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Author: Mr. Angelo Espinoza Valles
Samara National Research University (Samara University), Russian Federation

Mr. Petr Nikolaev
Samara National Research University (Samara University), Russian Federation
Mr. Victor Romero-Alva
Image Processing Research Laboratory (INTI-Lab). Universidad de Ciencias y Humanidades - UCH, Peru

A MULTI-SENSOR DIFFERENTIAL EVOLUTION APPROACH FOR MEMS GYROSCOPE CALIBRATION DURING THE SAMSAT-ION NANOSATELLITE MISSION

Abstract

This work presents a new approach for the calibration of gyroscopes using measurements from multiple sensors within the context of the SamSat-ION Nanosatellite Mission. SamSat-ION is a university 3U CubeSat, which was launched on June 2023 on a Soyuz-2.1b launcher for the study of the state of plasma of the Earth's ionosphere along orbital trajectory by contact and remote methods. Attitude determination algorithms involve direct measurements from sensors, such as magnetometers and gyroscopes for accurate estimating orientation in space. Sensors based on microelectromechanical systems (MEMS) are widely used in nanosatellite missions due to their low cost, small size and low-power consumption. However, measurements from these sensors are subject to a series of systematic and stochastic errors, which are need to take into account before using them in the control loop of the angular motion of a nanosatellite. In particular, gyroscopes measurements are susceptible to gradual change of bias over time due to environmental factors. Therefore, periodical on-orbit calibration of gyroscopes becomes imperative to counteract bias instability and sustain optimal sensor accuracy. The SamSat-ION nanosatellite is equipped with an active attitude control system consisting of magnetic coils, inertial measurement instruments (gyroscopes, accelerometers), high-precession magnetometer, sun and infrared light angle sensors. Our proposed method utilizes magnetic field and angular velocity measurements to estimate calibration parameters of MEMS gyroscopes in every communication session, enhancing the reliability and precision of real-time attitude determination. In order to estimate with high accuracy gyroscope calibration parameters, a differential evolution algorithm is used for multidimensional function optimization. As a result, all systematic errors of the gyroscopes, including bias, scale factor, non-orthogonality and misalignment errors can be estimated. The effectivity of the method is demonstrated on the telemetry data from the SamSat-ION nanosatellite mission.

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