Imaging Interferometer Testbed at NASA's Goddard Space Flight Center.

The device is a variation of the calibrated hyperspectral image projector developed by the National Institute of Standards and Technology in Gaithersburg, MD. It uses Gooch & Housego Visible and Infrared OL490 Agile Light Sources to generate arbitrary spectra. The two light sources are coupled to a digital light processing (DLP™) digital mirror device (DMD) that serves as the spatial engine. Scenes are displayed on the DMD synchronously with desired spectrum. Scene/spectrum combinations are displayed in rapid succession, over time intervals that are short compared to the integration time of the system under test.

This work was done by Matthew Bolcar of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16422-1

Three-Axis Attitude Estimation With a High-Bandwidth Angular Rate Sensor

Commercial applications include pointing of cameras on space telescopes, spacecraft instrument payloads, moving vehicles, and surveillance from airborne platforms.

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A continuing challenge for modern instrument pointing control systems is to meet the increasingly stringent pointing performance requirements imposed by emerging advanced scientific, defense, and civilian payloads. Instruments such as adaptive optics telescopes, space interferometers, and optical communications make unprecedented demands on precision pointing capabilities. A cost-effective method was developed for increasing the pointing performance for this class of NASA applications.

The solution was to develop an attitude estimator that fuses star tracker and gyro measurements with a high-bandwidth angular rotation sensor (ARS). An ARS is a rate sensor whose bandwidth extends well beyond that of the gyro, typically up to 1,000 Hz or higher. The most promising ARS sensor technology is based on a magnetohydrodynamic concept, and has recently become available commercially. The key idea is that the sensor fusion of the star tracker, gyro, and ARS provides a high-bandwidth attitude estimate suitable for supporting pointing control with a fast-steering mirror or other type of tip/tilt correction for increased performance. The ARS is relatively inexpensive and can be bolted directly next to the gyro and star tracker on the spacecraft bus.

The high-bandwidth attitude estimator fuses an ARS sensor with a standard three-axis suite comprised of a gyro and star tracker. The estimation architecture is based on a dual-complementary filter (DCF) structure. The DCF takes a frequency-weighted combination of the sensors such that each sensor is most heavily weighted in a frequency region where it has the lowest noise.
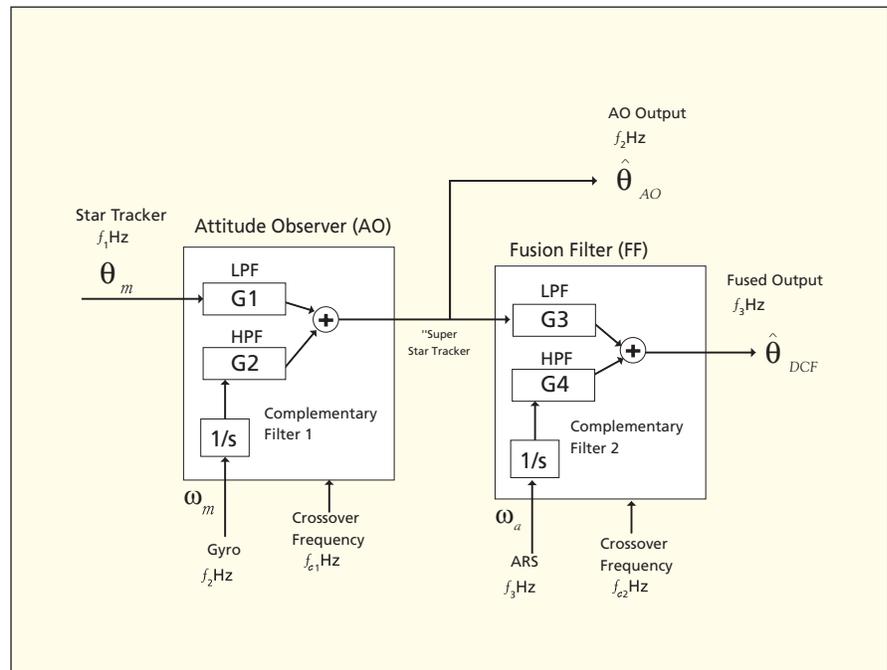
Dual Complementary Filter (DCF) architecture blends ARS with star tracker and gyro measurements to produce an accurate high-bandwidth attitude estimate. (Note: LPF and HPF are low-pass and high-pass filters, respectively.)

An important property of the DCF is that it avoids the need to model disturbance torques in the filter mechanization. This is important because the disturbance torques are generally not known in applications. This property represents an advantage over the prior art because it overcomes a weakness of the Kalman filter that arises when fusing more than one rate measurement.

An additional advantage over prior art is that, computationally, the DCF requires significantly fewer real-time calculations than a Kalman filter formulation. There are essentially two reasons for this: the DCF state is not augmented with angular rate, and measurement updates occur at the slower gyro rate instead of the faster ARS sampling rate.

Finally, the DCF has a simple and compelling architecture. The DCF is exactly equivalent to flying two identical attitude observers, one at low rate and one at high rate. These attitude observers are exactly of the form currently flown on typical three-axis spacecraft.

This work was done by David S. Bayard and Joseph J. Green of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48171