

targets, all of which are corner-cube retroreflectors. The targets are covered with filters that pass the 850-nm light and block the 800-nm light. The short-range targets are positioned around, and are smaller than, the long-range targets. The short-range targets are equipped with plano-concave lenses; this is necessary to make these targets visible to the camera over a range of angles at distances <1.5 m.

The operating cycle begins with the firing of the 800-nm lasers and capturing the resulting frame of video data; this frame represents a background image because the target filters block the returns from the targets at the 800-nm wavelength. Then the 850-nm lasers are

fired to capture another frame of video data; this frame represents an image that contains the target spots because target filters allow reflection at the 850-nm wavelength. Because the camera operates at a standard 30-Hz video frame rate, the time between frames is short enough to reduce motion-induced noise to an acceptably low level.

To remove the background (and thereby obtain target-image data alone), the DSP subtracts the first frame of video data from the second, and then subtracts a threshold from the resulting frame. Then the DSP processes the image data to group the illuminated pixels into spots and recognizes the targets by associating

the patterns of spots with the known target patterns. The number of targets and their positions in the assembly are designed so that the relative positions and orientations of the sensor head and the target assembly can be computed by iterative numerical solution of the equations that relate the camera/sensor-head geometry to the positions of the target spots in the video image.

This work was done by Richard T. Howard, Thomas C. Bryan, and Michael L. Book of Marshall Space Flight Center and John L. Jackson of Micro Craft, Inc. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. MFS-31283

Hybrid Piezoelectric/Fiber-Optic Sensor Sheets

Multiple sensors of different types could be installed on or in structures.

Marshall Space Flight Center, Alabama

Hybrid piezoelectric/fiber-optic (HyPFO) sensor sheets are undergoing development. They are intended for use in non-destructive evaluation and long-term monitoring of the integrity of diverse structures, including aerospace, aeronautical, automotive, and large stationary ones. It is anticipated that the further development and subsequent commercialization of the HyPFO sensor systems will lead to economic benefits in the form of increased safety, reduction of life-cycle costs through real-time structural monitoring, increased structural reliability, reduction of maintenance costs, and increased readiness for service.

The concept of a HyPFO sensor sheet is a generalization of the concept of a SMART Layer™, which is a patented device that comprises a thin dielectric film containing an embedded network of distributed piezoelectric actuator/sensors. Such a device can

be mounted on the surface of a metallic structure or embedded inside a composite-material structure during fabrication of the structure. There is has been substantial interest in incorporating sensors other than piezoelectric ones into SMART Layer™ networks: in particular, because of the popularity of the use of fiber-optic sensors for monitoring the “health” of structures in recent years, it was decided to incorporate fiber-optic sensors, giving rise to the concept of HyPFO devices.

The development of HyPFO devices has included the development of novel techniques to incorporate fiber-optic sensors into SMART Layer™ devices, as well as the development of ancillary optoelectronic hardware and software. The advantages expected to be afforded by HyPFO sensor sheets include the following:

- It would not be necessary to install each fiber-optic or piezoelectric sensor indi-

vidually on a structure. Sensors would be embedded in thin, flexible films that could easily be mounted on structures in minimal amounts of installation time.

- Because piezoelectric and fiber-optic transducers exploit different signal-transmission mechanisms, interference between piezoelectric and fiber-optic transducers is expected to be minimal.
- Multiple measurements could be performed. For example, fiber-optic sensors could be used to measure temperatures, piezoelectric transducers could be used to measure concentrations of hydrogen, and sensors of both types could be used to monitor acoustic emissions.

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Multisensor Arrays for Greater Reliability and Accuracy

Calibrations and replacements are needed less frequently than they are for single sensors.

John F. Kennedy Space Center, Florida

Arrays of multiple, nominally identical sensors with sensor-output-processing electronic hardware and software are being developed in order to obtain accuracy, reliability, and lifetime greater than those of single sensors. The conceptual basis of this development lies in the sta-

tistical behavior of multiple sensors and a multisensor-array (MSA) algorithm that exploits that behavior. In addition, advances in microelectromechanical systems (MEMS) and integrated circuits are exploited. A typical sensor unit according to this concept includes multiple MEMS

sensors and sensor-readout circuitry fabricated together on a single chip and packaged compactly with a microprocessor that performs several functions, including execution of the MSA algorithm.

In the MSA algorithm, the readings from all the sensors in an array at a given