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# A ROBUST APPROACH MERGING DEEP LEARNING AND UNSCENTED KALMAN FOR VISION BASED SPACE RENDEZ-VOUS

**Abstract**

Autonomous space rendezvous (RDV) is gaining increasing significance in tandem with the advancement of on-orbit services and operations, such as refueling, debris removal, in-orbit assembly, and transportation. Several of these applications require the ability to navigate around non-prepared targets, where specific navigation aids are unavailable.

In this context, vision-based navigation approaches present cost-effective solutions. Furthermore, the recent strides in deep learning methodologies have enhanced the robustness and performance of image processing. The considerable advances in on-board computation capabilities, coupled with the concurrent development of deep learning deployment chains, allows the on-board integration of such approaches. These progresses open up the opportunity of incorporating deep learning-based vision approaches in navigation solutions for satellite rendezvous missions.

This paper presents a navigation solution developed with the objective of conceiving an on-board subsystem able to plan and realize autonomously a rendezvous mission. The conceived end-to-end navigation approach combines the use of an Artificial Neural Network (able to estimate the positions of keypoints in the processed images) and of an Unscented Kalman filter (able to bring the knowledge of both geometry and dynamics to provide relative pose estimation). Particular attention has been paid to develop a robust solution suitable for an operational use and on-board processor deployment.

Significantly, a dedicated dataset has been simulated to test the solution's robustness against gaps in image domains. Additionally, exhaustive efforts have been made to formulate a robust initialization algorithm to ensure the convergence of navigation. This processing step is indeed critical in an operational environment and constitutes the most important contribution of this deep learning solution. To improve precision and detect outliers, a specialized interface between the Artificial Neural Network and the Unscented Kalman filter is proposed. Finally, the performance of the solution has been thoroughly evaluated using a realistic dataset of approach sequences.