Technology Focus: Data Acquisition

Cloud Absorption Radiometer Autonomous Navigation System — CANS

The system captures navigational data in real time while keeping the sensor centered on a fixed target.

Goddard Space Flight Center, Greenbelt, Maryland

CAR (cloud absorption radiometer) acquires spatial reference data from host aircraft navigation systems. This poses various problems during CAR data reduction, including navigation data format, accuracy of position data, accuracy of airframe inertial data, and navigation data rate. Incorporating its own navigation system, which included GPS (Global Positioning System), roll axis inertia and rates, and three-axis acceleration, CANS expedites data reduction and increases the accuracy of the CAR end data product.

CANS provides a self-contained navigation system for the CAR, using inertial reference and GPS positional information. The intent of the software application was to correct the sensor with respect to aircraft roll in real time based upon inputs from a precision navigation sensor. In addition, the navigation information (including GPS position), attitude data, and sensor position details are all streamed to a remote system for recording and later analysis.

CANS comprises a commercially available inertial navigation system with integral GPS capability (Attitude Heading Reference System—AHRS) integrated into the CAR support structure and data system. The unit is attached to the bottom of the tripod support structure. The related GPS antenna is located on the P-3 radome immediately above the CAR. The AHRS unit provides a RS-232 data stream containing global position and inertial attitude and velocity data to the CAR, which is recorded concurrently with the CAR data. This independence from aircraft navigation input provides for position and inertial state data that accounts for very small changes in aircraft attitude and position, sensed at the CAR location as opposed to aircraft state sensors typically installed close to the aircraft center of gravity. More accurate positional data enables quicker CAR data reduction with better resolution.

The CANS software operates in two modes: initialization/calibration and operational. In the initialization/calibration mode, the software aligns the precision navigation sensors and initializes the communications interfaces with the sensor and the remote computing system. It also monitors the navigation data state for quality and ensures that the system maintains the required fidelity for attitude and positional information. In the operational mode, the software runs at 12.5 Hz and gathers the required navigation/attitude data, computes the required sensor correction values, and then commands the sensor to the required roll correction. In this manner, the sensor will stay very near to vertical at all times, greatly improving the resulting collected data and imagery.

CANS greatly improves quality of resulting imagery and data collected. In addition, the software component of the system outputs a concisely formatted, high-speed data stream that can be used for further science data processing. This precision, time-stamped data also can benefit other instruments on the same aircraft platform by providing extra information from the mission flight.

This work was done by Duncan Kahle of Goddard Space Flight Center, Charles Gatebe of the University of Baltimore, Bill McCune of Adaptive Aerospace, and Dustan Hellwig of Chesapeake Technology International. Further information is contained in a TSP (see page 1). GSC-16395-1

Software Method for Computed Tomography Cylinder Data Unwrapping, Re-slicing, and Analysis

Visualization of the data is possible in one view without having to rotate the volume rendering.

John H. Glenn Research Center, Cleveland, Ohio

A software method has been developed that is applicable for analyzing cylindrical and partially cylindrical objects inspected using computed tomography (CT). This method involves unwrapping and re-slicing data so that the CT data from the cylindrical object can be viewed as a series of 2D sheets (or flattened "onion skins") in addition to a series of top view slices and 3D volume rendering. The advantages of viewing the data in this fashion are as follows: (1) the use of standard and specialized image processing and analysis methods is facilitated having 2D array data versus a volume rendering; (2) accurate lateral dimensional analysis of flaws is possible in the unwrapped sheets versus volume rendering; (3) flaws in the part "jump out" at the inspector with the proper contrast expansion settings in the unwrapped sheets; and (4) it is much easier for the inspector to locate flaws in the unwrapped sheets versus top view slices for very thin cylinders. The method is fully automated and requires no input from the user except proper voxel dimension from the CT experiment and wall thickness of the part.

The software is available in 32-bit and 64-bit versions, and can be used with binary data (8- and 16-bit) and BMP type CT image sets. The software has memory (RAM) and hard-drive based modes. The advantage of the (64-bit) RAM-based mode is speed (and is very practical for users of 64-bit Windows operating systems and computers having 16 GB or more RAM). The advantage of the hard-drive-based analysis is one can work with essentially unlimited-sized data sets.

Separate windows are spawned for the unwrapped/re-sliced data view and any image processing interactive capability. Individual unwrapped images and unwrapped image series can be saved in common image formats.

More information is available at http://www.grc.nasa.gov/WWW/OptInstr/NDE_CT_CylinderUnwrapper.html.

This work was done by Don J. Roth of Glenn Research Center. Further information is contained in a TSP *(see page 1)*.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18808-1.

Discrete Data Qualification System and Method Comprising Noise Series Fault Detection

Noise fault detector detects an unreasonably high or low variance or standard deviation.

John H. Glenn Research Center, Cleveland, Ohio

A Sensor Data Qualification (SDQ) function has been developed that allows the onboard flight computers on NASA's launch vehicles to determine the validity of sensor data to ensure that critical safety and operational decisions are not based on faulty sensor data. This SDQ function includes a novel noise series fault detection algorithm for qualification of the output data from LO_2 and LH_2 low-level liquid sensors. These sensors are positioned in a launch vehicle's propellant tanks in order to detect propellant depletion during a rocket engine's boost operating phase. This detection capability can prevent the catastrophic situation where the engine operates without propellant. The output from each LO_2 and LH_2 low-level liquid sensor is a discrete valued signal that is expected to be in either of two states, depending on whether the sensor is immersed (wet) or exposed (dry). Conventional methods for sensor data qualification, such as threshold limit checking, are not effective for this type of signal due to its discrete binary-state nature.

To address this data qualification challenge, a noise computation and evaluation method, also known as a noise fault detector, was developed to detect unreasonable statistical characteristics in the discrete data stream. The method operates on a time series of discrete data observations over a moving window of data points and performs a continuous examination of the resulting observation stream to identify the presence of anomalous characteristics. If the method determines the existence of anomalous results, the data from the sensor is disqualified for use by other monitoring or control functions.

This work was done by Christopher Fulton, Edmond Wong, and Kevin Melcher of Glenn Research Center; and Randall Bickford of Expert Microsystems, Inc. For more information, contact kimberly.a.dalgleish@nasa.gov.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18694-1.

Simple Laser Communications Terminal for Downlink From Earth Orbit at Rates Exceeding 10 Gb/s

Implementation of this technology will surpass the spectrum-allocation and bandwidth limitations of current RF systems.

NASA's Jet Propulsion Laboratory, Pasadena, California

A compact, low-cost laser communications transceiver was prototyped for downlinking data at 10 Gb/s from Earth-orbiting spacecraft. The design can be implemented using flight-grade parts. With emphasis on simplicity, compactness, and light weight of the flight transceiver, the reduced-complexity design and development approach involves:

1. A high-bandwidth coarse wavelength division multiplexed (CWDM) (4×2.5 or 10-Gb/s data-rate) downlink transmitter. To simplify the system, emphasis is on the downlink. Optical uplink data rate is modest (due to existing and adequate RF uplink capability).
2. Highly simplified and compact 5-cm-diameter clear aperture optics assembly is configured to single transmit and receive aperture laser signals. About 2 W of 4-channel multiplexed (1,540 to 1,555 nm) optically amplified laser power is coupled to the optical assembly through a fiber optic cable. It contains a highly compact, precision-pointing capability two-axis gimbal assembly to coarse point the optics assembly. A fast steering mirror, built into the optical path of the optical assembly, is used to remove residual pointing disturbances from the gimbal. Acquisition, pointing, and tracking are assisted by a beacon laser transmitted from the ground and received by the optical assembly, which will allow transmission of a laser beam.
3. Shifting the link burden to the ground by relying on direct detection optical receivers retrofitted to 1-m-diameter ground telescopes.
4. Favored mass and volume reduction over power-consumption reduction. The two major variables that are avail-