Software

Simulation of Attitude and Trajectory Dynamics and Control of Multiple Spacecraft

Goddard Space Flight Center, Greenbelt, Maryland

Agora software is a simulation of spacecraft attitude and orbit dynamics. It supports spacecraft models composed of multiple rigid bodies or flexible structural models. Agora simulates multiple spacecraft simultaneously, supporting rendezvous, proximity operations, and precision formation flying studies. The Agora environment includes ephemerides for all planets and major moons in the solar system, supporting design studies for deep space as well as geocentric missions. The environment also contains standard models for gravity, atmospheric density, and magnetic fields. Disturbance force and torque models include aerodynamic, gravity-gradient, solar radiation pressure, and "third-body" gravitation. In addition to the dynamic and environmental models, Agora supports geometrical visualization through an OpenGL interface.

Prototype models are provided for common sensors, actuators, and control laws. A clean interface accommodates linking in actual flight code in place of the prototype control laws. The same simulation may be used for rapid feasibility studies, and then used for flight software validation as the design matures.

Agora is open-source and portable across computing platforms, making it customizable and extensible. It is written to support the entire GNC (guidance, navigation, and control) design cycle, from rapid prototyping and design analysis, to high-fidelity flight code verification.

As a top-down design, Agora is intended to accommodate a large range of missions, anywhere in the solar system. Both "two-body" and "three-body" flight regimes are supported, as well as seamless transition between them. Multiple spacecraft may be simultaneously simulated, enabling simulation of rendezvous scenarios, as well as formation flying. Built-in reference frames and orbit perturbation dynamics provide accurate modeling of precision formation control.

This work was done by Eric T. Stoneking of Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15737-1

Integrated Modeling of Spacecraft Touch-And-Go Sampling

NASA's Jet Propulsion Laboratory, Pasadena, California

An integrated modeling tool has been developed to include multi-body dynamics, orbital dynamics, and touch-and-go dynamics for spacecraft covering three types of end-effectors: a sticky pad, a brush-wheel sampler, and a pellet gun.

Several multi-body models of a free-flying spacecraft with a multi-link manipulator driving these end-effectors have been tested with typical contact conditions arising when the manipulator arm is to sample the surface of an asteroidal body. The test data have been infused directly into the dynamics formulation including such information as the mass collected as a function of end-effector longitudinal speed for the brush-wheel and sticky-pad samplers, and the mass collected as a function of projectile speed for the pellet gun sampler. These data represent the realistic behavior of the end effector while in contact with a surface, and represent a low-order model of more complex contact conditions that otherwise would have to be simulated. Numerical results demonstrate the adequacy of these multibody models for spacecraft and manipulator-arm control design.

The work contributes to the development of a touch-and-go testbed for small-body exploration, denoted as the GREX Testbed (GN&C for Rendezvous-based EXploration). The GREX testbed addresses the key issues involved in landing on an asteroidal body or comet; namely, a complex, low-gravity field; partially known terrain properties; possible comet outgassing; dust ejection; and navigating to a safe and scientifically desirable zone.

This program was written by Marco Quadrelli of Caltech for NASA's Jet Propulsion Laboratory.

This software is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (626) 395-2322. Refer to NPO-44371.

Spacecraft Station-Keeping Trajectory and Mission Design Tools

NASA's Jet Propulsion Laboratory, Pasadena, California

Two tools were developed for designing station-keeping trajectories and estimating delta-v requirements for designing missions to a small body such as a comet or asteroid. This innovation uses NPOPT, a non-sparse, general-purpose sequential quadratic programming (SQP) optimizer and the Two-Level Differential Corrector (T-LDC) in LTool (Libration point mission design Tool) to design three kinds of station-keeping scripts: vertical hovering, horizontal hovering, and orbiting.

The T-LDC is used to differentially correct several trajectory legs that join hovering points. In a vertical hovering, the maximum and minimum range points must be connected smoothly while maintaining the spacecraft's range from a