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**Jyothi** Engineering College  
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A CENTRE OF EXCELLENCE IN SCIENCE & TECHNOLOGY BY THE CATHOLIC ARCHDIOCESE OF TRICHUR



NBA accredited B.Tech Programmes in Computer Science & Engineering, Electronics & Communication Engineering, Electrical & Electronics Engineering and Mechanical Engineering valid for the academic years 2016-2022. NBA accredited B.Tech Programme in Civil Engineering valid for the academic years 2019-2022.

## Ship Detection Using SAR Imagery

### PROJECT INTERIM REPORT

**NITHIN PETER (JEC17CS075)**

**JEVIN PAULY (JEC17CS055)**

**TESSA SHYJU (JEC17CS102)**

*in partial fulfillment for the award of the degree  
of*

**BACHELOR OF TECHNOLOGY (B.Tech)**

in

**COMPUTER SCIENCE & ENGINEERING**

of

**A P J ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

Under the guidance of

**Mr. ANIL ANTONY**



**JANUARY 2021**

**Department of Computer Science & Engineering**



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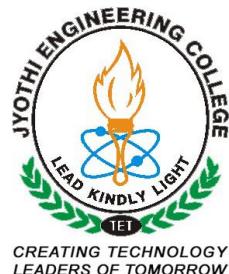
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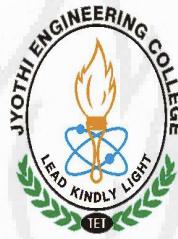
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JANUARY 2021

**BONAFIDE CERTIFICATE**

This is to certify that the main project report entitled **Ship Detection Using SAR Imagery** submitted by **Nithin Peter (JEC17CS075)**, **Tessa Shyju (JEC17CS102)** and **Jevin Pauly (JEC17CS055)** in partial fulfillment of the requirements for the award of **Bachelor of Technology** degree in **Computer Science and Engineering** of **A P J Abdul Kalam Technological University** is the bonafide work carried out by them under our supervision and guidance.

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- C410.2 Students will be able to identify an engineering problem, analyse it and propose a work plan to solve it.
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- C410.4 Students will have attained the practical knowledge of what they learned in theory subjects.
- C410.5 Students will become familiar with usage of modern tools.
- C410.6 Students will have ability to plan and work in a team.

## **ACKNOWLEDGEMENT**

We take this opportunity to express our heartfelt gratitude to all respected personalities who had guided, inspired and helped us in the successful completion of this interim project. First and foremost, we express my thanks to **The Lord Almighty** for guiding us in this endeavour and making it a success.

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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.

Keywords - Detection, Identification, Synthetic aperture radar, You Only Look Once, Convolutional neural networks.

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## List of Abbreviations

<b>CNN</b>	: <i>Convolutional Neural Network</i>
<b>R – CNN</b>	: <i>Recurrent Convolutional Neural Network</i>
<b>CRNN</b>	: <i>Convolutional Recurrent Neural Network</i>
<b>YOLOV3</b>	: <i>You Only Look Once v3</i>
<b>RGB</b>	: <i>Red – Green – Blue</i>
<b>HSV</b>	: <i>Hue – Saturation – Value</i>
<b>UAV</b>	: <i>Unmanned Aerial Vehicle</i>
<b>YOLO</b>	: <i>You Only Look Once</i>
<b>SSD</b>	: <i>Single Shot Object Detection</i>
<b>SAR</b>	: <i>Synthetic Aperture Radar</i>
<b>FC</b>	: <i>Fully Connected</i>

# CHAPTER 1

## INTRODUCTION

### 1.1 Overview

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. [5]

## 1.2 Objectives

- Build a ship detection system for SAR images.
- Make a system that has high accuracy.
- Increase the speed of the system without sacrificing accuracy.

## 1.3 Organization of the project

The report is organised as follow:

- **Chapter 1:Introduction** Gives an introduction to "Ship Detection Using SAR Imagery".
- **Chapter 2:Literature Survey** Summarizes the various existin techniques that helps in achieving the desired result.
- **Chapter 3: Problem Statement** Discusses about the need for the proposed system
- **Chapter 4:Project Management** Contains the effective project management model to be used for the project.
- **Chapter 5:Proposed System** Describes the various steps involved to produce this project.
- **Chapter 5:System Requirements & Specification**Describes the various technologies needed for implementation.
- **Chapter 6:Conclusion** Concludes with the future scope of implementation.
- **References** Includes the references for the project.

## CHAPTER 2

### LITERATURE SURVEY

#### **2.1 Ship Detection: An Improved YOLOv3 Method**

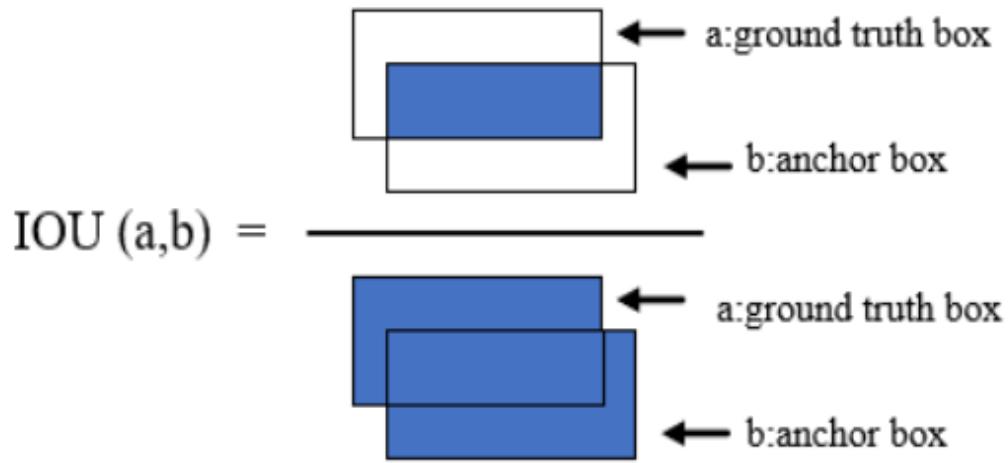
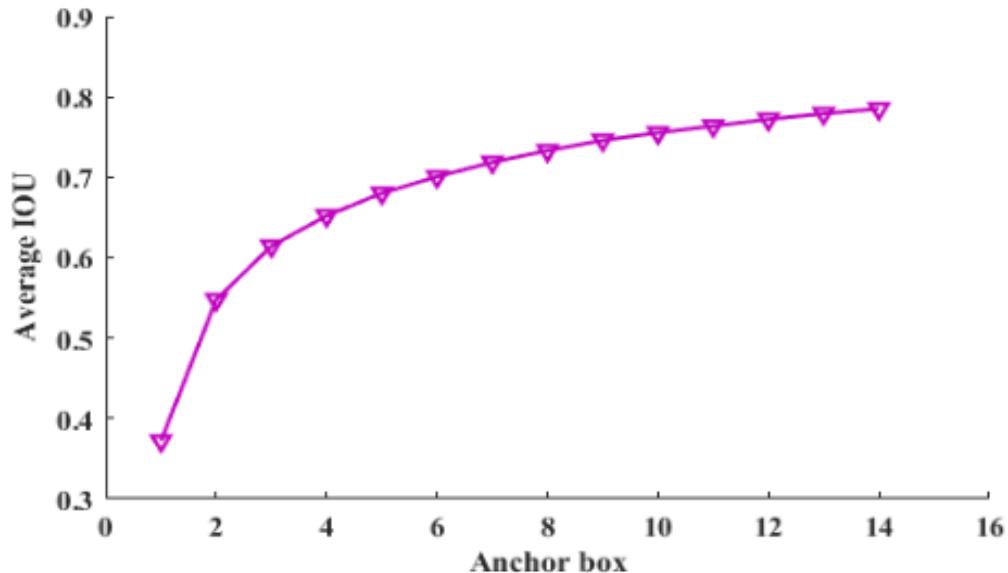
The main contributions of this method is to determine the anchor settings for the ship dataset by kmeans++ algorithm. Here we Design a convolutional neural network named Darknet-ship to solve the problem of excessive YOLOv3 parameters. Embedding the Squeeze-and-Excitation module in YOLOv3 to increases the network's ability to extract global features. [3]

##### **2.1.1 Dimension Clusters**

YOLOv3 introduces anchors, a set of initial candidate boxes with fixed width and height. The settings of anchors boxes affect the detection accuracy and speed. Kmeans algorithm is selected to conduct dimension clusters in YOLOv3. However, the kmeans algorithm is sensitive to the initial points. Therefore, an improved clusters algorithm named kmeans++ is introduced to solve this problem. The distance function of K-means++ algorithm is defined as:

$$d(a, b) = 1 - IOU(a, b)$$

where a is the size of rectangular box, b is centroid of the rectangular box. The IOU function represents the overlapping ratio of two rectangular boxes, as shown in Fig. 3.1.

**Figure 2.1: The description of IOU function****Figure 2.2: The relationship between the number of anchor boxes and average IOU**

To determine the settings of anchor box, the relationship between average IOU and anchor box is depicted in Fig.3.2. According to the inflection point method, we selects six clusters and divide up the six clusters on three scales. the corresponding sizes of six clusters are: (31, 15), (65, 26), (115,42), (156, 28), (221, 55), (304, 104)

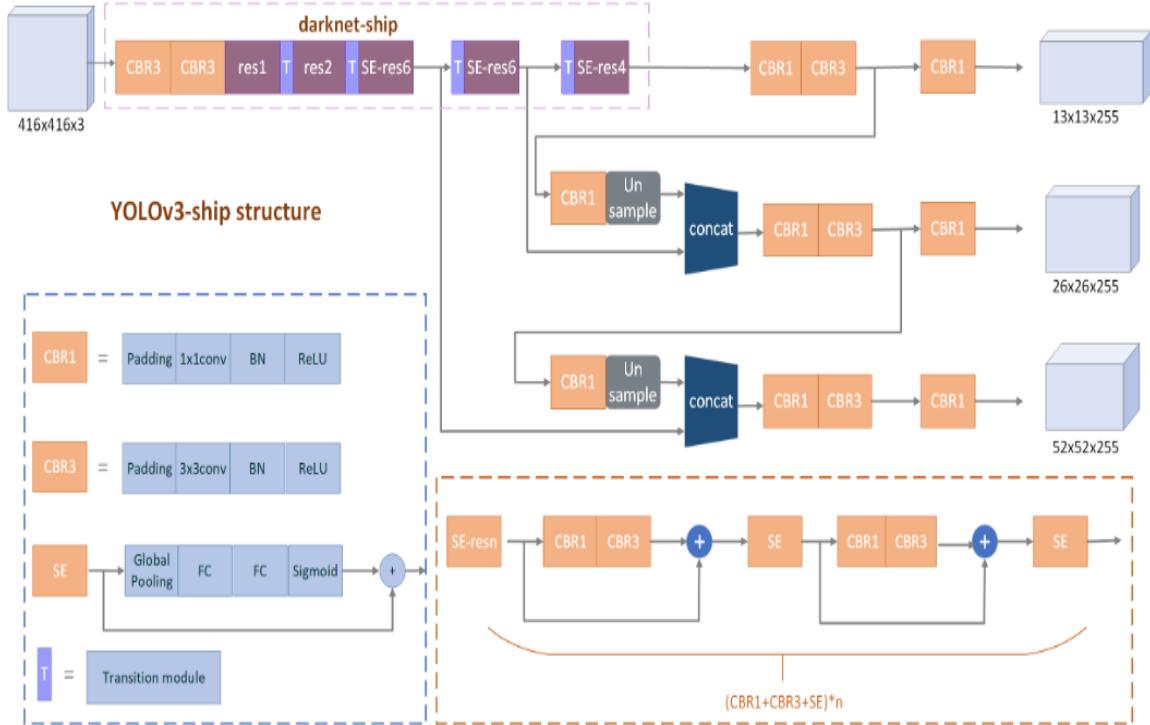


Figure 2.3: The description of YOLOv3-ship structure

### 2.1.2 Embedding of the Squeeze-and-Excitation Module

Squeeze-and-Excitation(SE) module is a ConvNet structure proposed by J. Hu in 2017, which won the championship of the imangenet classification competition. The SE module improves the expressive ability of network by accurately modeling the interaction between channels of convolution features. In the last three resnet blocks in Darknet-ship, the SE module is introduced to increase the receptive field and enhance the ability of network to extract global information. The SE module and the YOLOv3-ship structure are shown in Fig.3.5

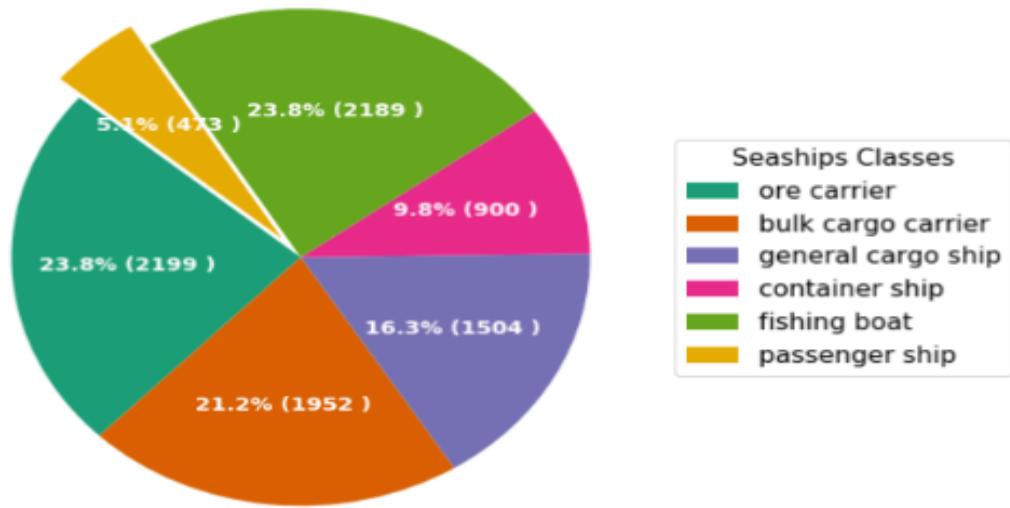


Figure 2.4: The numbers of bounding boxes for each class

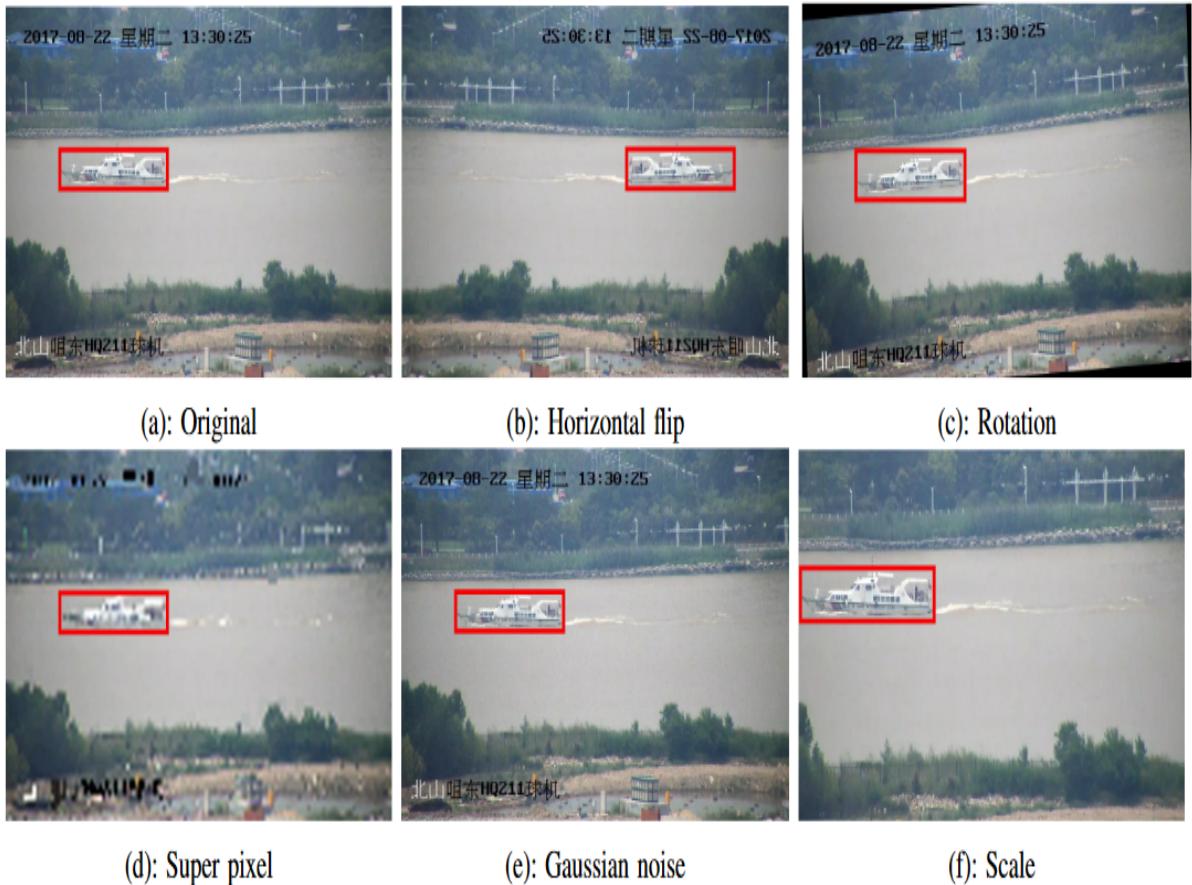


Figure 2.5: Some samples of the augmentation methods

## 2.2 High-Speed Ship Detection In SAR Images By Improved YOLOv3

Ship detection in synthetic aperture radar (SAR) images plays an important role in marine transportation, fishery management, and maritime disaster rescue. 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. In this method we modify YOLOv3 to increase speed of detection without compromising the accuracy in ship detection from SAR images.

### 2.2.1 Improved Method

In order to improve the speed of ship detection, we have improved the original YOLOv3. 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. The network structure of improved YOLOv3 is shown in fig.4.2. The detailed improvements are shown in the table1. From fig.4.2 and fig.4.3, to reduce the size of the network, we will use Darknet-19 as the backbone of the improved YOLOv3, which can reduce detection time. We also deleted repeated layers in YOLOv3-Scale1, YOLOv3-Scale2, and YOLOv3-Scale3. Finally, in order to make full use of the features extracted from the network, we have added two feature concatenation paths, which can improve the detection accuracy.[7]

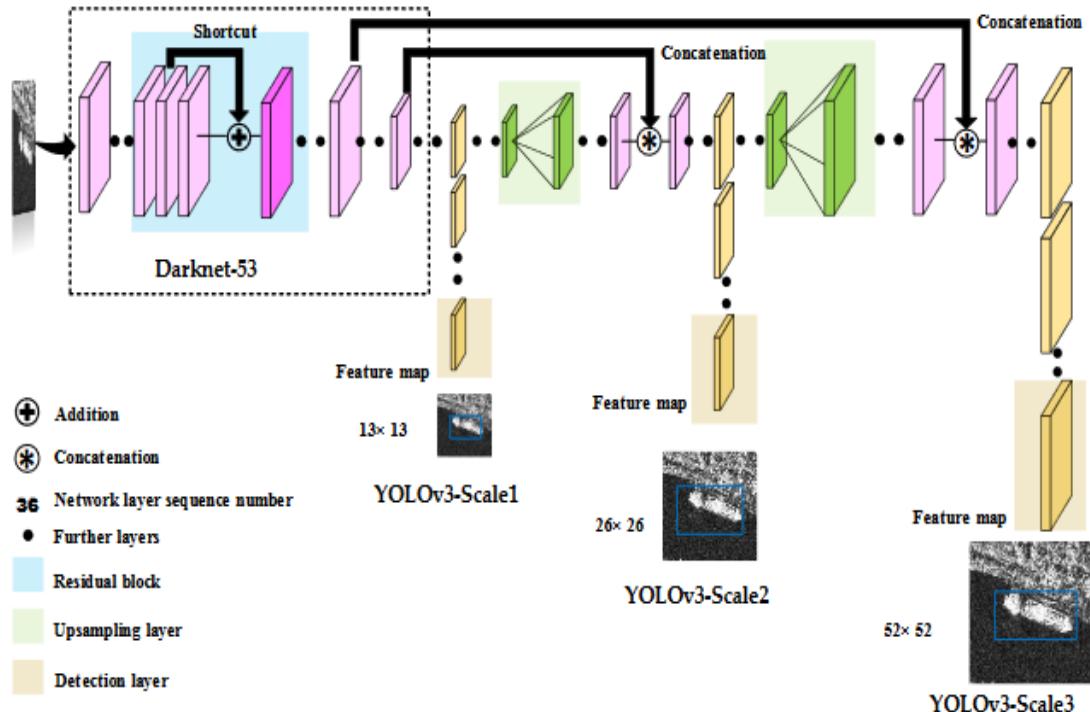


Figure 2.6: The network structure of original YOLOv3

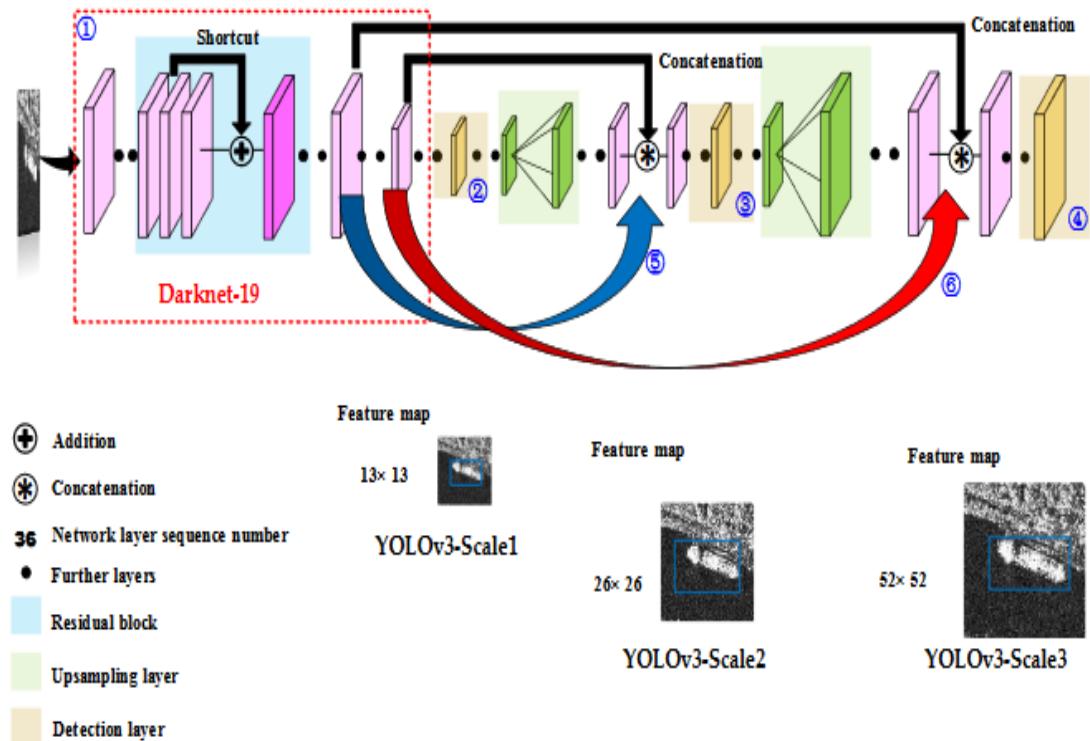


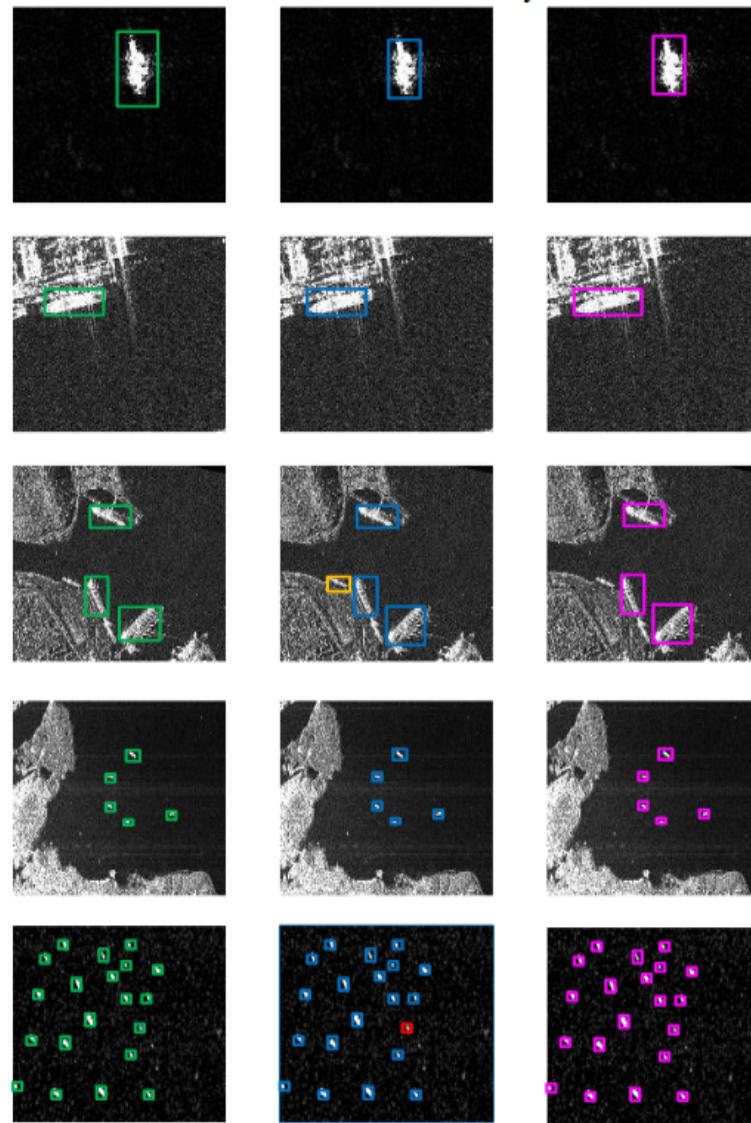
Figure 2.7: The network structure of improved YOLOv3

Number	Explanation
1	Change the backbone from Darknet-53 to Darknet-19.
2	Delete repeated layers of YOLOv3-Scale1.
3	Delete repeated layers of YOLOv3-Scale2.
4	Delete repeated layers of YOLOv3-Scale3.
5	Increase a concatenation.
6	Increase a concatenation.

**Figure 2.8: The detailed improvements.**

### 2.2.2 SAR Ship Detection Results

After some reasonable trainings, when the loss reaches the minimum, we get the final detection model. Then, we perform the actual SAR ship detection on the test set. The detection results of some samples are shown in the fig.4.4. From fig.4.4, almost all real ships can be detected correctly, and the original YOLOv3 and the improved YOLOv3 have similar detection accuracy.



**Figure 2.9: SAR ship detection results. (a) Ground truth. (b) Original YOLOv3. (c) Improved YOLOv3.**

**Red is miss-detection and yellow is false alarm.**

Fig.4.5 is the comparison of their quantitative evaluation indicators. From fig.3 and fig.4.5, the performance of the improved YOLOv3 is slightly better than the original YOLOv3, but the gap is narrow. More importantly, on the premise of keeping the accuracy basically unchanged, the improved network is smaller and lighter, which can reduce the detection time. In addition, due to the added two concatenation, the detection accuracy can remain unchanged. [7]

Method	Recall	Precision	mAP	F1-score
Original YOLOv3	89.12%	88.57%	90.14%	0.89
Improved YOLOv3	91.10%	89.36%	90.08%	0.90

Figure 2.10: Improvement Comparison.

## 2.3 Using convolutional neural network approach for ship detection in Senital-1 SAR imagery

In this method we use 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.[6]

Conventional ship detection consists of the following main stages: land masking, pre-processing and discrimination. This study explores how faster R-CNN VGG16 neural network technique can be applied for ship detection and counting in congested areas, using SAR imagery. In first stage, pre-processing of SAR image is carried out. In pre-processing back-geocoding, averaging, binary conversion and image morphology are performed. After image morphology reflectance values of the images are normalized to a standard reflectance value. The convolutional neural network layers are used to classify the ships in SAR images.

### 2.3.1 PREPROCESSING OF SAR IMAGES

Sentinel-1A SAR images used in this study are single look complex images. Sub swaths of forty images are processed and back-geocoded. Back-geocoding is a digital elevational model (DEM) based coarse registration of images.

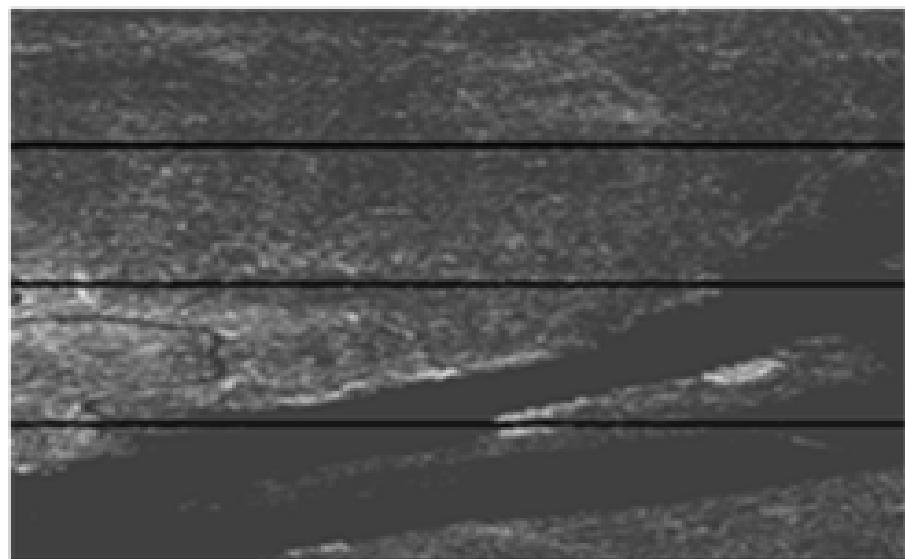


**Figure 2.11: Single Back-coded SAR Image**

A median of all these back-geocoded images is generated using this following formula.

$$(n + 1) \div 2^{\text{th}}$$

where “n” is the number of items in the set and “th” just means the (n)th number.

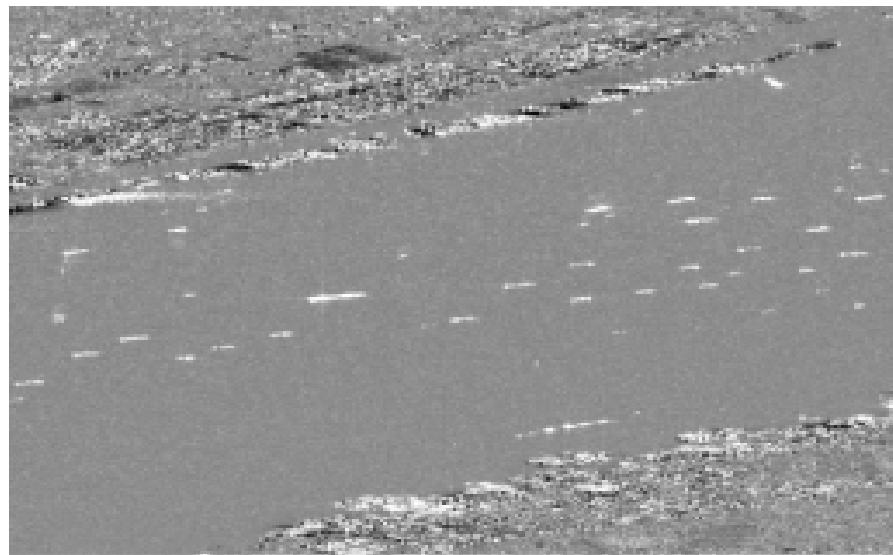


**Figure 2.12: Median Image**

Single back-geocoded images are differenced with median image in order to get a final

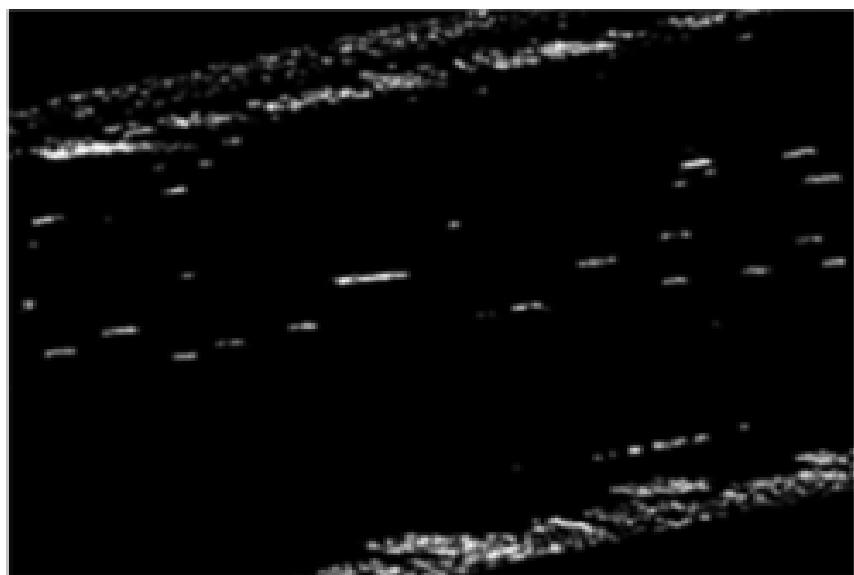
image using following formula.

$$\text{Differenced image} = \text{single image} - \text{median image}$$



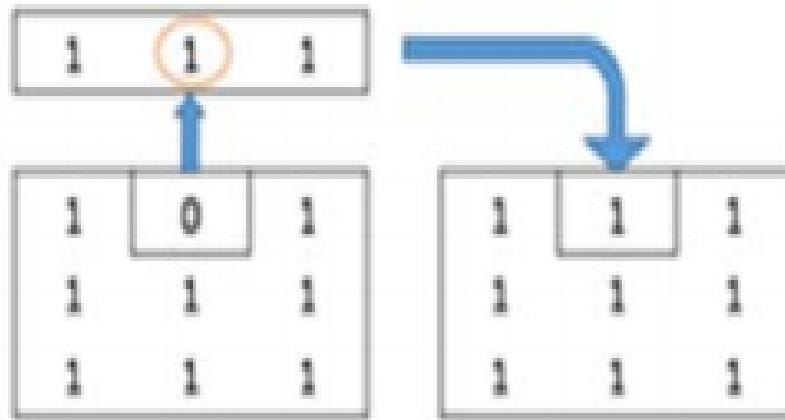
**Figure 2.13: Difference Image**

Each differenced image is then converted into binary. The image is then refined and performed adaptive adjustment to achieve the desired bright points on the black background by setting a threshold.



**Figure 2.14: Binary Image With Specific Threshold**

The elements on the surface are not very clear, because there are many holes in it. In order to make the elements clearer and visible, a process of “dilation” is carried out. This process is a mathematical morphology operation that is used to enhance the pixel size in a binary image. Figure illustrates the process of dilation.



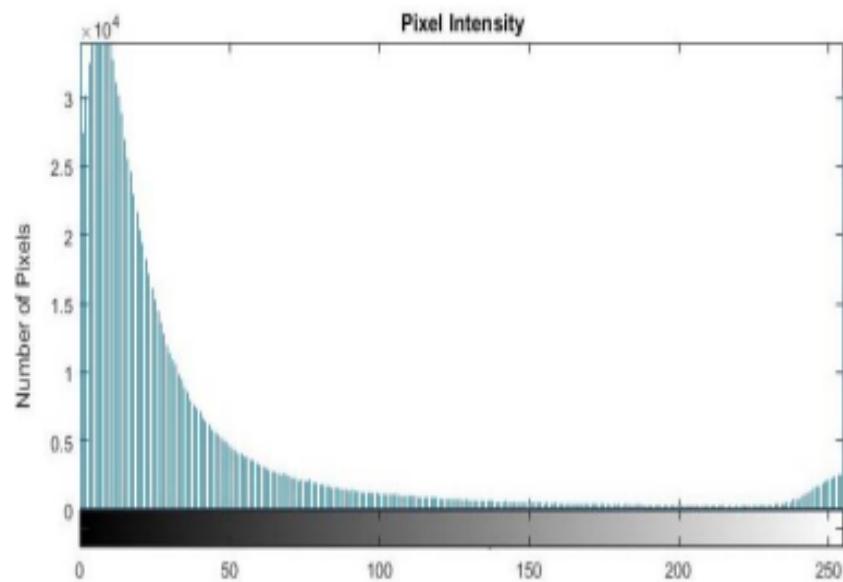
**Figure 2.15: Dilation In Binary Image**

This process uses the highest value of all the pixels in the neighbourhood as the value of the corresponding pixel in the output image. After that, the dilated image is further processed and a threshold is set to remove small elements in the image.



**Figure 2.16: Dilated Image With Removed Small Objects**

All the small holes are filled after the successful implementation of dilation process. This process will help in better identification and extraction of ship feature that will lead to the accurate detection of ship. After the process of dilation, the normalized value of pixel intensities in images are calculated to set a standard threshold.



**Fig 8. Average pixel intensity values**

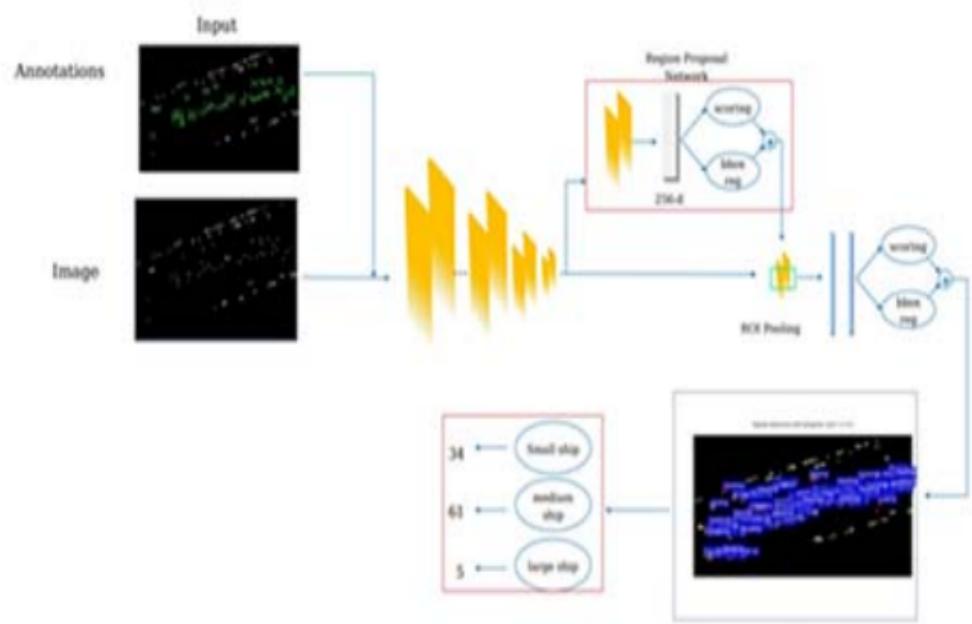
**Figure 2.17: Average Pixel Intensity Values**

Figure shows the excessive concentration of black pixels however, we see number of bright intensities on the right side which depicts the brighter pixels of ships in the image. This pixel intensity is used to set a standard threshold for discriminating ships from other bright (grey or light-grey) pixels with less intensity.

### 2.3.2 TARGET CLASSIFICATION MODEL BASED ON CNN

:

In order to detect ships, we have to use R-CNN models. In this process of classification, an image passes through series of convolutional network layers, nonlinear, pooling and fully connected layer to get an output. The input images are passed through a previously trained CNN model and end up in convolutional feature map. Then it uses the features computed by CNN to locate and obtain predefined number of regions (bounding boxes) that may have objects. Finally R-CNN modules classify the elements in bounding boxes and adjust their coordinates. Ships are categorized into small medium and big.



**Figure 2.18: Ship Detection CNN Architecture**

### 2.3.3 SHIP DETECTION

In the process of ship detection the image is classified into ship and sea. The image is further processed in convolutionary networks for extraction, selection and detection. In pre-processing stage back geocoding, averaging of image, image difference, thresholding and dilation are performed. Thus ship features are extracted. This is then passed through neural network layers and finally the ship is detected.



**Figure 2.19: Ship Detection Process**

## 2.4 Significance Based Ship Detection From SAR Imagery

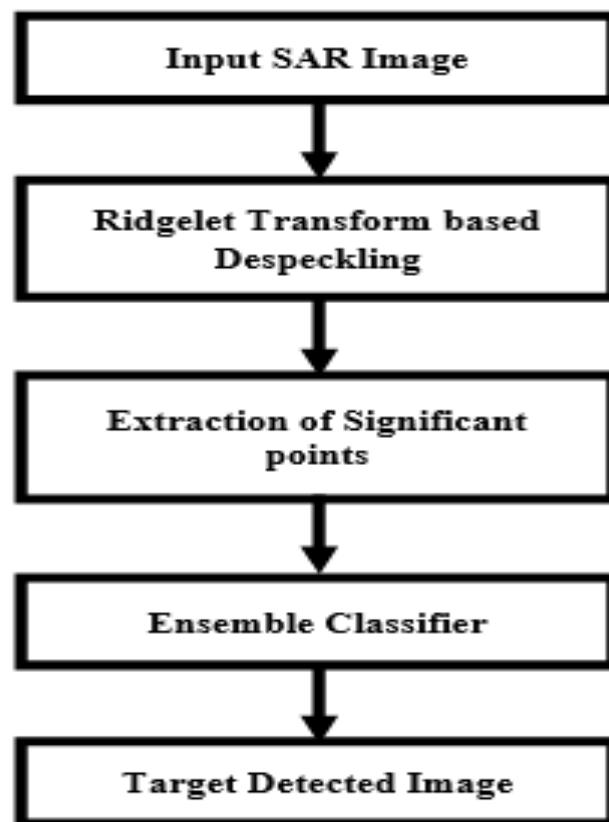
Synthetic Aperture Radar images have potential applications in the surveillance scenario and hence automated target detection algorithms prove to be a useful tool in monitoring and crime control as well as in marine traffic management. The advancements in marine trade have lead to the increase in the number of ships in the world waters. 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. These are the significant pixels in an image which can be gathered to detect the ship targets. During heavy sea state conditions and 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.[1]

SAR images when acquired, suffer from patterns of constructive and destructive interference of backscattered signals from multiple distributed objects. This disturbance called as speckle noise being the largest source of noise in SAR images, results in bright and dark spots in the image, provoking complications in image interpretation, like failure to extract bright spots which can be possible targets or giving false alarms by identifying other disturbances as targets. Speckle noise is a locally correlated noise in multiplicative form due to which the image processing techniques sense great difficulties when applied on SAR imagery. The heterogeneity of sea clutter, different weather conditions and the unclear appearance of targets

caused by different imaging angle in SAR imagery also adds to the difficulty in image interpretation [2]. In SAR oceanography, speckle noise is caused by the ripples and other objects on ocean that produces scattering. So the effect of speckle noise has to be reduced, in order to enhance the subsequent processes such as identification and characterization of the marine targets. A variety of methods have been attempted for despeckling by many researchers.

#### 2.4.1 PROPOSED SHIP DETECTION ALGORITHM

A significance based ship detection method is proposed in this work as shown in Figure 2.5. The potential target pixels obtained by extracting the significant points in the image which are then discriminated as ship pixels and non-ship pixels using an ensemble classifier to improve the precision of the algorithm.



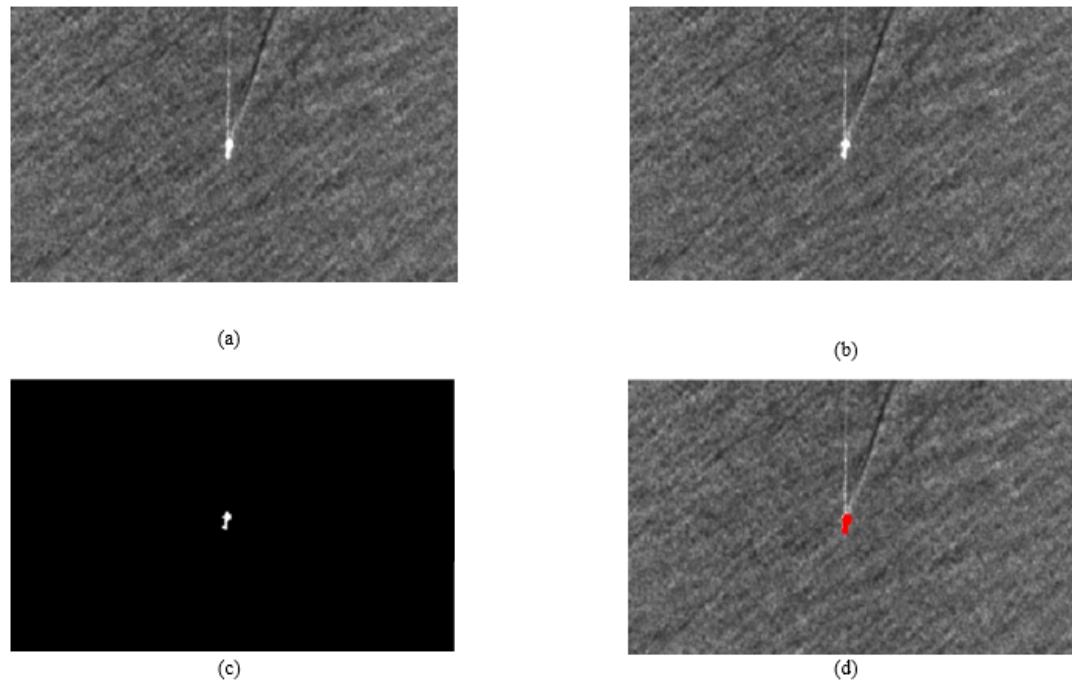
**Figure 2.20: Proposed Target Detection Method**

Adhering to the fact that, the ship pixels appear to be brighter than the background clutter pixels in the oceanographic SAR images, the target detection algorithm is proposed to capture the significant pixels as the potential target points. The background clutter, ocean waves, ship

wakes and other structures in the ocean may also appear as bright points. So, an ensemble classifier is used to discriminate the ship and non-ship pixels based on their features. Prior to target detection, Ridgelet transform based despeckling is performed to enhance the further processing.

#### 2.4.2 EXPERIMENTAL RESULTS AND DISCUSSIONS

The experimentation of the proposed work was carried out using seven SENTINEL 1A SAR images. These are VV polarized, Ground Range Detected, Strip Map products acquired at high resolution mode. These images have  $23 \times 23$  (rg x az) m resolution.



**Figure 2.21:** (a) Input SAR Patch; (b) Despeckled Patch; (c) Significance Patch; (d) Target Detected Patch

A significance based ship detection method is proposed in this work. The potential target pixels obtained by extracting the significant points in the image which are then discriminated as ship pixels and non-ship pixels using an ensemble classifier to improve the precision of the algorithm. Proposed Target Detection Method Adhering to the fact that, the ship pixels appear to be brighter than the background clutter pixels in the oceanographic SAR images, the target detection algorithm is proposed to capture the significant pixels as the potential target points. The background clutter, ocean waves, ship wakes and other structures in the ocean may also

appear as bright points. So, an ensemble classifier is used to discriminate the ship and non-ship pixels based on their features. Prior to target detection, Ridgelet transform based despeckling is performed to enhance the further processing.

## 2.5 Classification of Patterns on High Resolution SAR Images

The SAR sensors are capable to operate in all types of weather conditions. Also they are capable to operate from very long ranges and also over wide areas of coverage. These features make them extremely attractive for monitoring the Earth's resources. We can analyze the presence of vegetation, mountains, oil sources, mineral resources etc. on a particular region even on other planets by pattern classification on SAR images. SAR images have achieved a prominent position in the field of remote sensing. Remote sensing is a means of acquiring information using airborne equipment and techniques to determine the characteristics of an area. Over the past few decades, SAR imaging has witnessed numerous advancements due to active research and development in it. These images will find many applications in resource management, agriculture, mineral exploration and environmental monitoring. But the effective use of SAR images requires an understanding of the nature and limitation of the data and of the various methods for processing the image and interpreting data from it.

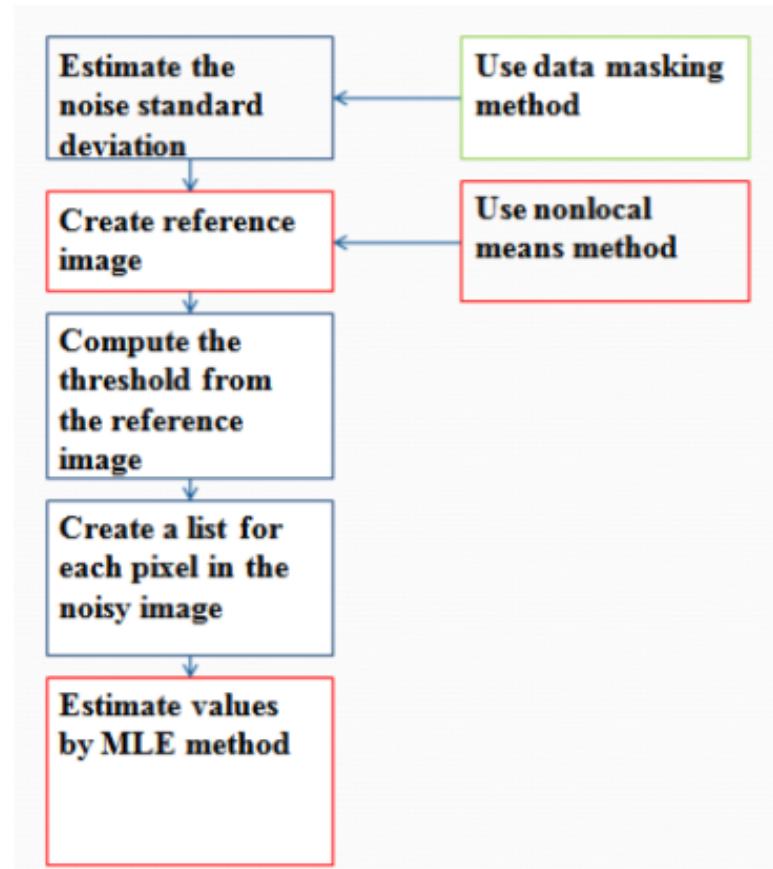
The images obtained from radar contain noise, especially speckle noise. It adds to SAR images a granular aspect with random spatial variations. It degrades the quality of the image. The consequence with the speckle noise is that, the fine features of the SAR image could be lost while analyzing the image for certain purposes like pattern classification. Thus, the speckle noise present in SAR images hinders the proper interpretation of data and thereby makes the processes of segmentation, classification, and analysis of patterns in the image increasingly difficult and inaccurate. Thus we have to perform denoising prior to any processing in the SAR images. By denoising, the clarity of the data in the image gets enhanced and it helps in the proper interpretation of data.

Mainly all denoising techniques aim at better preserving image structures while reducing the noise. Once the image is denoised, we can perform pattern classification on it. Patterns can be anything like rivers, vegetation, urban areas etc. Pattern classification can be done with the help of some features that is obtained from the region of interest. These features are mainly obtained using certain feature extraction methods. Finally, the classification is done using proper classification algorithm that is having better classification accuracy and less time complexity. In this project, we are focusing on detecting different patterns like water regions, buildings and land areas and finally the farmlands and vegetation. [2]

### 2.5.1 Denoising

Denoising is done prior to feature extraction in the classification problem to remove the unwanted speckle noise present in the high resolution SAR images. The speckle noise adds to SAR images a granular aspect with random spatial variations. It degrades the quality of the image. The consequence with the speckle noise is that, the fine features of the SAR image could be lost while analyzing the image for certain purposes like pattern classification. This is because the presence of speckle noise reduces the possibilities of visual interpretation. Here, the denoising process is based on Maximum Likelihood estimation method using a robust mes-timator known as Geman-McClure estimator. This method denoises the image without any loss in fine features or edge structures. Also, this method increases the accuracy of further processing on the SAR images.

Among the existing denoising technologies, NL means algorithm can be adaptively ex-tended to get better results in denoising. This technology is based on the redundancy of neighboring patches in the image. In this technology, the noise free estimated value of a pixel is defined as a weighted mean of pixels in a certain region. The local and Non local ML es-timation methods have some drawbacks. The local ML estimation causes blurring of edges and the distortion of fine structures in the image while the Non local ML estimation causes either under or over-smoothing. For denoising, maximum likelihood estimation along with the Geman-McClure estimator is used.



**Figure 2.22: Block diagram for denoising**

### 2.5.2 Estimation of noise standard deviation

From the noisy input image, estimation of noise standard deviation is performed by data masking technique. Spatial filtering is done in the conventional manner of convolving the image with a moving window called mask. In data masking, one method to estimate the noise standard deviation is to first filter the image to remove the image structure. By this, we get the image with only noise. For detecting edge structures Sobel edge detector is applied. Then the given image is subtracted from the Laplacian filtered image which results in the suppression of the image details.

### 2.5.3 Creating reference image

For creating reference image, Restricted Non Local Means method is used. Mainly the NL Means method was based on the Markovian hypothesis which states that pixels with a similar neighborhood have a similar gray level value. Here the filtered value at noisy pixel at

a particular location is calculated using the NL Means method as a weighted average of all the pixels in the image.

$$v_i = \frac{1}{C_i} \sum_{j \in \Omega_s} w_{i,j} m_j \quad (1)$$

where

$$C_i = \sum_{j \in \Omega_s} w_{i,j} \quad (2)$$

This indicates normalization constant and the weight is given by the similarity of the Gaussian neighborhood between pixels and is expressed as

$$w_{i,j} = \exp\left(-\frac{\|N_i - N_j\|_2^2, a}{h^2}\right) \quad (3)$$

Because of the fact that exponential function degrades edge preserving in denoised image, our method uses Robust M-estimator function for weight calculation. Here we use Geman-McClure estimator function for calculating weight for Non Local Means method.

$$w(x,y) = \vartheta_{\sigma_s}(\sum_{t \in \Xi} GM_{\sigma_c}(t)(s(x+t) - (s(y+t))^2)) \quad (4)$$

$$:= \vartheta_{\sigma_s}(\|s(x) - s(y)\|_2, \sigma^2) \quad (5)$$

After creating reference image, next we have to find the threshold value from it. This threshold value is used for further denoising process. On each 3X3 block of the reference image, we find the range value. Actually range value indicates the difference of largest value and smallest value in that particular block. Then, find the mode value of the range values obtained from the block. From this, we obtain the thresholds.

#### 2.5.4 Maximum likelihood estimation

Before performing maximum likelihood estimation, we need to create list of pixels from the noisy image. Here we compare the pixel values in the noisy input image and pixel values in the noise free reference image. Then take the difference between the corresponding pixels in both the images using 3x3 block neighborhoods. Then the difference is compared with that of the threshold values obtained from reference image. Now those pixels in the noisy images

with values less than the threshold will be used for denoising of the image using maximum likelihood estimation.

---

**Algorithm 1 DENOISING ALGORITHM**


---

**Input:** Noisy SAR image.

**Output:** Denoised image.

1. Estimate the noise standard deviation from the input

magnitude using data masking technique

2. Create the reference image using non local means method.

3. Compute the threshold  $t$  from the reference image by

applying

$$t = \text{mode}(\text{range}(v_f)_w)$$

**for** every pixel  $m$  of  $M$  (input image) **do do**  
create the list,

$$l_i = m_j, (j \in \Omega_m) | abs(f(m_j) - f(m_i)) < t \quad (11)$$

4. Using  $l_i$  values, estimate intensity values by maximum

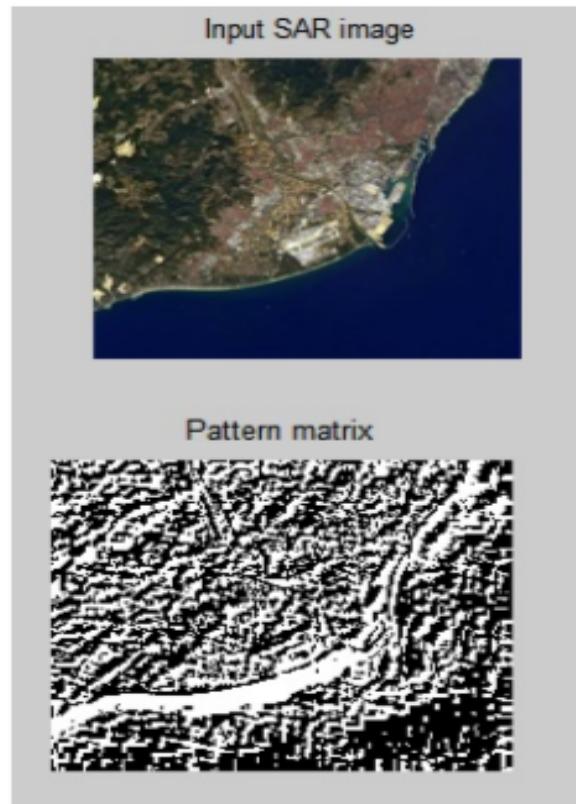
likelihood method

**end for**

---

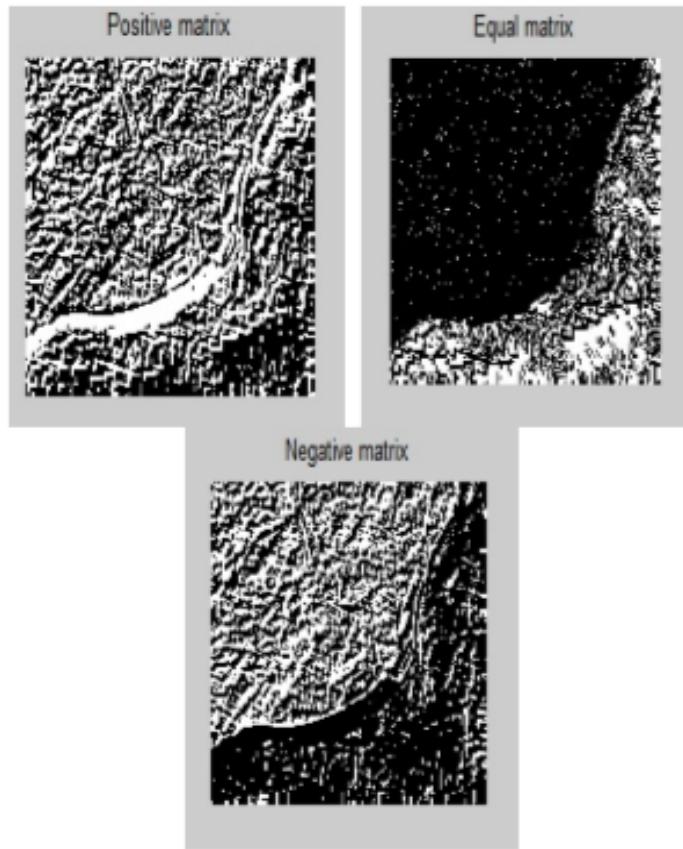
### 2.5.5 Feature extraction

On the denoised high resolution SAR images, we could apply our fusion based method for the classification of target patterns. Here, we are considering pixel intensity difference by using Local Binary patterns (LBP). LBP is the particular case of the Texture Spectrum model. It has been found that Local Binary Pattern is a powerful feature for texture classification. By using LBP, we could distinguish homogeneous as well as heterogeneous areas in SAR images. The Local Binary pattern is based on the local relationships of pixel intensities. Image quantization is done, matrix splitting is done to facilitate the movement of the window and connected components are traced out within the window.



**Figure 2.23: Input SAR image and its pattern matrix.**

The second step is the splitting of the pattern matrix into three matrices: a 'positive matrix', a 'negative matrix' and an 'equal matrix' according to the values in the pattern matrix. Fig.5 shows the three matrices for a pattern matrix of an input SAR image. The three matrices play different roles in the image representation. The positive matrix captures brilliant patterns. That means points or regions which are significantly brighter than the central pixel. The negative matrix describes dark patterns, and the equal matrix captures a homogeneous regions.



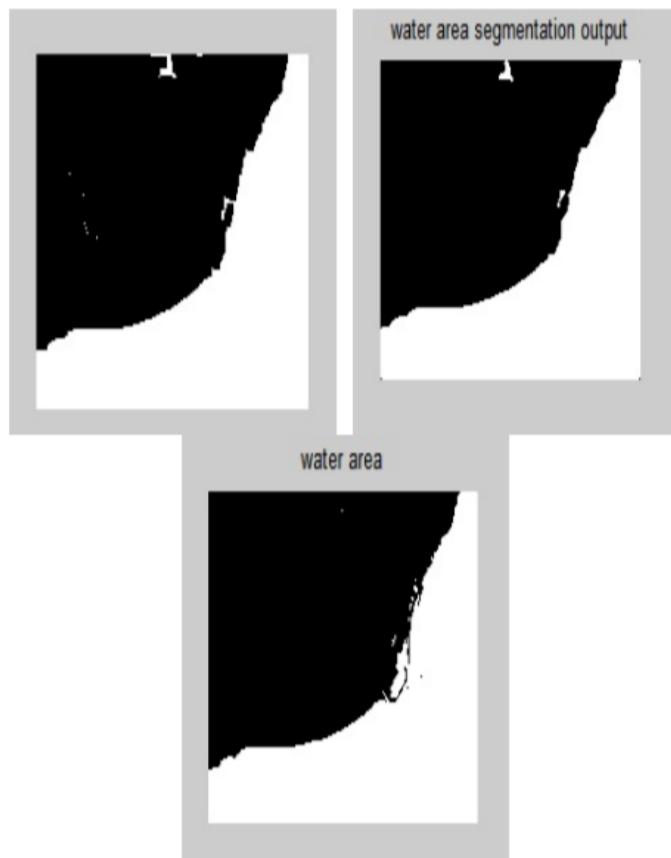
**Figure 2.24: Pattern matrix of the input SAR image, positive matrix, equal matrix and negative matrix.**

We are using color as a feature vector that is fed as input to the Artificial Neural Networks for classifying different patterns on SAR images. For that the neural network is trained using some known input-output samples based on color feature. That means we are training the ANN with the RGB values of different patterns on the SAR image. That means, the RGB combination of a particular pattern say, river has some uniqueness while comparing with other patterns. The values of R, G and B varies according to different patterns. We use this feature as input and provides output accordingly to the RGB value of the patterns.

### 2.5.6 Classification

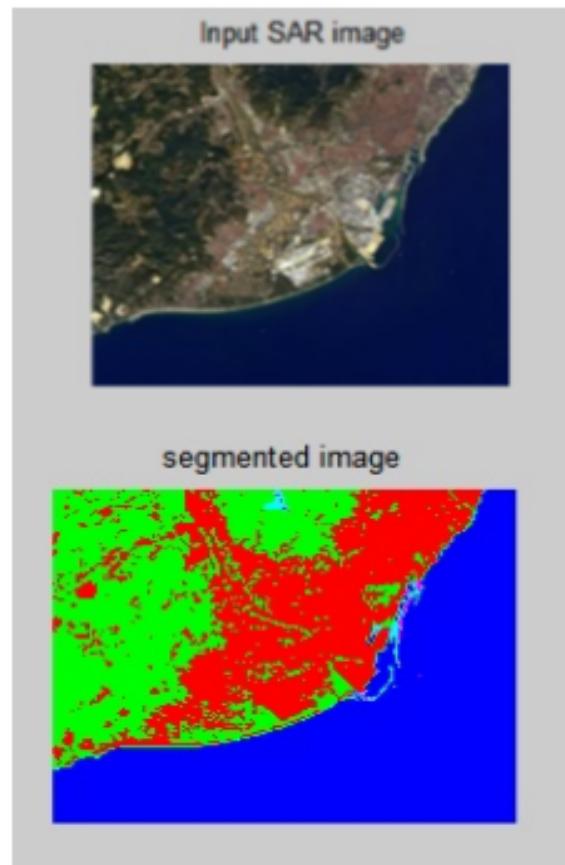
Classification is the final stage by which different patterns like water region, farm lands and vegetation, buildings and urban areas etc get segmented. Here a fusion method is proposed for classifying these patterns on high resolution SAR images. We get segmented images of these patterns by using the three features LBP, HSV and RGB. Fig:4.4 shows the segmented images of water regions obtained by using LBP and HSV and the final segmented water region.

The results obtained from these methods are finally combined with the result obtained from RGB method together gives the final classification output. The output obtained from ANN classifier is again thresholded according to the target pattern.



**Figure 2.25:** Segmented images obtained by using LBP, HSV and the final segmented water region.

Finally, we get the output image with patterns classified according to different colors where red indicates buildings and land areas, Green indicates vegetation and farm lands and blue indicates water regions. Fig:4.5 shows the final result of classification



**Figure 2.26: Input SAR image and its corresponding output image with patterns classified according to color.**

## **CHAPTER 3**

### **PROBLEM STATEMENT**

Ship detection has great demands in civil and military fields. For example, in the civil field, ship detection can supervise transportation, marine traffic and illegal smuggling. In the military field, it can be used to monitor cross-border 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. Ship detection in synthetic aperture radar (SAR) images 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. This project aims to provide a method for ship detection that is fast and also accurate. [4]

## CHAPTER 4

# PROJECT MANAGEMENT

### 4.1 Introduction

Project management is the discipline of planning, organizing, securing, managing, leading, and controlling resources to achieve specific goals. A project is a temporary endeavor with a defined beginning and end (usually time-constrained, and often constrained by funding or deliverables), undertaken to meet unique goals and objectives, typically to bring about beneficial change or added value. The temporary nature of projects stands in contrast with business as usual (or operations), which are repetitive, permanent, or semi-permanent functional activities to produce products or services. In practice, the management of these two systems is often quite different, and as such requires the development of distinct technical skills and management strategies.

In our project we are following the typical development phases of an engineering project

1. Initiation
2. Planning and Design
3. Execution and Construction
4. Monitoring and Controlling Systems
5. Completion

#### 4.1.1 Initiation

The initiating processes determine the nature and scope of the project. The initiating stage should include a plan that encompasses the following areas :

1. Analysing the business needs/requirements in measurable goals
2. Reviewing of the current operations
3. Financial analysis of the costs and benefits including a budget
4. Stakeholder analysis, including users, and support personal for the project

5. Project charter including costs, tasks, deliverables, and schedule

#### **4.1.2 Planing and design**

After the initiation stage, the project is planned to an appropriate level of detail (see example of a flow-chart). The main purpose is to plan time, cost and resources adequately to estimate the work needed and to effectively manage risk during project execution. As with the initiation process, a failure to adequately plan greatly reduces the project's chances of successfully accomplishing its goals.

- Determining how to plan
- Developing the scope statement
- Selecting the planning team
- Identifying deliverables and creating the work breakdown structure
- Identifying the activities needed to complete those deliverables
- Developing the schedule
- Risk planning

#### **4.1.3 Execution**

Executing consists of the processes used to complete the work defined in the project plan to accomplish the project's requirements. The execution process involves coordinating people and resources, as well as integrating and performing the activities of the project in accordance with the project management plan. The deliverables are produced as outputs from the processes performed as defined in the project management plan and other frameworks that might be applicable to the type of project at hand.

#### **4.1.4 Monitoring & controlling**

Monitoring and controlling consists of those processes performed to observe project execution so that potential problems can be identified in a timely manner and corrective action can be taken, when necessary, to control the execution of the project. The key benefit is that project performance is observed and measured regularly to identify variances from the project management plan.

## 4.2 System Development Life Cycle

The Systems development life cycle (SDLC), or Software development process in systems engineering, information systems, and software engineering, is a process of creating or altering information systems, and the models and methodologies that people use to develop these systems. In software engineering, the SDLC concept underpins many kinds of software development methodologies. These methodologies form the framework for planning and controlling the creation of an information system.

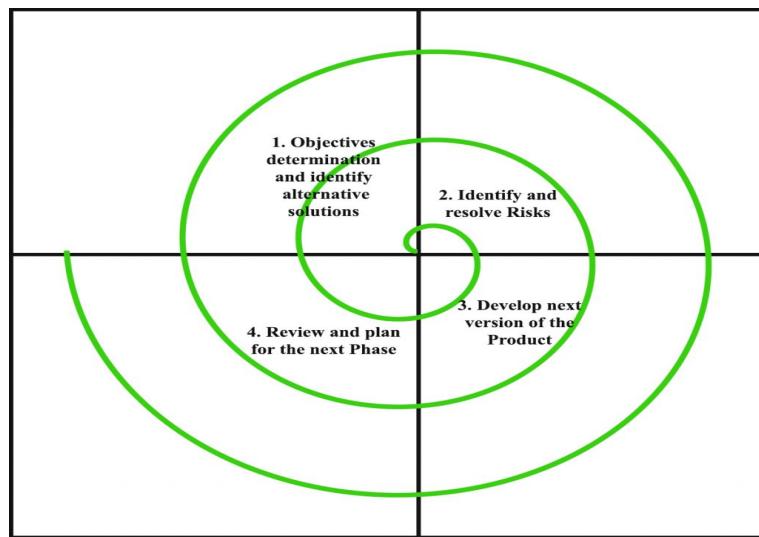
The SDLC phases serve as a programmatic guide to project activity and provide a flexible but consistent way to conduct projects to a depth matching the scope of the project. Each of the SDLC phase objectives is described in this section with key deliverables, a description of recommended tasks, and a summary of related control objectives for effective management. The project manager must establish and monitor control objectives during each SDLC phase while executing projects. Control objectives help to provide a clear statement of the desired result or purpose and should be used throughout the entire SDLC process.

### 4.2.1 Spiral Model

We have used the Spiral model in our project. The Spiral model incorporates the best characteristics of both- waterfall and prototyping model. In addition, the Spiral model also contains a new component called Risk Analysis, which is not there in the waterfall and prototype model. In the Spiral model, the basic structure of the software product is developed first. After the basic structure is developed, new features such as user interface and data administration are added to the existing software product. This functionality of the Spiral model is similar to a spiral where the circles of the spiral increase in diameter. Each circle represents a more complete version of the software product. The spiral is a risk-reduction oriented model that breaks a software project up into main projects, each addressing one or major risks. After major risks have been addressed the spiral model terminates as a waterfall model. Spiral iteration involves six steps:

1. Determine objectives, alternatives and constraints.
2. Identify and resolve risks.
3. Evaluate alternatives.
4. Develop the deliverables for the iteration and verify that they are correct.
5. Plan the next iteration.

6. Commit to an approach for the next iteration.



**Figure 4.1: Spiral Model**

## CHAPTER 5

# METHODOLOGY

### **5.1 System Requirements & Specifications**

#### **5.1.1 Windows 10**

Windows 10 is a series of personal computer operating systems produced by Microsoft as part of its Windows NT family of operating systems. It is the successor to Windows 8.1 and was released to manufacturing on July 15, 2015, and to retail on July 29, 2015. Windows 10 receives new builds on an ongoing basis, which are available at no additional cost to users. There are test builds of Windows 10 available to Windows Insiders. Devices in enterprise environments can receive these updates at a slower pace, or use long-term support milestones that only receive critical updates, such as security patches, over their ten-year lifespan of extended support.

#### **5.1.2 Python 3.6.2**

Python is a dynamic object-oriented programming language that can be used for many kinds of software development. It offers strong support for integration with other languages and tools, comes with extensive standard libraries, and can be learned in a few days. Many Python programmers report substantial productivity gains and feel the language encourages the development of higher quality, more maintainable code.

Python runs on Windows, Linux/Unix, Mac OS X, OS/2, Amiga, Palm Handhelds, and Nokia mobile phones. Python has also been ported to the Java and .NET virtual machines. Python is distributed under an OSI-approved open source license that makes it free to use, even for commercial products.

#### **5.1.3 TensorFlow**

Created by the Google Brain team, TensorFlow is an open source library for numerical computation and large-scale machine learning. TensorFlow bundles together a slew of machine learning and deep learning (aka neural networking) models and algorithms and makes them useful by way of a common metaphor. It uses Python to provide a convenient front-end

API for building applications with the framework, while executing those applications in high-performance C++. TensorFlow can train and run deep neural networks for handwritten digit classification, image recognition, word embeddings, recurrent neural networks, sequence-to-sequence models for machine translation, natural language processing, and PDE (partial differential equation) based simulations. Best of all, TensorFlow supports production prediction at scale, with the same models used for training.

#### 5.1.4 Jupyter Environment

JupyterLab is a web-based interactive development environment for Jupyter notebooks, code, and data. JupyterLab is flexible: configure and arrange the user interface to support a wide range of workflows in data science, scientific computing, and machine learning. JupyterLab is extensible and modular: write plugins that add new components and integrate with existing ones. The Jupyter Notebook is an open-source web application that allows you to create and share documents that contain live code, equations, visualizations and narrative text. Uses include: data cleaning and transformation, numerical simulation, statistical modeling, data visualization, machine learning, and much more.

## 5.2 Proposed System

### Modules

#### 5.2.1 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.

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 % of the training set.

**D3:** The test set will be the overall leftover 20 % of the dataset, which we set aside for the final evaluation.

#### 5.2.2 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.

### 5.2.3 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.

### 5.3 Data Flow Diagrams

#### 5.3.1 Data Flow Diagram- Level 0



Figure 5.1: DFD- Level 0

#### 5.3.2 Data Flow Diagram- Level 1

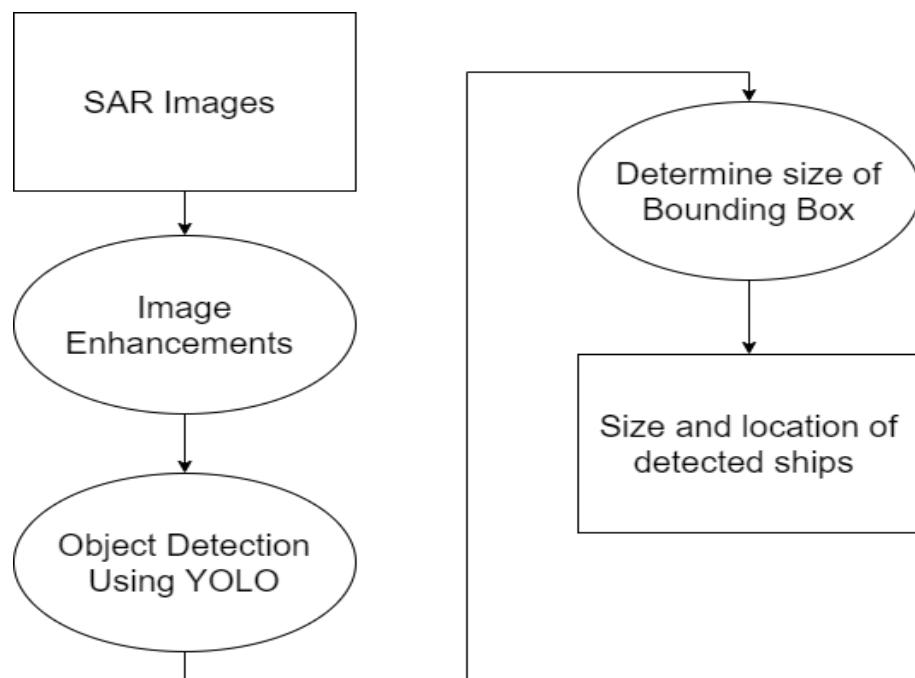


Figure 5.2: DFD- Level 1

### 5.3.3 Data Flow Diagram- Level 2

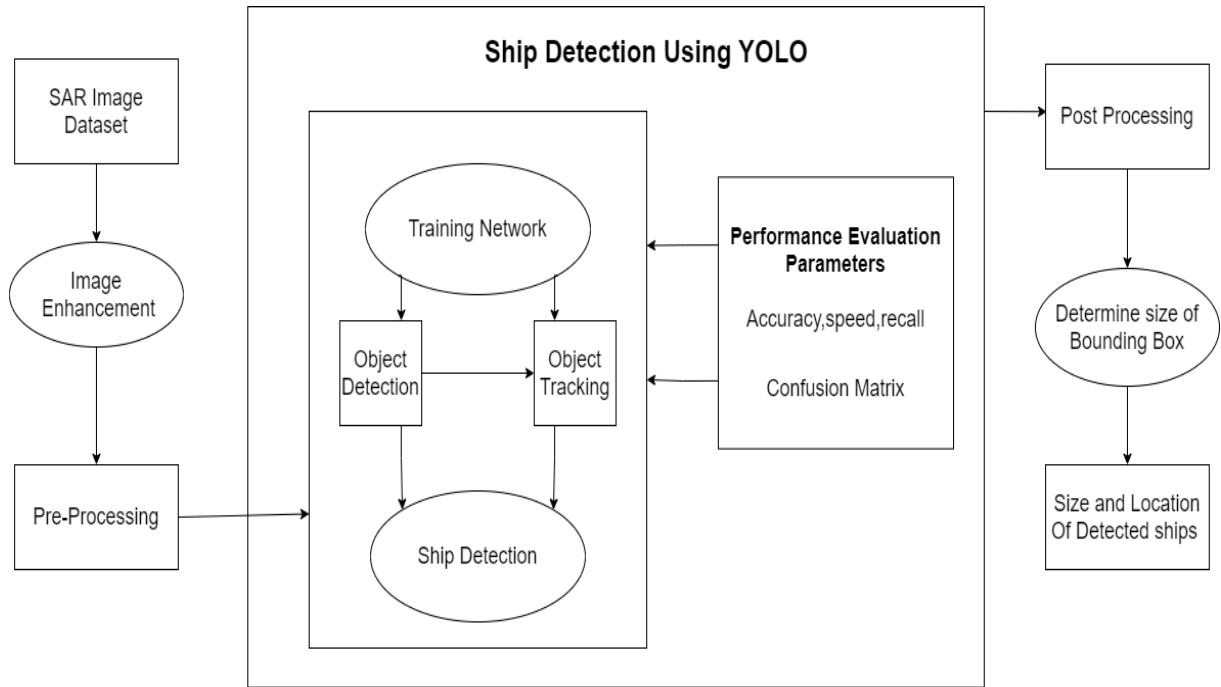


Figure 5.3: DFD- Level 2

## 5.4 Flow Chart

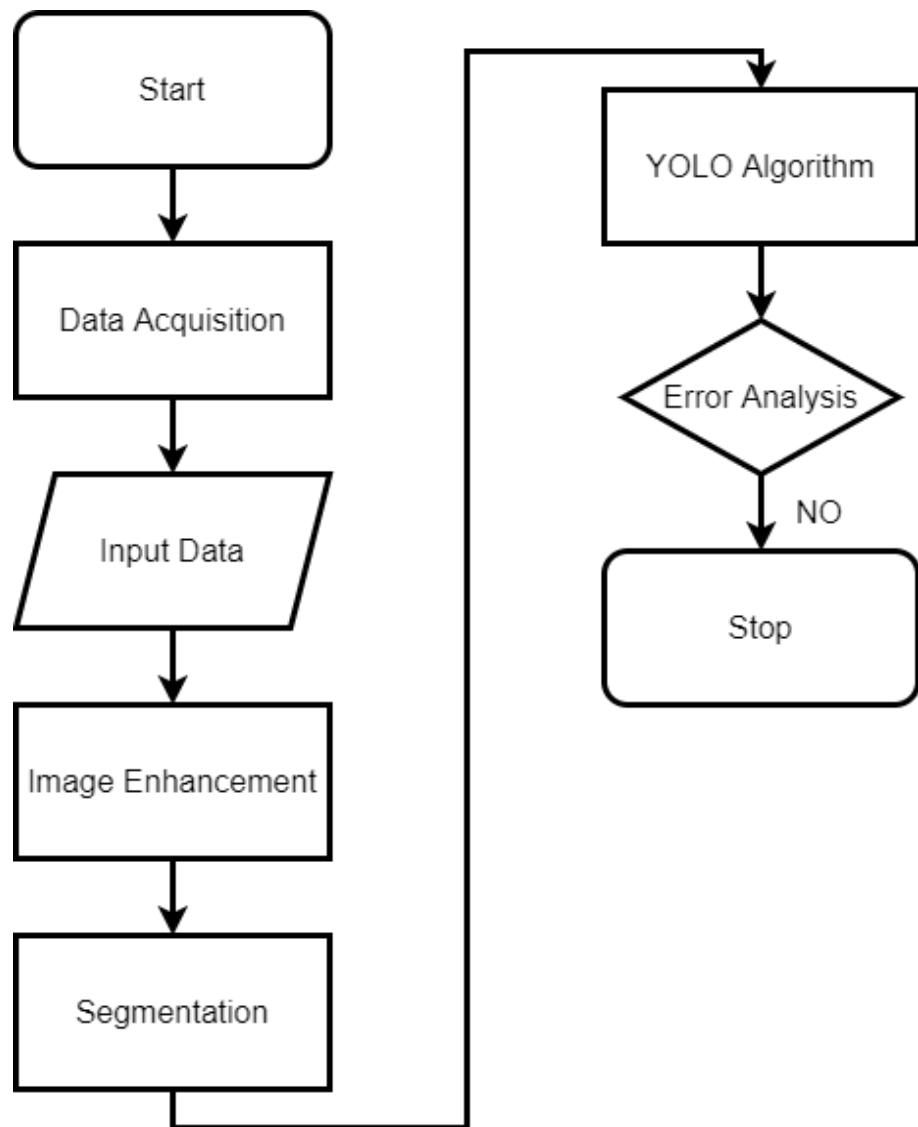


Figure 5.4: Flow Chart

## 5.5 Architecture

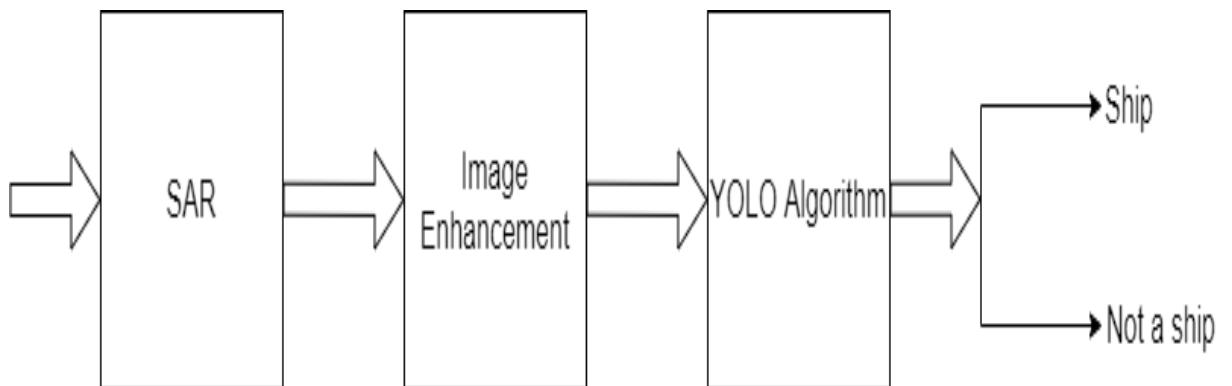


Figure 5.5: Architecture

## **CHAPTER 6**

## **RESULTS**

- A ship detection system based on YOLO will be created
- The system will detect ships from SAR images
- The system will be both fast and accurate
- It will be effective in different weather conditions

## **CHAPTER 7**

### **CONCLUSION AND FUTURE WORKS**

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 monitoring.

In future we can try and implement GIS into our project. We can also try and improve the speed and accuracy.

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