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 vdetection 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 cillia 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,