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POSE ESTIMATION OF A KNOWN TEXTURE-LESS SPACE TARGET USING CONVOLUTIONAL NEURAL NETWORKS

Abstract

Orbital debris removal and On-orbit Servicing, Assembly and Manufacturing [OSAM] are major focus areas for future robotic space missions. To achieve intelligence and autonomy in these missions, technologies such as guidance and navigation, grasping, gripper are the focus of research and development in recent years. To carry out robotic operations autonomously in orbit, it is essential to have autonomous guidance and navigation (especially vision-based navigation) combined with the knowledge of the in-situ environment. Recently, Deep Learning [DL] approaches for object detection and camera pose estimation advanced to be on par with classical feature- or template-based approaches; these advancements can unlock several new opportunities on the above missions and one such area is spacecraft pose estimation. The state-of-the-art approaches in DL-based spacecraft pose estimation are the keypoint-based hybrid approaches (i.e. learning keypoints and computing pose via classical Perspective-n-Point [PnP] approaches) because of its performance compared to the end-to-end methods. These hybrid approaches are suitable for rendezvous trajectory generation during the proximity approach, but it is less suitable in a mission scenario such as estimating the pose of texture-less and possibly symmetric objects like nozzles, etc. For example, debris removal missions targeting spent rocket stages or apogee kick motors require an approach that estimates the pose without using any keypoints.

This paper presents a method for real-time detection and accurate pose estimation of the texture-less space object. We consider two targets, an apogee kick motor and a rocket nozzle, for this work. A brief review of the target selection and its use in a real mission scenario is presented. DL requires a large amount of data to train the models in order to achieve reliable performance. We created a new texture-less space object dataset for the above two objects. It includes both the synthetic images generated from the simulator (developed for rendering synthetic space imagery) and the laboratory-generated images of the scaled target mock-up with the emulated space conditions. Two test cases are evaluated, first using both synthetic and real images for training and performing validation on the real images; second, using only synthetic images for training and performing validation on the real images. A summary of the evaluation results including the mean error in the estimation position and orientation for the above two cases will be presented.