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MULTIBODY TETHER CONCEPT FOR ASTEROIDS CAPTURE

Abstract

Asteroids missions are now receiving a lot of consideration both in the context of resources mining and redirect missions. Grab-and-drag architectures based on harpoons, nets or inflatable containers attached to a tug spacecraft are currently under investigation.

This study presents a radically different approach, where a multi-body chaser is composed of several nodes in a tethered ring configuration. While the spinning circular shape allows for the center of mass of the spacecraft to be in empty space, the tethers enable a variable radius ring, which can be used to approach and capture the object of interest. This method conveniently palaces the spacecrafts on the equatorial plane of the asteroid where, using gimballed engine the trajectory of the object can be controlled. Thanks to these characteristics, the spacecraft can superimpose its center of mass to that of the target which creates a de-facto artificial orbit, not bounded by the gravitational properties of the coupled system. This can provide a simultaneous 360 degrees inspection of the asteroid at any relative angular velocity. Absolute angular velocity can be controlled by extending or retracting the inter-modules cables. For spinning objects with negligible tumbling rates, which constitutes the majority of small near earth bodies, careful control of the ring's radius of allows for contact at zero relative speed. The zero net force distribution guaranteed by the ring configuration renders bouncing events negligible; invasive and disruptive connecting techniques such as drills or harpoons are therefore superfluous. Mechanical connection is guaranteed by the tension in the tethers, and the whole manoeuvre can be accomplished at the speed it best suits the mission.

To fully exploit the capabilities granted by this architecture we investigate sensitivity to initial errors in target position and angular velocity estimations. While in the open/dispersed configuration, rigid body dynamics is not directly applicable and special care has to be taken in the design of the impulsive manoeuvres.Using simplifying assumptions, we develop an analytical tool to evaluate in plane controllability of the spinning extended tether configuration. Using only internal forces, controlling the cables length and reaction wheels acceleration, we study the zero fuel consumption manoeuvre capabilities of the spacecraft. An hypothesis of a suitable controller is developed from the simplified behaviour of the analytical model and then verified in Matlab. The aim of the simulation is to test the limits of the control algorithm once the simplifying assumption are lifted.