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Author: Mr. Yuya Kakehashi
Keio University, Japan, kakehashi@a7.keio.jp

Dr. Masaki Takahashi
Keio University, Japan, takahashi@sd.keio.ac.jp

A DESIGN OF NAVIGATION SYSTEM FOR THE FEASIBILITY VERIFICATION OF A NEW SPACE PLANE CONCEPT

Abstract

One of the most important issues in a design of navigation system is to estimate the system state accurately with limited sensors. This study aims at proposing a method for the navigation system of space plane. In this method, the Unscented Kalman Filter (UKF) is used for the state estimation of the nonlinear system. This proposed navigation system is evaluated by numerical simulation and flight experiment.

First of all, to achieve the autonomous flight of space plane, it is necessary to estimate the state of itself accurately. The most widely used algorithm is the Extended Kalman Filter (EKF). However, using the EKF is not enough for the small system to fill the required estimate accuracy of the autonomous flight. The small navigation system has few sensors and gets its high noise and low accuracy. Using the EKF for the state estimation of the small system can seriously affect the estimate accuracy or even lead to divergence of the system. Therefore, in this study, the UKF which has higher accuracy compared with the EKF is used.

In order to verify the availability of the proposed method, this method applies to an experimental plane of the space plane. This experimental plane is used to verify the feasibility of a new space plane concept we have proposed to enable the space tourism or the supersonic plane in Japan. In this concept, the space plane takes off horizontally from the sea using a ship that is a taking-off and landing assist system and lands on the same ship. This concept using the ship overcomes geographical constraints of Japan.

In the navigation system of the experimental plane, the GPS and inertial navigation system (INS) is used as small system. To overcome the low precision of the sensors, this study consider Earth self-rotation, system noise and aircraft dynamics. From the simulation results, it is shown that the proposed method using the UKF can reduce the estimate accuracy error compared with the EKF implementation. Additionally, the UKF reduces divergence rate of the system caused by the initial parameter. In flight experiment, the navigation system indicates likelihood of the autonomous flight.

In conclusion, this paper finds the availability of applying the UKF to the navigation system of the space plane and shows the possibility of the achievement of the autonomous flight of the experimental plane. It is one giant leap for a new space plane concept.