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TERRAIN RECONSTRUCTION METHOD BASED ON WEIGHTED ROBUST LINEAR ESTIMATION THEORY FOR SMALL BODY EXPLORATION

Abstract

With the increasing range of deep space exploration, optical information based autonomous navigation has become one of the key technologies with the advantages of high accuracy, low weight, low power, and high level of autonomy. The performance of optical information based autonomous navigation relies on the landmark information from terrain model of the target body. The purpose of terrain reconstruction is to generate the terrain model, so it is an important contributor to the accuracy of subsequent navigation and control. Although many researches have been done in this field, the accuracy and efficiency of terrain reconstruction for small body exploration still need to be discussed.

The paper focuses on the issue of terrain reconstruction for small body, which is one of the vital technologies for small body exploration. Based on the investigation of previous and present terrain reconstruction algorithm, a novel terrain reconstruction method for small body on the basis of weighted robust linear estimation theory is proposed. The method brings in observation error analysis and compromises between accuracy and simplicity of algorithm. The terrain reconstruction is conducted utilizing observation data of the small body. Owing to multi measurement errors of sensors as well as nonlinear error propagation, non-Gaussian gross errors may occur in the observation. The robust linear estimation theory is introduced for both the improvement of the robustness to gross errors and the enhancement of the efficiency. Furthermore, the position and orientation of the probe around the small body are the great contributors to the measurement error propagation, observability, and observation data depth. For the purpose of using the measurement data more effectually as well as increasing the accuracy of the method, propagation weighting matrix, observability weighting matrix and data depth weighting matrix are presented with the consideration of the contribution of different measurement errors, and integrated weighting matrix is composed. Finally, mathematical simulations are performed based on Eros 433 asteroid terrain model including 64,800 data points so as to verify the performance of proposed method. The probe flies around the asteroid and makes the observation virtually. The simulation runs 10,000 times, and observation data is stored for further analysis. The simulation results demonstrate the correctness and efficiency of the proposed method. In addition, the interference of different gross errors can also be suppressed efficaciously.