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A NEW METHOD OF 3D POSITION AND ATTITUDE ESTIMATION FOR PINPOINT LUNAR LANDING

Abstract

Autonomous navigation is one of the key technologies for space missions. In order to achieve pinpoint and safe lunar landing, it is necessary for autonomous navigation to provide lander's precise state parameters in real time. In the descent phase, due to the long communication delay, traditional wireless measurement and control from the earth is not suitable. And the Inertial Navigation System (INS) can not meet the precision requirement of pinpoint landing because of error accumulation. Now some vision based state estimation methods have been put forward, however, these methods also have their own limitations. With the development of lunar exploration, the higher resolution lunar maps are described and lunar terrain 3D models are established. The position information of lunar ground control points can be determined from them. These results should be enough applied to estimating lander's state parameters. Based on lunar ground control points, a new method of 3D position and attitude estimation for the lunar lander in descent phase is presented. The lunar maps of the covered area during descent are processed to obtain reference data. The data include positions and geometric characteristics of feature objects, indexes and lunar ground control points information. Through correlating the reference data with a descent 2D image, the corresponding image points of the lunar ground control points are located. According to the relation between the lunar lander, lunar ground control points and their image points, the lander's state equations can be established. The equations are complex and nonlinear, so the differential form is adopted to linearize them. Then the differential form equations are transformed into the increment form equations and the least square method is used. At last using the iterative method, the equations are solved. And the lunar lander's 3D position and attitude parameters are obtained through a series of coordinates transforms. Using simulate data, the feasibility and validity of the method are verified. The error and error factors are analyzed in theory. It can be concluded that the precision of this method is satisfying. If the existing higher resolution lunar maps are used, the precise state parameters can be achieved. This method is simple to realize. By using the reference data and a 2D image, the 3D position and attitude parameters can be obtained. This method can integrate with INS to eliminate the accumulation error and provide lunar lander's precise state parameters for pinpoint and safe lunar landing.