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Author: Mr. Shijun Xin
National University of Defense Technology, China

Prof. Wei Zheng
National University of Defense Technology, China
Dr. Yidi Wang
China
Ms. Lu Zhang
China

AUTONOMOUS NAVIGATION METHOD FOR LUNAR PROBES USING THE HETEROGENEOUS CONSTELLATION

Abstract

Navigational positioning is a pivotal technology of lunar exploration missions. At present, the navigation information is mostly provided by the ground test and control system. Nevertheless, for the lunar probe (LP), it cannot get the navigation information timely because of the large communication delay. Furthermore, weakening of the signal also reduce the positioning precision of the LP. In order to decrease the operating cost and improve the autonomy and viability of the LP, it is necessary to realize LP's autonomous navigation.

The inter-satellite ranging is an important way for the constellation's autonomous navigation. Nevertheless, it lacks the information of absolute position, and the integral rotation of several spacecraft cannot be restrained. Therefore, the absolute space information must be brought in to completely determine the position of the constellation.

The pulsar is a kind of neutron star, whose rotation period has a long-term stability. So it can be regarded as the natural navigation beacon and clock. Compared with the satellite navigation, the pulsar navigation system is not restrained by space and not disturbed by human factors. Compared with the celestial navigation, it can determine the position, attitude and time of the spacecraft at the same time. Using pulsars to provide absolute navigation information for the heterogeneous constellation is an effective and reliable way.

Contraposing the difficulty of LP's autonomous navigation, we proposed a corresponding method using the heterogeneous constellation, which based on the earth's high orbit and the earth-moon system's libration point. Firstly, utilizing the pulsar detector and the equipment of inter-satellite ranging to obtain the corresponding observed quantities, and realize autonomous navigation of the heterogeneous constellation. Then, using the facility of inter-satellite ranging installed on the LP to observe the heterogeneous constellation and obtain its location information, and confirm the position and velocity of itself by using the extended Kalman filter (EKF). Compared with the navigation method based on the ground system, this method has characters of small communication delay and high navigation efficiency. Figure 1 shows the navigation results of the heterogeneous constellation method and the pulsar navigation system. Compared with the pulsar navigation system, the positioning precision of the method by observing the heterogeneous constellation is higher.