Ship Detection in Satellite Imagery

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Abstract

- A tool that intakes a start date, an end date, and area of interest and returns the number of ships for each date
- Uses Synthetic Aperture Radar (SAR) satellite imagery
- Split the problem into inshore/offshore
- Utilize current object detection models to detect ships in images

Background

Increase in Operating Satellites

*2021 data covers January-April   © 2021 Union of Concerned S...
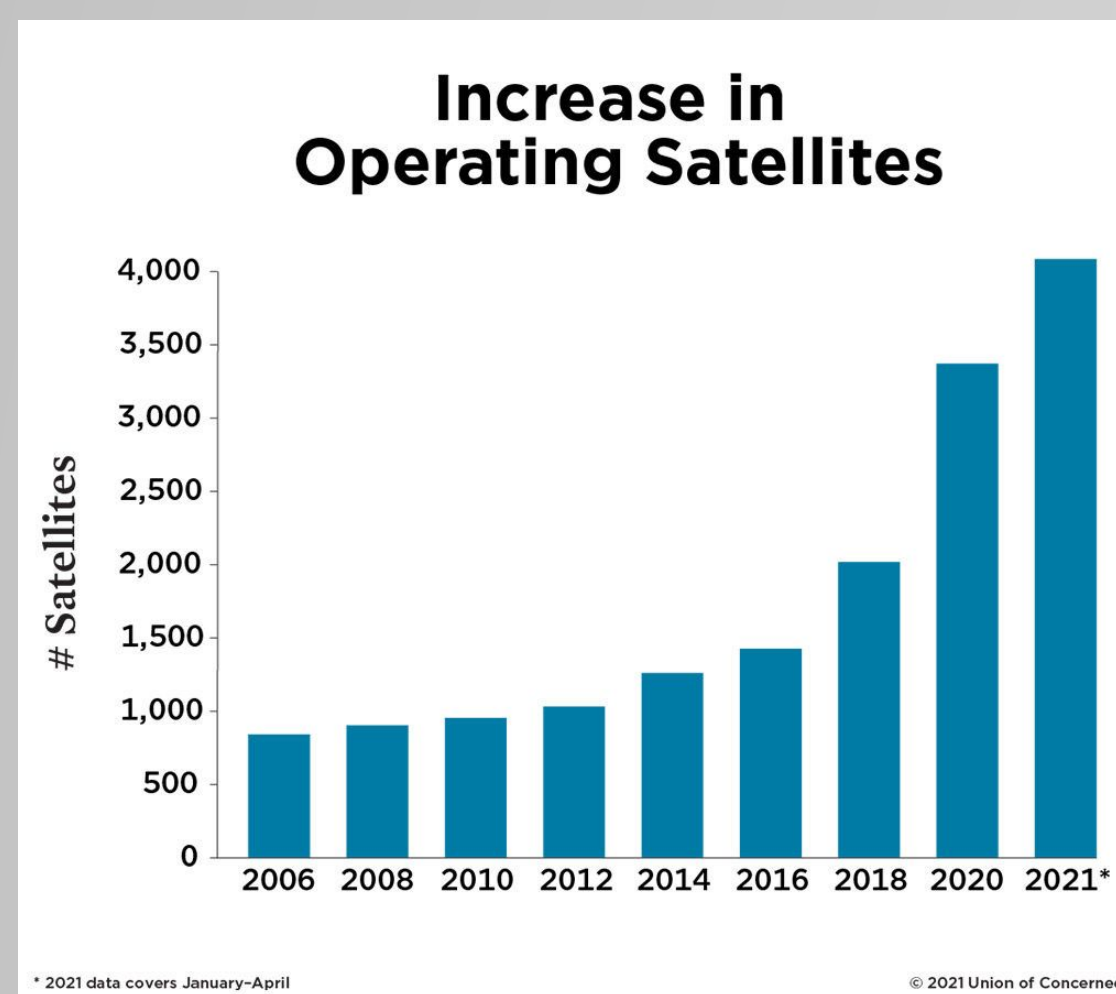
WHY SATELLITES?
- ~5,000 satellites orbiting Earth by the end of 2021
  - 1,700 satellites launched in 2021 alone
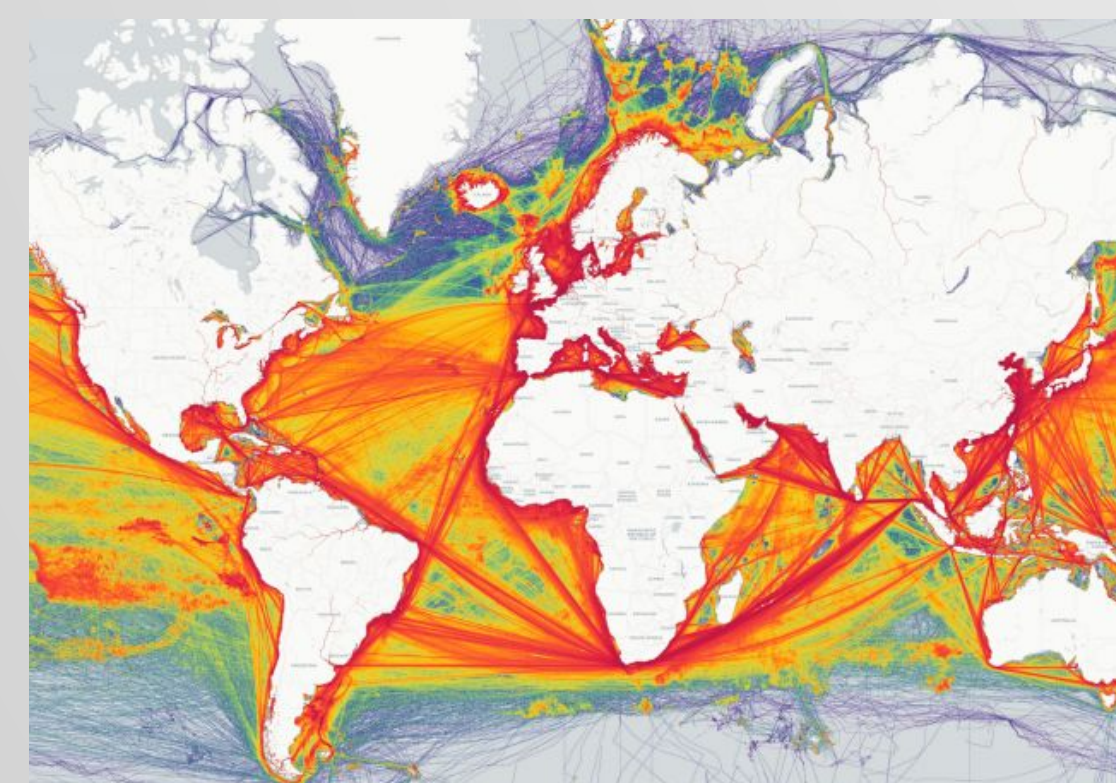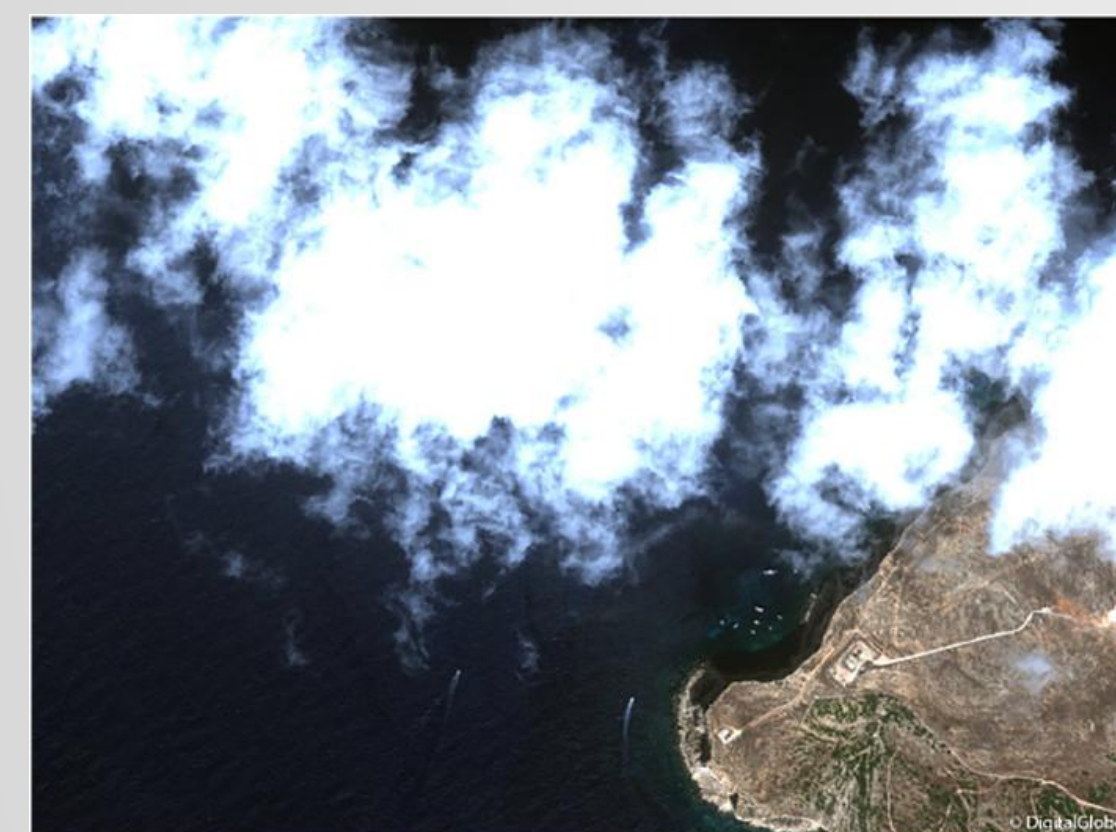
WHY SYNTHETIC APERTURE RADAR (SAR)?
- Optical satellites = high resolution, **but** sensitive to weather and time
- SAR uses radio waves to penetrate clouds and reflect off metal
- Spatial resolution: 20 meter per pixel
- Temporal Resolution: every 6 days

Why ships?
- 80% of the worlds goods travel by sea
- Give insight into military operations
- Rescue missions
- Economic modeling

Dataset

- Large-Scale SAR Ship Detection Dataset-v1.0
- 15 large scale images of size 24,000 x 16,000 pixels (10 train, 5 test) cut into 9000 equal sized pieces of 800 by 800 pixels to fit on GPU
- Expertly annotated using GIS data from ships
- ~60% of images are blank open water with no ships

	Inshore	Offshore	Totals
Ships	4%	16%	20%
No Ships	24%	56%	80%
Totals	28%	72%	100%

Methods and Workflow

Acquire raw SAR images
- Google Earth Engine API to download images of area of interest during given time frame

Preprocessing
- Clip pixel values between -20 & 0
  - Removes gray tint
- Zero-Pad Image
- Shard into 800x800 sub-images
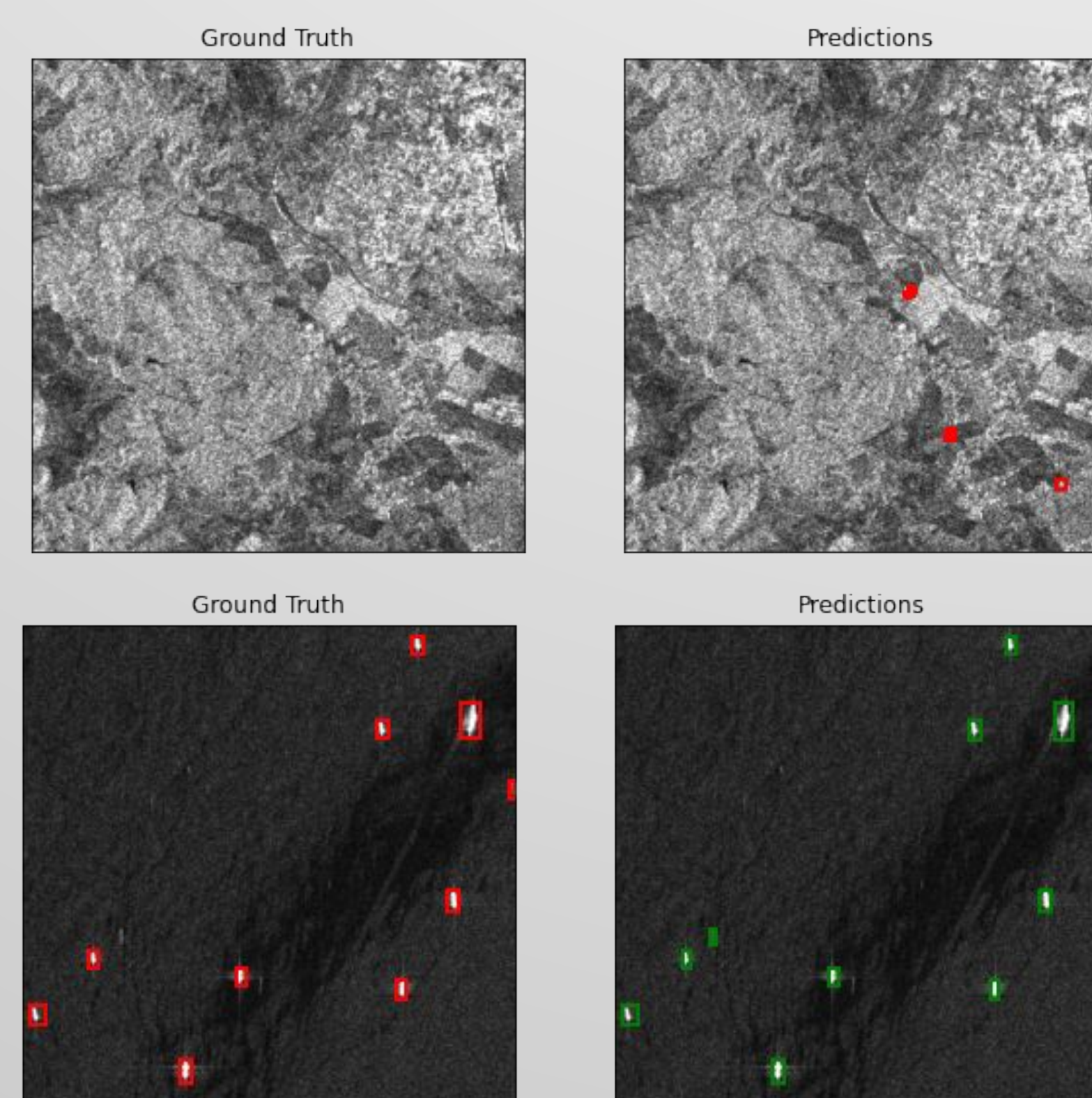
Inshore-Offshore Classifier
- Take in sub-image and classify whether it's inshore or offshore
- K-NN with 5 neighbors
- Used 30th, 50th, 80th and 90th percentile of pixels values as features

K-NN Classifier

0 - Inshore   1 - Offshore

Object Detection Models
- Inshore
  - Faster R-CNN
- Offshore
  - RetinaNet

Faster R-CNN   **RetinaNet**

Ship Count
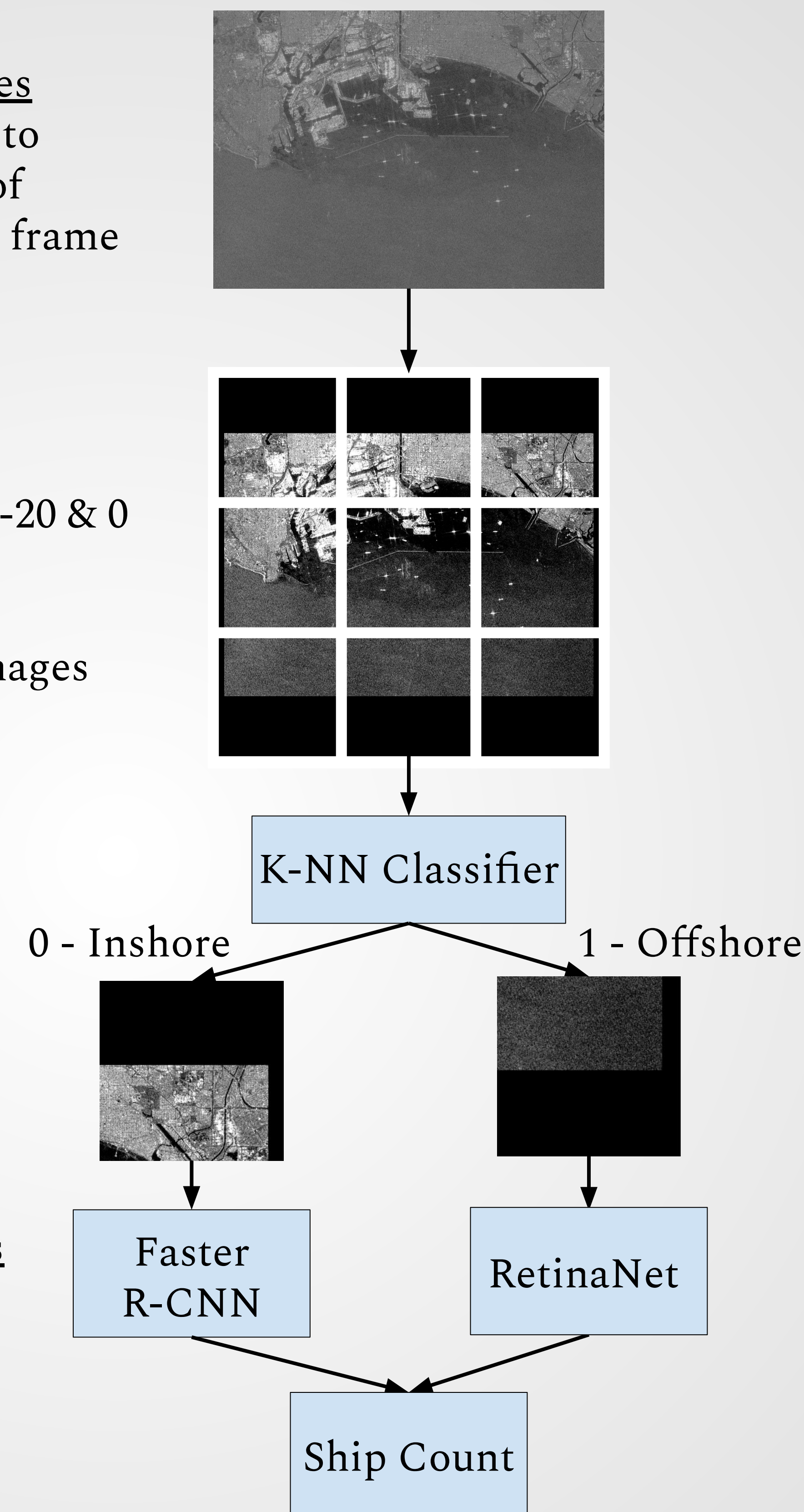
Faster R-CNN Test Set Predictions

Ground Truth   Predictions

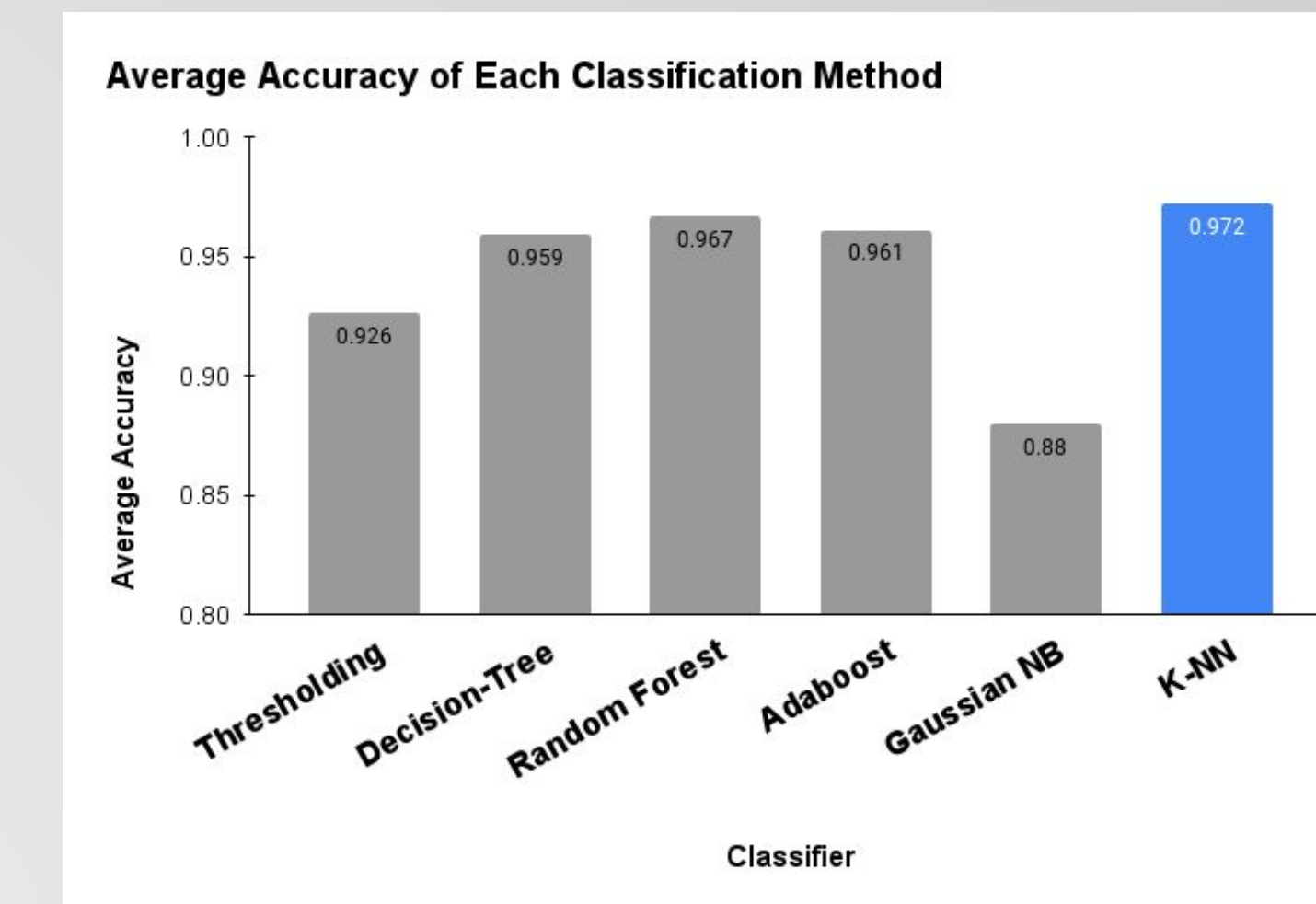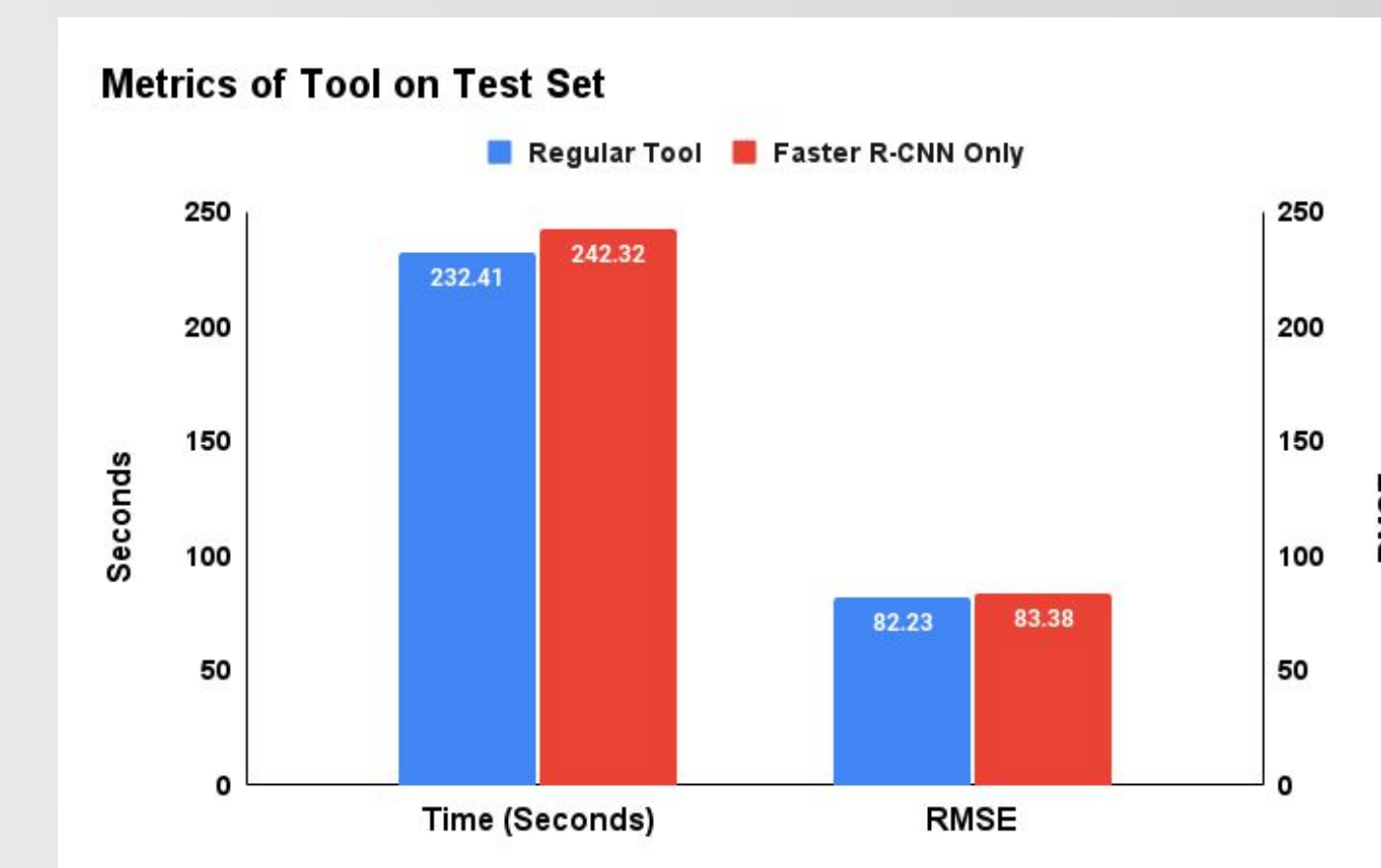Ground Truth   Predictions

Training
- Inshore-Offshore Classifier
  - Trained on 3000 labeled images
  - 70/30 train test split
  - Model metric: average accuracy score
  - Feature selection: 5-fold cross validation
- Object Detection
  - Trained on images with ships only (67/33) train test split
  - All models trained for 300 epochs
  - Other models considered:
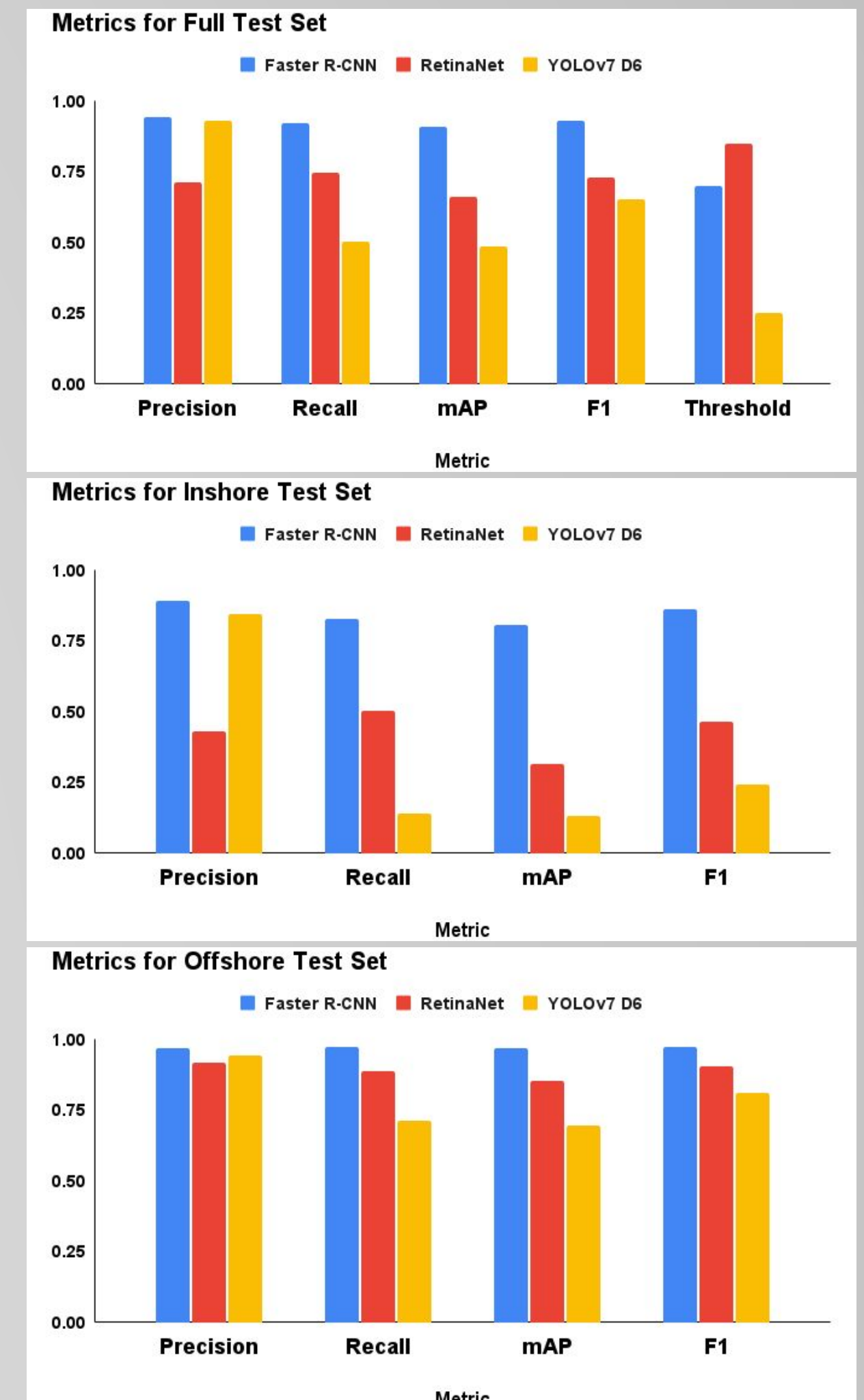   - YOLOv7 D6
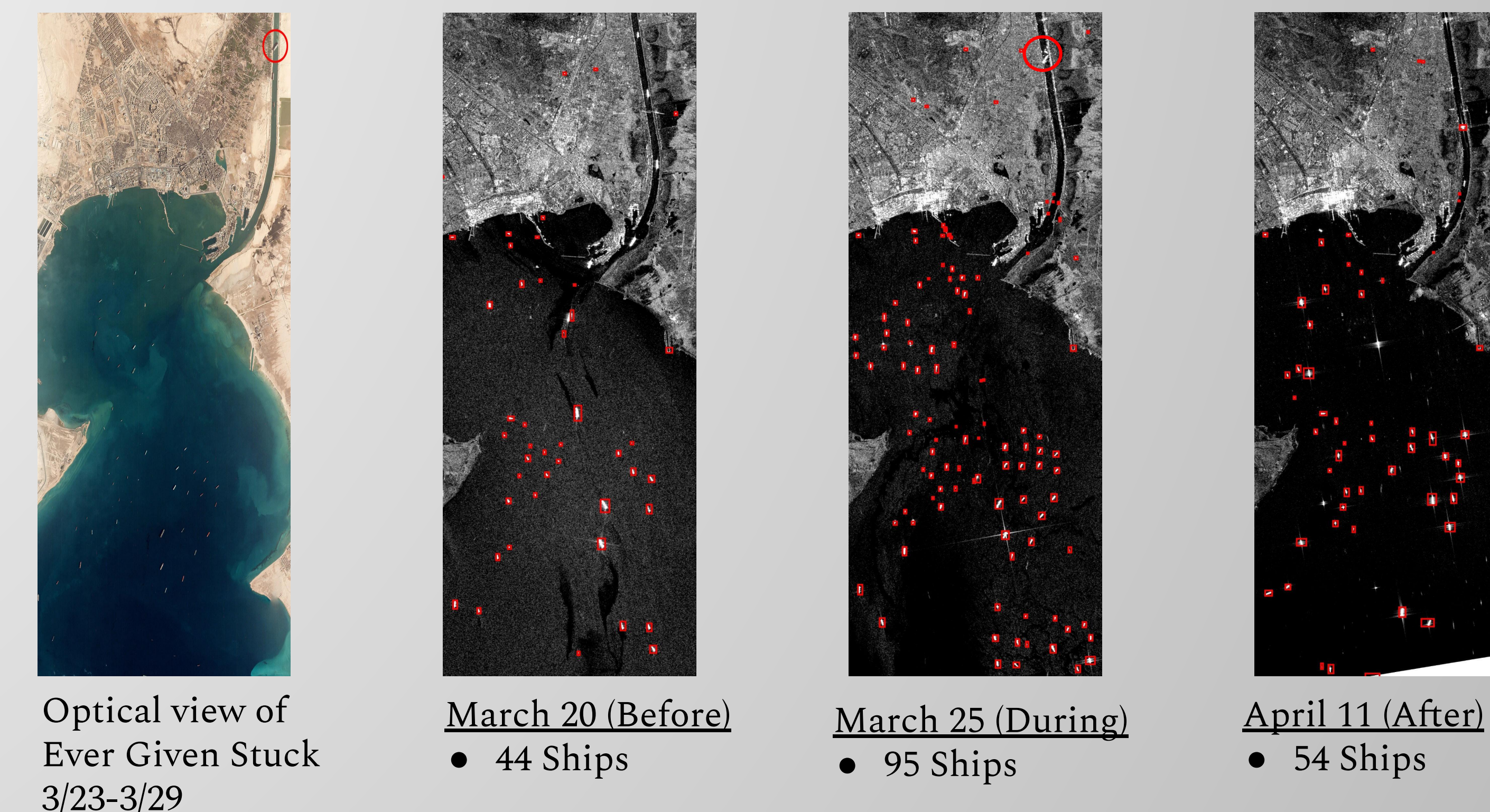   - YOLOv7 W6

Results

Inshore-Offshore Classifier

Average Accuracy of Each Classification Method

Object Detection Models

Metrics for Full Test Set

Metrics for Inshore Test Set

Application

Metrics of Tool on Test Set

Metrics for Offshore Test Set

Application

Ever Given ship stuck in the Suez Canal in 2021

Optical view of Ever Given Stuck 3/23-3/29

March 20 (Before)
- 44 Ships

March 25 (During)
- 95 Ships

April 11 (After)
- 54 Ships

Other Applications
- Detecting Illegal Activity
- Political Policy Effects
- Port Traffic Modeling
- Rescue Missions

Github   ## Website