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DEEP LEARNING BASED RESOLUTION OF ATTITUDE AMBIGUITIES FOR RELATIVE POSE ESTIMATION OF UNKNOWN AND UNCOOPERATIVE TARGETS

Abstract

In recent years, the surge in space activities has led to a proliferation of resident space objects (RSOs) orbiting the Earth. Among these, space debris presents a substantial and escalating threat to current and future missions, stemming from the occurrences of explosions and collisions. Recognizing the critical need for a solution, the scientific community has turned its attention to On-Orbit Servicing and Active Debris Removal. Consequently, the ability to safely execute proximity operations has become a vibrant area of research. Addressing the inherent challenges, especially when dealing with uncooperative and unknown RSOs lacking a priori information, demands innovative approaches. Enter CoMBiNa (COarse Model-Based relatIve NAvigation), a cutting-edge technique designed for the autonomous inspection of such objects. Leveraging stereo-vision measurements, CoMBiNa integrates simultaneous localization and mapping, the model-based Bayesian Coherent Point Drift technique for pointset registration, and an Unscented Kalman Filter to accurately estimate the pose and inertial properties of the target. However, CoMBiNa encounters limitations in converging with symmetrical RSOs due to unobservable rotations around their symmetry axes. This issue prompted a reformulation, specifically tailored for symmetric targets. In this refined approach, state variables are changed, enabling the estimation of relative position and velocity between the chaser and the target, along with the orientation of the target body's symmetry axis. Nonetheless, this method falls short of computing the complete attitude and angular velocity of the target. Building on this experience and harnessing the power of deep Convolutional Neural Networks (CNNs), this novel project proposes a formulation to reconstruct the full relative pose and target angular velocity, even for symmetric targets. The working principle of the algorithm relies on the CNN to identify specific features on the target. After their localization through object detection, the extracted information can be integrated in the existing CoMBiNa algorithm to achieve comprehensive state estimation by breaking symmetries. The pose estimation pipeline is further enhanced by introducing multiple methods for deriving measurements based on the number of visible features.