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MOMENTUM BASED CLASSIFICATION FOR ROBOTIC ACTIVE DEBRIS REMOVAL

Abstract

Recent spacecraft collisions with debris and various near misses have highlighted the need for pursuing Active Debris Removal (ADR) of space debris. Robotic manipulators provide a versatile way to capture, detumble, and eventually deorbit the debris. This paper explores the classification of space debris and robotic manipulators based on angular momentum. Previous classifications have considered the tumble rates, size, and orbit of the debris. However, a momentum-based classification gives an insight into the selection of the robot arm appropriate for specific debris removal targets as shown in this paper. A momentum analysis of the common shapes from the DISCOS database from ESA is carried out. For this, various mass distributions and tumble rates are considered in this study. The change in momentum due to the tumble rate and inertia is analysed for the debris shapes and they are then categorized based on their momentum. Furthermore, a study on the momentum capture capabilities of previously flown robotic manipulators is performed. This gives an impression of the capabilities of the flight-heritage robotic manipulators for their use in ADR missions. These analyses provide the data required to perform a matching of the momentum of the debris with the momentum capabilities of the existing robotic manipulators. From this, the selection of an appropriate target for ADR based on its momentum and the capabilities of the robotic manipulators is discussed. Additionally, the application of the classification onto the real targets from DISCOS is illustrated, using the results from the space debris ontology for ADR capture methods selection that considers not only the physical and dynamical properties of a target but also its breakup hazard inferred from statistical data. Finally, these results are also used to provide input for future manipulator development for ADR missions.