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Author: Dr. Marco Sabatini
Sapienza University of Rome, Italy

Prof. Giovanni B. Palmerini
Sapienza University of Rome, Italy
Prof. Paolo Gasbarri
Università di Roma "La Sapienza", Italy

A TESTBED FOR VISUAL BASED NAVIGATION AND CONTROL DURING SPACE RENDEZVOUS OPERATIONS

Abstract

Space rendezvous operations are usually extremely demanding in terms of relative navigation accuracy and control precision. In fact, undesired collisions must be in all ways avoided; moreover the docking mechanism is usually not robust to large errors in the relative position acquired. In space missions history, the rendezvous operations have been commanded or monitored by human crew; alternatively, automatic rendezvous has been performed between a controlled spacecraft (the chaser) and a cooperative target. The interest in on-orbit servicing missions, together with the well-known challenge of approaching and de-orbiting debris objects, has pushed the research towards techniques for automatic navigation and control of a spacecraft with uncooperative targets. In this frame, visual based techniques are considered an interesting option for determining the relative configuration (i.e. attitude and position) during close proximity operations. Even though accurate simulations are of course mandatory, the performance concerning the cameras used for the navigation can be hardly predicted numerically. The varying lighting conditions, the image resolution, the computing time required for image processing by the on board hardware, are all factors which greatly influence the GNC loop performance. For this reason ground tests must be considered a necessary step to assess the soundness of a given rendezvous strategy. Also the contact dynamics between free flying bodies can be a harsh matter to handle numerically, since they are strongly dependent on the parameters chosen to describe the (very short) time intervals in which the contact actually happens. In this work, a two dimensional approach is used for replicating on ground the space conditions, by using air bearings to remove the friction between the two free floating platforms and the working flat surface. In this way, a 6 degrees of freedom system is realized: the navigation and control strategies, first developed in a numerical multibody environment, are tested with the experimental set-up, with particular attention dedicated to the performance and the limitations of the vision based algorithm (such as a possible excessive computation time), and to the contact and post-contact dynamics. Undesired drift or tumbling of the chaser + target aggregate system must be avoided by carefully studying not only the post-docking phases, but also the steps immediately before the docking. In fact the plume impingement due to the chaser's thrusters, reproduced in the experiments, could generate a disturbance force on the target satellite, which must be minimized with an ad hoc approach guidance algorithm.