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SPACE DEBRIS DETECTION AND CHARACTERIZATION FROM THE ESO VST ARCHIVE

Abstract

Earth's orbit is a busy place. After sixty years of exploring and exploiting space, it has become increasingly challenging to ensure the safety of our orbiting assets. Active satellites perform hundreds of collision avoidance manoeuvres daily and it is clear that active space debris removal will be necessary to maintain the usability of certain orbits. Although space surveillance networks make enormous observational efforts to track an ever-increasing number of objects, very little is known about the rotational and physical properties of defunct satellites and space debris. This information is essential for active space debris removal, as well as precise conjunction risk characterisation. To overcome this knowledge gap, we extract and analyze observations of space objects from the VST/OmegaCam data archive. The instrument's exceptional sensitivity and photometric precision enable us to detect targets as small as 5 cm in LEO and 30 cm in GEO. Processing the archive, which comprises over 400000 individual observations acquired over the past 12 years, requires highly advanced image processing techniques. We have developed an innovative method for detecting streaks using a convolutional neural network enhanced by a Hough transform layer. The algorithm's performance is analysed in terms of achievable SNR, processing speed, and detection accuracy. The detected streaks are then used to implement and test photometric reduction methods, which are necessary for extracting light curves and determining the rotational properties of observed objects. Obtaining additional data on space debris and satellites in orbit is essential due to the growing risks involved. This work's results are vital for selecting targets for future active space debris removal missions and understanding the rotational evolution of defunct satellites and space debris. The photometric measurements will also help us understand the impact of space objects on astronomical observations. This information is crucial for developing mitigation strategies for future space missions, particularly those involving mega-constellations with thousands of satellites.