Using the Extended Kalman Filter to Navigate Around a Double Asteroid

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The interest in asteroids has increased in recent years, with several missions underway or in the planning phase. Asteroids are a potential risk to life on Earth, because they may collide with our planet. In this way, it is important to study those bodies in more detail, because knowing them better can help in designing missions to change their orbits or even to destroy them. Considering the technological challenges for navigation around such small bodies, often dealing with multiple systems, such as the asteroid binary system 65803 Didymos (1996 GT), our study analyzed the use of the Extended Kalman Filter in minimizing position and velocity errors in the navigation of a spacecraft in a binary system of asteroids. A complete model was developed, which was numerically integrated. This model will provided the reference measurements. A white noise was added to these reference measurements obtained from the complete model. The spacecraft will be subject to the gravitational forces of both bodies of the system, as well as the non-sphericity of the largest body. The model also considers the solar radiation pressure and the gravitational forces of the bodies in the vicinity. It is considered eccentric orbits for the asteroids, because this is the most common situation. It is also considered the perturbation caused by the gravity fields of Earth, Jupiter, Mars and Venus.

After the development of the filter for a generic double system, a case of study was made for the asteroid Didymos 65803 (1996 GT), which is a binary system, including the analysis of the filter regarding the error of position and velocity of observations of the orbit of the moon, called Didymoon.

The present study considered linear measurements, where the measurements are provided in a linear manner directly by the simulated sensor. The Kalman filter consists of two phases, the propagation and updating phases. The tuning of the filter was a great challenge, because it was a twelve states. At the end of the study, the effectiveness of the Kalman extended filter is clear in minimizing the errors from the sensor noise, reducing position errors of the order of 100 meters for errors of 2 meters, with standard deviation of 20 meters, and errors in the components of the velocity of the order of 1 m/s tending to zero.

Topic: Advancements in Near Earth Object (NEO) Discovery

Prospects for future NEO survey systems and efforts.