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MULTI-SENSOR FUSION FOR AUTONOMOUS DEEP SPACE NAVIGATION

Abstract

Deep space is far away from the earth, and the communication between the spacecraft and the earth takes a long time, resulting in a large delay in the navigation of the spacecraft. Therefore, in the deep space, the spacecraft must rely on its own sensors to achieve positioning and environmental perception. The key problem of autonomous navigation in deep space is the nonlinear state estimation of the spacecraft in a dynamic 3D environment. In this study, we combine the observations of stars in the deep space with the dynamics of celestial objects to analyze the state of spacecraft. We propose a distributed multi-sensor fusion method based on the Cubature Kalman Filter to solve the multi-sensor fusion problem of spacecraft. Specifically, we perform the Cubature Kalman Filter on sensor data obtained from gyroscopes, interferometers, star trackers, planet sensor, sun sensors, and earth sensors. During the Cubature Kalman Filter update process, we establish an information contribution matrix. The matrix is updated synchronously with the filter, and finally it is input to the information fusion center for information fusion state estimation. Additionally, based on the multi-sensor fusion, we propose an environmental active perception method based on the information contribution matrix. Specifically, we estimate the possible position and attitude of the spacecraft at the next moment based on the sensor's information contribution matrix and the expected observability of the reference star. The proposed multi-sensor fusion method will be compared with the existing traditional Kalman Filter method, and active perception method will also be compared with other active perception method based on Kalman Filter, and corresponding conclusions will be drawn.