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A NOVEL PINPOINT AUTONOMOUS NAVIGATION SCHEME IN THE HAZARD AVOIDANCE PHASE OF LUNAR SOFT LANDING

Abstract

The moon is recognized as an important destination for space science and exploration. During the late 1950s and early 1960s, various landings on the Moon were made by Surveyor, Apollo and Russian Lunar spacecraft. In the new century, the lunar soft landing missions have been proposed by the American new plan to return to the Moon, the EuroMoon 2000 of ESA, the Japanese SELENE-B, and Chinese ChangE-3 Project etc. Early completed landings were all aimed at targets at low to medium latitudes where the ground conditions were felt to be reasonably level and suitable for a landing in relatively unknown territory. Future lunar exploration missions will require the capability to perform precision autonomous navigation and guidance to the selected landing site. Pinpoint landing capability will allow to reach landing sites which may lie in areas containing hazardous terrain features (such as escarpments, craters, rocks or slopes) or to land accurately at select landing sites of high science value. To complete such precision landing mission, the pinpoint autonomous navigation is required. Hazard avoidance phase is one of the most important flight phases in lunar descent and safe landing. In this phase, the navigation system must take the capability of detecting hazards, designating a safe site and guiding the lander to the selected safe site, besides the normal ability of providing the information about position, velocity and attitude. The basic navigation instrument in hazard avoidance phase is Inertial Navigation System (INS). In order to eliminate the accumulated calculation errors in INS, the measurements from other sensors are always introduced, such as optical cameras and laser radar. The feasible way is using IMU as the major navigation sensor and utilizing position/distance measurement information to update IMU navigation result. In this paper, a accurate relative navigation method for safe landing based on information fusion is proposed and some simulation works are carried out. optical cameras can provide horizontal corrected position information by matching and tracking those selected image features. Laser radar can measure the distance information for altimetric compensation. A new information fusion technique integrated with Unscented Kalman Filtering (UKF) based on federated filter is investigated and applied to the above navigation system. The simulation platform is set up for verifying the autonomous navigation scheme and some simulation results are given. The simulation results show the feasibility of the navigation scheme to reduce the INS errors, and validate benefits of the proposed algorithm for hazard avoidance and pinpoint landing on the moon. Finally, the problems still existing are pointed out, and some suggestions are made for further improvements.