Concerns that were addressed during the presentation: Is there a time penalty? No operational time delay is incurred with lower accelerations used. Is radial center of gravity offset a problem? Not unless it is significantly outside the CTV diameter.

59-74
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p. 2

Optical Correlators for Automated Rendezvous and Capture

by Richard D. Juday, NASA JSC

The paper begins with a description of optical correlation. In this process, the propagation physics of coherent light are used to process images and extract information. The processed image is operated on as an area, rather than as a collection of points. An essentially instantaneous convolution is performed on that image to provide the sensory data. In this process, an image is sensed and encoded onto a coherent wavefront, and the propagation is arranged to create a bright spot of the image to match a model of the desired object. The brightness of the spot provides an indication of the degree of resemblance of the viewed image to the mode, and the location of the bright spot provides pointing information.

The process can be utilized for AR&C to achieve the capability to identify objects among known reference types, estimate the object's location and orientation and interact with the control system. System characteristics (speed, robustness, accuracy, small form factors) are adequate to meet most requirements. The correlator exploits the fact that Bosons and Fermions pass through each other. Since the image source is input as an electronic data set, conventional imagers can be used. In systems where the image is input directly, the correlating element must be at the sensing location.

Active programs in the development of this technology are already in place within NASA (JSC, JPL, ARC), the military, industry and academia. These programs have developed systems that are essentially ready to be flown in space. The two major elements may be characterized as algorithms/architectures and modulators. Numerous correlator architectures and the associated algorithms already exist and are available in original or modified form. Modulators, while in existence, are not as technologically advanced as the algorithms and architectures. Numerous small business proposals are under consideration to further this technology.

The Johnson Space Center is involved in all aspects of the AR&D activity, including the software and hardware developments. Algorithms such as "Backscratch," estimation filters, pattern recognition, and correlator architectures either are under development or are under influence of JSC personnel. Digital image processors and Spatial Light Modulators are examples of hardware currently being developed under JSC cognizance. According to the author, JSC is at the forefront of Fourier optics pattern recognition.

Some work has been done to estimate the funding required to qualify the hardware to a space environment and to build a flight system. One benefit which may accrue to the program is the ability to piggyback the flight qualification on an ongoing DARPA program. The DARPA correlator will be ready for ground testing in the Fall of 1993. It is estimated that space qualifiable hardware could be available a year later.

At this time, technological challenges are in the areas of developing Spatial Light Modulators to control light, continuing to develop software of filters and noise rejection capability, and improving sensitivity to scale and rotation. Emphasis should be placed on development of the modulators, since the algorithm and architecture development is ahead at this time.

Concerns/questions that arose at the end of the presentation: Existing DARPA program will take hardware through qualification and field testing at levels similar to and often exceeding space needs. What is the range accuracy? Two (2) percent of the range. Can tilt and roll could be determined? Yes, it can, using the Synthetic Estimation Filter.

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Office of Spaceflight Standard Spaceborne Global Positioning System (GPS) User Equipment Project

by Penny E. Saunders, NASA, JSC

P. 1

The Global Positioning System (GPS) provides: 1) position and velocity determination to support vehicle GN&C, precise orbit determination and payload pointing; 2) time reference to support onboard timing systems and data time tagging; 3) relative position and velocity determination to support cooperative vehicle tracking; and 4) attitude determination to support vehicle attitude control and payload pointing.

The expected GPS performance depends on system implementation, hardware design, software design, and GPS service. The standard spaceborne GPS user equipment project was begun by JSC to identify the benefits of a standard GPS receiver development for the STS, SSF, and ACRV and the potential benefits to other NASA programs. The Office of Space Flight then recommended the collection of NASA-wide GPS requirements and preparation of a project plan including cost and schedule estimates. A common GPS system can reduce development, maintenance, and logistics costs.

There are two services provided by GPS, standard and precise. Some commercial applications have achieved centimeter level accuracy using GPS. However, commercial off-the-shelf systems cannot handle the high velocities and Doppler shift. Nevertheless, ACRV, CTV, SSF, and STS can use militarized systems that use Coarse Acquisition, the standard service.

A task team of representatives from JSC, MSFC, GSFC, and JPL was formed to develop a Standard Spaceborne GPS Receiver. The design approach is to maximize the use of available hardware and software, minimize user program integration cost, and provide upgrade options for unique requirements and anticipated future requirements. The design also should reflect: a modularized approach in receiver architecture for incorporation of user-unique requirements, addition of NASA unique command, control and data interfaces, and modified software to accommodate vehicle dynamics; addition of NASA's safety, reliability, and quality standards; and addition of radiation protection.

The project consists of three phases: the definition phase, development phase, and production phase. The definition phase should be completed in September of 1993, the development phase completed in December of 1995, and the production phase starting in January of 1996 and continuing until completion of the last flight unit that is needed.

The GPS application to AR&C consists of placement on both the chaser vehicle and the target vehicle. It includes a communication link between the vehicles so that relative position data can be determined. The expected performance depends on: (1) number of common satellites; (2) receiver measurement accuracy and measurement types; (3) relative state processing algorithms, (4) receiver/processor commonality; and (5) type of GPS service used.

In summary, standard GPS User Equipment development ensures commonality and coordination between user programs, thus providing overall NASA cost reduction and improvement in relative tracking capability. The cost reduction is due to the one-time versus multiple nonrecurring engineering efforts, quantity purchases of flight units, and consolidated engineering supporting development, logistics, operations, and maintenance. The use of a common hardware and software design results in the improvement in relative tracking capability and also improves accuracy and simplifies interfaces.