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AUTOMATIC SHIP WAKE DETECTION FROM SENTINEL-2 IMAGES BY DEEP LEARNING

Abstract

A critical role in monitoring and understanding human activities at sea is held by the detection of moving vessels, a challenging task that can be accomplished, in specific conditions, by inspecting their long trails left in the sea. To solve the ship wake detection problem, the traditional methodology based its research on domain transformation from lines to points, such as the Radon or the Hough transform. Assuming wakes as linear features, such a class of algorithms is not capable of capturing irregular or curved wakes and shows poor generalization. Nevertheless, the current digital era is dominated by Deep Learning (DL) techniques thanks to their capability of abstract feature extraction. Representation learning has proven to tackle the increasing speed and breadth of "Big Data", outperforming humans on a variety of challenging tasks. Convolutional Neural Networks (CNNs) can glean relevant patterns from remotely sensed images and represents the origin of the paper which intends to realize an automatic wake recognition system from spaceborne optical images. Several state-of-the-art DL-based approaches are benchmarked with model baselines including both object detection and instance segmentation architectures, including one-, two-, and multi-stage methods. The usage of ResNet backbones as the main features extractor is motivated by their effectiveness on many computer vision datasets. FPN (Feature Pyramid Network), used as a neck of the backbone, grants for the multi-size detection. To perform supervised learning, a novel dataset is built and proposed in the paper. The Multispectral Ship Wake Dataset (MSWD) is represented by multispectral chips extracted from the European Sentinel-2 mission, selected for its publicly available data policy. Chips are extracted from Level-2A ortho-images. MSWD is composed of 888 wakes gathered from 50 multispectral granules. Data variety was curated selecting wakes in multiple dimensions and orientations, and data veracity is assured by the corresponding AIS (Automatic Identification System) information. A transfer learning strategy is applied on the bands B2 (blue), B3 (green), B4 (red), B8 (Infrared), and their combinations, all characterized by the same spatial resolution. The comprehensive analyses proved that this class of algorithms is capable of detecting the vast majority of wakes with high confidence scores, very low probability of false alarm, and fast processing speed. In the end, domain shifting is proven against Landsat-9 imagery, demonstrating that the learning strategy was effective.