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AI BASED LOCATION ESTIMATION USING DIGITAL TWINS IN RENDEZVOUS AND DOCKING SCENARIOS

Abstract

Automated rendezvous and docking (RvD) is a key technology in space flight. In order to perform a RvD maneuver, an exact relative localization of the chaser with respect to the target is of great importance. One new method for RvD maneuvers is laser scanner-based localization approach combined with point cloud matching. A disadvantage of this approaches is that point cloud matching is performed iteratively, which requires a sufficiently accurate a-priori estimation of the initial pose. This estimation is typically based on knowledge from the mission specification. To become independent of this a-priori knowledge, current research attempts to obtain the initial location estimation by means of AI methods. The major challenge in developing AI-based solutions for space applications is the availability of training and validation data. Real data from reference missions are mostly rare to non-existent and do not provide the necessary amount and diversity of variants.

This paper faces this challenge and presents an infrastructure and processes for the effective and efficient development, validation, and use of a modern AI approach for RvD applications. By means of comprehensive Digital Twins, the presented infrastructure allows to efficiently generate training and validation data. Here, Digital Twins provide the sematic units to build holistic simulation models (e.g. a calibrated Digital Twin of a space LIDAR and detailed 3D models of the targets like e.g. the ISS or Envisat).

To be able to generate the required amount of training data, the infrastructure provides an automated process for the generation of scenario variations based on Digital Twins. The scenarios are then run in a comprehensive Virtual Testbed based on the simulation platform VEROSIM. The data gained from these simulation runs are managed in a result repository, and then used to train and validate an AI-based algorithm presented first at i-SAIRAS 2018. Afterwards, this approach also allows for the validation of the behavior of the overall system and provides intuitive decision support methods for the optimization of the AI.

Based on the boundary conditions of the RvD scenario, specific challenges arise: with respect to the possible range of approach angles, different views of the target need to be sampled for training data generation and validation. Depending on the target structure, challenges further comprise self-occlusion by the target, partial visibility and possible changes in structure.