Software

Analyzing Dynamics of Cooperating Spacecraft

A software library has been developed to enable high-fidelity computational simulation of the dynamics of multiple spacecraft distributed over a region of outer space and acting with a common purpose. All of the modeling capabilities afforded by this software are available independently in other, separate software systems, but have not previously been brought together in a single system. A user can choose among several dynamical models, many high-fidelity environment models, and several numerical-integration schemes. The user can select whether to use models that assume weak coupling between spacecraft, or strong coupling in the case of feedback control or tethering of spacecraft to each other. For weak coupling, spacecraft orbits are propagated independently, and are synchronized in time by controlling the step size of the integration. For strong coupling, the orbits are integrated simultaneously. Among the integration schemes that the user can choose are Runge-Kutta Verner, Prince-Dormand, Adams-Bashforth-Moulton, and Bulirsh-Stoer. Comparisons of performance are included for both the weak- and strong-coupling dynamical models for all of the numerical integrators. The library was designed for ease of integration with high-fidelity environment models already in use in the Flight Dynamics Analysis Branch, which is one of seven institutional support branches within the Mission Engineering and Systems Analysis Division at Goddard Space Flight Center.

This program was written by Stephen P. Hughes and David C. Folta of **Goddard Space Flight Center** *and Darrel J. Conway of Thinking Systems, Inc. Further information is contained in a TSP (see page 1).*
GSC-14735-1

Spacecraft Attitude Maneuver Planning Using Genetic Algorithms

A key enabling technology that leads to greater spacecraft autonomy is the capability to autonomously and optimally slew the spacecraft from and to different attitudes while operating under a number of celestial and dynamic constraints. The task of finding an attitude trajectory that meets all the constraints is a formidable one, in particular for orbiting or fly-by spacecraft where the constraints and initial and final conditions are of time-varying nature. This approach for attitude path planning makes full use of *a priori* constraint knowledge and is computationally tractable enough to be executed onboard a spacecraft. The approach is based on incorporating the constraints into a cost function and using a Genetic Algorithm to iteratively search for and optimize the solution. This results in a directed random search that explores a large part of the solution space while maintaining the knowledge of good solutions from iteration to iteration. A solution obtained this way may be used 'as is' or as an initial solution to initialize additional deterministic optimization algorithms. A number of representative case examples for time-fixed and time-varying conditions yielded search times that are typically on the order of minutes, thus demonstrating the viability of this method. This approach is applicable to all deep space and planet Earth missions requiring greater spacecraft autonomy, and greatly facilitates navigation and science observation planning.

This work was done by Richard P. Kornfeld of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-40107.

Forensic Analysis of Compromised Computers

Directory Tree Analysis File Generator is a Practical Extraction and Reporting Language (PERL) script that simplifies and automates the collection of information for forensic analysis of compromised computer systems. During such an analysis, it is sometimes necessary to collect and analyze information about files on a specific directory tree. Directory Tree Analysis File Generator collects information of this type (except information about directories) and writes it to a text file. In particular, the script asks the user for the root of the directory tree to be processed, the name of the output file, and the number of subtree levels to process. The script then processes the directory tree and puts out the aforementioned text file. The format of the text file is designed to enable the submission of the file as input to a spreadsheet program, wherein the forensic analysis is performed. The analysis usually consists of sorting files and examination of such characteristics of files as ownership, time of creation, and time of most recent access, all of which characteristics are among the data included in the text file.

This program was written by Thomas Wolfe of Caltech for **NASA's Jet Propulsion Laboratory**. *Further information is contained in a TSP (see page 1).*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-40165.

Document Concurrence System

The Document Concurrence System is a combination of software modules for routing users expressions of concurrence with documents. This system enables determination of the current status of concurrences and eliminates the need for the prior practice of manually delivering paper documents to all persons whose approvals were required. This system runs on a server, and participants gain access via personal computers equipped with Web-browser and electronic-mail software. A user can begin a concurrence routing process by logging onto an administration module, naming the approvers and stating the sequence for routing among them, and attaching documents. The server then sends a message to the first person on the list. Upon concurrence by the first person, the system sends a message to the second person, and so forth. A person on the list indicates approval, places the documents on hold, or indicates disapproval, via a Web-based module. When the last person on the list has concurred, a message is sent to the initiator, who can then finalize the process through the administration module. A background process running on the server identifies concurrence processes that are overdue and sends reminders to the appropriate persons.

This program was written by Mansour Muhsin and Ian Walters of Lockheed Martin Corp. for **Stennis Space Center**.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Intellectual Property Manager, Stennis Space Center, (228) 688-1929. Refer to SSC-00179.

Managing an Archive of Images

The SSC Multimedia Archive is an automated electronic system to manage images, acquired both by film and digital cameras, for the Public Affairs Office (PAO) at Stennis Space Center (SSC). Previously, the image archive was based on film photography and utilized a manual system that, by today's standards, had become inefficient and expensive. Now, the SSC Multimedia Archive, based on a server at SSC, contains both catalogs and images for pictures taken both digitally and with a traditional, film-based camera, along with metadata about each image. After a "shoot," a photographer downloads the images into the database. Members of the PAO can use a Web-based application to search, view and retrieve images, approve images for publication, and view and edit metadata associated with the images. Approved images are archived and cross-referenced with appropriate descriptions and information. Security is provided by allowing administrators to explicitly grant access privileges to personnel to only access components of the system that they need to (i.e., allow only photographers to upload images, only PAO designated employees may approve images).

This work was done by Vince Andres and David Walter of **Stennis Space Center** *and Charles Hallal, Helene Jones, and Chris Callac of Lockheed Martin Corp.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Intellectual Property Manager, Stennis Space Center, (228) 688-1929. Refer to SSC-00185.

MPT Prediction of Aircraft-Engine Fan Noise

A collection of computer programs has been developed that implements a procedure for predicting multiple-pure-tone (MPT) noise generated by fan blades of an aircraft engine (e.g., a turbofan engine). MPT noise arises when the fan is operating with supersonic relative tip Mach No. Under this flow condition, there is a strong upstream running shock. The strength and position of this shock are very sensitive to blade geometry variations. For a fan where all the blades are identical, the primary tone observed upstream of the fan will be the blade passing frequency. If there are small variations in geometry between blades, then tones below the blade passing frequency arise — MPTs. Stagger angle differences as small as 0.1° can give rise to significant MPT. It is also noted that MPT noise is more pronounced when the fan is operating in an "unstarted" mode. Computational results using a three-dimensional flow solver to compute the complete annulus flow with non-uniform fans indicate that MPT noise can be estimated in a relatively simple way. Hence, once the effect of a typical geometry variation of one blade in an otherwise uniform blade row is known, the effect of all the blades being different can be quickly computed via superposition. Two computer programs that were developed as part of this work are used in conjunction with a user's computational fluid dynamics (CFD) code to predict MPT spectra for a fan with a specified set of geometric variations:

- The first program ROTBLD reads the users CFD solution files for a single blade passage via an API (Application Program Interface). There are options to replicate and perturb the geometry with typical variations stagger, camber, thickness, and pitch. The multi-passage CFD solution files are then written in the user's file format using the API.
- The second program SUPERPOSE requires two input files: the first is the circumferential upstream pressure distribution extracted from the CFD solution on the multi-passage mesh, the second file defines the geometry variations of each blade in a complete fan. Superposition is used to predict the spectra resulting from the geometric variations.

The user would typically generate a multi-passage mesh (ROTBLD) with the geometry of one blade perturbed — typically, four or five passages are required. A CFD solution would then be generated for this mesh. Using this solution and specified geometry variations for a complete fan, the MPT spectra can be estimated using SUPERPOSE.

These programs were written by Stuart D. Connell of General Electric Corp. for **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, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, OH 44135. Refer to LEW-17386.

Improving Control of Two Motor Controllers

A computer program controls motors that drive translation stages in a metrology system that consists of a pair of two-axis cathetometers. This program is specific to Compumotor Gemini (or equivalent) motors and the Compumotor 6K-series (or equivalent) motor controller. Relative to the software supplied with the controller, this program affords more capabilities and is easier to use. Written as a Virtual Instrument in the LabVIEW software system, the program presents an imitation control panel that the user can manipulate by use of a keyboard and mouse. There are three modes of operation: command, movement, and joystick. In command mode, single commands are sent to the controller for troubleshooting. In movement mode, distance, speed, and/or acceleration commands are sent to the controller. Position readouts from the motors and from position encoders on the translation stages are displayed in marked fields. At any time, the position readouts can be recorded in a file named by the user. In joystick mode, the program yields control of the motors to a joystick. The program sends commands to, and receives data from, the controller via a serial cable connection, using the serial-communication portion of the software supplied with the controller.

This program was written by Ronald W. Toland of **Goddard Space Flight Center**. *Further information is contained in a TSP (see page 1).*
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