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Design And Implementation Of Security System For Ship Intervention

Vijayalakshmi G V
Electronics And Communication, Dr.T.Thimmaih Institute of Technology, KGF, India
vijayalakshmi@drttit.edu.in

Jabeen Firdous C P, Neha J G, Jhansi Lakshmi K, Priyanka U
Electronics And Communication, Dr. T. Thimmaiah Institute of Technology, KGF, India

Abstract: Nowadays, Surveillance is a major problem for harbor protection, border control and security of various commercial facilities. This paper proposes Ship Intrusion Detection Security System which targets on the aspect of surveillance of coastal areas with meticulous ship detection in a highly dynamic environment. The main facet of this paper is to develop a system which will work mainly in dynamic environment of seashore where surveillance is required 24/7 for various security purposes. Using the combination of both Image processing and SVM machine learning technique, it is a new state-of-the-art system which renders the setbacks of the existing system like expensive setups, inaccurate detection, algorithmic error which can be annihilated to achieve an efficient system. Hence, this system can be used as a real time security system at seashore areas.

Keywords: Intrusion detection; Machine learning; Support Vector Machine (SVM); Histogram of oriented Gradients (HOG) algorithm

I. INTRODUCTION

Security sureveillance is an important component in video surveillance systems.[1]. People are living with a fear of being attacked by terrorists, burglars, vandals and thieves. Nowadays, intrusion detection on the sea is a critical surveillance problem for harbor protection, border security, and commercial facilities protection, such as oil platforms and fisheries facilities. The traditional methods of detecting ships are with radars or satellites which are very expensive. Except the high cost, the satellite image is easily affected by the cloud. And it is difficult to detect small boats or ships on the sea with marine radar due to the noise or clutters generated by the uneven sea surface. In order to be secured, it has become a necessity to realize and introduce smart surveillance system. Hence, this system presents a state-of-the-art solution for ship intrusion detection using image processing and SVM. Typical applications of ship intrusion detection focuses on the preservation of security at coastal areas to ensure harbor protection and border control. It can be installed in naval base, ports and various commercial facilities to safeguard the vast near-coast sea surface and hustling harbor areas from intervention of unauthorized marine vessels, such as trespassing boats and ships. [2]

The rest of the paper is as organized, section II describes about the literature survey, section III explains about dataset, section IV provides detail information about methodology, section V presents the performance evaluation, section VI gives the results and discussion of the proposed method, section VII describes advantages of proposed system and section VIII deals with conclusion.

II. LITERATURE SURVEY

Willhauck et al., (2005) described a work on The architecture of a ship detection prototype based on an object-oriented methodology to support the monitoring tasks. The system's architecture comprises a fully-automatic coastline detection tool, a tool for fully or semiautomatic ship detection in off-shore areas and a semi-automatic tool for ship detection within harbour-areas. Its core was based on the client-server environment of the first object-oriented image analysis software on the market named eCognition. The described ship detection system had been developed for panchromatic VHR satellite image data and had proven its capabilities on Ikonos and QuickBird imagery under different weather conditions and for various regions of the world.

Gu et al.,(2005) presented the detection and classification system in a cutting-edge surveillance sensor network, which classifies vehicles, persons, and persons carrying ferrous objects, and tracks these targets with a maximum error in velocity of 15%. They discussed the sensing subsystem using ExScal mote in the VigilNet surveillance system and described the action of the hierarchical classification architecture for enabling the system to conduct efficient information processing, including detection and classification, in a large-scale WSN.

Malhotra et al., (2008) addressed the problem of classification of ground vehicles. They have devised a distributed framework for vehicle classification in WSN and proposed three distributed classifications algorithms that are based on the k-nearest neighbor (k-NN) classification method. Target classification becomes more challenging if there are multiple targets of various types. Consider the scenario of a battlefield in which there may be tanks, jeeps and other types of military vehicles. Furthermore, there may be a number of vehicles of the same type, e.g. tanks of a particular make. The classification problem they considered was to identify which vehicle belongs to which class of vehicles.

Chitnis et al (2009) have presented the wireless line sensor network architecture for visual surveillance using Flex Board - line sensor node with Software-based line sensor. The proposed line sensor architecture is capable of capturing a continuous stream of temporal one dimensional image (line image). The associated one dimensional image processing algorithms are able to achieve a significantly faster processing result with much less storage and bandwidth requirement while conserving the node energy. The framework has been illustrated through a testbed using IEEE 802.15.4 communication stack and a real-time operating system along with one dimensional image processing.

Alves et al., (2010) presented a FPGA-based reconfigurable electronic system used in an autonomous sailing boat. The FPGA implements a RISC microprocessor surrounded by several custom designed peripherals that interface with the sensors and actuators used in the sailboat. The hardware reconfigurability feature of the FPGA enabled short design iteration and fast in-circuit reconfigurations of the running hardware.

Guillaume Hajduch et al (2011) presented a short overview of general strategies for ship detection on SAR images. They proposed an algorithm to discriminate azimuth ambiguities (ghost targets) and short lifetime events (breaking waves) from true ship artifacts by sub-looks processing of Single Look Complex images

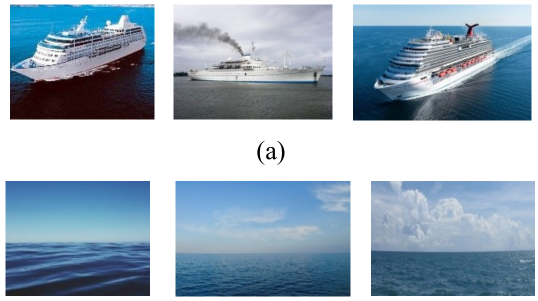
Bu-Geun Paik et al., (2015) employed wireless sensor network as a ubiquitous technology for monitoring of equipment and for fire prevention in real ship. The Zigbee protocol was used to construct a communication system. In addition, several problems regarding real-ship application were identified, and basic experiments about the characteristics of WSN were conducted at the test bed ashore to provide reference data for the appropriate design of the WSN for a real ship.

III. DATASET

The dataset used in our paper consists of Training and Testing database of 100 images with ship and non-ship. The Training database contains 80% of 100 images i.e., 80 images where 40 images are with ship and other 40 images are non-ship. Similarly, Testing database contains 20% of 100 images i.e., 20 images where 10 images are with ship and other 10 images are non-ship. Fig below shows few sample images of our database.

IV. METHODOLOGY

Methodology includes the complete flow of ship intrusion detection security system using image processing and SVM classifier as shown in Fig 2. Further the contribution of each block is explained below



(a) (b)

Fig 1. Samples images of Database (a) Ships (b) Non-ships

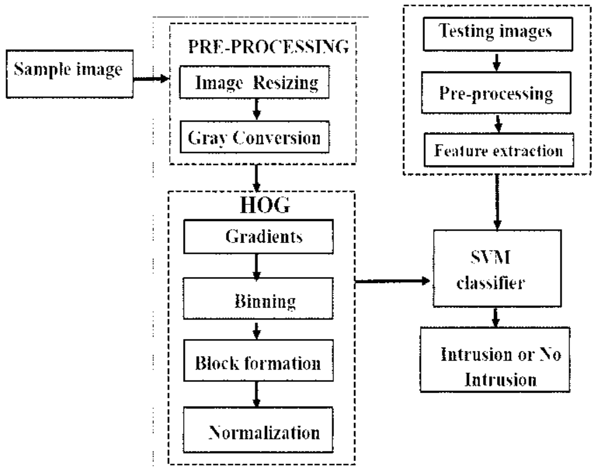


Fig 2. Block diagram of proposed system

A. *Pre-processing*

As explained in section III the Training and Testing dataset contains images of size which varies from 275x183 to 4000x 2500. To reduce the complexity and computational time we preprocess the images which inclues resizing and RGB to gray scale conversion, in this paper the images are resized to 128x 128 and then it is converted to gray scale.

B. *Feature Extraction*

After image is preprocessed, the features are to be extracted for further processing i.e., HOG (Histogram of Orientation Gradients) algorithm is a feature descriptor that is used for object detection and this is understood from the following example.

Step 1:Divide the entire image into mxn cells.

For example, consider an [4x4] image matrix given by:

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I=

12	15	16	18
20	30	50	40
100	150	10	13
23	35	45	22

Step 2: The values of vertical and horizontal gradients using Gx and Gy are computed in the following manner:

$$Gx = I(x+1, y) - I(x-1, y)$$

$$Gy = I(x, y+1) - I(x, y-1)$$

(where I is the considered matrix)

Gx=

3	4	3	2
10	30	10	-10
50	-90	-137	3
12	22	-13	-23

Gy=

8	15	34	22
88	138	11	11
50	90	137	18
77	117	46	24

Step 3: Computing the magnitude and angle using formula Magnitude is calculated as,

$$\text{Magnitude: } G = \sqrt{Gx^2 + Gy^2}$$

8	15	34	22
88	135	-6	-5
3	5	-5	-18
-77	-115	35	9

$$\text{Angle}: \propto = \tan^{-1}\frac{Gy}{Gx}$$

69	75	84	84
83	77	149	26
3	177	2	100
99	101	111	159

Step 4: Now, according to the orientation, the pixels are classified into 8 evenly spaced bins using unsigned of orientation (0-360) degree and 8 bins or directions. All the pixels having the angles lying in the same bin and the sum of the corresponding magnitudes will give the value of the bin.

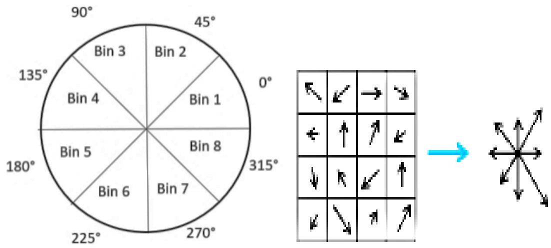

Fig 3. Orientation binning

Step 5: Normalization is performed in order to remove unwanted zeros present in the sample image and it is done using below formula,

$$\text{L2 norm: } |x|_2 = \sqrt{\sum_{i=1}^{N} |x_i|^2}$$

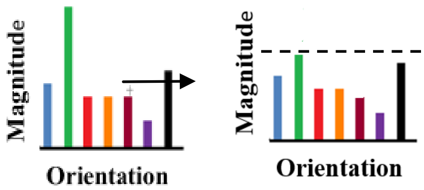

Fig 4. Normalization of HOG

Finally, Descriptor of all the positive samples (foreground images with ship intrusion) and negative samples (background images without ship intrusion) are computed and fed into SVM for recognition.

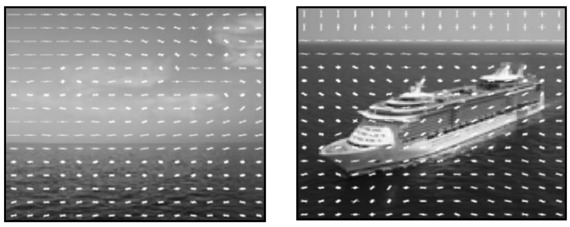

Fig 5. Extracted HOG Features

C. SVM Classifier

The feature extracted from the images in Training and Testing is used for classifier training. Different classes of images in the Training dataset are used, so first the images are labelled correctly and the following algorithm is used to determine the class to which a new test sample belongs to.

Support Vector Machine (SVM) is a supervised machine learning algorithm which can be used for both classification or regression challenges. However, it is mostly used in classification problems [3].

In this algorithm, each data item is plotted as a point in n-dimensional space (where n is number of features you have) with the value of each feature being the value of a particular coordinate. Then, classification is performed by finding the hyper-plane that differentiate the two classes.

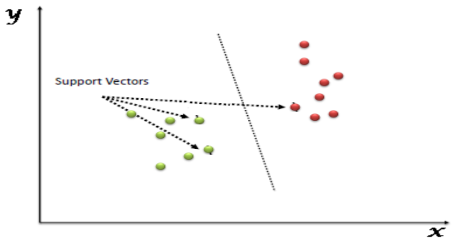

Fig 6. Generation of Hyper plane

V. PERFORMANCE EVALUATION

In the field of machine learning a confusion matrix, also known as an error matrix,is a specific table layout that allows visualization of the performance of an algorithm. Each row of the matrix represents the instances in a predicted class while each column represents the instances in an actual class (or vice versa).

Confusion matrix is a table with two rows and two columns that reports the number of false positives, false negatives, true positives, and true negatives. This allows more detailed analysis than mere proportion of correct classifications (accuracy) [5].

Accuracy is not a reliable metric for the real performance of a classifier, because it will yield misleading results if the data set is unbalanced (that is, when the numbers of observations in different classes vary greatly).

Table 1. Confusion matrix for two class classifier

		Predicted	
		Positive	**Negative**
Actual	**Positive**	**A**	**B**
	Negative	**C**	**D**

Accuracy is the proportion of the total number of predictions that were correct. It is determined using the equation:

$$\text{Accuracy} = (A+D)/(A+B+C+D) \qquad (1)$$

Recall or true positive rate (*TP*) is the proportion of positive cases that were correctly identified, as calculated using the equation

$$TPR = A/(A+B) \qquad (2)$$

False positive rate (*FP*) is the proportion of negatives cases that were incorrectly classified as positive, as calculated usingthe equation:

$$FPR = C/(C+D) \qquad (3)$$

True negative rate (TN) is defined as the proportion of negatives cases that were classified correctly, as calculated using the equation:

$$TNR = D/(C+D) \qquad (4)$$

False negative rate (FN) is the proportion of positives cases that were incorrectly classified as negative, as calculated using the equation:

$$FNR = B/(A+B) \qquad (5)$$

where, A is the number of correct predictions that an instance is negative, B is the number of incorrect predictions that an instance is positive, C is the number of incorrect predictions that an instance is negative, and D is the number of correct predictions that an instance is positive.

VI. RESULTS AND DISCUSSION

The proposed work in ship intrusion detection system was carried out using HOG features and SVM classifier.

Initially, as discussed in section IV, this project was carried with 2 stages i.e., Training module with 100 images and Testing Module with 20 images. In Training Module the database was created and features were extracted. Using the extracted features the SVM was trained and the actual output for trained images is as shown in Fig 7, after testing the predicted output is shown in Fig 8.

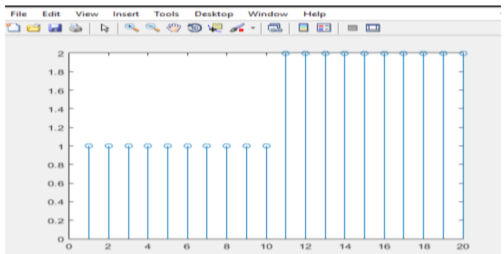

Fig 7. Actual Output

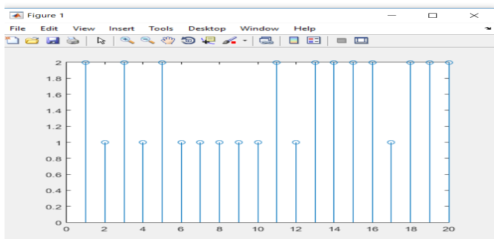

Fig 8. Predicted Output

After Training and Testing, the performance of the system was evaluated by confusion matrix using four entries as shown in Table 2. From the confusion matrix, the accuracy obtained was about 75%.

$$\text{Accuracy} = (A+D) / (A+B+C+D) = (7+8) / (7+3+2+8)$$

Accuracy = 75%

Since there are 5 misclassifications in Fig 8, the same process was carried out by Training the SVM with more number of images and the predicted output is shown in Fig 9. Hence the accuracy is increased to 80%

Table 2. Confusion matrix

		Predicted Class	
		Ship	**Non-Ship**
Actual Class	**Ship**	7	3
	Non-Ship	2	8

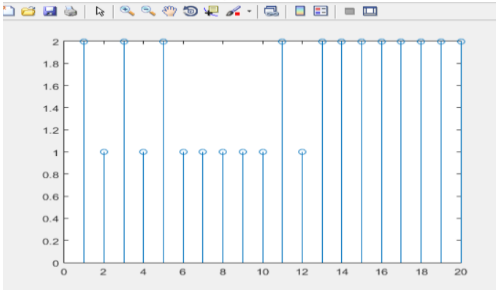

Fig 9. Predicted output

Table 3. Confusion Matrix

		Predicted Class	
		Ship	**Non-Ship**
Actual Class	**Ship**	7	3
	Non-Ship	1	9

Accuracy = (A+D) / (A+B+C+D) = (7+9) / (7+3+1+9)

Accuracy = 80%

Further this project was carried out using Video input of about 2 seconds and then it was converted to 58 frames . These frames are given to trained SVM Classifier and thus the accuracy was improved to 100% and the snapshots of the output is shown in Fig 10.

VII. ADVANTAGES

A. Fully Automated

The system requires some initial training time for the SVM which must be supervised by human. Further, the system will not require any human supervision or intervention except while initializing the system.

B. Easy to install

Installing the system requires just setting of an external camera towards the direction of the seashore environment which is to be surveiled. No excessive wiring or CCTV setup is required.

C. Quick to response and Raise Alert

As soon as there is any intrusion of ship detected, authoritive person is alerted and actions could be taken accordingly.

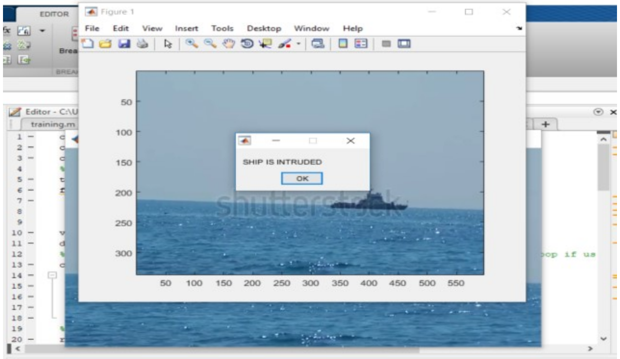

Fig 10. Ship Intrusion Output

D. Economical

All it requires is a high-resolution camera, no need to pay server cost, or any person for continuously monitoring the seashore. No excessive wiring and CCTV cost.

E. Portability System

It can be ported anywhere anytime by installing camera on the respective seashore for serving needful security purposes.

VIII. CONCLUSION

This paper gives the innovative solution for the people who cross over the border and saves more lives. This proposed system mainly deals with highly dynamic environment and thus will use machine learning concept SVM (Support Vector Machine) and image processing technique to detect intrusion at seashores. Using the interworking mechanisms of these two techniques, this system can detect the intruding ship from the constantly changing sea environment. Hence, this system can be used as a real time security system at seashore areas.

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