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Maritime Security - Illegal Fishing Detection Using Deep Learning

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***Abstract*— Illegal fishing is an unresolved and internationally pervasive problem that occurs both on the high seas and in areas within national jurisdiction. Existing technologies use anomaly detection algorithms that examine the data from Automatic Identification System (AIS) and radar cameras having long range. It is capable of covering 44.4km. These algorithms also include clustering, density- based methods, or neural networks that are used to identify unusual behavior or patterns in fishing vessel data. These algorithms can flag vessels that deviate from typical fishing patterns, helping authorities target suspicious activities. However, they fail to identify the complex patterns and accurately detect illegal fishing. We propose a system that increases the accuracy of algorithms by identifying complex patterns to send an alert to respective authorities. These alerts play a role in decreasing illegal fishing to some extent. Based on [1] US Food and Agriculture Organization's illegal fishing activities have an economic value of US$10- 23 billion (estimates) and are responsible for the loss of 11-26 million tons of fish every year. We are proposing a system based on remote sensing data i.e., satellite images with higher resolution**

Keywords*— *Illegal fishing, vessel, Deep Learning, Remote sensing, alerts

I. INTRODUCTION

Marine life is one of the most biologically diverse on the earth. It covers up to 71 percent of oceans on land [2]. In the year 2021-2022, the total of India's fish production is 162.4 lakh tonnes, nearly 15 lakh tonnes more than 2020- 2021 production.

Illegal fishing (IUU) is a major threat to the marine ecosystem and economy of the country. Fishing without a license, fishing during the breeding phase, and fishing in prohibited areas comes under IUU fishing. The illegal fishing rate in India is about 25 percent of total fishing. In 2023, illegal fishing rank of India is 52 out of 152 countries in the world. In India, fishing is prohibited beyond 15km from the coastal line. So the proposed system calculates the distance of a boat from land to its zone. If the distance exceeds the limit it classifies it as illegal fishing. The ultimate objective is to create a robust early warning system capable of alerting the corresponding authorities about potential illegal fishing activities with a high degree of precision. It is a combination of satellite imagery analysis and deep learning algorithms-**YOLOv5** to detect illegal fishing and perform targeted actions.

The motivation behind this research is to protect oceans and preserve marine biodiversity. The integration of remote sensing technologies with deep learning techniques enhances the accuracy, and scalability of detection making it a better approach for tackling IUU fishing. The paper provides an in- depth exploration of tools, and datasets followed by methodology and obstacles with satellite images and future work.

II. LITERATURE SURVEY

Monitoring of illegal fishing in oceans is time-consuming and logistically challenging for maritime authorities to patrol. GPS is required to track the exact position of a vessel. It becomes difficult because vessels will turn off their GPS transponders and go undetected or may manipulate their location -"Spoofing"[4].

Detecting vessels i.e., spoofing by Automatic Identification System(AIS) will provide information of past details[5].

Ousman K. L. Drammeh et al. [6], proposed illegal, unreported, unregulated fishing in underdeveloped and developing countries, and how they were unable to find IUU. The authors did not propose anything related to detection and prevention techniques related to the reduction of illegal fishing.

The author [7] proposed a system using the information obtained from 4 satellites to calculate the latitude, longitude, altitude, and time of the vessels. They proposed a system by mapping the current location of the vessel with the restricted areas API to detect illegal fishing. This method requires more information and this model is currently implemented in Western countries only.

Saeed Arasteh et al. [8] detected the patterns of vessels using longitudinal data and AIS vessel data. The author has used AI technology to find complex patterns in the AIS

vessel data. But this approach requires more money and storage as we have to maintain vessel data.

III. METHODLOGY

Illegal fishing may occur in many ways as mentioned in the introduction part. Of those conditions, the project mainly works on the condition distance from the coastal line up to how much distance a boat can go and fish. In Andhra Pradesh, the restricted distance for fishing is 12 nautical miles i.e. 22.224 kilometres whereas 1 nautical mile is 1.852 kilometres. The project proposes a model to detect vessels that are approximately 23 kilometres away from the coastal line. Fig.1 depicts how the model is going to find how much distance the vessel is from the coastal line. If it is greater than 23 kilometres an alert will be sent to the coastal guard.

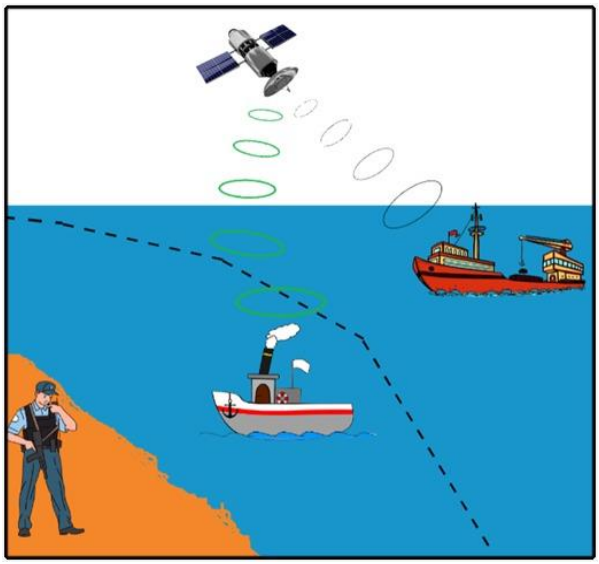

Fig.1. Working of Proposed Model

In this model, firstly consider the Satellite images collected from Google Pro Earth.

Google Pro Earth can provide images with a resolution of [9] [10]

- Current imagery: 15 meters to 15 centimetres
- Historical imagery: 15 meters to 100 meters
- Street View imagery: 0.15 meters to 10 meters

Fig.1 describes how the proposed model works.

We are taking a certain distance i.e. legal for fishing then the boat is considered as legal denoted by green rings.The ship which is at a distance greater than legal fishing are considered illegal and denoted by black color rings and whenever the boats are detected in illegal ranges a notification will be sent to the coastal guard.

Figure 2 describes the sample image taken for testing process.

Fig.2. Image taken for testing

A. *Proposed System*

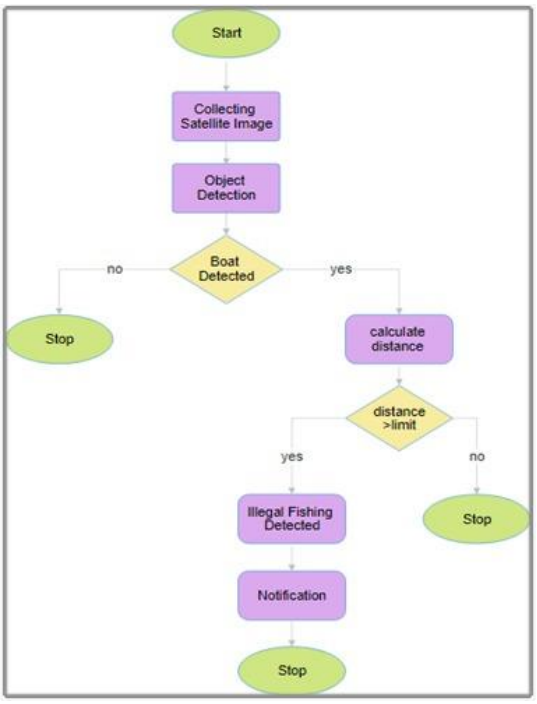

Fig. 3. Process of the model

Figure 3 describes about the flowchart of project by considering whether the boat is detected or not and then identifying distance.

B. *Packages*

In this project, the packages included are Opencv, PyTorch, and Numpy. Opencv is used for reading images as input **cv2.imread()**, to display output image **cv2_imshow()**, coordinating boxes **cv2.rectangle()**, saving output image. PyTorch is used for loading the yolov5 model **torch.hub.load()** function. Numpy is used for storing coordinate boxes and confidences.

C. *Object Detection*

For object detection, yolov5 is used. It is a pre-trained model that helps us to detect boats. Yolov5 is a pre-trained model with 1500 images. It helps us to decrease our time for training a model and to detect objects.

Fig.4. Object Detection

Figure 4 describes about detection of boat from the given sample image.

D. *Bounding Box Coordinates Conversion*

At this stage, the model is detecting ships in the satellite image which is given as input with representation of specific coordinates for each ship detected, indicating the box around the ship and confidence of the objects within the input image. These bounding boxes are assigned based on certain conditions like when ship is detected and separate bounding box to represent the illegal fishing ship when there are a large no of ships in one input image. For example, if the width of an image is 1000 pixels, a value of 0.9 would correspond to 90% of the image width, representing the position of an object within that image. PyTorch, a widely used framework, is employed for performing tensor operations that are essential for manipulating these bounding box coordinates.

E. *Conditions*

To identify instances of illegal fishing, we are currently examining specific conditions. We begin by assigning coordinates to the observed locations and then proceed to evaluate whether these coordinates fall within the range of 0 to 1, with a threshold of 0.9 being used to determine illegality. This criterion is based on our observation that the images we have captured originate from the coastal line and extend beyond the designated area for fishing, resulting in distances greater than 30 km. These conditions have been established to identify and address instances of illegal fishing in Andhra Pradesh. The satellite images which are given as input are far away from the India border so by applying these conditions the model can detect illegal fishing ship more accurately.

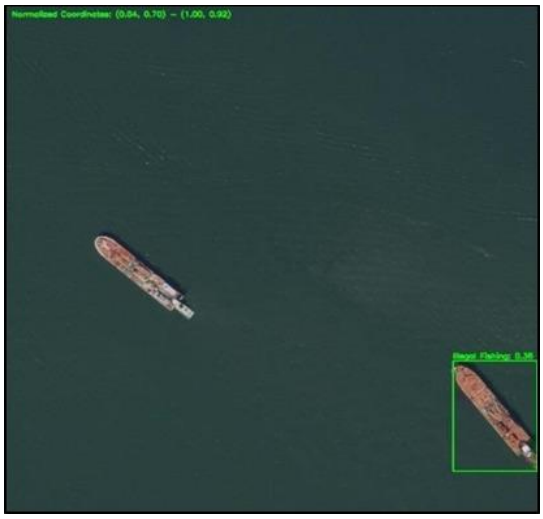

Fig.5. Detection of illegal fishing

Figure 5 shows that illegal fishing boat is detected by yolov5 algorithm.

F. *Notification to authorities*

The Telepot package is an essential tool for seamlessly integrating the model with Telegram via a Telegram Bot API. This API, specifically designed for Telegram, allows us to establish a connection between our model and the Telegram platform. By utilizing this integration, we can conveniently send the output of the detected boats directly to the Telegram platform, including accompanying images. This functionality ensures that users can receive real-time updates.

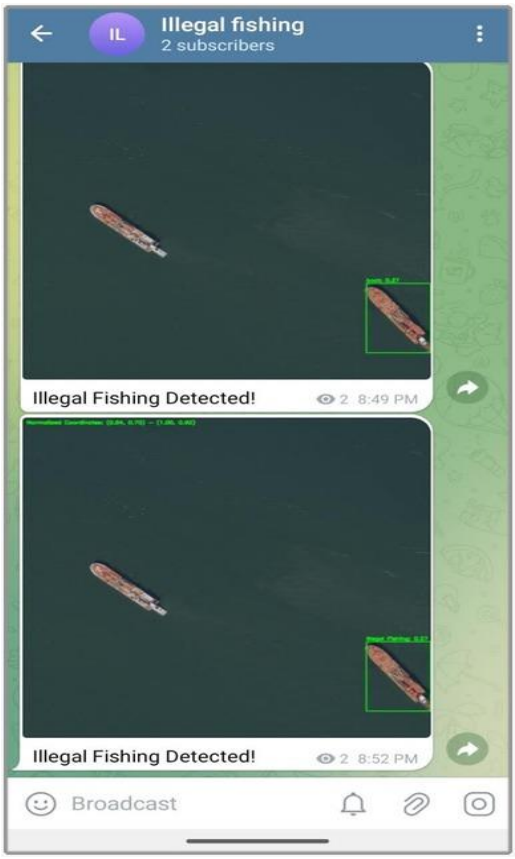

Fig.6. Telegram Notification

Figure 6 shows the alert given to the coastal guards along with image of the ship.

IV. RESULT

By using satellite images and the condition of distance we can detect whether illegal fishing is taking place. An immediate action taken at the time of illegal fishing may reduce the effect. It can be happened via telegram alert given to the authorities.

```
Predicted Boxes:
[[     169.54      460.28      361.84      638.12     0.75382          37]
 [     861.18      718.75      1023.4      942.97     0.35999          36]
 [     862.13      717.08      1023.3      938.11     0.28881          31]
 [     862.24      716.95      1023.2      938.31      0.2698          30]]
Confidence Scores:
[    0.75382     0.35999     0.28881      0.2698]
Ground Truth Box:
[100 150 300 400]
```

Fig.7.Performance Matrix

Figure 7 describes the Ground Truth Box values and Confidence Scores. Ground truth box gives the relative coordinates of the particular region. It is for hand-picked training.

The probability of detecting image correctly and the percentage is given by Confidence Score. It is calculated as an evaluation standard.

Figure 8 shows the accuracy obtained while detection of illegal fishing by deep learning

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Accuracy: 72.423405%
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Fig.8.Accuracy

TABLE I. COMPARITIVE ANALYSIS

Model	Accuracy
Random Forest	0.97
Gradient Boosting	0.97
Yolov7	0.729
Resnet	0.97
Yolov5	0.725

Table I describes different methods used to detect illegal fishing and their corresponding accuracy values.

V. SUMMARY

The illegal fishing detection project aims to support the Coastal security system by providing an alert system. The design of the problem aims to generate alerts while suspicious activities going on. This alert system awakens the guards and marks the geolocation of a particular vessel. The system enables real- time monitoring of Fishing activities, especially in the breeding and bad weather forecast times. The paper delineates the objectives, methodology, and outcomes of the expected structure. It mainly focuses on the benefits of using deep learning techniques along with real-time monitoring and generating alerts for professionals and coastal guards. Overall, the system addresses illegal Fishing detection, reducing economic loss through it and improving Legal Fishing activities.

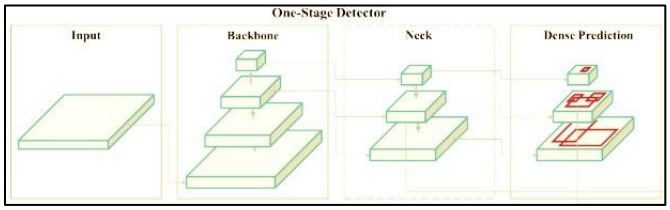

Fig.9. YOLOv5 architecture diagram

To perform the activity a deep learning method YOLOv5 algorithm is used. You Only Look Once used for detecting objects. It offers high accuracy rates. Depending upon the size the dataset YOLOv5 takes time to train as it has many variants like extra-large, large, small. It identifies small objects easily. Through input images features are created by YOLO v5 algorithm and draw the prediction boxes around the objects and classifies them. Input, Backbone, Head are main parts of the algorithm.

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