Paper ID: 14270
oral
student

ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation and Control (3) (3)

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COLLABORATIVE GUIDANCE NAVIGATION AND CONTROL OF DISAGGREGATED SPACECRAFT IN THE PROXIMITY OF MINOR BODIES

Abstract

This paper presents an investigation of different state estimation techniques to data fuse the measurements coming from multiple heterogeneous sensors mounted on a disaggregated spacecraft flying in formation with a minor body. Each satellite employs and processes the measurements coming from its own on board measurements combined with the information available from the other members of the formation. Embarked sensors may include LIDAR, radar altimeter, high resolution cameras, Sun sensors, Earth sensors and other available on-board measurements. Different sensors are mounted on different satellites in the formation. Three sequential filtering techniques are analysed to obtain a state estimation of each spacecraft in the formation and of the formation as a whole: an unscented Kalman filter, an unscented particle filter and a Kalman filter based on high order expansions. Trajectory correction manoeuvres are then optimally allocated in order to keep the spacecraft orbiting in formation with the asteroid. Solar pressure and the gravity of the asteroid are seen as perturbations to the proximity motion dynamics. In particular, the rotation of the inhomogeneous gravity field of the asteroid is included in the description of the motion of the formation. The analysis in this paper will assess the resilience of a multi-sensor decentralised state estimation process to failures. When a sensor failure on a single spacecraft occurs, the information from the other members of the formation is processed to determine the state of each spacecraft. A particular strategy generally applicable to N spacecraft is developed and tested on a four spacecraft formation case. The use of a disaggregated spacecraft architecture will endow each of the members of the formation with a higher degree of autonomy, allowing for robust and flexible autonomous orbit determination without increasing the complexity of each spacecraft. This capability goes into the direction of reducing mission management costs and increasing real time operations which enable to extend mission objectives. Highly autonomous missions require the definition of particular navigation strategies and systems able to cope with both unknown environment and system performance uncertainties. A collaborative disaggregated architecture represents a promising solution. The paper will present a few case studies of a collaborative spacecraft formation flying in the proximity of a minor body.