

Enhancing Maritime Surveillance in the Taiwan Strait through SAR Images

*Tsung-Ying, Tsai*¹, Kuo-Hsin, Tseng¹*

¹ Center for Space and Remote Sensing Research, National Central University

The Taiwan Strait exhibits a distinct geological setting, characterized by shallow bathymetry and gentle topography composed mainly of sandy substrate types. In the expansive region of Taiwan Strait, the water depth is notably limited, rarely exceeding a mere 100 meters, and remarkably, it can be even shallower, descending to a depth below 20 meters in the vicinity of the Taiwan Shoal area. Hence, over the past few years, there has been a notable increase in the occurrence of unauthorized sand dredging activities in the Taiwan Strait area. In consequence, these activities have raised considerable concerns regarding maritime domain awareness, as they pose a substantial threat to the marine ecology and subsequent erosion of the adjacent coastline.

The primary goal of this research is to tackle the aforementioned issue by leveraging Synthetic Aperture Radar (SAR) technology in satellite remote sensing. The aim is to monitor the spatial-temporal hotspots of suspicious vessels in specific areas. Spaceborne SAR instruments offer several advantages, including exceptional penetration capabilities, high-resolution imaging, and the ability to operate independently of sunlight. These attributes make them an excellent tool for detecting objects over the sea. For this research, three specific Sentinel-1 SAR image frames covering Taiwan Strait have been selected and images from 2017 to 2021 are obtained to perform analysis. A comprehensive detection system has been devised, consisting of four steps: preprocessing, land masking, prescreening, and discrimination & classification to identify and analyze the specific targets. Based on our preliminary findings, the developed algorithm demonstrates the capability to automatically detect targets above a certain size. To assess the performance of the system, it was evaluated on 15 randomly selected images. The results were then verified against manually identified ground truth. The validation process yielded an average detection accuracy, in terms of F1-score, of 0.88 on average. Regarding the spatial-temporal hot spot analysis, distinct distributions and movements were observed among the three target areas. Notably, the detection numbers peaked around 2019 and 2020, indicating significant activity during those periods. In conclusion, SAR images prove to be valuable tools for ship detection, and the developed system effectively monitors the distribution of suspicious activities. This capability is instrumental in enhancing the efficiency of subsequent law enforcement efforts.

Keywords: Synthetic aperture radar (SAR), Object detection, Taiwan Strait, Maritime domain awareness