Exploring Illegal, Unreported, and Unregulated Fishing Detection using AIS Data and Machine Learning

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What is the Issue with IUU Fishing?

- Environmental & economic impacts
- Tied to drug & human trafficking
- Estimated cost of $23 billion annually

Automatic Identification Systems (AIS)

- What are they?
  - Standard tracking devices on vessels used primarily for collision avoidance
- Commonly illegally exploited on fishing nets or buoys to protect large hauls
- These impersonated AIS signals are harmful towards legal vessels, leading to a critical need for improved IUU regulation.

Data Overview:

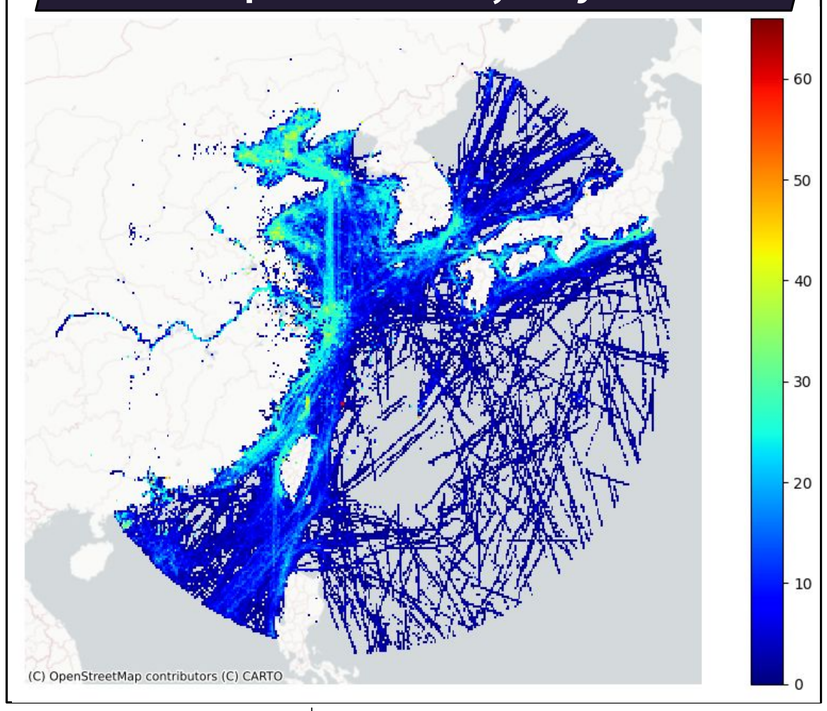
- Region of Interest: Southeast Asia
- Spatial, temporal, & user inputted data obtained from CCRi
- Pre-processing steps:
  - Aggregated by distinct device trips
  - *'Red flag'*: Indicators of non-standard naming conventions and movement characteristics (score from 0 - 4)
  - These indicators are then used for performance analysis or labelling

1. *net_name*	Names including a 'V', '%', 'buoy', or 'net'
2. mmsi_length	MMSI values not equal to 9 digits
3. spawn_offshore	Vessels whose first transmission is offshore (1 nautical mile off the coastline)
4. spoof	Devices with unreasonably high calculated speeds (>= 150 knots)

Regional Analysis

1. Overlay region with grid between 107° to 142° longitude and 14° to 44° latitude, with 1°x1° cells – approximately 36 mi²
2. Position each AIS signal within its corresponding grid cell
3. Calculate *hot_score*: total number of unique red flags, divided by the total count of unique vessels
4. Aggregate together each hours *hot_score* per grid cell and obtain a total
5. Assign a color gradient to each grid cell based on these scores

September 1st, Day 1



Goal:

Explore how AIS data be used to aid in IUU fishing net detection

Modeling Approaches ✎

⟶ UNSUPERVISED ⟵

- Treats dataset as truly unlabelled
- Performs iterative application of hierarchical density-based clustering
- Model develops 10 cluster groups of varying densities, with 3 distinct clusters as primarily illegal nets
- Proves: AIS positional features may serve as good indicators of IUU nets

⟶ SEMI-SUPERVISED ⟵

- Manually labels dataset based on created 'red flag' conditions
  - Illegal vessels chosen by having a bad naming convention and more than 3 red flags
- Trains on small sample of labelled AIS data
- Iteratively builds pseudo-labels on remaining observations and retrains on updated labelled dataset
- Employed with gradient boosted decision trees (XGBoost) and ANN

⟶ SUPERVISED ⟵

- Manually labels dataset based on created 'red flag' conditions
  - Illegal vessels chosen by having a bad naming convention and more than 3 red flags
- Uses pseudo-labeled training data once to build model
- Employed with fundamental ANN

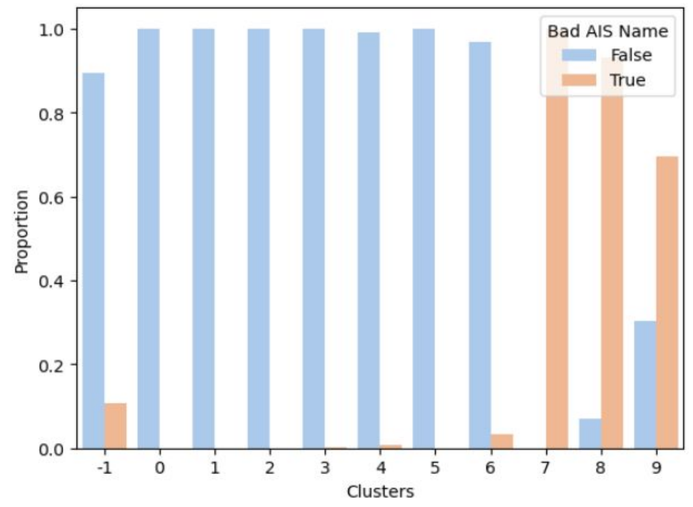
Results ✓

Model	Test Accuracy	TPR	TNR
Semi-supervised XGBoost	0.867	0.915	0.817
Semi-supervised ANN	0.853	0.899	0.805
ANN	0.844	0.920	0.764

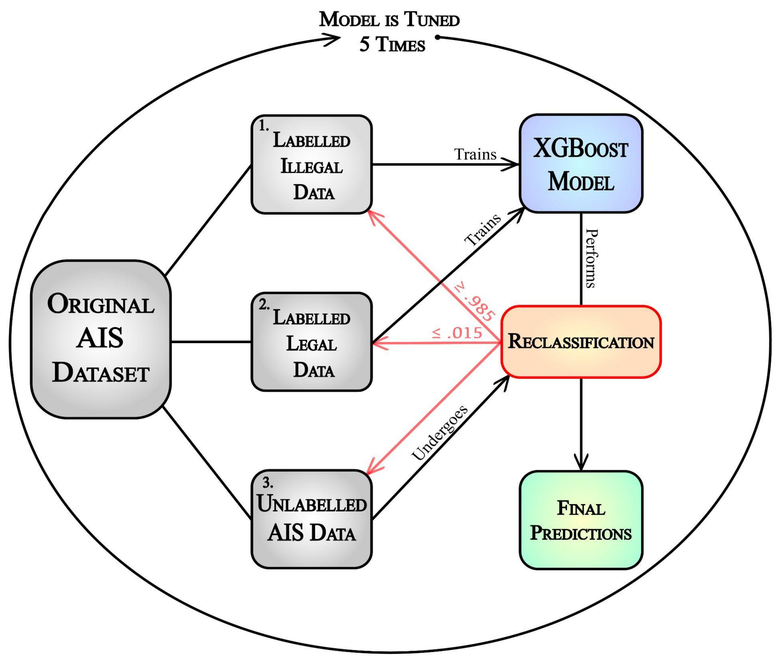
Future Work ↗

- Process a longer duration of AIS data
- Expand model applications to alternative, larger regions
- Explore a recurrent neural network (RNN) with AIS temporal data, then process with positional features

Clustering Analysis

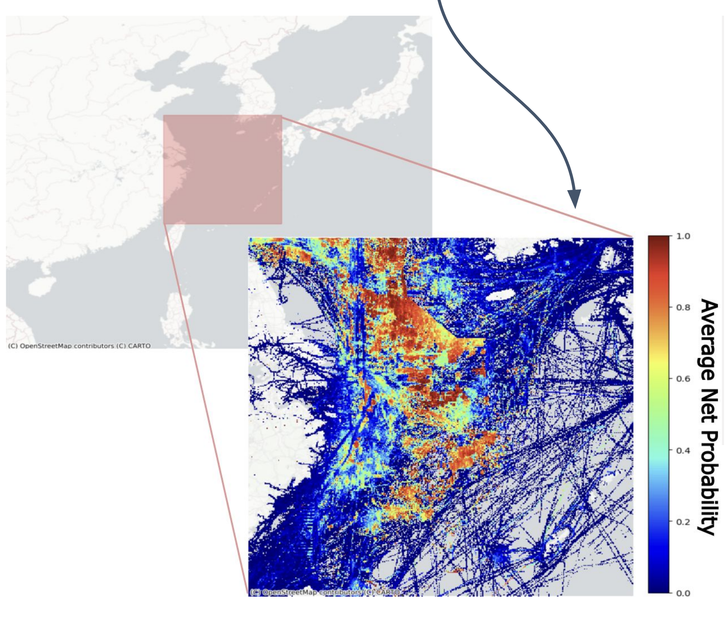


XGBoost Model Workflow



ANN Test Region Predictions

- Projecting 50 hours of data
- Output probability of 1 indicates illegal activity likely to have occurred in region
- Looking at restricted area



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