SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 1 (2A)

Author: Prof. Dayi Wang
Beijing Institute of Control Engineering, China Academy of Space Technology (CAST), China, dayiwang@163.com

Dr. xiangyu huang
Beijing Institute of Control Engineering, China Academy of Space Technology (CAST), China, huangxyhit@sina.com
Dr. ji li
China, jerem-lee@sohu.com
Dr. Maodeng Li
1.Beijing Institute of Control Engineering, 2.National Key Laboratory of Science and Technology on Space Intelligent Control, China, China, mdeng1985@gmail.com

AN APPROACH OF INTEGRATED AUTONOMOUS NAVIGATION SYSTEM FOR POWERED DESCENT PHASE OF LUNAR SOFT LANDING

Abstract

This paper outlines the guidance, navigation and control (GNC) system scheme and flight profiles of lunar soft landing missions during the powered descent phase, which includes a main baking phase, an attitude adjustment phase and an autonomous hazard avoidance, and the terminal descent sub-phase. This paper is concerned with the inertial measurement unit (IMU)-based autonomous navigation design.

In support of high precision hazard avoidance and safe landing, an IMU, two altimeters and multiple velocimeters are configured. An extended Kalman filter is developed to fuse output of inertial navigation with observations of altimeters and velocimeters. To reduce onboard burden and to enhance navigation system's robust to signal loss caused by uncertainties of lunar terrain, environment, and sensors, two issues are discussed to modify the implementation of the extended Kalman filter. Firstly, altitude update and velocity update are processed independently and the updating coefficients are adjusted from a predefined linear function according to the flight phases. Secondly, 3-axis velocity update is derived using a least-square algorithm if three and more than three velocimeters' beams are available.

The performance of the proposed navigation is evaluated through the Chang'E-3 project. At the beginning of the main braking phase, only inertial navigation was used whereas observations of altimeters were introduced to correct altitude information provided by IMU at the end of the main braking phase. After the lander was transited into the hazard avoidance phase, accuracy of velocimeters increased gradually and then velocity correction was processed. At the terminal descent phase, only inertial navigation was employed because the performance of the altitude and velocimeters was disturbed by dust caused by the thruster plume. Flight results showed that the proposed navigation approach can meet the requirement of high precision hazard avoidance guidance and soft landing.