# Small Vessel Detection in Satellite Imagery

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## Problem Statement

Illegal, Unreported, and Unregulated (IUU) fishing poses an existential risk for the future of our planet's oceans. Although national legislation and international accords have been developed to limit IUU activity in commercial fishing fleets, where vessels tend to be larger, small vessels operated by independent (sometimes referred to as "artisanal") fishers are often not subject to the more stringent regulations which the commercial fishers face. And even when small-scale fishers are subject to regulation, enforcement is often difficult because their small vessels are extremely difficult to identify through traditional methods such as the use of spotting vessels.

The major problem with monitoring the behavior of these small vessels, however, is that the ones which are engaged in IUU fishing do not wish to make their actions known. Therefore these vessels are unlikely to use systems such as Automatic identification system (AIS), the tracking system which all large vessels are required by international law to utilize, because it broadcasts sensitive information such as location. We thus need remote, passive data sources to monitor their behavior, and one such source is satellite imagery.

Researchers and commercial organizations have developed several algorithms for the automatic detection of vessels, but these systems tend to perform poorly when labeling small vessels. This is to be expected since most users of such systems are interested in monitoring large commercial ships (e.g. liquid natural gas tankers). But the poor performance on small vessels is not just a result of the lack of interest in them: these ships are just too small to reliably identify in standard resolution satellite imagery. To develop a system which can identify these vessels with an acceptable level of performance, we must approach this problem in a new way.

## Approach

Although small vessels themselves are often too small to reliably identify in satellite imagery, they generate one feature which is much easier to spot: wake.

All moving vessels generate some degree of wake, and this may be identified easily by experts. By focusing on the wake, rather than solely the vessel itself, I intend to develop an algorithm which can reliably identify small vessels which are in operation in coastal waters.

My first task is to create a labeled dataset containing images of small vessels creating wake. I will label the vessel itself, and the wake, using two bounding boxes. Following the approach of previous research [1], I estimate that roughly 3,000 samples is adequate for the creation of a training set, and roughly 300 samples should be reserved for validation and testing. Although labeling 3,000 samples is non-trivial, each PlanetScope scene, a 7 by 24 kilometer image, may be divided into approximately 16 training samples. Thus only around 220 unique images are necessary to create a dataset of adequate size.

Once the dataset is created, I will then design several different algorithms for vessel detection and labeling. These models will attempt to both identify the wake of a vessel and the location of the vessel itself in relation to the wake. Following the current state-of-the-art in object detection and image segmentation, these models will be based on convolutional neural network architectures. Using a standard hyperparameter optimization framework I will train each model on the training data, select optimal hyperparameters, and then choose the model which performs best on the test data.

By using the wake as a signal source, we not only hope to improve the performance of the vessel detection model but also to infer the direction of travel of the vessels. This information is particularly useful for identifying the intentions of fishers and whether their behavior is suspicious and possibly indicative of their being engaged in IUU activity.

# References

[1] Jaeyoon Park et al. "Illuminating dark fishing fleets in North Korea". In: *Science Advances* 6.30 (2020). DOI: 10.1126/sciadv.abb1197. eprint: https://advances.sciencemag.org/content/6/30/eabb1197.full.pdf. URL: https://advances.sciencemag.org/content/6/30/eabb1197.