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FEATURE FLOW AND CRATER LANDMARK BASED NAVIGATION FOR PINPOINT LUNAR LANDING

Abstract

Space missions that involve landing on planets, moon, comets and asteroids are inherently challenging. Autonomous landing spacecraft on moon and planetary bodies close to the pre-selected landing zone with high scientic value, especially in an area of rough terrain, is a rather difcult and risky task. Because of the long communication delay induced by the large distance between the target asteroid and base station on the earth, the traditional Deep Space Network (DSN) is not suitable for pinpoint lunar landing. The current lunar landing navigation system is based on the integration of acceleration and rotational velocity measurements from an Inertial Measurement Unit (IMU). Because of the error accumulation in position estimate, it resulted in large landing error ellipses with axes of dimensions in the order of 100-300km, it can not meet the required precision of pinpoint landing. Current technology does not provide the capability to land safely and precisely, so other new techniques must be investigated. NASA, ESA and JAXA are pursuing vision-based relative navigation technologies to achieve pinpoint planetary landing within 10 to 100 meters. There are two main vision based navigation function: landmark based global position estimation and feature flow based velocity estimation. However, due to the database's finite resolution of landmark, landmark cannot be extracted or matched during the last stages of the descent, and the feature flow based relative velocity estimate method result in large position error due to error accumulation. In the present work, we present an approach for feature flow and crater landmark based navigation for pinpoint lunar landing. According to the feature flow based motion estimation, the lander's relative attitude and velocity can be estimated accurately. Crater landmarks which 3D positions can be pre-determined are the most notable lunar terrain features, it clearly distinguishable all the way from approach to the moon to a very low lunar orbit. This approach use an extend Kalman filter (EKF) to integrate the feature flow and crater landmark, and it captures the advantages of both features to improve the performance of navigation system. Simulation result will be given to show the accuracy improvement of this approach to either the feature flow or the crater landmark based navigation.