Ship Detection Using SAR Imagery

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***Abstract*—Ship detection plays an important role in marine transportation, fishery management, and maritime disaster rescue. Nowadays, the current researches almost are focusing on improving detection accuracy while detection speed is neglected. However, it is also extraordinarily important to increase the ship detection speed, because it can provide real-time ocean observation and timely ship rescue. Boat identification is also a very important and challenging task in maritime traffic monitoring, the difficulty of this task lies in the accurate positioning and identification of relatively small boats in complex scenes. Synthetic aperture radar (SAR) imagery has been used as a promising data source for monitoring maritime activities, and its application for oil and ship detection has been the focus of many previous research studies. Many object detection methods ranging from traditional to deep learning approaches have been proposed. However, majority of them are computationally intensive and have accuracy problems. The huge volume of the remote sensing data also brings a challenge for real time object detection. YOLO is a network for object detection. The detection task consists in determining the location on the image where certain objects are present, and classifying those objects. Previous methods for this, like R-CNN and its variations,used a pipeline to perform this task in multiple steps. This may be slow to run and also hard to optimize because each individual component must be trained separately. YOLO does it all with one neural network. You Only Look Once (YOLO) can be optimised to be used for ship detection. This algorithm makes it possible to do real time ship detection in an efficient manner. We are proposing a new and better method for ship detection using YOLO.**

***Index Terms*—- Detection, Identification, Synthetic aperture radar, You Only Look Once, Convolutional neural networks**

I. Introduction

With the development of economic globalization, maritime transportation is becoming more and more frequent. Due to complex shipping scenes, boat crossing, fog shielding and other problems, traffic accidents are constantly occurring. Ship detection has great demands in civil and military fields.For example, in the civil field, ship detection can supervise transportation, marine traffics and illegal smuggling. In the military field, one can monitor for cross-border smuggling or other illegal behaviors. However, traditional ship detection is based on naked eyes monitoring, which causes huge labor costs. Computer-aided detection method greatly saves the labor cost and improves detection efficiency at the same time. Nowadays, with the development of artificial intelligence technology, more and more experts begin to study the methods of ship detection based on data-driven and artificial intelligence. Probably a simple explanation to this fact comes from that artificial intelligence methods can automatically extract ship's features, avoiding the manual feature engineering of traditional methods, which greatly improves the detection efficiency. Synthetic aperture radar (SAR), an all-weather and all-time microwave sensor, is one of the most important tools in remote sensing filed. Up to now, many scholars have proposed many SAR ship detection methods, which have greatly promoted the development of SAR image interpretation. According to my survey, in SAR ship detection field, many scholars are focusing on improving the accuracy of ship detection while the detection speed is neglected. In fact, it is also extraordinarily important to increase the ship detection speed, because it can provide real-time ocean observation and timely ship rescue. Here we will look at various modifications that can be made to the YOLOv3 algorithm to optimize it for ship detection specifically. We will look at methods that not only improve the accuracy but also increase the speed of detection.

II. Literature Review

The literature review includes papers which covers almost all aspects of ship detection. The details of some papers are given here :

A. Ship Detection: An Improved YOLOv3 Method [1]

The main contributions of this method is to determine the anchor settings for the ship dataset by kmeans++ algorithm. Here we Design a convolutional neural network named Darknet ship to solve the problem of excessive YOLOv3 parameters. Embedding the Squeeze-and-Excitation module in YOLOv3 to increases the network's ability to extract global features.

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B. High-Speed Ship Detection In SAR Images By Improved YOLOv3 [2]

Up to now, many scholars have proposed many SAR ship detection methods, which have greatly promoted the development of SAR image interpretation. In this method they modify YOLOv3 to increase speed of detection without compromising the accuracy in ship detection from SAR images.Different from the original YOLOv3 where 20 types of targets need to be detected, SAR target detection this method contains only one class that is ship, so the reduction of network size does not significantly reduce accuracy by our research findings.

In this paper they improved YOLOv3 by reducing the size of the network to reduce time consumption which can further increase the detection speed.The detection speed of our improved YOLOv3 is 2.3 times faster than the original YOLOv3. This approach achieves high speed ship detection in SAR images, requiring only 24ms per image. The improvements made maintained the accuracy and at the same time increased speed of detection.

C. Using convolutional neural network approach for ship detection in Senital-1 SAR imagery [3]

In this method a Convolutional Neural Networks (CNNs) method, the Faster R-CNN VGG16 in a SAR based image to detect the location of ships. This methodology is designed to detect and categorize the ships in congested areas of seaports where ships are close to each other.

Here the images are cropped into a smaller size to apply to neural network process to detect ships. Faster R-CNN Vgg16 takes almost 24 hours to complete the process with 30 images Ships are categorized into small medium and big. This method helps to maintain a real time surveillance of ships with its size and route.

D. Significance of ship based detection from SAR imagery [4]

Synthetic Aperture Radar images have potential applications in the surveillance scenario which is a useful tool in monitoring and crime control as well as in marine traffic management. Ships can be easily discerned in the SAR images due to their bright intensity which results due to the strong radar back - scatter from their metal surface. But presence of speckle noise, sea ice and coastline structure, the ship detection process is affected since these non-ship features in the sea also exhibit high intensities in the SAR image. So this paper is proposed to differentiate ship and non ship targets.

The experimentation of the proposed work was carried out using seven SENTINEL 1A SAR images. The algorithm used is simple and easy to implement. To reduce the complexity of target detection process, only the significant points which are the brightest points in the SAR image are identified and used for discrimination process, thus strengthening the efficacy of the proposed algorithm.

E. Classification of Patterns [5]

First step in classifying patterns is image denoising which is followed by feature extraction and classification. Here Non Local Means filter method is used for denoising This proposed method uses the features of Local Binary Patterns (LBP), RGB color space, HSV color space. Denoising is done due to the speckle noise found in SAR images which causes loss of the fine features required for pattern classification. Pattern classification can be done with the help of feature extraction obtained from the region of interest.

Proposed algorithm is based on the fusion of three features for SAR image classification. Three feature extraction method is applied on the input image Input image contains different patterns which are highlighted using different colours in the output. Results from this proposed method reveal improvements in terms of accuracy in classifying different patterns in SAR images.

III. Proposed System

In this project we provide a High speed ship detection system using YOLOv5. Fast detection means we can have real time detection is possible. SAR images are used so that we can detect ships even in adverse weather conditions. As result we would obtain bounding boxes for all the ships located with in a SAR image.

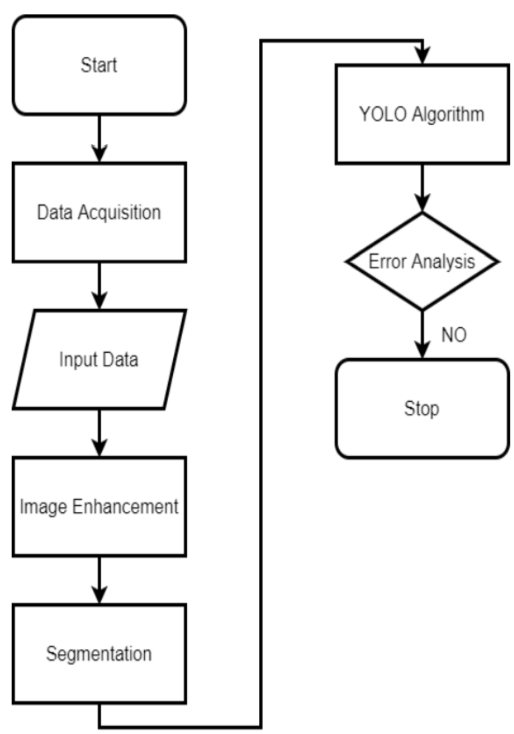

Fig. 1. Flow Chart

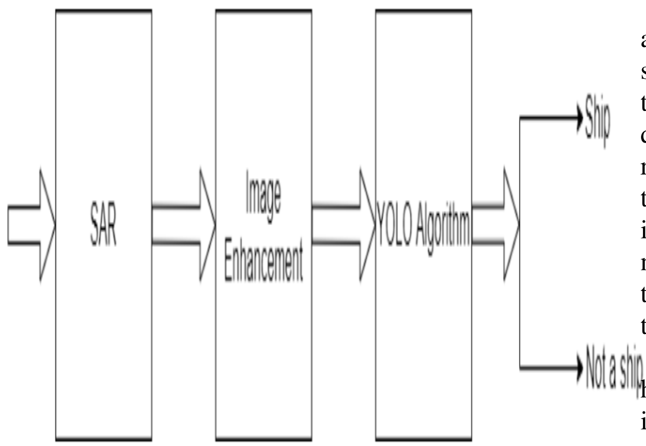

Fig. 2. Architecture

The different modules of the system are as follows:

A. Data Acquisition Module

A large number of SAR images of ships are collected. In order to make the model as versatile as possible we use SAR images that come from different satellites, different polarization modes and different resolutions. Moreover, the backgrounds of ships are various. This ensures that the dataset is diverse and that the model can be used in various settings and can detect ships that are in various different backgrounds and locations.

Here the HRSID Database is used. High resolution sar images dataset (HRSID) is a data set for ship detection, semantic segmentation, and instance segmentation tasks in highresolution SAR images. This dataset contains a total of 5604 high-resolution SAR images and 16951 ship instances. HRSID dataset draws on the construction process of the Microsoft Common Objects in Context (COCO) datasets, including SAR images with different resolutions, polarizations, sea conditions, sea areas, and coastal ports. This dataset is a benchmark for researchers to evaluate their approaches. For HRSID, the resolution of SAR images is as follows: 0.5m, 1 m, and 3 m.

In order to evaluate the effect of different methodological choices, we prepared three standard data sets for training and prediction:
D1: The standard training gives the model an insight into different types of scenarios where ships can be detected and identified. Different SAR image sets have been provided for this purpose.
D2:The prediction set or validation set includes the rest 30 percentage of the training set.
D3: The test set will be the overall leftover 20 percentage of the dataset, which we set aside for the final evaluation.

B. Image Enhancement Module

The SAR images like any other radar technology will have a lot of noise. Synthetic Aperture Radar (SAR) images are strongly corrupted by the speckle noise due to random electromagnetic waves interference. The speckle noise reduces the quality of images and makes their interpretation and analysis really difficult, so it's necessary to filter images to remove the noise in order to preserve as much as possible the most important features of the signal. It is important to remove this noise before these images are used for ship detection because they may cause variations in our model and training. So In this module we will remove that unwanted noise.

SAR images in the dataset will be of various sizes and we have to resize those images to our required size. This process is also done in this module. All the images are resized to fit our requirement.We use the HRSID database for our project. Initially the database was in the MS COCO format, that is the annotations were in the form of a Json file. We converted this file to the YOLO format. In the YOLO format each image has a text file containing the annotations. The text file will have the same name as the image file. All the images in the database were then resized to 416x416 to make the training easier. YOLO can be best trained when the size of the image is a multiple of 32.

Various image augmentation steps were added to vary the images slightly. We added +/-5 percentage noise , +/- 3 percentage brightness and +/-3 percentage contrast. Other augmentation types like reshape and mosaic were avoided as those kinds of images will not be produced in SAR and also they had a negative impact on the performance of the model.

C. Ship Detection Module

This module identifies the presence and location of the given SAR images. This is done with the help of YOLO algorithm. YOLO uses a totally different approach. YOLO is a clever convolutional neural network (CNN) for doing object detection in real-time. The algorithm applies a single neural network to the full image, and then divides the image into regions and predicts bounding boxes and probabilities for each region. These bounding boxes are weighted by the predicted probabilities. With YOLO, a single CNN simultaneously predicts multiple bounding boxes and class probabilities for those boxes. YOLO trains on full images and directly optimizes detection performance.

This model uses YOLOv5 that is the latest version of YOLO. YOLOv5 has multiple versions available, of which here the smallest model is used which is YOLOv5s. This verion is also the fastest and more than sufficient as there is only one class that we need to identify which is ship.

The HRSID database contains more than 5000 images. After we applied the augmentation steps the total number of images came up to more than 15000. We trained our model with 70 percentage of the images. We then reduced the size of each layer and also the number of layers so as to prevent the model from over fitting. This also increased the efficiency of the model. The model depth multiple was set to 0.32 and the layer channel multiple was set to 0.24. It reduced the GPU usage, CPU usage and memory usage. This helped increase the accuracy of the model and make the model much faster. The model was trained only for 60 epochs. The best result was obtained in epoch 33 but we let it run a little longer to see if a better result could be obtained.

The size and location of the ship is calculated using the bounding box details produced by the model after it is used for detection. The size is calculated in terms of the number of pixels covered by the ship. The location of the ship is calculated by assuming a coordinate for the bottom left corner and top right corner of the image. This is used to calculate the exact location of all the ships identified in the image.

IV. Results and Discussions

A ship detection system based on YOLO was created The system will detect ships from SAR images. The system will be both fast and accurate to provide an accuracy of about 93.6 percentage. It will be effective in different weather condition. The Accuracy, Precision, Recall and map are used for evaluating the performance of the system. All the ships with in an image with their size and locations are obtained.

With each consecutive Epoch the precision, recall and mean average precision slowly increases. To avoid over-fitting 60 Epochs were used. the model got a precision of 93.6best thing is it only takes an average of 10ms to detect ships in an image. This shows that the model is both fast and accurate. The model is better than other similar models in both respects.

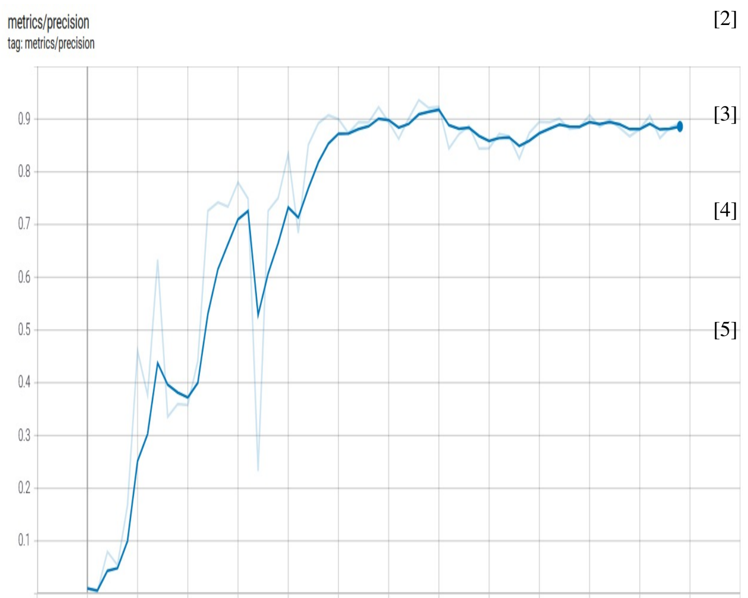

Fig. 3. Precision

After the ships have been identified in a given image, a text file of the same name is created that contains the X and Y coordinates of one point of the ship, length, breadth, size (in pixels), longitude and latitude. The size and location were calculated from the bounding box details received from the model.

V. Future Works and Conclusions

This YOLO based ship detection system can be used in different purposes like disaster management, military use, port authorities, surveillance, etc. This system can be used in different weather conditions like during fog, rain, storm, cyclone, etc. The system is both fast and accurate so it can also be used for real time monitorin Ships are detected by applying our model on SAR images. All the ships within an image are detected along with this their size and location are also identified. Our model has 93.6 percentage accuracy. The system is very fast and uses less amount of resources.

In the future, we can try to modify the system to not only get the size and location of the ship but also to compare various images spanning across a given timeline to track the route of any given ship. This can help in figuring out the cause of certain shipwrecks and missing ships. It is also possible to calculate the speed of the ship from the wave. we also plan to try and implement GIS into our project.

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