troscopy. The surface localized field enhancement could be used to probe the upper layers of a sample surface.

WGM resonances (1, 2, X =also termed morphology-dependent resonances) take place when an incident light becomes trapped near the inner surface of a particle resulting from total internal reflection. This results in enhancement of the evanescent electromagnetic field at certain nodes near the surface of the particle. WGM resonance structures have been proposed as chemical sensors and when coupled with conventional Plasmon-based SERS, for single-molecule spectroscopy.

Very large enhancements are feasible by using 5-micron silica microspheres. Enhancement factors comparable to those seen from noble metal spheroids are possible enhancements when the Raman-scattered radiation also overlaps with a WGM resonance. For microspheres with radius of 5 microns, the enhancement factor can exceed an order of magnitude. This is a significant result that indicates that it would be possible to observe SERS with nonresonant scatterers.

This work was done by Mark S. Anderson of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, NASA Management Office–JPL. Refer to NPO-47604.

3D Hail Size Distribution Interpolation/Extrapolation Algorithm

Multiple sensors are not required.

John F. Kennedy Space Center, Florida

Radar data can usually detect hail; however, it is difficult for present day radar to accurately discriminate between hail and rain. Local ground-based hail sensors are much better at detecting hail against a rain background, and when incorporated with radar data, provide a much better local picture of a severe rain or hail event.

The previous disdrometer interpolation/extrapolation algorithm described a method to interpolate horizontally between multiple ground sensors (a minimum of three) and extrapolate vertically. This work is a modification to that approach that generates a purely extrapolated 3D spatial distribution when using a single sensor.

A 3D high-resolution mapping of hail, as well as rain, is desirable in many instances. For example, hail mapping in the vicinity of a launch vehicle on the launch pad would help determine whether or not damage has occurred following a hail event. In addition to quantifying the size and quantity of hail, it is desirable to know where on the vehicle hail impacts may have occurred. A method that was previously developed, and that required multiple ground sensors, has been modified to accommodate a single sensor. The 3D extrapolation from a single (or multiple) ground sensor can then be compared to the 3D radar-generated spatial map.

The 3D hydrometeor size interpolation scheme described in previous work assumes that a minimum of three hydrometeor disdrometers (rain or hail) are required for successful interpolation/extrapolation of the hydrometeor distribution in time and space. By simply bypassing the "gravity interpolation algorithm" for multiple sensors, it is shown that good agreement between single sites vs. multiple sites vs. radar is obtained.

The software modification allows any number of sensors, from 1 to *N*, to be used in the 3D-DSD algorithm. As would be expected, the more sensors that are available, the better, but the requirement for a minimum of three sensors has now been eliminated. This disclosure demonstrates that multiple sensors are not required for successful implementation of the 3D interpolation/extrapolation algorithm. This is a great benefit, since it is seldom that multiple sensors in the required spatial arrangement are available for this type of analysis. This can be used in conjunction with a single sensor or an array of hail monitors, or single or multiple rainfall disdrometers.

This work was done by John Lane of ASRC Aerospace Corporation for Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-13244

Color-Changing Sensors for Detecting the Presence of Hypergolic Fuels

Chemochromic pigment indicates the presence of hypergols, improving workers' safety.

John F. Kennedy Space Center, Florida

Hypergolic fuel sensors were designed to incorporate novel chemochromic pigments into substrates for use in various methods of leak detection. There are several embodiments to this invention that would provide specific visual indication of hypergols used during and after transfer. The ability to incorporate these pigments into various polymer matrices provides a unique opportunity to manufacture nearly any type of sensor shape that is required. The vibrant color change from yellow to black instantaneously shows the worker the presence of hypergols in the area, providing the worker the ability to immediately evacuate the area.

The chemochromic pigments are prepared in powder or liquid form for addition into many different materials in different articles. With the ability to incorporate the pigment into a wide range of materials, the sensor can take any embodiment allowed by various manufacturing methods. For example, the sensor can be manufactured in the form of polymer tape that can have several unique structures designed for different applications, from several layers to protect the tape from environmental conditions, to re-useable adhesive to allow for repositioning of the sensor. The sensor can be extruded into various size tapes or sheets, injection molded into uniquely shaped parts, or incorporated into fibers with fiber-spinning methods to make fabrics or personal protective equipment. Additionally, the sensor can be incorporated into a badge holder to be used as a point leak detector. This can be done by creating a clear, or nearly clear, polymer cap for connection points, and placing the sensing material at the end of the cap where it can be seen by a technician.

These sensors provide the capability for numerous areas to be constantly visually monitored for leaks. These sensors are easy to replace and have a very low implementation cost.

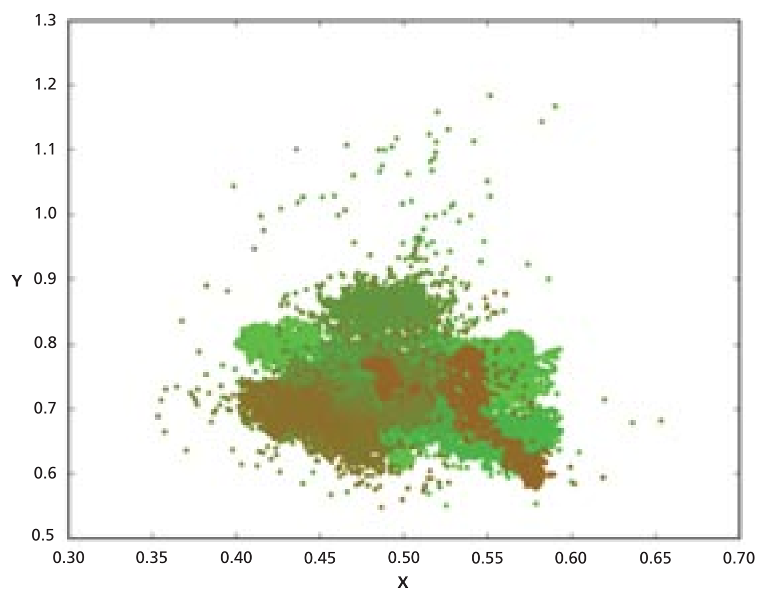
This work was done by Luke Roberson, Janine Captain, Edgardo Santiago-Maldonado, and Stanley Starr of Kennedy Space Center; and Robert DeVor of ASRC Aerospace Corporation. For more information, contact the Kennedy Space Center Innovative Partnerships Office at 321-867-5033. KSC-13351/636

Artificial Intelligence Software for Assessing Postural Stability

Lyndon B. Johnson Space Center, Houston, Texas

A software package reads and analyzes pressure distributions from sensors mounted under a person's feet. Pressure data from sensors mounted in shoes, or in a platform, can be used to provide a description of postural stability (assessing competence to deficiency) and enables the determination of the person's present activity (running, walking, squatting, falling). This package has three parts: a preprocessing algorithm for reading input from pressure sensors; a Hidden Markov Model (HMM), which is used to determine the person's present activity and level of sensing-motor competence; and a suite of graphical algorithms, which allows visual representation of the person's activity and vestibular function over time.

In this innovation, the Hidden Markov Model algorithm assesses center-of-force time series data. Using the Viterbi algorithm acting on center-of-force velocity, these trajectories can be classified into local equilibria separated by dynamic regions. These dynamic regions represent control failures and, ordinarily, lead into a new equilibrium. However, the local equilibria wander inside a broad "safe zone" of which the size and shape are able to be quantified (see figure). By quantifying the dwell time, size, and shape of the equilibria, the dynamic trajectories and the safe zone as a whole, sensing-motor performance can be assessed. For instance, equilibria for subjects with their eyes closed are shorter and more diffuse than those for subjects with eyes open.



The **"Safe Zone"**: Eighteen subjects stood for two intervals of two minutes each on an EquiTest platform. Weight distribution from left foot (0) to right foot (1) is shown on the x-axis. Center-of-force in the anterior (1)/posterior (0) direction is plotted on the y-axis, normalized by foot length. Color corresponds to individual. The safe zone is elliptical in shape, but is far larger than the region encompassed by a single equilibrium or any 2-minute standing interval.

This same algorithm can easily distinguish quiescent standing from squatting or a hand raise and may be useful in checking how well an astronaut is adjusting to changes in gravitational field strength, in the context of Earth re-entry following space travel, or a Moon or Mars mission. Also, this innovation can be used to help a physical therapist gauge the progress of a stroke patient relearning skills like standing, walking, and running. The algorithm can be used as a training tool for athletes by quantifying their daily behavior (time spent running, etc) during training.

This work was a joint effort done by Erez Lieberman, MIT and Harvard; Katharine Forth, USRA; and William Paloski, NASA Johnson Space Center. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to MSC-24387-1, volume and number of this NASA Tech Briefs *issue, and the page number.*