World Academy of Science, Engineering and Technology
International Journal of Computer and Information Engineering
Vol:11, No:08, 2017

Comparison of Extended Kalman Filter and Unscented Kalman Filter for Autonomous Orbit Determination of Lagrangian Navigation Constellation

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Abstract : The history of satellite navigation can be dated back to the 1960s. From the U.S. Transit system and the Russian Tsikada system to the modern Global Positioning System (GPS) and the Globalnaya Navigatsionnaya Sputnikovaya Sistema (GLONASS), performance of satellite navigation has been greatly improved. Nowadays, the navigation accuracy and coverage of these existing systems have already fully fulfilled the requirement of near-Earth users, but these systems are still beyond the reach of deep space targets. Due to the renewed interest in space exploration, a novel high-precision satellite navigation system is becoming even more important. The increasing demand for such a deep space navigation system has contributed to the emergence of a variety of new constellation architectures, such as the Lunar Global Positioning System. Apart from a Walker constellation which is similar to the one adopted by GPS on Earth, a novel constellation architecture which consists of libration point satellites in the Earth-Moon system is also available to construct the lunar navigation system, which can be called accordingly, the libration point satellite navigation system. The concept of using Earth-Moon libration point satellites for lunar navigation was first proposed by Farquhar and then followed by many other researchers. Moreover, due to the special characteristics of Libration point orbits, an autonomous orbit determination technique, which is called 'Liaison navigation', can be adopted by the libration point satellites. Using only scalar satellite-to-satellite tracking data, both the orbits of the user and libration point satellites can be determined autonomously. In this way, the extensive Earth-based tracking measurement can be eliminated, and an autonomous satellite navigation system can be developed for future space exploration missions. The method of state estimate is an unnegligible factor which impacts on the orbit determination accuracy besides type of orbit, initial state accuracy and measurement accuracy. We apply the extended Kalman filter(EKF) and the unscented Kalman filter(UKF) to determinate the orbits of Lagrangian navigation satellites. The autonomous orbit determination errors are compared. The simulation results illustrate that UKF can improve the accuracy and z-axis convergence to some extent.

Keywords : extended Kalman filter, autonomous orbit determination, unscented Kalman filter, navigation constellation
Conference Title : ICMCCN 2017 : International Conference on Multimedia, Communications and Computer Networks
Conference Location : Bangkok, Thailand
Conference Dates : August 30-31, 2017