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Ship Intrusion Detection Security System Using HoG & SVM

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***Abstract*— Surveillance is a paramount problem for harbor protection, border control and security of various commercial facilities. It is particularly challenging to protect the vast near-coast sea surface and busy harbor areas from intrusions of unauthorized marine vessels, such as trespassing boats and ships. In our project, we present a state-of-the-art solution for ship intrusion detection using image processing and Support Vector Machine (SVM). The main aim is to detect the ships, which cross over the border and secured industrial spaces. Using the interworking mechanisms of these two techniques, we can detect the intruding ship from the constantly changing sea environment. SVM can be used as a machine learning to train the system by exposing it to different seashore environments. Hence, it can be used as a real time security system at seashore areas.**

Index Terms*— Harbor protection; Marine vessels; Image processing; Seashore environment; Intrusion detection; Machine learning; Support Vector Machine (SVM); Histogram of oriented Gradients algorithm; Camera.

I. INTRODUCTION

Our project presents a state-of-the-art solution for ship intrusion detection. In imaging science, image processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or a set of characteristics or parameters related to the image. The image is processed by adjusting hue, saturation, brightness etc. Security sureveillance is an important component in video surveillance systems. [1] Insecurity, terrorism and other crimes constitute some major problems facing the immediate society today. People are living with a fear of being attacked by terrorists, burglars, vandals and thieves. In today's world, security is one of the major issues and having a 24x7 human surveillance is just not possible. In order to be secured of safety, it has become a necessity to realize and introduce smart surveillance system.

II. LITERATURE SURVEY

SVM (Support Vector Machine): Support Vector Machine (SVM) is a supervised machine learning algorithm, which can be used for both classification and regression problems. [3] The SVM, on being given data sets of two separate classes generates a hyper plane such that the margin between the two classes is maximum. Thus the SVM learns to generate an optimal hyper plane that can be used to separate the two classes.

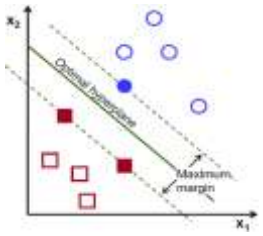

Figure 1: Generation of hyper plane [5]

In our project, training data (already categorized into two classes- foreground and background) is entered into the SVM and on the basis of the analysis of the given data set; SVM generates the optimal hyper plane that will differentiate the background and foreground points. Now, this hyper plane, thus generated from the training sample data can be used to predict the class i.e. background or foreground of the real-time data, which will be acquired during the intrusion detection process.

One of the properties that made us choose SVM is that it can be used to classify data plotted in n-dimensions i.e. data is classified on the basis of various parameters. One of the parameters used in this project is the centroid of each region in the video frame.

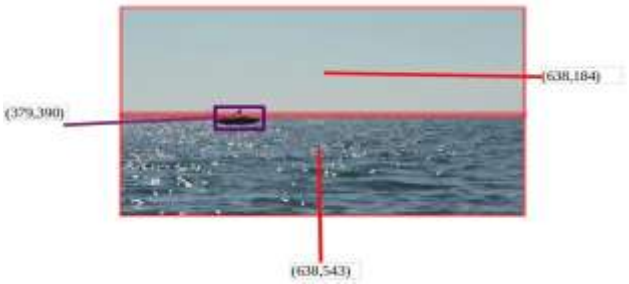

Figure 2: Centroid values of all the segments

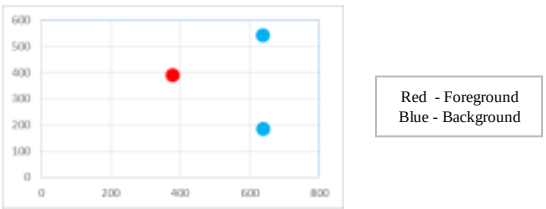

Figure 3: Plotting of centroid points for a single frame image

The points will be plotted according to data from multiple frames according to different intrusion and background videos that will be fed to the SVM during the training session. The hyper plane will be generated from the training data set.

Histogram of oriented Gradients (HoG): The histogram of oriented gradients (HOG) is a feature descriptor used in computer vision and image processing for the purpose of object detection. The technique counts occurrences of gradient orientation in localized portions of an image. This method is similar to that of edge orientation histograms, scale invariant feature transform descriptors, and shape contexts, but differs in that it is computed on a dense grid of uniformly spaced cells and uses overlapping local contrast normalization for improved accuracy. [4]

Implementation of the HOG descriptor algorithm is as follows [8]:

1. Divide the image into small-connected regions called cells, and for each cell compute a histogram of gradient directions or edge orientations for the pixels within the cell.
2. Discretize each cell into angular bins according to the gradient orientation.
3. Each cell's pixel contributes weighted gradient to its corresponding angular bin.
4. Groups of adjacent cells are considered as spatial regions called blocks. The grouping of cells into a block is the basis for grouping and normalization of histograms.
5. Normalized group of histograms represents the block histogram. The set of these block histograms represents the descriptor.

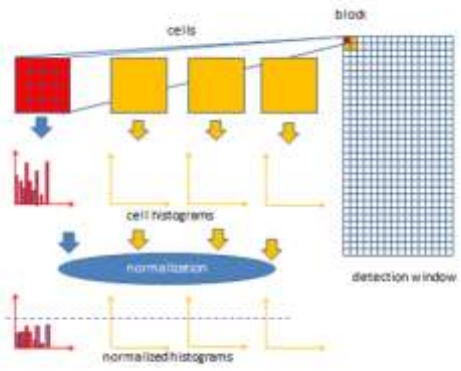

Figure 4: HoG Algorithm [7]

Problem Statement: To surveil a seashore environment and detect ship intrusion i.e. ship approaching or entering the shore. Though there might be many entry points in the environment, the area of the seashore environment surveiled depends upon the camera's specification. Usually there won't be any ships in the seashore since the system will be used for security purposes but there will exist background disturbances in it like fierce winds, sea waves, etc., thus making the seashore environment dynamic i.e. changing frequently. Any moving object of dimension greater than the parameters defined as that of ship will be considered as an intruder. The system should surveil throughout the day and night 24x7.

III. Proposed System

This proposed system mainly deals with highly dynamic enviroment and thus will use machine learning concept SVM (Support Vector Machine) to detect intrusion at seashores. Dynamic Environment means an environment, which is not fixed i.e. it is always in motion due to some or the other external factors. [2] These external factors may include motion produced by constantly changing sea waves, or light i.e. variations in brightness or contrast. Whenever any intrusion occurs, the intruder will be found on the foreground video frames. The task is to not include the changing waves that are a part of the changing environment. A foreground segment containing a boat or ship will be shown as an intrusion.

Machine learning is integrated with the intrusion detection system so as to teach the system to adapt to the changing seashore environment. Thus even when the background changes due to the changing waves and light intensity, it is not detecting the background change as intrusion.

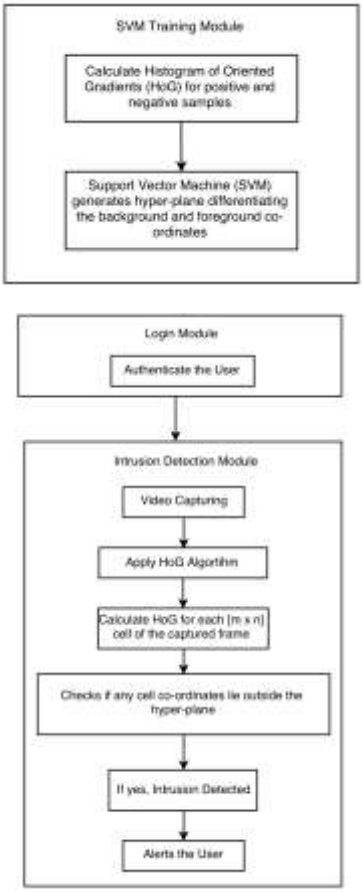

Figure 5: Block Diagram

A. *Support Vector Module (SVM) Training Module*

In this module, the system is trained in the different possible situations and environment.

- **Calculate HoG for positive and negative samples:** Images containing positive (foreground) and negative (background) samples will be treated as an input to the SVM.
- **Generation of hyper plane:** In the training, the background and foreground coordinates are plotted and using SVM, the hyper plane differentiating the background and foreground is generated. This process is repeated for different situations and environments. The final general hyper plane will be used when the system is to be used.

B. *Login Module*

In this module, the user is authenticated via the user credentials like user-name and password.

C. *Intrusion Detection Module*

This module is where the image is segmented and intrusion is detected.

- **Video Capturing:** The video camera is used to capture the surveillance video. Each frame is then sent for further analysis.
- **Apply HoG Algorithm:** Here, the image is divided into different [m x n] cells using HoG algorithm.
- **Calculate HoG for each [m x n] cell of the captured frame:** The coordinates of all the cells are calculated.
- **Check if any segment coordinates lie outside hyper plane:** On the basis of the hyper plane generated by the SVM, we can check if any of the segments coordinates lie outside the hyper plane.
- **Intrusion Detection**: If any segment coordinates lies outside the hyper plane for long time, then intrusion is detected.
- **Alert the user:** On intrusion being detected, the user is alerted by displaying an intrusion message on the display device.

Figure 6: DFD Level -0

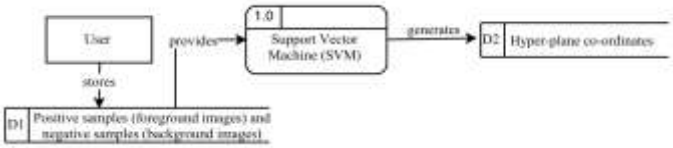

Figure 7: DFD Level -1 (SVM Training Module)

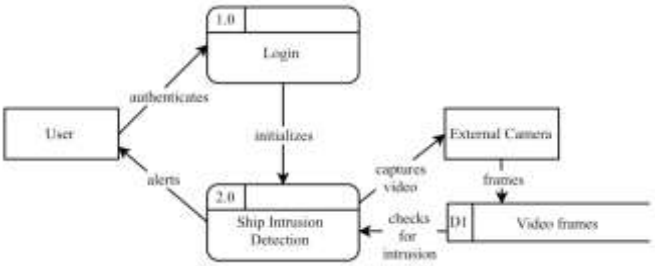

Figure 8: DFD Level -1 (Ship Intrusion Detection Module)

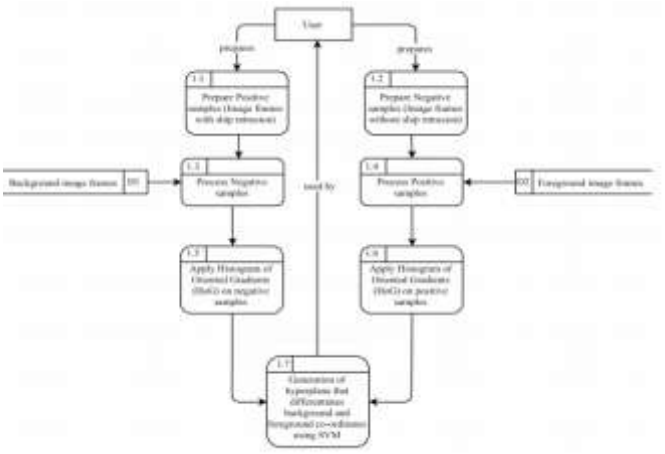

Figure 9: DFD Level -2 (SVM Training Module)

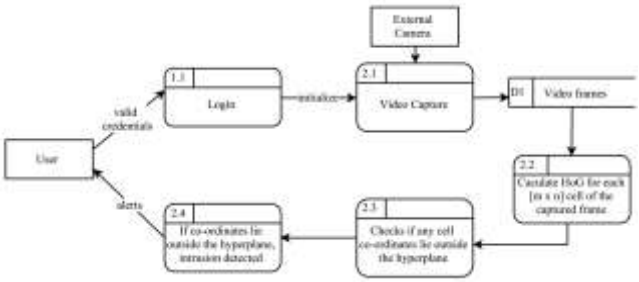

Figure 10: DFD Level -2 (Ship Intrusion Detection Module)

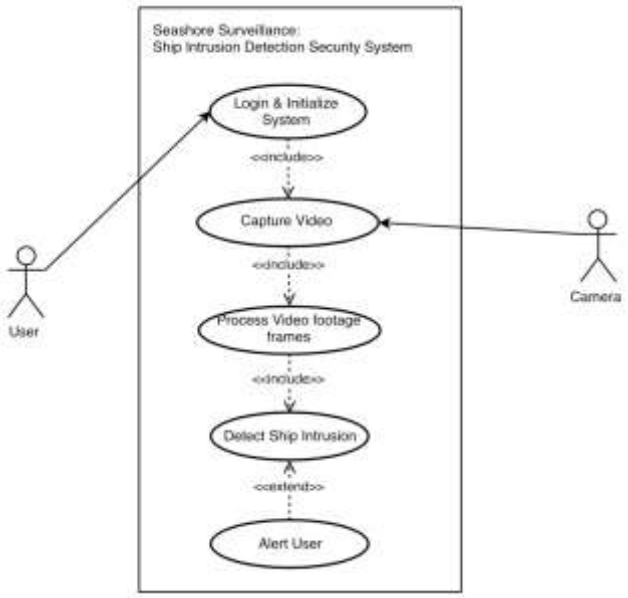

Figure 11: Use-case Diagram

IV. Advantages

A. *Fully Automated*
The system will require some initial training time for the SVM which has to be assisted by human. Further, the system will not require any human intervention except while initializing the system.

B. *Easy to install*
Setting up the system requires just installation 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 suspicious movement, authoritive person gets to know about it via Alert alarm. Further action can be taken accordingly.

D. *Affordable*
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 can be ported anywhere, we just need to install the camera on the respective seashore for serving needful security purposes.

V. Applications

Our project can be used for security surveillance to ensure harbor protection and border control. It can be installed in naval base, ports and various commercial facilities to protect the vast near-coast sea surface and busy harbor areas from intrusions of unauthorized marine vessels, such as trespassing boats and ships.

VI. Conclusion

Seashore ship intrusion detection system focuses on the aspect of surveillance of coastal areas with accurate ship detection in a highly dynamic environment. Using the combination of both i.e. image processing and SVM machine learning technique, it is a new state-of-the-art system which overcomes the setbacks of the existing system like expensive setups, inaccurate detection, algorithm error which can be trounced to achieve an efficient system. The main facet of the project is to design such a system which will work mainly in dynamic environment of coastal and seashore areas of research centres, naval base, ports where surveillance is required 24x7 for various security purposes.

Acknowledgment

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[4] https://en.wikipedia.org/wiki/Histogram_of_oriented_gradients

[5] http://docs.opencv.org/2.4/_images/optimal-hyperplane.png

[6] https://users.cs.cf.ac.uk/Dave.Marshall/Vision_lecture/region_growing.gif

[7] https://software.intel.com/sites/default/files/did_feeds_images/0EF01A88-F874-4ECB-B2B6-3ADC38636CD4/0EF01A88-F874-4ECB-B2B6-3ADC38636CD4-imageId=6A72422F-6619-4E3D-92A2-BC640A6572CC.png

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