Paper ID: 6337
student

ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation, and Control (3) (7)

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VISUAL NAVIGATION SYSTEM FOR ORBIT AND ATTITUDE DETERMINATION OF FAILED/DEAD SATELLITES ON ORBIT

Abstract

Visual navigation system has a wide area of applications. In the context of this paper the visual navigation refers to on-orbit applications to recover or retrieve dead or failed satellites from its orbit. The space object servicing area has a very important appeal in space flight dynamics mainly in these days when the scientific community is deeply concerned with space debris and the risk those objects impose on other space missions and even on the ecosystem not to say risk on human life on ground. Failed or dead satellites are classified as non-cooperative targets when under the goal of space cleaning or space maintenance by space tugs. A chase spacecraft would have to have the capability to rendezvous and grasp the dead satellite or other space debris, taking it out of its orbit for the sake of fixing problems, refueling, or just for cleaning purposes, without any cooperation from the target vehicle. In this sense failed or dead satellites become non-cooperative targets that are not able to provide any information on their position and attitude and eventually are not capable of maneuvering to cooperate with the docking operation. Position and attitude here shall be understood as relative orbital position and relative attitude between the chase and target space vehicles or chase vehicles and other space objects. This paper presents an algorithm developed for estimating targets attitude and position based on visual navigation. The algorithm gathers the strength of classical attitude estimation methods to obtain real-time applicability conditions when adopting a Kalman filter for sequential state estimation. The visual system is monocular and model-based. Therefore, it does not rely on any marker attached to the target satellite. The navigation solution allows for a vast category of applications such as space debris removal, servicing for stranded satellites, and interception of hostile objects. The approach is first tested with synthetic image data from a spacecraft object generated in virtual reality. A visual simulator is implemented to simulate the on-orbit optical environment, a scaled satellite model and a CCD camera in order to evaluate the algorithm for real-time application. A combination of three dimensional (3D) model-based attitude estimation and filtering time series of images produce the real time solution for the estimation problem and increases the reliability of the relative attitude and position results.