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SPACECRAFT COMPONENTS DETECTION METHOD BASED ON RANDOMIZED IMAGE ENHANCEMENT

Abstract

Spacecraft components detection is the foundation and prerequisite for conducting space debris autonomous docking, grappling and repair, and other proximity operations. For those proximity operation tasks, the key to successfully completing them is to detect the information of the target autonomously and accurately. At present, the commonly used spacecraft component detection method is the image matching algorithm, which takes the approach of manually designed features for target feature matching and detection with high reliability. However, this approach relies on manually designed features, which is difficult to apply in the scenario of interaction with non-cooperative targets in space. In contrast, the deep learning-based detection method does not require manually designed parameters and also has global feature extraction and semantic segmentation capabilities, but the reliability of this algorithm is highly dependent on the quality of the image dataset, and the accuracy of the detection results can be low when the image data used for deep learning model training is insufficient. However, because in-orbit spacecraft images are difficult to obtain and the data are very sensitive, there is no reliable spacecraft image dataset for detection, segmentation, and part identification. To address these problems, the authors propose a randomized image enhancement method for spacecraft component detection, which not only generates a large number of spacecraft images simulating real scenes, but also avoids the manual annotation process. First, a spacecraft synthetic image generator for neural network model training is designed. The modeling software is used to render multiple types of spacecraft models, and then scripts are written to generate a diversity of spacecraft images and corresponding component pixel masks to construct a spacecraft synthetic image dataset. Second, to solve the problems of insufficient model generalization capability and complex real image noise, data enhancement is performed on the synthetic image data based on domain randomization. The background interference and various optical noises are randomly added to make the synthetic images more realistic. Then, a two-channel semantic segmentation network is designed based on Mask R-CNN. The data set is then used to train the network model, which can automatically and accurately detect the solar wing and antenna of the spacecraft. Finally, the effectiveness and feasibility of the method are verified by conducting simulation tests using synthetic images of unknown spacecraft models and images of real captured spacecraft in orbit.