Books & Reports

Smart Data Node in the Sky

A document discusses the physical and engineering principles affecting the design of the Smart Data Node in the Sky (SDNITS) — a proposed Earth-orbiting satellite for relaying scientific data from other Earth-orbiting satellites to one or more ground station(s). The basic concept of the SDNITS is similar to that of NASA's Tracking Data Relay Satellite System (TDRSS). However, the SDNITS would satisfy the needs of the next generation of Earth-observing satellite missions, including, notably, the need to relay data at much higher rates — of the order of 10 Gb/s versus ≤400 Mb/s for the TDRSS.

The document characterizes the problem of designing the telecommunication architecture of the SDNITS as consisting of two main parts: (1) finding the most advantageous orbit for the SDNITS to gather data from the scientific satellites and relay the data to the ground, taking account of such factors as visibility and range; and (2) choosing a telecommunication architecture appropriate for the intended relay function. The design of the SDNITS would incorporate technological advances — especially in the field of high-rate data transmission — that have occurred during the three decades since the TDRSS was designed.

This work was done by Faiza Lansing and Anil Kantak of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).
NPO-30904

Pseudo-Waypoint Guidance for Proximity Spacecraft Maneuvers

A paper describes algorithms for guidance and control (G&C) of a spacecraft maneuvering near a planet, moon, asteroid, comet, or other small astronomical body. The algorithms were developed following a model-predictive-control approach along with a convexification of the governing dynamical equations, control constraints, and trajectory and state constraints. The open-loop guidance problem is solved in advance or in real time by use of the pseudo-waypoint generation (PWG) method, which is a blend of classical waypoint and state-of-the-art, real-time trajectory-generation methods. The PWG method includes satisfaction of required thruster silent times during maneuvers. Feedback control is implemented to track PWG trajectories in a manner that guarantees the resolvability of the open-loop-control problem, enabling updating of G&C in a provably robust, model-predictive manner. Thruster firing times and models of the gravitational field of the body are incorporated into discretized versions of the dynamical equations that are solved as part of an optimal-control problem to minimize consumption of fuel or energy. The optimal-control problem is cast as a linear matrix inequality (specifically a second-order cone program), then solved through semidefinite-programming techniques in a computationally efficient manner that guarantees convergence and satisfaction of constraints.

This work was done by Ahmet Açikmeşe and John M. Carson III of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-42753.

Update on Controlling Herds of Cooperative Robots

A document presents further information on the subject matter of "Controlling Herds of Cooperative Robots" (NPO-40723), *NASA Tech Briefs*, Vol. 30, No. 4 (April 2006), page 81. To recapitulate: A methodology for controlling a herd of cooperative and autonomous mobile robots exploring the surface of a remote planet or moon (specifically, Titan or Titan-like) is undergoing development. The proposed configuration of mobile robots consists of a blimp and a herd of surface sondes. The blimp is the leader of the herd, and it commands the other robots to move to locations on the surface or below the surface to conduct science operations. Once a target is chosen, the sondes cooperatively aim sensors at the target to maximize scientific return. This hierarchical and cooperative behavior is necessary in the face of such unpredictable factors as terrain obstacles and uncertainties in the model of the environment.

This document describes the cooperation architecture and the estimation algorithm. Dynamical and kinematical models of the blimp and surface sondes are derived, and a robust guidance and control algorithm, based on a potential-field mathematical model, is developed. This guidance-and-control algorithm can compute actuator forces needed for moving the surface sondes across the terrain while avoiding hazards and collisions with each other and at the same time remaining within communication range with the blimp.

The document describes the results of the computational simulations of a one-blimp, three-surface-sonde herd in various operational scenarios, including sensitivity studies as a function of distributed communication and processing delays between the sondes and the blimp. From results of the simulations, it is concluded that the methodology is feasible, even if there are significant uncertainties in the dynamical models.

This work was done by Marco Quadrelli and Johnny Chang of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-35031.

Simulation and Testing of Maneuvering of a Planetary Rover

A report discusses the development of a computational model of a Mars Explorer Rover maneuvering across terrain under varying conditions. The model is used to increase understanding of the rover dynamics. Increased understanding is helpful in planning further tests and in extending the operational range of the rover to terrain conditions that would otherwise have to be avoided in a conservative approach. The model is implemented within MSC.ADAMS®, a commercial suite of computer programs for simulating a variety of automotive and aeronautical mechanical systems. Following its initial formulation, the model has been successively refined in an iterative process of simulation, testing on simulated terrain, correlation of simulation results with test results, and adjustment of model parameters to increase degrees of matching between simulation and test results. In particular, three aspects of the model have been refined, as follows:

- Wheel radius, which was set to cancel effects of cleats, and of compliance and roughness of the ground surface;
- A submodel of friction between the wheels and a high-friction mat used in the tests; and
- A submodel of internal and external power losses that includes no-load power consumed by wheel mechanisms and nominal rolling resistance.

This work was done by Gary Ortiz and Randel Lindemann of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

The software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-42547.