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 standard 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 reducing 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 electronics, 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-

tion of very thin composite 20-cm-diameter laminate face sheets with good as-fabricated optical figure was developed. The approach is a new mandrel resin surface deposition onto previously fabricated thin composite laminates.

2. Matrix (regenerative) power topology: Waveform correction can be achieved across an entire face sheet at 6 kHz, even for large actuator counts. In practice, it was found to be better to develop a quadrant drive, that is, four quadrants of 169 actuators behind the face sheet. Each quadrant has a single, small, regenerative power supply driving all 169 actuators at 8 kHz in effective parallel.
3. Q-switch drive architecture: The Q-switch innovation is at the heart of the matrix architecture, and allows for a very fast current draw into a desired actuator element in 120 counts of a MHz clock without any actuator coupling.

This work was done by Gareth J. Knowles, Ross W. Bird, and Brian Shea of QorTek and Peter Chen of the Catholic University of America for Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15666-1

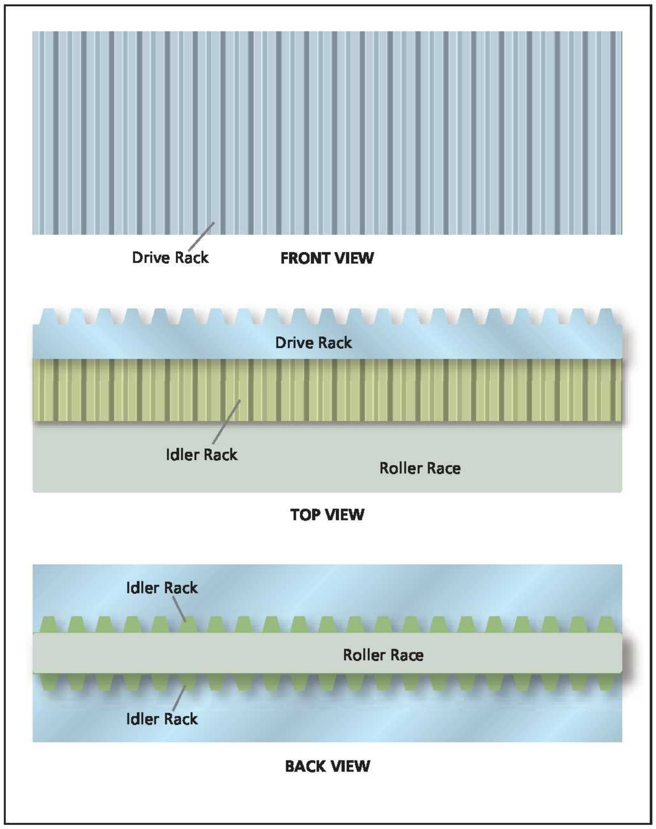
T-Slide Linear Actuators

These long-stroke linear slide actuators can hold their position with power off.

Goddard Space Flight Center, Greenbelt, Maryland

T-slide linear actuators use gear bearing differential epicyclical transmissions (GBDETs) to directly drive a linear rack, which, in turn, performs the actuation. Conventional systems use a rotary power source in conjunction with a nut and screw to provide linear motion. Non-back-drive properties of GBDET's make the new actuator more direct and simpler. Versions of this approach will serve as a long-stroke, ultra-precision, position actuator for NASA science instruments, and as a rugged, linear actuator for NASA deployment duties.

The T slide can operate effectively in the presence of side forces and torques. Versions of the actuator can perform ultra-precision positioning. A basic T-slide actuator is a long-stroke, rack-and-pinion linear actuator that, typically, consists of a T slide, several idlers, a transmission to drive the slide (powered by an electric motor) and a housing that holds the entire assembly. The actuator is driven by gear action on its top surface, and is guided and constrained by gear-bearing idlers on its other two parallel surfaces.



Front, top, and back views of the **T Slide and Idlers**. The slide is driven by gear action on its top surface and is guided by gear-bearing idlers on its other two parallel surfaces.

The geometry, implemented with gear-bearing technology, is particularly effective. An electronic motor operating through a GBDET can directly drive the T slide against large loads, as a rack and pinion linear actuator, with no break and no danger of back driving. The actuator drives the slide into position and stops. The slide holes position with power off and no brake, regardless of load. With the T-slide configuration, this GBDET has an entire T-gear surface on which to operate. The GB idlers coupling the other two T slide parallel surfaces to their housing counterpart surfaces provide constraints in five degrees-of-freedom and rolling friction in the direction of actuation. Multiple GB idlers provide roller bearing strength sufficient to support efficient, rolling friction movement, even in the presence of large, resisting forces.

T-slide actuators can be controlled using the combination of an off-the-shelf, electric servomotor, a motor angle resolution sensor (typically an encoder or resolver), and microprocessor-based intelligent software. In applications requiring precision positioning, it may be necessary to add strain gauges to the T-slide housing. Existing sensory-interactive motion control art will work for T slides. For open-loop positioning, a stepping motor emulation technique can be used.

This work was done by John Vranish of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15023-1