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ON-LINE CENTER OF MASS AND INERTIA DETERMINATION OF A SPACE DEBRIS DURING A DEORBITING MISSION

Abstract

The problem of removing debris from LEO or GEO is broadly recognized as one of the most pressing in the near future and passive mitigation obtained by reducing the de-orbiting time after the operational satellite lifetime is demonstrated to be an insufficient remedy. Active debris removal by means of a chaser satellite is therefore being intensively studied. In particular, space manipulators appear to be a promising solution, due to their long operational history in the space environment. With this approach the chaser, clamped to the target debris, changes its orbital altitude by applying a pushing thrust, which is an unstable configuration from the attitude control point of view: a misalignment between the force vector and the chaser+target system center of mass (CoM) leads to a torque that must be continuously compensated, which could be an unacceptable cost in terms of attitude control. Unfortunately, this misalignment must be expected, since the target inertia characteristics are known with only a limited degree of confidence. In this framework, the determination of the characteristics of the chaser+target system is studied by means of a Kalman filtering approach, in a simulation environment in which both the multibody dynamics and the orbital dynamics are taken into account. The estimate variables are the components of the inertia tensor and (above all) the coordinates of the system's CoM, while the measurements are limited to the angular velocity coming from the gyro sensor. It is fundamental for the success of the inertia determination to excite the system dynamics, and this could be done by using the robotic connection between chaser and target, which however brings good results only if the mass of the target is not much larger than the mass of the chaser. Alternatively, the chaser could apply small controlled forces to the system, using the resulting attitude dynamic as input for the filter. More interestingly, this algorithm for center of mass determination can be run even during the deorbiting push: the algorithm is included in closed loop with a thrust vector control, continuously analyzing the attitude motion and improving the knowledge of the CoM position (which by the way will vary due to the fuel consumption). In this way the direction of the thrust is corrected and the attitude control is relieved by the heavy task of compensating the thrust misalignment.