
▶ **Guaranteeing Failsafe Operation of Extended-Scene Shack-Hartmann Wavefront Sensor Algorithm**

Fast analysis rejects frames at the first sign of unacceptable quality instead of waiting until the full analysis is complete.

NASA's Jet Propulsion Laboratory, Pasadena, California

A Shack-Hartmann sensor (SHS) is an optical instrument consisting of a lenslet array and a camera. It is widely used for wavefront sensing in optical testing and astronomical adaptive optics. The camera is placed at the focal point of the lenslet array and points at a star or any other point source. The image captured is an array of spot images. When the wavefront error at the lenslet array changes, the position of each spot measurably shifts from its original position. Determining the shifts of the spot images from their reference points shows the extent of the wavefront error.

An adaptive cross-correlation (ACC) algorithm has been developed to use scenes as well as point sources for wavefront error detection. Qualifying an extended scene image is often not an easy task due to changing conditions in scene

content, illumination level, background, Poisson noise, read-out noise, dark current, sampling format, and field of view. The proposed new technique based on ACC algorithm analyzes the effects of these conditions on the performance of the ACC algorithm and determines the viability of an extended scene image. If it is viable, then it can be used for error correction; if it is not, the image fails and will not be further processed. By potentially testing for a wide variety of conditions, the algorithm's accuracy can be virtually guaranteed.

In a typical application, the ACC algorithm finds image shifts of more than 500 Shack-Hartmann camera sub-images relative to a reference sub-image or cell when performing one wavefront sensing iteration. In the proposed new technique, a

pair of test and reference cells is selected from the same frame, preferably from two well-separated locations. The test cell is shifted by an integer number of pixels, say, for example, from $m=-5$ to 5 along the x -direction by choosing a different area on the same sub-image, and the shifts are estimated using the ACC algorithm. The same is done in the y -direction. If the resulting shift estimate errors are less than a pre-determined threshold (e.g., 0.03 pixel), the image is accepted. Otherwise, it is rejected.

This work was done by Erkin Sidick of Caltech for NASA's Jet Propulsion Laboratory.

The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-46582.

⊗ **Cloud Water Content Sensor for Sounding Balloons and Small UAVs**

Goddard Space Flight Center, Greenbelt, Maryland

A lightweight, battery-powered sensor was developed for measuring cloud water content, which is the amount of liquid or solid water present in a cloud, generally expressed as grams of water per cubic meter. This sensor has near-zero power consumption and can be flown on stan-

dard sounding balloons and small, unmanned aerial vehicles (UAVs).

The amount of solid or liquid water is important to the study of atmospheric processes and behavior. Previous sensing techniques relied on strongly heating the incoming air, which requires a major

energy input that cannot be achieved on sounding balloons or small UAVs.

This work was done by John A. Bognar of Anasphere, Inc. for Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15638-1

⊗ **Pixelized Device Control Actuators for Large Adaptive Optics**

This technology can be used in military surveillance and relay mirrors, imaging for retinal disease, reconnaissance mapping, and missile detection and targeting.

Goddard Space Flight Center, Greenbelt, Maryland

A fully integrated, compact, adaptive space optic mirror assembly has been developed, incorporating new advances in ultralight, high-performance composite mirrors. The composite mirrors use Q-switch matrix architecture-based pixelized control (PMN-PT) actuators, which achieve high-performance, large adaptive optic capability, while reduc-

ing the weight of present adaptive optic systems.

The self-contained, fully assembled, 11×11×4-in. (≈28×28×10-cm) unit integrates a very-high-performance 8-in. (≈20-cm) optic, and has 8-kHz true bandwidth. The assembled unit weighs less than 15 pounds (≈6.8 kg), including all mechanical assemblies, power elec-

tronics, control electronics, drive electronics, face sheet, wiring, and cabling. It requires just three wires to be attached (power, ground, and signal) for full-function systems integration, and uses a steel-frame and epoxied electronics. The three main innovations are:

1. Ultralightweight composite optics: A new replication method for fabrica-