Multi-Trace does not address many degrees of freedom for the calibration process (i.e., rotational, scaling, tangential translation), a hybrid algorithm offers a possible improvement

upon these algorithms. ADFS offers marked improvements on the DFS, DHS algorithm, and opens possibilities for broader applications of these processes.

This work was done by Joshua A. Spechler, Daniel J. Hoppe, Norbert Sigrist, Fang Shi, Byoung-Joon Seo, and Siddarayappa A. Bikkannavar of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47688

➤ Neural Network Back-Propagation Algorithm for Sensing Hypergols

A software technique working with carbon nanotube sensors provides near-real-time detection of hazardous substances.

John F. Kennedy Space Center, Florida

Fast, continuous detection of a wide range of hazardous substances simultaneously is needed to achieve improved safety for personnel working with hypergolic fuels and oxidizers, as well as other hazardous substances, with a requirement for such detection systems to warn personnel immediately upon the sudden advent of hazardous conditions, with a high probability of detection and a low false alarm rate. Current detection methods rely on dosimetry badges that are not processed instantaneously, but rather at the end of work shifts.

A software technique provides pattern recognition for monitoring large numbers of channels of carbon nanotube sensors to detect a wide range of substances, including simultaneous hypergolic fuel and oxidizer detections, in near real time. It is useful for providing continuous monitoring of potentially hazardous substance leaks, with the additional ability to add detection capabilities without requiring hardware changes. It also includes software techniques to achieve quick neural network

training with little to no human intervention, through the use of innovative adaptive training techniques.

The primary purpose of this software is to read the voltage outputs from voltage dividers containing carbon nanotube sensors as a variable resistance leg, and to recognize quickly when a leak has occurred through recognizing that a generalized pattern change in resistivity of a carbon nanotube sensor has occurred upon exposure to dangerous substances, and, further, to identify quickly just what substance is present through detailed pattern recognition of the shape of the response provided by the carbon nanotube sensor.

The software consists of input nodes, hidden nodes, and output nodes, with all input nodes connected to all hidden nodes through a set of weighted pathways, and with all hidden nodes connected to all output nodes through a set of weighted pathways. Bias terms, in addition to sums of weighted prior node layer values, are also added, for both the hidden layer nodes as well as the output

layer nodes. The number of hidden nodes must be of the order of $2n+1$, or slightly larger, where n is the dimensionality of the data space being monitored.

Modular implementation permits reusing the basic gradient-descent, simulated-annealing adaptive training algorithm for training to detect any set of patterns for any particular application, not only carbon nanotubes. This means that the pattern recognition capability using carbon nanotubes can easily be added for a wide range of detections, ranging from detecting hypergol leaks, to detecting biological agents such as anthrax, or perhaps even improvised explosive devices, provided that vapors are emitted. Carbon nanotubes may respond well to detecting biological agents due to the cilia present on biological agents likely to respond to the carbon nanotubes.

This work was done by Jose Perotti, Mark Lewis, and Pedro Medelius of Kennedy Space Center; and Gary Bastin of ASRC Aerospace Corporation. For more information, contact the KSC Technology Transfer Office at (321) 861-7158. KSC-13500

➤ Bulk Moisture and Salinity Sensor

This sensor uses electrodes on the inside of the growth container to measure capacitance and conductance over the enclosed bulk volume.

John F. Kennedy Space Center, Florida

Measurement and feedback control of nutrient solutions in plant root zones is critical to the development of healthy plants in both terrestrial and reduced-gravity environments. In addition

to the water content, the amount of fertilizer in the nutrient solution is important to plant health. This typically requires a separate set of sensors to accomplish.

A combination bulk moisture and salinity sensor has been designed, built, and tested with different nutrient solutions in several substrates. The substrates include glass beads, a clay-like substrate,

and a nutrient-enriched substrate with the presence of plant roots. By measuring two key parameters, the sensor is able to monitor both the volumetric water content and salinity of the nutrient solution in bulk media.

Many commercially available moisture sensors are point sensors, making localized measurements over a small volume at the point of insertion. Consequently, they are more prone to suffer from interferences with air bubbles, contact area of media, and root growth. This makes it difficult to get an accurate representation of true moisture content and distribution in the bulk media. Additionally, a network of point sensors is required, increasing the cabling, data acquisition, and calibration requirements.

A vessel with electrodes was devised to measure the dielectric properties of

a material in the annular space of the vessel. Because the pore water in the media often has high salinity, a method to measure the media moisture content and salinity simultaneously was devised. Characterization of the frequency response for capacitance and conductance across the electrodes was completed for 2-mm glass bead media, 1- to 2-mm Turface (a clay like media), and 1- to 2-mm fertilized Turface with the presence of root mass. These measurements were then used to find empirical relationships among capacitance (C), the dissipation factor (D), the volumetric water content, and the pore water salinity.

Conventional moisture sensors only measure moisture over a small volume. Since water will stratify in the media due to gravity, the sensors will not accurately

represent the moisture available to a plant growing in a container containing such a sensor. The sensor described here uses electrodes on the inside of the growth container to measure capacitance and conductance over the enclosed bulk volume. These measurements are then used to determine the volumetric water content and salinity of nutrient solution available to the plant. From preliminary plant growth tests, it appears that the sensor is insensitive to the presence of root mass, a problem that affects many sensors available on the market today.

This work was done by Mark Nurge of Kennedy Space Center; and Oscar Monje, Jessica Prenger, and John Catechis of Dynamac Corporation. For more information, contact the KSC Applied Physics Laboratory at (321) 861-9068. KSC-13039

Change-Based Satellite Monitoring Using Broad Coverage and Targetable Sensing

NASA's Jet Propulsion Laboratory, Pasadena, California

A generic software framework analyzes data from broad coverage sweeps or general larger areas of interest. Change detection methods are used to extract subsets of directed swath areas that intersect areas of change. These areas are prioritized and allocated to targetable assets.

This method is deployed in an automatic fashion, and has operated without human monitoring or intervention for sustained periods of time (months).

This work was done by Steve A. Chien, Daniel Q. Tran, and Joshua R. Doubleday of Caltech; and Thomas Doggett of Arizona

State University for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

This software is available for commercial licensing. Please contact Dan Broderick at Daniel.F.Broderick@jpl.nasa.gov. Refer to NPO-48147.