Deep Learning Detection of Cargo Ships Using Synthetic Aperture Radar Imagery from Sentinel-1 Satellite

By: Alexander Makhratchev and Sean Ng

Abstract

In the past, synthetic aperture radar (SAR) images did not have a high resolution, and required immense computational power to create. However, due to recent advances in computer vision, SAR image quality has significantly increased and is becoming a hot topic in research. One application of these images is to detect container ships traveling through bodies of water. This paper uses the Large-Scale SAR Ship Detection Dataset-v1.0 (LS-SSDD-v1.0) which contains large scale SAR images from Sentinel 1 satellites that contain ships and their respective labels. These large images are cut into smaller pieces in order to train a variety of object detection models including Detectron2, and YOLOv7. Then, we deploy the model by scraping SAR images from Google Earth Engine from anywhere in the world and modeling the number of cargo containers in the region.

Introduction

With recent advances in algorithms and technology within the realm of computer vision, the problem of object detection is that much more relevant. Specifically, analyzing satellite imagery for ship detection has been subject to a lot of research where different satellites and detection models have been created and improved on for better speed and accuracy. One of the most widely used image data within this sphere has been the Synthetic Aperture Radar (SAR) images. Previously, optical satellites have been known to produce some of the highest resolution images, however with the drawback that it can only produce high resolution images under certain time of day and weather conditions [2]. SAR's strengths lie in the fact that it can produce high quality images even if it is cloudy or at night time.

In September 2020, a research group in China [1] released their paper on ship detection and the accompanying dataset that they used. Their goal was to create the most accurate and useful dataset for cargo ship detection from SAR images. They utilized ship tracking and Google Earth in order to provide the ground truth labeling for their images and included lots of small ships as well. Also, lots of images with the plain background are added in order to diversify the training set. Furthermore, their paper dives into why other similar datasets such as "AIR-SARShip-1.0" and "SAR-Ship-Dataset" do not provide the same utility as theirs. One major problem with other datasets, is that it doesn't represent the environment in which the model will be deployed on: SAR images have extremely wide swatch characteristics. The images are often hundreds of kilometers wide of one specific area rather than a small specific area. For the model, they used MMDetection toolbox, which is a modified version of faster R-CNN and it provided fairly accurate results, but the inference time took a while.

Many of the algorithms developed for object detection such as convolutional neural networks (CNN), region-based convolutional neural networks (R-CNN), Fast R-CNN, and Faster R-CNN. However, as Chang et al. described, these models were not accurate enough, so they utilized the You Only Look Once (YOLO) that contains the entire pipeline into one network to make

optimization easier. [2] With the YOLO framework, they were able to beat Faster R-CNN and other frameworks. However, at the time of publishing in 2019, they only used the second version of YOLO and since then, a version 7 of YOLO has come out.

The dataset from [1] labeled LS-SSDD-v1.0 pulls images from the Sentinel-1. The dataset consists of 15 images with 24,000 x 16,000 pixels which are then broken down into 9000 800x800 pixel sub-images. The ground truth of the labels for the dataset were determined by experts as mentioned in the previous section. They include a variety of geographical features for the machine learning algorithm to be able to distinguish.

References

[1] LS-SSDD-v1.0: A Deep Learning Dataset Dedicated to Small Ship Detection from Large-Scale Sentinel-1 SAR Images

i. https://www.mdpi.com/2072-4292/12/18/2997/htm

[2] Ship Detection Based on YOLOv2 for SAR Imagery

ii. https://www.mdpi.com/2072-4292/11/7/786/htm