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HOVERING CONTROL OF A SPACECRAFT OVER A BINARY ASTEROID

Abstract

In the last two decades studies related to missions to asteroids has gained much attention in the space sciences community. This is due to many reasons: to learn more about the origin of life, because asteroid could have played a substantial role in the transport of water to the Earth, they also can give us clues about the formation of our solar system and are the main interplanetary threat to life on Earth. Among all known asteroids, it is estimated that binary asteroids make up 15% of the total, although they never have been explored before. In fact, in the next decade, NASA should launch the DART spacecraft to the Dydimos binary asteroid in order to test a kinect impactor to estimate effects in future deflection strategies. This mission should be followed by the ESA's Hera mission, with the same target, to characterize the pair and the impact site left by DART spacecraft. Due to the low-gravity environment, asteroids present challenges to the guidance, navigation and control, and binaries could imply in additional challenges depending on the mission objectives. For this reason, we plan to study the control of a spacecraft operating in a binary system of asteroids. We are mainly interested in hovering motion about the lower mass body of the system. This close proximity operation is studied through the circular restricted three-body problem, considering the J_2 non-spherical gravity component for the main body and this term and other higher order components for the lower mass body. A bounded dead-band control and a sliding mode nonlinear control law are derived, and then tested in a more complete dynamical simulation considering perturbations due the solar radiation pressure and unmodelled non-spherical perturbations of the main body. We also test different mass ratios for the system and specifically extend the analysis to the Mars-Phobos system, which could be an even more challenging operation because of the high mass ratio and high perturbations due the Mars gravity field. As widely known, although the sliding-mode control present high robustness to perturbations, its main limitation is the chattering effect introduced by the switching behavior in the sliding surface. Therefore, we derive our sliding-mode law considering a saturated thrust and change-rate. This and the bounded dead-band law are compared in terms of control effort and steady state error in the more complete dynamical system.