Enhancing Maritime Coastal Security

Millend Roy, Abhinav Gautam, Aayush Sugandhi

OVERVIEW

Yes, Absolutely true.

Identification at sea continues to remain a challenge as coastal waters are highly crowded. Identification of a target boat midst large number of our own fishing boat and dense shipping traffic is very difficult. Unregulated fishing further complicates identification of friendly or foe.

Our Detailed Solution

Ideation

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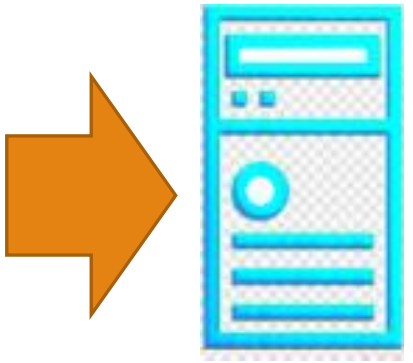


AIS

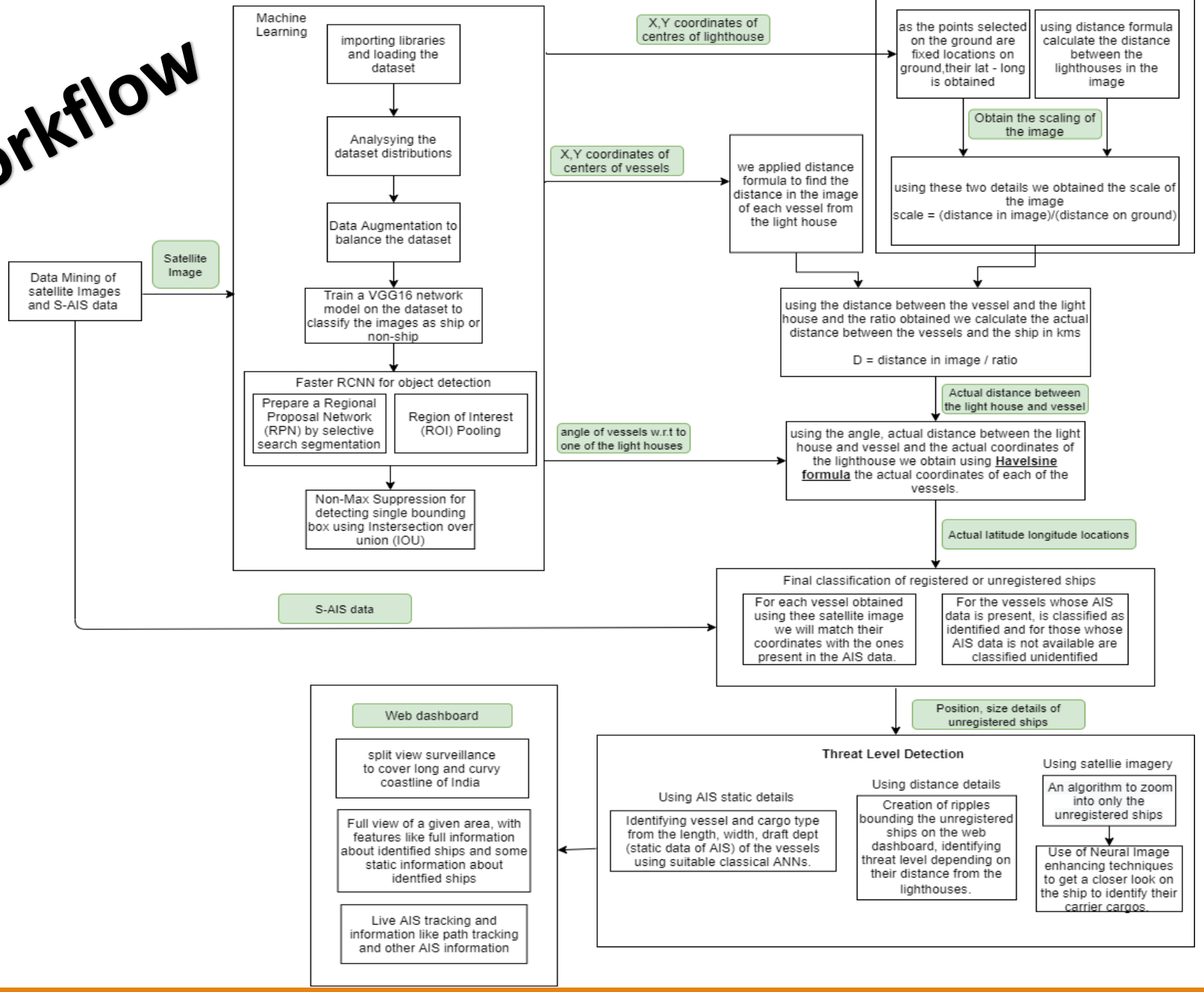
Satellite image data mining

Developing Machine Learning Object-detection Model

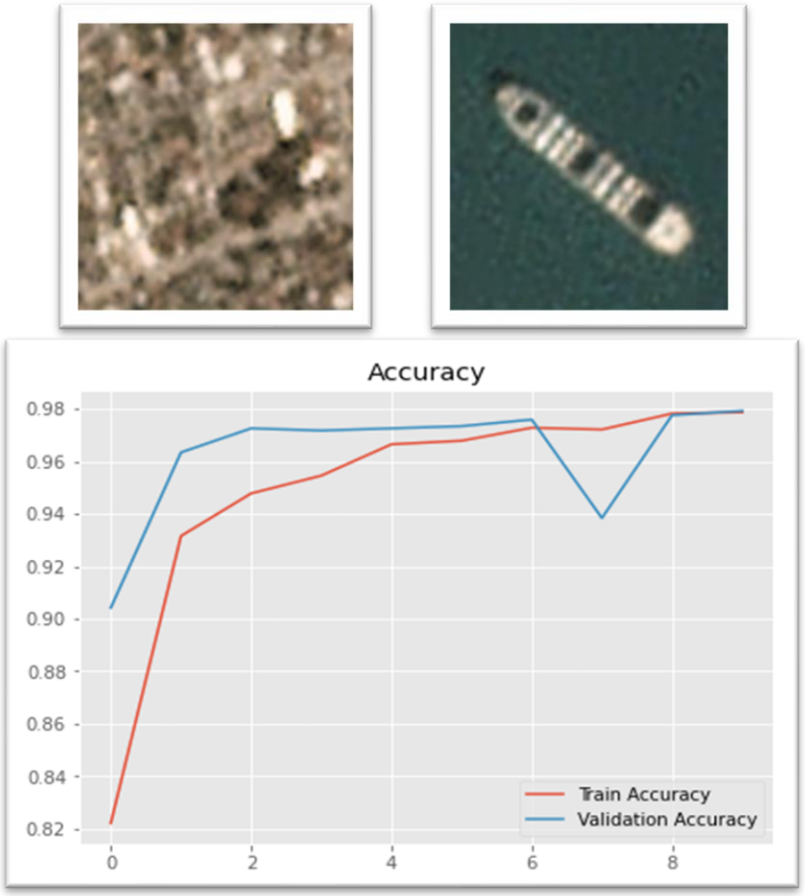
Synchronizing with AIS Data

Final Identification of registered and unregistered vessels on web-dashboard

Product Workflow

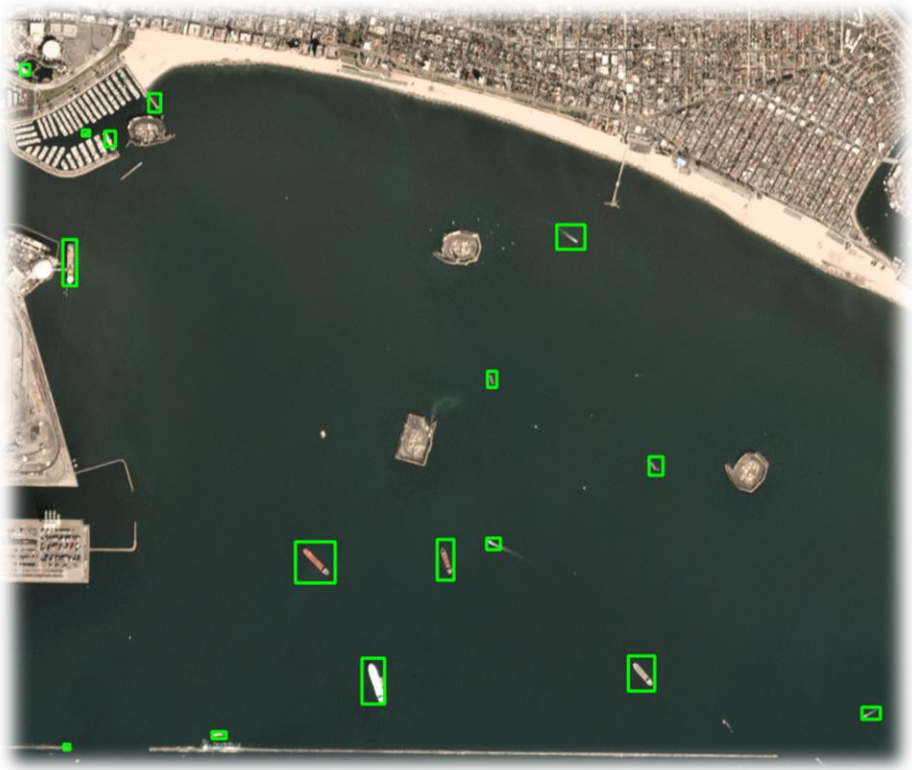


Detection of Vessels from Satellite Images - I



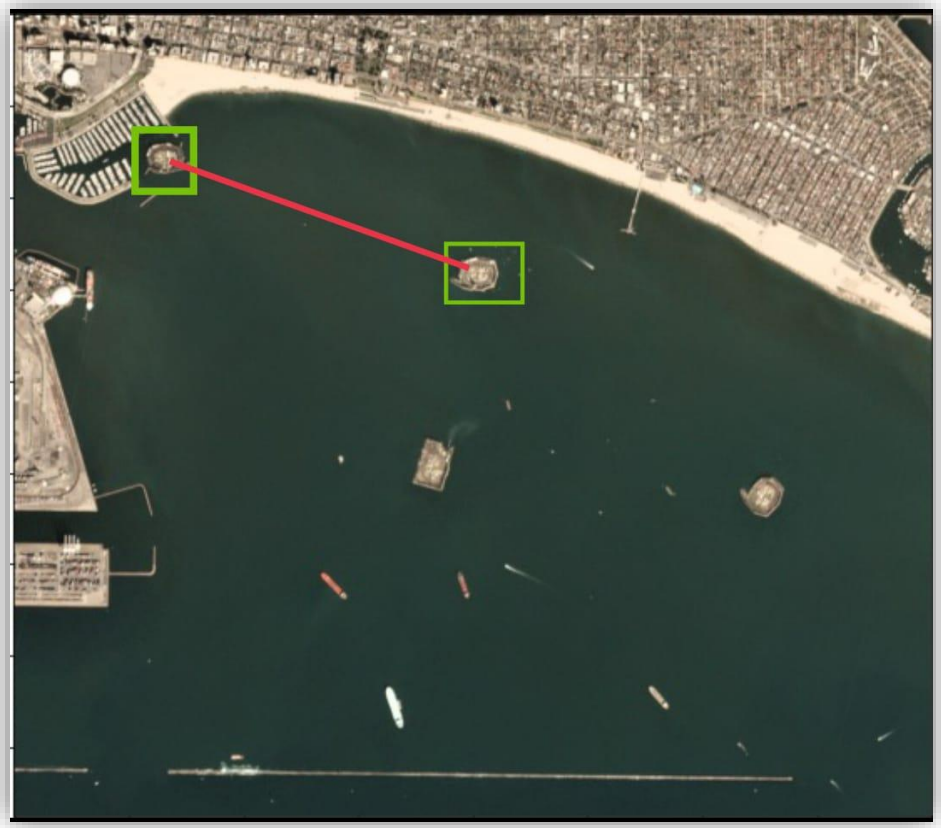
- The task of vessel detection requires classification and then object detection.
- Classification steps:
  - A dataset of cropped satellite images of ships (1000) and non-ships (3000) was downloaded from Kaggle-datasets.
  - Data Augmentation {Horizontal flips, random crops, strengthening and weakening of brightness and contrasts, applying affine transformations} was implemented so as to equalize the number of classes in the imbalanced dataset.
  - Trained on VGG16 network to create a classification model that classifies ships and non-ships with an accuracy of 0.98.
  - Finally, model saved for further use.

Detection of Vessels from Satellite Images - II



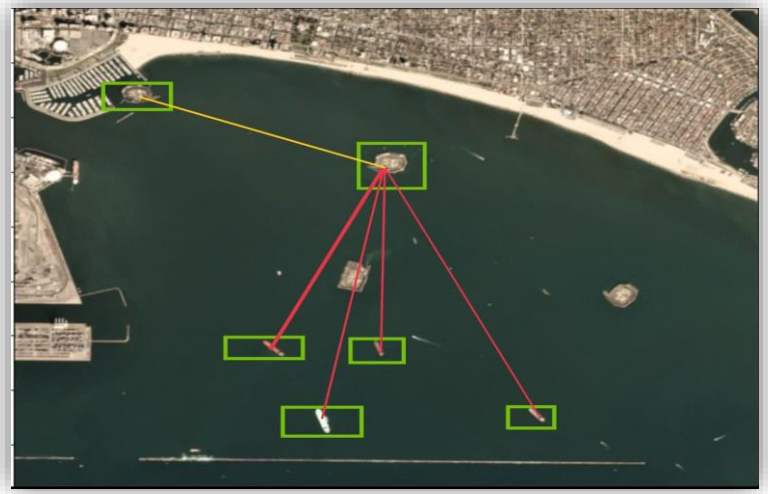
- Object Detection steps:
  - Available Scenes from the coastal regions of California and San Franscico Bay are used in the process.
  - Here, instead of running classification sequentially over the total image, a selective search segmentation method is used which distinguishes main region of interests (ROIs) and then the saved VGG16 classification model is run on that.
  - This makes the object detection algorithm faster since the model runs just over the predetermined proposed regions (Faster RCNN).
  - Since there is no ground truth data in real-scenario, instead of applying non-max suppression only Intersection over union thresholds are identified, which helps get rid of the unnecessary bounding boxes.

Setting Virtual Lighthouses



- We will setup virtual lighthouses by choosing some of the points on the land near the waters.
- Then we will use the distance between any of these two lighthouses to calculate the scale of the image.
- We have used a small assumption here that there will always at least 2 points in the image of which we know the coordinates in advance.

Using Lighthouses to find coordinates of vessels



- We will use one of the lighthouses and find the distance and bearing angle of all the vessels identified in the image.
- Then we will calculate the actual distance using the map scale as described in the previous slide.
- We will use the following formula for generating the coordinates of the vessels using coordinates of the light house , distance and bearing angle.

$$lat2 = \arcsin(\sin(lat1)*\cos(d/R) + \cos(lat1)*\sin(d/R)*\cos(\theta))$$

$$lon2 = lon1 + \operatorname{atan2}(\sin(\theta)*\sin(d/R)*\cos(lat1), \cos(d/R)-\sin(lat1)*\sin(lat2))$$

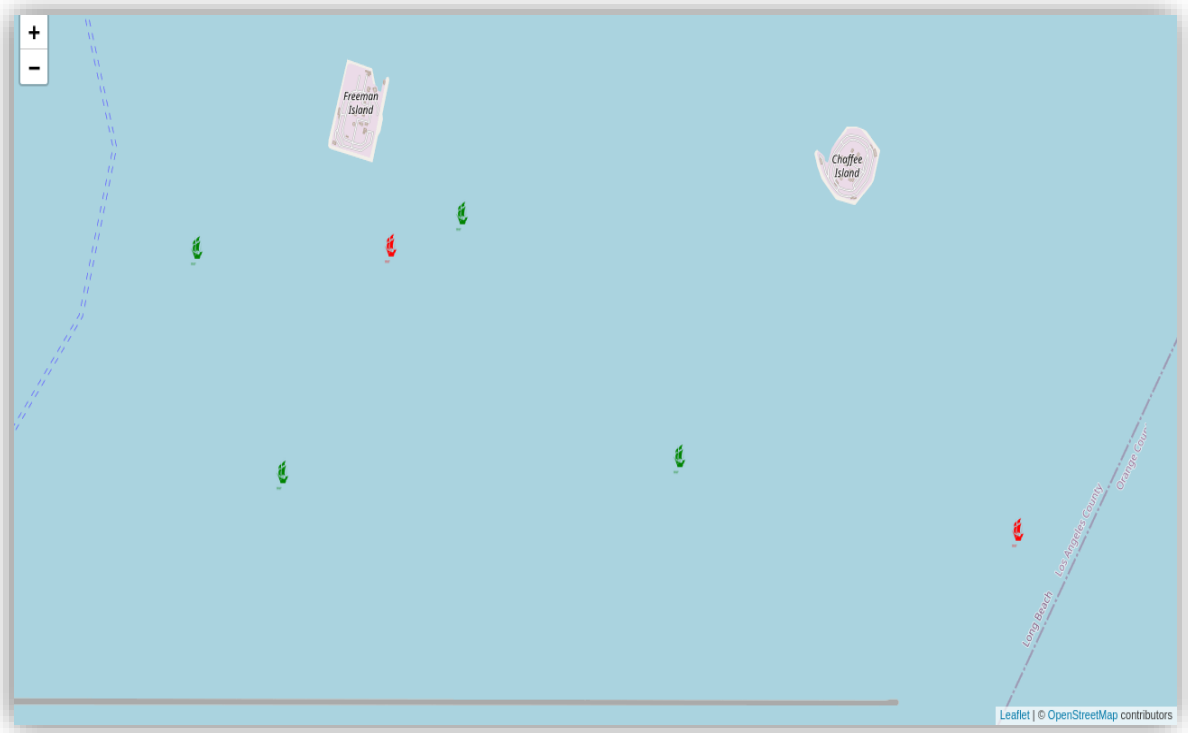
```
asin          = arc sin()
d             = distance (in any unit)
R             = Radius of the earth (in the same unit as above)
and hence d/r = is the angular distance (in radians)
atan2(a,b)    = arc tan(b/a)
θ is the bearing (in radians, clockwise from north);
```

Matching with the AIS data for confirmation

A	B	C	D
MMSI	BaseDateTime	LAT	LON
368636409	2019-12-31T00:00:00	33.7343884	-118.1695653
316003982	2019-12-31T00:00:00	33.7274275	-118.1654614
366845000	2019-12-31T00:00:00	33.7344714	-118.1603183
367350050	2019-12-31T00:00:00	33.7354877	-118.1569457
366950020	2019-12-31T00:00:00	33.7535956	-118.1515081
367771050	2019-12-31T00:00:00	33.7279289	-118.1465791
367567350	2019-12-31T00:00:00	33.7256534	-118.1305097

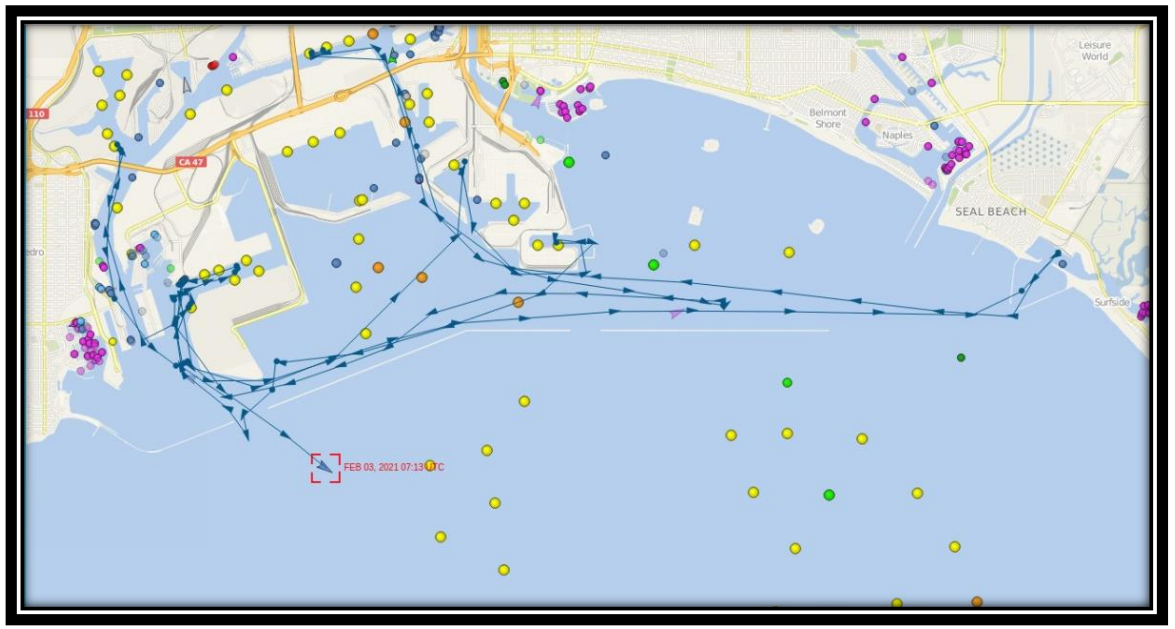
- We match the coordinates of the vessels obtained using satellite images with the AIS data available.
- If we find a vessel which is there on the satellite image but not on the AIS data, we flag that vessel, and the corresponding data is shown on the frontend.

Showing the registered and unregistered vessels within 12 NM boundaries



- After obtaining the coordinates of the vessels, we plot their locations on the map in the dashboard.
- It shows the live location of all the vessels in the 12NM of territorial waters.
- The map refreshes automatically every 10sec for live feed user experience.
- We have divided the map into 5 frames for clearer, zoomed and more accurate view.

LIVE-WEB DASHBOARD VIEW

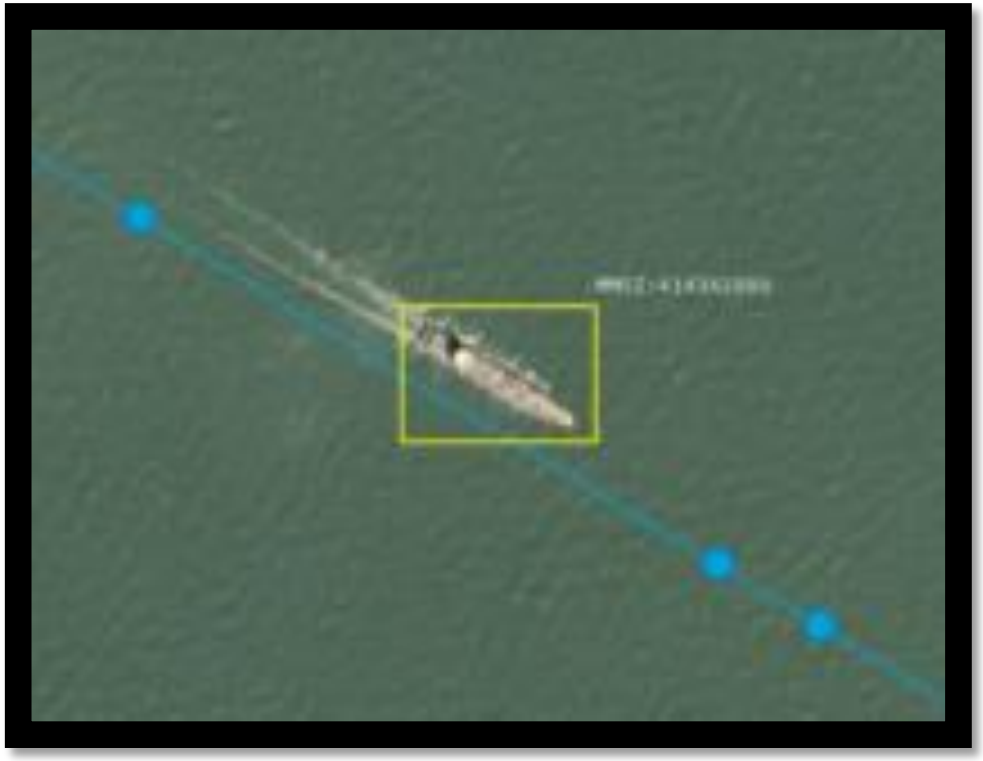


- The live dashboard has a view of CCTV-surveillance for better user experience
- Here we will show the live status of the territorial waters of the India(nation under consideration).
- Here there will be feature of zooming into each of the views for detailed information.
- Path plotting for the ships are also shown when clicked on based on the time framed AIS data locations.

Dashboard View of Registered and Unregistered Ship Clusters

- The red ship clusters show that they are unregistered and their ship details are not present in the AIS data. Therefore, when clicked on, we get the exact location and size details derived from the detection algorithm.
- The green ship clusters show that they are registered and when clicked on, we get all the details of the ship achieved from the S-AIS data (including MMSI, location, IMO, size details, transceiver class)

Future Scope



PAIR with real-time AIS and maritime datasets can help provide:

- *Better understanding of movement and vessel activity at sea.*
- *Monitoring for activity where AIS signal has been turned off or lost by forecasting course prediction and tracking their changes in heading angle from real time synchronized data.*
- *Observation of dark activity by validating with the corresponding AIS data and protection against spoofing.*