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DEVELOPMENT OF PRECISION POINTING CONTROLLERS WITH AND WITHOUT VIBRATION SUPPRESSION FOR THE NPS PRECISION POINTING HEXAPOD

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Satellite optical payloads demand better vibration control and finer precision pointing than ever before. Fortunately, the Stewart-Gough platform offers the potential of accomplishing both of these simultaneously.

Using the Precision Pointing Hexapod at NPS (a Stewart-Gough platform), several controllers for precision pointing, with and without vibration disturbances, were developed. Unlike the traditional means of pointing a hexapod, (i.e. sensing and controlling strut length to orient payload), this research used the payload orientation derived from payload mounted position sensors to determine orientation and provide feedback to the actuator controller. Small and large angle controllers were developed and evaluated for accuracy using static pointing and dynamic tracking tasks. The pointing controllers were then added to an Adaptive Disturbance Canceller and evaluated for pointing accuracy and vibration suppression performance given a single tone disturbance.

The results showed a static pointing accuracy of ±0.008° and a dynamic pointing accuracy ranging from ±0.05° to ±0.2°, depending on the size and speed of the circular trajectory. Vibration suppression down to the noise floor was achieved in all static orientations tested. As for dynamic circle-tracking performance, at least a 20 dB reduction in the fundamental disturbance was obtained without degradation in pointing accuracy.

KEYWORDS: Precision Pointing, Hexapod, Steward Platform, Vibration Suppression, Adaptive Disturbance Canceller

DESIGN OF OPTIMAL CYCLERS USING SOLAR SAILS

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Ongoing interest in establishing a base on Mars has spurred a need for regular and repeated visits to the red planet using a cycling shuttle to transport supplies, equipment and to retrieve surface samples. This thesis presents an approach to designing an optimal heliocentric cycling orbit, or cycler, using solar sails. Results show that solar sails can be used to significantly reduce V_∞s at Mars and Earth. For example, using a reasonably high performance solar sail, a $V_\infty|_{Mars} = 2.5$ km/s is possible at every synodic period using a two-dimensional orbit model. Lower performance sails were also modeled resulting in paths that behaved more like a ballistic Aldrin cycler with higher V_∞s. Double rendezvous missions were explored where the spacecraft must match the velocities of both Earth and Mars, offering promising trajectories for Mars sample return missions. The solutions to these missions, although not necessarily cyclers, show that using a sail to rendezvous with and remain near Mars for an optimal amount of time will minimize the total

transit time between Earth and Mars. General-purpose dynamic optimization software, DIDO, is used to solve the optimal control problem using a pseudospectral method using both two- and three-dimensional elliptic orbit models.

KEYWORDS: Cycler Trajectory, Solar Sail, Optimal Design, DIDO, Mars Mission, Trajectory Design, Cycling Orbits

AN IMPROVED ALGEBRAIC GRID GENERATOR FOR NUMERICAL AERODYNAMIC ANALYSES OF AIRFOIL CROSS-SECTIONS

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Although computer-processing power has increased dramatically over the past few decades, minimizing computation time is still critical when conducting numerical aerodynamic analyses. One area where this is evident is the grid generation routines used in most code for this area of research. While many more sophisticated grid generation techniques are available, algebraic grid generation is still in use today due strictly to efficiency. Computational efficiency is of particularly great concern during analyses that involve motion of the surface being analyzed, since computing a new grid at each time step is often required. Unfortunately however, few if any, algebraic grid generation routines exist that are powerful enough to produce a grid with no overlapping gridlines and minimal distortion, yet still minimize computation time. As a result, the purpose of this thesis was to design such a routine. The end result is a C-Grid generating routine with a Graphical User Interface (GUI) called Astro Grid.

KEYWORDS: Algebraic Grid Generator, Aeronautical Engineering, Navier-Stokes, Flow Solver, Numerical Aerodynamic Analyses, Airfoil Cross-Section, Computational Fluid Dynamics, CFD