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Author: Dr. Stefano Silvestrini
Politecnico di Milano, Italy

Dr. Andrea Colagrossi
Politecnico di Milano, Italy
Dr. Michele Bechini
Politecnico di Milano, Italy
Mr. Michele Ceresoli
Politecnico di Milano, Italy
Ms. Gaia Letizia Civardi
Politecnico di Milano, Italy
Mr. Lorenzo Capra
Politecnico di Milano, Italy
Prof. Michèle Lavagna
Politecnico di Milano, Italy
Mr. Robin Biesbroek
ESA european space agency, The Netherlands

INTEGRATED GNC DESIGN AND IMPLEMENTATION FOR E.INSPECTOR MISSION: MULTI-SPECTRAL IMAGING FOR SPACECRAFT DEBRIS IN PREPARATION TO ACTIVE REMOVAL

Abstract

The rapid space technology miniaturization opens the chance to perform In-Orbit servicing missions with small satellites, gaining in servicers agility, flexibility, time to market and cost reduction. The e.Inspector mission, currently under phase B, is an ESA funded mission aimed at flyaround a debris – 600 km height flying - to precisely reconstruct the target shape and dynamics in preparation of its capture for removal. The GNC-IP architecture features two main submodes depending on the distance from the selected target. In particular, the main difference is the image acquisition strategy and consequent processing. The proximity phases starts after the absolute orbital transfer. The rationale behind the hand-over to relative navigation is to balance two functionalities: during absolute phase the target position is estimated only with provided TLE whereas the relative measurements are acquired when a robust target detection can be performed. When the target is only few pixels in the cameras FOV, namely at the initialization of the proximity phase, long exposure images are foreseen. Whereas, as soon as the target blob increases to few tenths of pixel the frame acquisition is static. The VIS pipeline works as a blob detector using the invariance of the star illumination conditions against the illumination condition of the artificial target. The TIR feature detection resembles the centroid technique. Cross-reprojection of VIS-TIR detection is used as feature fusion and to derive indications on measurement uncertainty to be fed to the filter. The proximity navigation exploits the usage of a differential absolute filter, which estimates the absolute state of both the target and the chaser. In terms of measurements, the filter again receives the target Line of Sight (LOS) unit vector that is extracted from the VIS and TIR cameras, while Two Line Elements of the target are periodically uploaded from ground. To enhance the filter's robustness to faulty measurements an outlier rejection routine based on the Mahalanobis distance check is introduced.

Model Predictive Control (MPC) is selected as the baseline algorithm for the guidance and control implementation, to perform the transitions between the hold point/orbits and the drift orbits around the target. The transfer trajectories and the control input, in the form of an acceleration vector, are provided by the MPC controller which works optimally and effectively within the defined constraints and considering the interactions between system variables. The MPC implementation is based on a quadratic convex optimization with linear description.