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Author: Mr. Ted Steiner
Massachusetts Institute of Technology (MIT), United States

Prof. Jeffrey Hoffman
Massachusetts Institute of Technology (MIT), United States

DEVELOPMENT AND ANALYSIS OF AN INTEGRATED NAVIGATION SENSOR FOR PLANETARY HOPPER NAVIGATION

Abstract

In recent years, considerable attention has been paid to hopping as a novel mode of planetary exploration. As the field of planetary science develops, the overall trend is towards increasingly targeted scientific objectives. Hopping vehicles provide advantages over traditional surface exploration vehicles, such as wheeled rovers, by enabling in-situ measurements in otherwise inaccessible terrain. However, significant development over previously demonstrated vehicle navigation technologies is required to overcome the inherent challenges involved in navigating a hopping vehicle, especially in adverse terrain.

This research describes relative inertial and planetary surface navigation techniques for a propulsive planetary hopper and results from preliminary demonstrations of these technologies. A survey of relevant navigation technologies, both those with flight heritage and those proposed in literature, will outline the general approaches conventionally taken to both planetary landing and surface navigation. While hoppers are in many ways similar to traditional landers and surface explorers, they incorporate additional, unique motions that must be accounted for. Building upon these concepts, an architecture for a navigation system specific to the motions and mission profiles of hopping is presented. This novel architecture unifies a forward-facing monocular vision system, a downward-facing stereo vision system, a scanning laser altimeter, and an inertial measurement unit to create a comprehensive navigation system capable of navigating hopping trajectories.

As part of this work, a modular sensor system, including a vision package, inertial measurement unit, and altimeter, has been developed to act as a proof-of-concept for a hopper navigation system incorporating unified inertial and terrain-relative navigation solutions. Testing results from this navigation sensor provide the basis for a discussion of tradeoffs between performance, cost, mass, and complexity, with regard to the use of advanced hardware versus complex algorithms to solve these problems. In addition, a detailed testing plan for advancing this system to mission-ready status will be proposed.