Phase Sensor for Aligning a Segmented Telescope Mirror

Alignment can be maintained even in the presence of atmospheric turbulence.

Marshall Space Flight Center, Alabama

A phase sensor has been developed for use in aligning a segmented telescope mirror to within a fraction of a wavelength in piston. (As used here, "piston" signifies displacement of a mirror segment along the optical axis of the telescope.) Such precise alignment is necessary in order to realize the full benefit of the large aperture achievable through segmentation.

This phase sensor is achromatic. It is based on two-wavelength shearing interferometry, and can be modified to utilize an extended or broad-band (e.g., white) light source. The sensor optics include a ruled diffraction grating and an imaging lens.

The sensor can measure the piston shift between segments as well as aberrations of the segments. It can measure the surface error of an individual segment, making it possible to compensate for the error with optimal amount(s) of piston and/or tilt. The precise capture range of the sensor depends partly on the telescope design; the largest relative piston shifts measurable by use of this sensor are of the order of 100 μm. The accuracy of the sensor also depends partly on the telescope design; in general, the accuracy is sufficient to enable alignment to within approximately half a wavelength. The interferometric image is digitized and processed by a simple algorithm in real time, and the output of the algorithm can be used to maintain alignment in real time, even in the presence of atmospheric turbulence.

The sensor is robust. Through calibration, it can be made insensitive to (and, hence, tolerant of) misalignments and aberrations of its own optics, most aberrations of the telescope as a whole (in contradistinction to aberrations of individual segments), and most aberrations introduced by atmospheric turbulence.

This work was done by H. Philip Stahl of **Marshall Space Flight Center** *and Chanda Bartlett Walker of Pace & Waite, Inc. Further information is contained in a TSP (see page 1).*

This invention is owned by NASA, and a patent application has been filed. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-31852-1.

Control Software for Advanced Video Guidance Sensor

Marshall Space Flight Center, Alabama

Embedded software has been developed specifically for controlling an Advanced Video Guidance Sensor (AVGS). [As described in several previous *NASA Tech Briefs* articles, a Video Guidance Sensor is an optoelectronic system that provides guidance for automated docking of two vehicles (spacecraft in the original intended application). Such a system includes pulsed laser diodes and a video camera, the output of which is digitized. From the positions of digitized target images and known geometric relationships, the relative position and orientation of the vehicles are computed.] The present software consists of two subprograms running in two processors that are parts of the AVGS. The subprogram in the first processor receives commands from an external source, checks the commands for correctness, performs commanded non-image-data-processing control functions, and sends image-data-processing parts of commands to the second processor. The subprogram in the second processor processes image data as commanded. Upon power-up, the software performs basic tests of functionality, then effects a transition to a standby mode. When a command is received, the software goes into one of several operational modes (e.g. acquisition or tracking). The software then returns, to the external source, the data appropriate to the command.

This program was written by Richard T. Howard, Michael L. Book, and Thomas C. Bryan of **Marshall Space Flight Center**. *Further information is contained in a TSP (see page 1).*

This invention has been patented by NASA (U.S. Patent No. 6,888,476). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-31865-1.

Generating Control Commands From Gestures Sensed by EMG

Electrical signals from muscles involved in gestures are recognized.

Ames Research Center, Moffett Field, California

An effort is under way to develop noninvasive neuro-electric interfaces through which human operators could control systems as diverse as simple mechanical devices, computers, aircraft, and even spacecraft. The basic idea is to use electrodes on the surface of the skin to acquire electromyographic (EMG) signals associated with gestures, digitize and process the EMG signals to recognize the gestures, and generate digital commands to perform the actions signified by the gestures.

In an experimental prototype of such an interface, the EMG signals associated with hand gestures are acquired by use of several pairs of electrodes mounted in sleeves on a subject's forearm (see figure). The EMG signals are sampled and digitized. The resulting time-series data are fed as input to pattern-recognition software that has been trained to distinguish gestures from a given gesture set. The software implements, among other things, hidden Markov models, which are used to recognize the gestures as they are being performed in real time.

Electrodes on a Subject's Forearm were used to acquire EMG signals in experiments on synthesizing joystick attitude controls for simulated airplane flight and synthesizing typing on a numerical keypad.

Thus far, two experiments have been performed on the prototype interface to demonstrate feasibility: an experiment in synthesizing the output of a joystick and an experiment in synthesizing the output of a computer or typewriter keyboard. In the joystick experiment, the EMG signals were processed into joystick commands for a realistic flight simulator for an airplane. The acting pilot reached out into the air, grabbed an imaginary joystick, and pretended to manipulate the joystick to achieve left and right banks and up and down pitches of the simulated airplane. In the keyboard experiment, the subject pretended to type on a numerical keypad, and the EMG signals were processed into keystrokes.

The results of the experiments demonstrate the basic feasibility of this method while indicating the need for further research to reduce the incidence of errors (including confusion among gestures). Topics that must be addressed include the numbers and arrangements of electrodes needed to acquire sufficient data; refinements in the acquisition, filtering, and digitization of EMG signals; and methods of training the pattern-recognition software.

The joystick and keyboard simulations were chosen for the initial experiments because they are familiar to many computer users. It is anticipated that, ultimately, interfaces would utilize EMG signals associated with movements more nearly natural than those associated with joysticks or keyboards. Future versions of the pattern-recognition software are planned to be capable of adapting to the preferences and day-to-day variations in EMG outputs of individual users; this capability for adaptation would also make it possible to select gestures that, to a given user, feel the most nearly natural for generating control signals for a given task (provided that there are enough properly positioned electrodes to acquire the EMG signals from the muscles involved in the gestures).

This work was done by Kevin R. Wheeler and Charles Jorgensen of **Ames Research Center**. *Further information is contained in a TSP (see page 1).*

This invention has been patented by NASA (U.S. Patent No. 6,720,984). Inquiries concerning rights for the commercial use of this invention should be addressed to the Ames Technology Partnerships Division at (650) 604-2954. Refer to ARC-14494-1.