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Author: Dr. Marco Sabatini
Sapienza University of Rome, Italy, marco.sabatini@uniroma1.it

Mr. Renato Volpe
Sapienza University of Rome, Italy, renato.volpe@uniroma1.it
Prof. Giovanni B. Palmerini
Sapienza University of Rome, Italy, giovanni.palmerini@uniroma1.it

CENTRALIZED VISUAL BASED NAVIGATION AND CONTROL OF A SWARM OF SATELLITES FOR ON ORBIT SERVICING

Abstract

The current growing interest into on-orbit proximity operations motivates the effort in designing mission architectures able to fulfill tasks such as repair, inspection and dismissal. Small satellites are appealing in terms of costs, effectiveness and realization, but present intrinsic power and mass limitations and are only equipped with basic instrumentation. However, it is possible to envisage not just one, but a fleet or swarm of small satellites which cooperate to reach a certain goal. In our research, a swarm of small satellites (called "children"), deployed from a larger platform (called "mother"), is employed in the inspection of a damaged spacecraft, which cannot be approached by large satellites for safety reasons. In order to complete the inspection procedure, each child must acquire a certain relative orbit around the target and therefore it needs precise state estimation to actuate the required control strategy. To this purpose, because of power and mass limitations on each child, the navigation process is delegated to the mother spacecraft, that is equipped with a passive camera, chosen for its capability to provide accurate and complete description of the observed scene. Based on images iteratively acquired by the camera, a navigation algorithm runs on the mother spacecraft which firstly identifies and then tracks the spacecraft framed in the scene. The complexity of this scenario is that the large number of spotted satellites could lead to false matches (i.e., incorrect tracking of a given child) as the dynamics of the swarm evolves. The navigation algorithm is made robust through the generation at each time step of a propagated virtual image (based on the previous estimate of the swarm state) which is compared to the acquired image for the correct identification of each child. While the estimation process runs, the mother continuously communicates to each child its current state, which is computed as part of the navigation algorithm. At this point, a control strategy can be implemented to make the swarm fulfill the required task. In our scenario, as an example of a possible application, the children aim to reach a closed relative orbit around the target, with the goal to simultaneously observe it from equally spaced points of view. Simulations are carried out to test the estimation algorithm performance in terms of precision of each child on its desired final state.