Night Time Pedestrian Detection for Advanced Driving Assistance Systems (ADAS) using Near Infrared Images

A Thesis Submitted in Partial Fulfillment

of the Requirements for the Award Degree of

Master of Technology

in

Electronics & Communication Engineering

by

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National Institute of Technology, Rourkela

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA

CERTIFICATE

This is to certify that the thesis report entitled **"NIGHT TIME PEDESTRIAN DETECTION FOR ADVANCED DRIVING ASSISTANCE SYSTEMS USING NEAR INFRARED IMAGES"** Submitted by **Mr. P GOVARDHAN** bearing roll no. **212EC6385** in partial fulfilment of the requirements for the award of Master of Technology in Electronics and Communication Engineering with specialization in **"Signal and Image Processing"** during session 2012-2014 at National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University / Institute for the award of any Degree or Diploma

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Place: Rourkela
Date:02-06-2014

Dedicated to my Family, Friends and Teachers

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I am really thankful to my all friends. My sincere thanks to everyone who has provided me with kind words, a welcome ear, new ideas, useful criticism, or their invaluable time, I am truly indebted.

At last, I would conclude with my deepest gratitude to my parents, my classmates and all my loved ones. My full dedication to the work would have not been possible without their blessings and moral support. This thesis is a dedication to them who did not forget to keep me in their hearts when I could not be beside them.

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ABSTRACT

From last decade, Safety plays a major role in automobile industry, which results in the invention of various safety measures such as air bags, central locking system, automatic breaking system, traffic signal detection etc. In such case pedestrian detection in night vision is one of the vital issues in advanced driving assistance systems. The main aim of the night vision systems is to avoid collision of vehicles with the pedestrians while driving on roads. It is very much important in night time, due to the varying light conditions it is very difficult to detect a pedestrian. With the presentation of night vision systems another sort of driver support is achieved, which can compensate the weaknesses of the human visual system after shutdown of sunlight.

A NIR (Near Infrared) camera is used in this system to take images of a night scene. As there are large intra class variations in the pedestrian poses, a tree structured classifier is proposed here to handle the problem by training it with different subset of images and different sizes. This research work discusses about combination of Haar-Cascade and HOG-SVM (Histogram of Oriented Gradients-Support Vector Machine) for classification and validation. Haar-Cascade is trained such that to classify the full body of humans which eliminates most of the non-pedestrian regions. For refining the pedestrians after detection, a part based SVM classifier with HOG features is used. Upper and lower body part HOG features of the pedestrians are used for part based validation of detected bounding boxes. A full body validation scheme is also implemented using HOG-SVM when any one of the part based validation does not validate that particular part. Combination of the different types of complementary features yields better results. Experiments on test images determines that the proposed pedestrian detection system has a high detection rate and low false alarm rate since it works on part based validation process.

This research targets to help a more secure road environment during the nighttime for pedestrians ultimately to the drivers too.

Keywords: Haar-Cascade, histogram of oriented gradients, pedestrian detection, support vector machine.

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CHAPTER 1

1.1 INTRODUCTION

Last few decades the automobile industry has grown very rapid and the number of cars producing by it are even more. This brought about increase in traffic and its rules with traffic signals, signs and police. Driving turned into a complex job and the amount of accidents increasing consistently year by year. About 1crore individuals get affected by accidents around the globe every year and twenty to thirty lakh of these people are harmed severely. Both automobile manufactures and mainstream researchers have helped the improvement of distinctive sorts of security frameworks so as to enhance traffic safety. At first, enhancements comprised of basic components like seat belts, however then more intricate devices, for example, electronically monitored slowing mechanisms, electronic adjustment projects, and airbags, were produced.

In the course of the most recent decade, research has moved to more advanced situations where a system can predict the chances of accidents and give the information to the driver for alertness. These are known as Advanced driving assistance systems (ADASs), since they aid the driver in checking chances of accidents, give motions in potentially safer driving circumstances, and execute balancing measures. A few illustrations are the versatile journey control, which keeps up a safe gap in between lane and the vehicle cautioning that does when the vehicle is determined out of a path coincidentally.

To decrease number of accidents, earlier automobile producers enhanced their vehicles with the presentation of better brakes and tires. It reduced the occurrences of accidents reliably for an extent, but it did not deal with the things which causes mainly for accidents. For that reason automobile industry put forward their research on other safety measuring elements such as air bags, automatic braking system etc. which is termed as Advanced Driving Assistance Systems

(ADAS), with this improvements they moved further for Night Vision systems which indeed works on mainly image processing principles with the assistance of a camera and processing unit.

The Night vision systems assists the driver of the vehicle by letting him to know the obstacles especially pedestrians on the road with the help of a camera and its displaying unit. In this systems pedestrian detection plays a major role. Pedestrian detection is significant and most challenging tasks in the image processing field. It has been widely used in robotics, surveillance and intelligent vehicles [1]. A lot of research works have been done on the detection of pedestrians in recent years, but the task of pedestrian detection is still challenging in the intelligent vehicle systems with cluttered backgrounds and varying light conditions in moving environment. Fig1.1 shows an example of a night vision pedestrian detection system inside of a BMW 7 series model car with Active lane departure warning system.

Fig1.1: Night vision pedestrian detection system inside of a BMW 7 series model

Since sight of a driver differs from person to person. Instead of upgrading the eye sight power of the driver, here we consider another view of sight which helps the driver called as a night vision system. Whenever infrared light is used in this night vision systems, it does not disturb the persons who else were using the road since it won't give dazzling effect to others. With Far infrared (FIR) camera system, the profit of fast person on foot distinguishment to a driver has been quantified. The near infrared (NIR) system has been introduced to market, and the capacity of pedestrian identification has been added as of late. Both FIR and NIR has its own added advantages. No illumination is required in the FIR systems, and the pedestrian appears as a bright object since it works on temperature of an object. The NIR system, which is nearer to the visible spectrum is having a higher picture resolution. The noise effect is also less so that chances of reaching information is more to the driver.

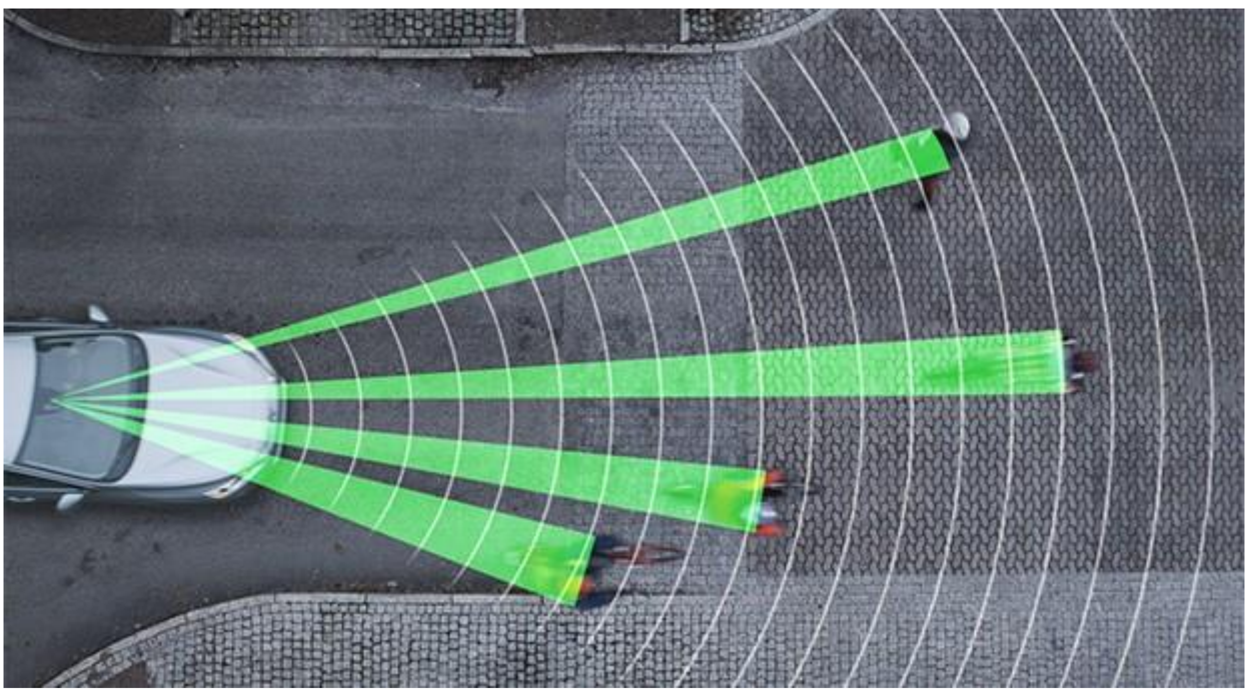


Fig1.2: The outer view of a smart car with night vision system

In the night vision systems, the cameras play a major role. In this type of systems, main focus should keep on type of sensing technology used in cameras which were using for night vision systems and also about its advantages and disadvantages. The cameras were generally placed inside the head beam light or topside of the vehicle so that it can have a better view. Fig1.2 represents the outer view of a smart car with night vision system with a camera which focuses the pedestrians and Fig1.3 (a) and 1.3 (b) shows the example of a pedestrian alert in the monitor of a smart car.

(a)

(b)

Fig1.3: (a) and (b) are the example of a pedestrian alert in the monitor of a car.

1.2 MOTIVATION

Every year there are thousands of pedestrians in India and millions of pedestrian across the world were meeting with severe road accidents. Especially in night times the chances of accidents were more due to varying light conditions and cluttering backgrounds. Till few years automobile industry concentrates about protection measures for the driver and his accompanies in the vehicle by means of many inventions such as seat belts, air balloons, central locking system, and automatic braking systems etc. but from last few years automobile industry and its researches were concentrating on developing the systems which safe guard the members in the outside world such as pedestrians from the vehicles.

Share of 'Road accident deaths' in total 'Accidental deaths' by un-natural causes during 2008 to 2012

Sl. No.	Year	Number of accidental deaths		Percentage share of 'Road accident' deaths in un-natural total deaths
		Road accidents	Total un-natural	
(1)	(2)	(3)	(4)	(5)
1	2008	1,18,239	3,18,316	37.1
2	2009	1,26,896	3,34,766	37.9
3	2010	1,33,938	3,59,583	37.2
4	2011	1,36,834	3,67,194	37.3
5	2012	1,39,091	3,72,022	37.4

Table no.1: The share of road accident deaths in India from 2008 to 2012

Growth in number of vehicles and road accidents in India (2008-2012)

Sl. No.	Year	Road accidents (in thousand)	% variation over previous year	Persons injured (in thousand)	% variation over previous Year	Persons killed (in nos.)	% variation over previous Year	No. of vehicles (in thousand)	% variation over previous Year	Rate of deaths per thousand vehicles (Col.7/ Col.9)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	2008	415.8	– 0.7	469.1	0.8	1,18,239	3.2	89,618	23.2	1.3
2	2009	421.6	1.4	466.6	-0.5	1,26,896	7.3	89,618	–	1.4
3	2010	430.6	2.1	470.6	0.9	1,33,938	5.5	1,14,953	28.3	1.2
4	2011	440.1	2.2	468.8	-0.4	1,36,834	2.2	1,14,953	–	1.2
5	2012	440.0	-0.02	469.9	0.2	1,39,091	1.6	1,41,867	23.4	1.0

Table no.2: Growth in number of vehicles and roads in India (2008-2012)

Statistics are from 'Road Transport Year Book' of Transport Research Wing, Ministry of Road Transport and Highways, Govt. of India. Table no. 1 shows the share of road accident deaths and its comparison with total accidental deaths in India from 2008 to 2012 and Table no.2 shows the increase of vehicles year by year in road accidents and the statistics of injuries and deaths from 2008 to 2012 in India.

1.3 OBJECTIVES

The main objectives of the Thesis are as follows:

i. Development of pedestrian detection technique based on Histogram of Oriented Gradients and Support Vector Machine using NIR images in night vision.
ii. Development of night time pedestrian detection technique by two stages based on cascade classification and validation using NIR images.
iii. Comparison of performance of both the techniques

1.4 THESIS ORGANIZATION

The overall thesis is described in 5 chapters including the introductory chapter. The organization of thesis is presented below:

Chapter-2 Literature Review

This chapter deals with chronological evolution of some pedestrian detection techniques which were existing and sensing technologies used for images in the night vision systems with its merits and demerits.

Chapter-3 Feature extraction and Classification Techniques for Pedestrian detection

First part of this chapter deals with the different types of feature extraction mechanisms implemented for object detection and different classification methods or learning algorithms deployed for classification of pedestrians. In the second part, a pedestrian detection technique with HOG-SVM combination is implemented and its performance is evaluated.

Chapter-4 Pedestrian detection technique in night vision using cascade classification and validation

This chapter is devoted to implement a two stage detection and validation procedure for detection of pedestrians in night vision using NIR images. In the first stage Haar features with cascade classifiers were used for detecting pedestrians and in second stage HOG-SVM combination is used for validating the detected pedestrians in the first stage. Finally performance evaluation is also been done.

Chapter-5 Conclusions

This chapter contains the overall conclusion about the thesis and the scope for further improvements regarding this research work.

CHAPTER 2

LITERATURE REVIEW

2.1 LITERATURE REVIEW

Since last decade, there has been an extensive research in the detection of pedestrians for intelligent systems. These approaches vary in different criteria such as in image sensing technologies, detection environment, complexity and robustness. Night vision pedestrian detection is one of the leading trends in research now a days. The overview of some of the popular pedestrian detection techniques have been discussed below.

- ***Survey on pedestrian detection in day and night time environment:*** There has been an extensive research going on in the area of pedestrian detection, where the detection of pedestrian in night time play major role [2] compared to the day time environment due to many reasons. Varying light conditions and cluttering background situations makes the system more vulnerable for the reduction of eyesight, in that context it gains more important to detect pedestrians at night time.

- ***Survey on image sensing technologies used in night vision systems:*** Two types of sensing technologies are used in current night vision systems: 1) Far-Infrared (FIR) imaging systems and 2) Near-Infrared (NIR) imaging systems. A survey on these two types of systems, about their advantages, disadvantages and their applications has been discussed in [3].The main aspects in both types of night-vision systems are capability of pedestrian detection, effectiveness for avoidance of collision, and the commercial attractiveness.

- ***HOG feature based pedestrian detection approaches:*** The Histogram of Oriented Gradients which gives the orientation of an object in an image with the help of its histograms out performs well in the detection of pedestrians. This was experimentally stated in the [4]. The HOG dataset was likely to be small so that the training and testing of the object becomes simple. Here HOG dataset of the training and testing image should be same. The false alarm rate decreases here compared to the other feature sets.

- ***Image segmentation techniques for preprocessing in pedestrian detection:*** There are many segmentation schemes implemented in the process of detection of pedestrians. In that mainly image segmentation based on threshold techniques were used in common. The advanced threshold segmentation techniques were implemented such as Dual Adaptive Image segmentation [5] which is more robust to noise.

2.2 IMAGE SENSING TECHNOLOGIES IN NIGHT VISION SYSTEMS

There are two types of sensing technologies present in the night vision systems

1) Far Infrared Imaging systems 2) Near Infrared imaging systems

Both of the systems are having its own advantages and disadvantages in the field of night vision. Both type of systems can be used with high beam headlights but a Near Infrared (NIR) system can have a normal functionality over Far Infrared (FIR) systems. These FIR systems work in darker places where the need of light is necessary. The main aspects in both types of night-vision systems are capability of pedestrian detection, effectiveness for avoidance of collision, and the commercial attractiveness.

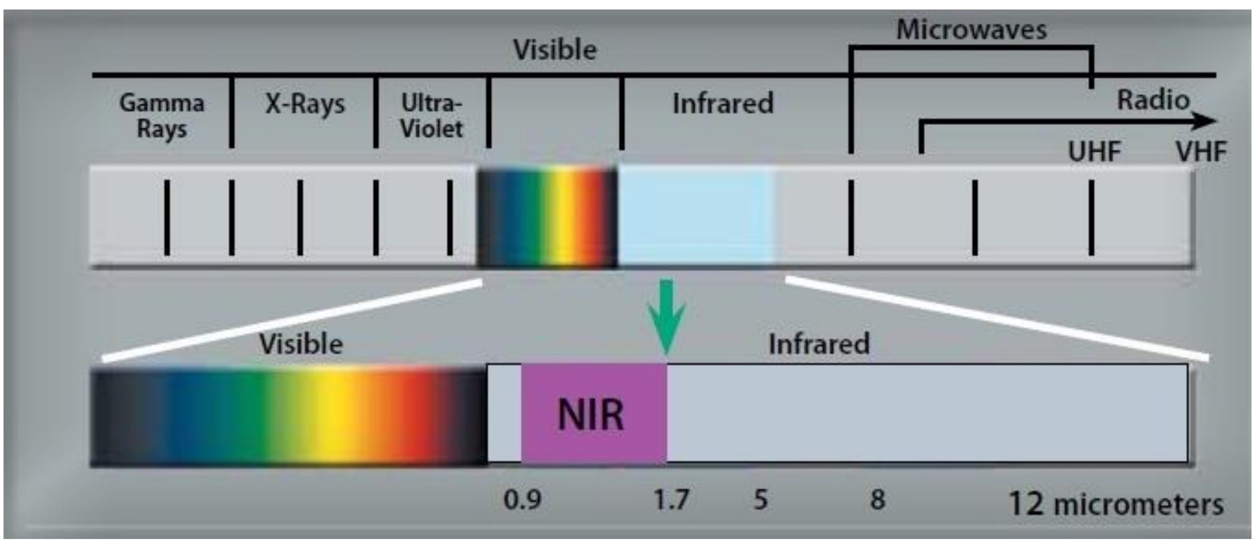


Fig2.1 shows the NIR and FIR band in electromagnetic spectrum based on its wavelengths.

2.2.1 Far Infrared Imaging systems: A Far Infrared Imaging system works on sensing temperature of an object, but at the time of summer, the temperature of the environment is almost equal to the body temperature which does not allow a pedestrian to differentiate from its background. In winter seasons, generally people wear heavy cloths which do not allow the camera to sense temperature. At these types of situations, it is very difficult to detect a pedestrian. These systems are expensive when compared with NIR systems. In the case of darker situations these systems are more robust since it senses the temperature emitted by a body.

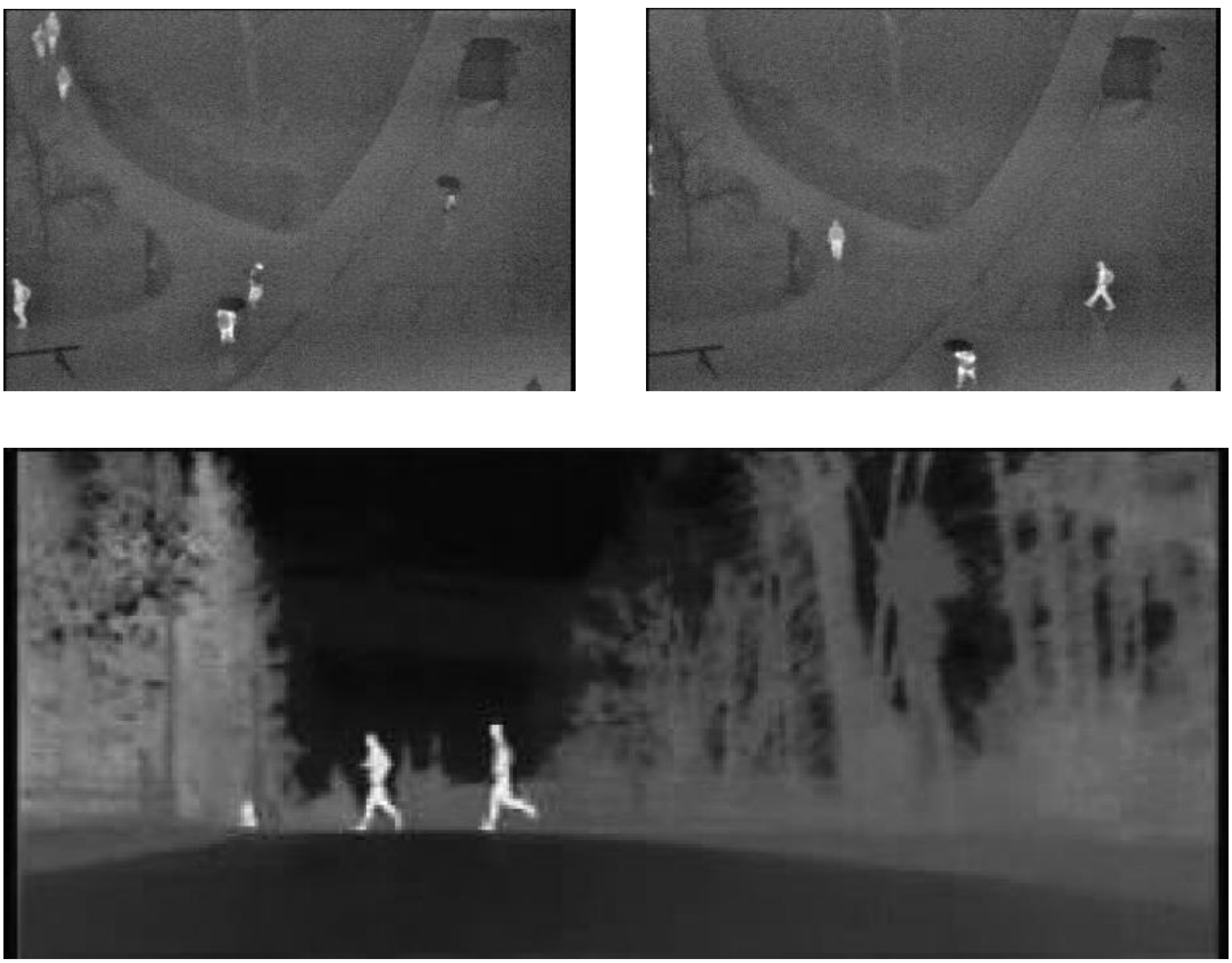


Fig 2.2 examples of FIR pedestrian images

2.2.2 Near Infrared Imaging systems: An NIR system is highly resistant to environment. Even at the time of summer or winter seasons, NIR systems don't have effect due to environment since it does not work on the principle of temperature sensing. There are many more advantages in NIR imaging systems in terms of image quality, commercial aspects and other visual information when compared with FIR imaging systems. The disadvantage of NIR system is visual cluttering. Cluttering was more when compared with FIR systems.

(a)

(b)

(c)

Fig 2.3: (a), (b), (c) Demo pictures of NIR pedestrian images.

CHAPTER 3

FEATURE EXTRACTION AND CLASSIFICATION BASED APPROACH

3.1 IMAGE FEATURES:

For any object detection and classification techniques, image features carries the object information in the image required for its detection. This particular image features should not carry any redundant or irrelevant information from the extraction. Here we were using a large class of data which needs a rapid extraction of features and its computation should also be easy enough. Besides, it should also robust to the background, illumination changes etc. For these reasons instead of going for a direct raw intensity images or gradients, one can go for a local feature descriptors of an image. These local features can be depends on gradients, points, intensities, blobs, color and its combinations. Depends on the application, the features of the images were determined for detection and classification.

There are different types of approaches for representing image features, which in general divided into four categories. In that one is of distinct approach which is based on points and the remaining three is of dense approach based on image intensities, wavelets and gradients.

3.1.1 Region of Interest / Key points based Approach:

In this method local features of an image is extracted by some distributed points around the region of interest which are called key points. This local features vectors are more informative regarding the position and intensity. The object classification completely depends on the reliability and accuracy of the key points. Few region of interest points detection techniques includes Forstner [7], scale invariant Harris-Laplace [8], Laplacian [9], Difference of Gaussians (DoG) [10].

However, many of the key point feature extraction techniques will have their own limitations for dealing with particular objects. One of the most popular approaches of this type of feature extraction is Scale Invariant Feature Transformation (SIFT) [10] [11] which is used mostly used for object recognition.

3.1.2 Intensity Image based approach:

In this type of approach, earlier formed an Eigen faces approach with simple intensity images and later on it was subjected to PCA for reduction of redundant data and to keep the most important data. One more work using intensity images is detecting faces where the correction of light in intensity images are performed by a method called histogram of intensities. The histogram of intensities consists of mainly two operations namely contrast stretching and histogram equalization.

3.1.3 Wavelet based Approach:

Wavelets that are made to have different frequencies could be joined and convolved with numerous different sorts of data, including sound signals and images, to extract information from the data. Scientifically, the wavelet will resound if the signal being convolved holds data of comparative frequency, which is the center idea for some reasonable application of wavelets, e.g., feature extraction based on Haar wavelets [12] and Gabor wavelets.

Haar like features:

Haar-like features are mainly used in object recognition, since it notes the detailed information of the object. These features are used in human face recognition system where it needs very fine details should be noted. This feature got the name due to its similarity with Haar wavelets.

The Haar-like feature adds the intensity values in each pixel location of a subsection image and computes the difference between the sums. Those differences can be used to identify the particular subsections of the image. For example, while recognition of Haar-like features, if the region of lips is darker than the region of nose. As a result, Haar-like features of a face is obtained by placing two rectangles over the lips and nose.

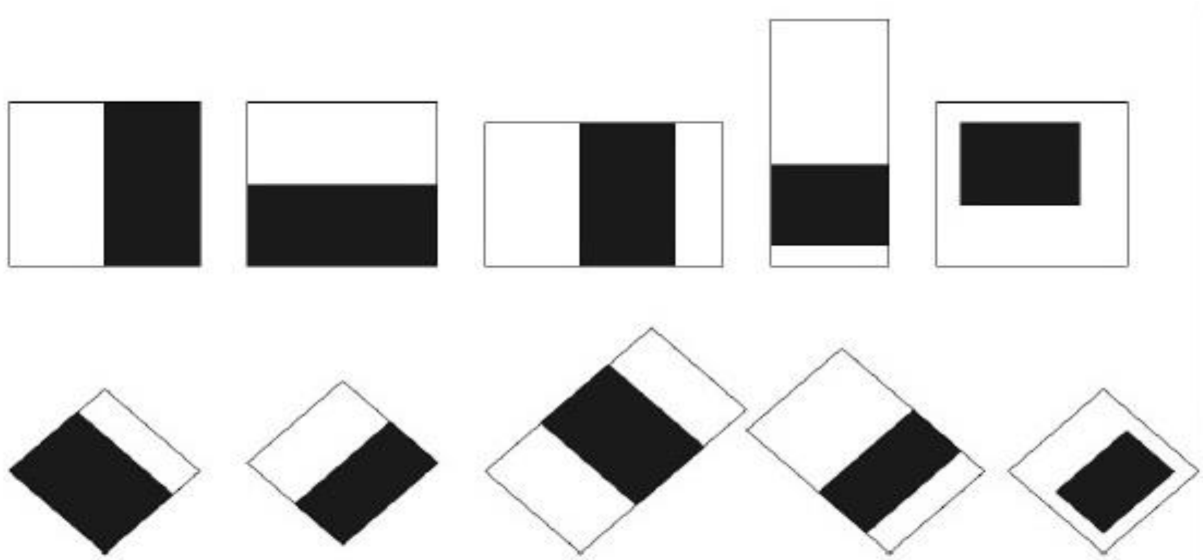


Fig3.1: Different types of Haar-like features

According to [12], a window of certain size is slides over the input image, in each and every subsection of an input image, Haar-like features is computed. Every time the difference of subsection image is compared and simultaneously learned to a detector for classification of desired object /non-object. However this type of scheme works little bit better than random guessing, but an iterative scheme is introduced to a large group of Haar-like features of similar object is trained by a classifier cascade to produce a strong classifier which can classify an object with high accuracy.

The main advantage of Haar-like features is computation speed. It has a high computation speed compared to others which makes the system competitive in real time object recognition. The fast computation of Haar-like features is determined by summed area tables [13], also called integral images. The rotated Haar-like features are also implemented for performance improvisation in object recognition, in [14] and [15]. Fig 3.1 shows the different types of Haar-like features with different orientations.

3.1.4 Gradient based Approach:

Edges of an object in an image has been one of the extensively used feature in object detection and classification. Why to choose this edge type feature is that the edges only contain the dominant gradient magnitude over the full image. A popular gradient based approach is histogram of oriented gradients (HOG). These HOG based feature extraction is majorly used pedestrian detection systems [4] and [16], where the shape of the pedestrian extracted by this descriptors is very informative and robust.

Histogram of Oriented Gradients:

HOG has been used as a key descriptor in the area of object detection, where a gradient orientation plays a major role. This HOG technique is almost similar to scale-invariant feature transform but differs in few situations where it performs on dense grid of uniform spaced cells. HOG feature descriptors which was first described in [4], where it shows a great success in detection of pedestrians in both images and videos, and even tested on few kind of common animals and vehicles in static images.

The essential thought behind HOG is that the appearances and shapes of nearby objects inside an image might be decently portrayed by the dissemination of intensity gradients as the votes for predominant edge directions. Such feature descriptor might be gotten by first separating the image into little coterminous locales of equivalent size, called cells, then gathering all the histogram of gradient orientations for every pixels inside each one cell, and finally joining all these histograms. With a specific end goal to enhance the recognition precision against illumination variation and shadowing, neighborhood contrast normalization could be connected by computing the values of an intensity over a bigger space of an image is called as a block, and utilizing the resultant quality to normalize all cells inside the block.

Thus HOG descriptors withstands greater advantages over other techniques. These feature were more robust to the movement of the pedestrian which is suitable for detection of humans. In general, there are four types of HOG-block techniques are available: Rectangular HOG (R-HOG), Fig 3.2 shows the Circular HOG(C-HOG), Bar HOG and Centre-surround HOG [16]

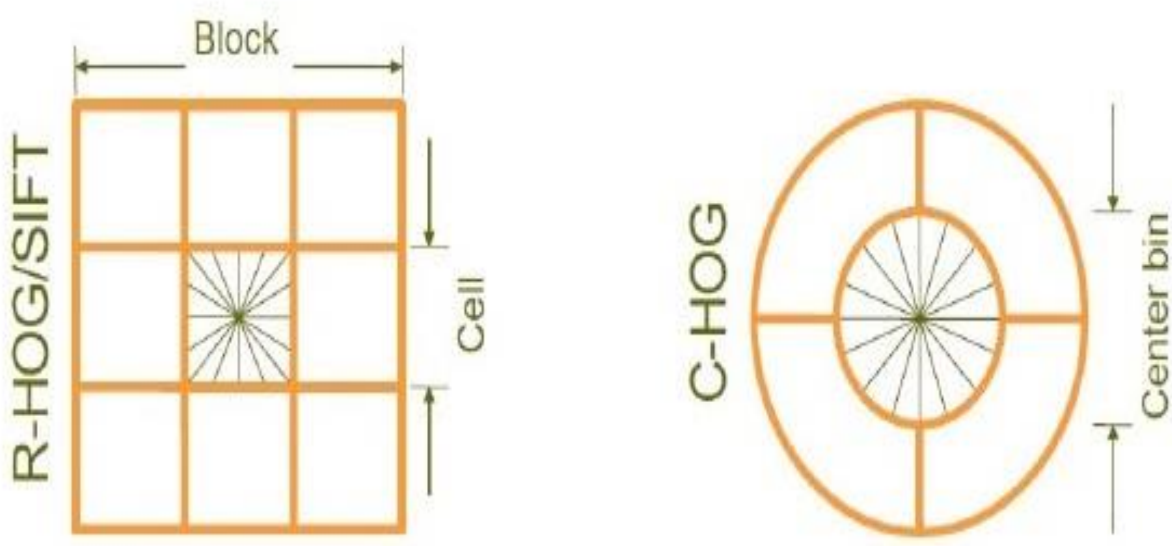


Figure 3.2: Left: R-HOG block. Right: C-HOG block.

❖ ***Gradient Computation***

The first step in extracting HOG features is of computing image gradients. A 1D centered derivative mask is applied both in the direction of horizontal and vertical for calculating Image gradients. The predominant filter kernel used in calculating gradients is given below

$$[1\ 0\ 1] \quad \text{and} \quad [1\ 0\ 1]^{T}$$

Actually there are many tedious masks, such as Canny, Sobel, Prewitt and diagonal masks, but the performance of these masks were poorer compared to the proposed window and Fig 3.2 and fig 3.3 were given by [4]. The computation of magnitude and orientation at each pixel location *I(x,y)* is calculated by

$$\begin{cases} G_{mag}(x,y) = \sqrt{G_x^2(x,y) + G_y^2(x,y)} \\ \theta(x,y) = \arctan(G_y(x,y)/G_x(x,y)) + \pi/2 \end{cases} \quad (1)$$

Where $G_x(x,y)$ and$G_y(x,y)$ are the gradients at each pixel location in horizontal and vertical direction, respectively.

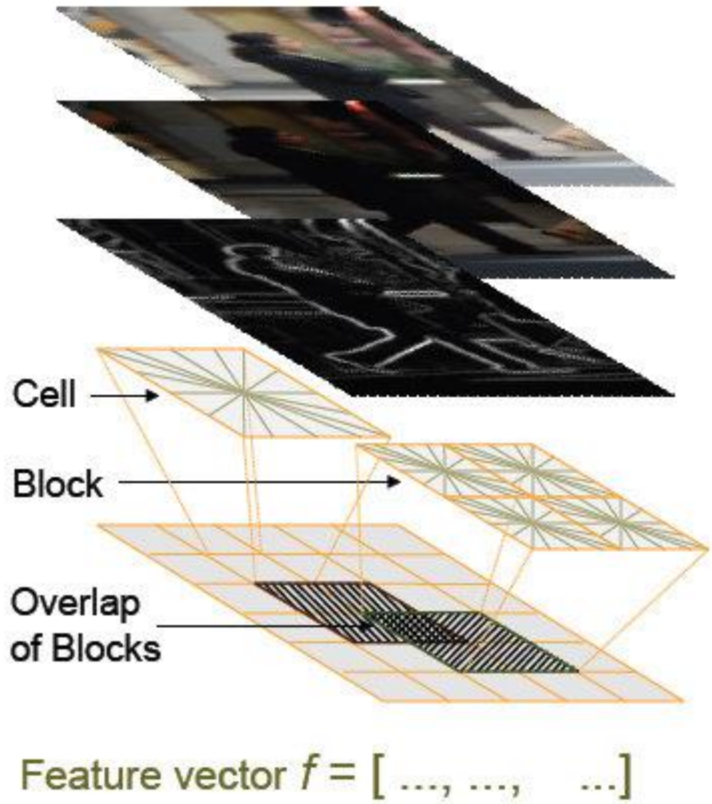


Figure 3.3: The processing chain of HOG feature descriptor.

In the case of color images the channel with lager magnitude gives the magnitude and orientation of the dominant pixel. While finding the angle it is necessary that to add π/2 since the angle value results in the range between –π/2 to π/2. It gives better performance when it ranges from 0 to π for an unsigned orientation.

❖ ***Orientation binning***

Here in this orientation binning procedure, Histogram of each cell is calculated and the cells which are group of pixel regions are either rectangular or radial in shape, and those bins were evenly distributed from $0^{\circ} to\ 180^{\circ}$, so every histogram bin will consists of a spread of 20°. Each and every pixel in a cell will consider its weighted voting to assign one of 9 bins according to its orientation. The weight of votes mainly considers its gradient magnitude but some other methods are also available for example the square or square root of the gradient magnitude etc. In general we can go for gradient magnitude.

- ***Block Descriptors***

Illumination and contrast variations makes the system more vulnerable to noise. To attain robustness the strength of the gradient should be normalized locally. This will makes the blocks with larger group of pixels or combination of few cells. These blocks overlaps with others in its neighboring hood to contribute its orientation more than once. As mentioned earlier there are four kinds of geometric blocks used among those rectangular blocks is commonly used. In general R-HOG block consists of square grids and the optimal parameters are said to be 2 X 2 cell blocks of 8 X 8 pixels each.

- ***Block normalization***

Normalization of blocks can be done by four different ways. Let υ denotes the non-normalized feature vector which collects the histogram of all cells in a block, $||\upsilon||_k$ denotes k-norm where k=1, 2 and ε is a small constant.

In this contest we were using a normalized scheme which is given below

Normalization scheme:

$$\frac{\upsilon}{\sqrt{||\upsilon||_2^2+\varepsilon^2}} \quad (2)$$

The final feature vector of HOG is containing the elements of normalized histograms from all of its block regions.

3.2 CLASSIFICATION METHODS:

There are many classification methods which will classify the objects based on different types of learning algorithms and with different features of the objects. Classification algorithms generally consists of two modules, one is of training module and another is testing module. All classification algorithms are focused around the presumption that the data being referred to holds one or more features, each of which fits in with one of a few unique and exclusive classes. Classification algorithms normally incorporates two progressive systems: training and testing. In the introductory training stage, an extraordinary depiction of each one class is made by learning with normal features removed from the training samples and dividing them in the peculiarity space. In the subsequent testing stage, these feature space partitions are utilized to group recently include characteristic vectors removed from the testing dataset.

The most popular classification techniques are AdaBoost and SVM which performs outstandingly. AdaBoost classification technique is used in object recognition and classification and SVM is a binary classifier which classifies a set of two.

3.2.1 AdaBoost:

AdaBoost is nothing but Adaptive Boosting. This technique is used for improving the performance of many algorithms. AdaBoost learning algorithm applies sequentially by its input training data and each prediction adds to an ensemble. When each ensemble is added the learning is weighted according to its accuracy. Even the dataset is also reweighted by samples which classifies correctly loses weight and samples classifies wrongly gains weight.

3.2.2 Support Vector Machine:

Support Vector Machine (SVM) is a popular technique for the classification. The main criteria in this technique is dealing with the training data and testing data. Here we have to train the system by using training data which should make learn the system to classify the object. This technique can be used very easily. Few examples where the classification can be done by using SVM is in hand written digit recognition, spam filtering, text classification and mainly used in pedestrian detection.

- Working procedure of an SVM is given below
- Training vectorsx_i where *i* =1,2….*l*
- Train SVM with training data x_i
- Consider a decision vector y with two classes which is a hyper plane separates all the data

$$y_i = \begin{cases} 1 & if\ x_i\ is\ in\ class\ 1 \\ -1 & if\ x_i\ is\ in\ class\ 2 \end{cases}$$

There are few problems regarding the separation of data in SVM. Few data sets which are given for classification can be linearly separable, whereas few data sets can't be linearly separable. A typical learning algorithm is achieved for separation of data for those type of cases.

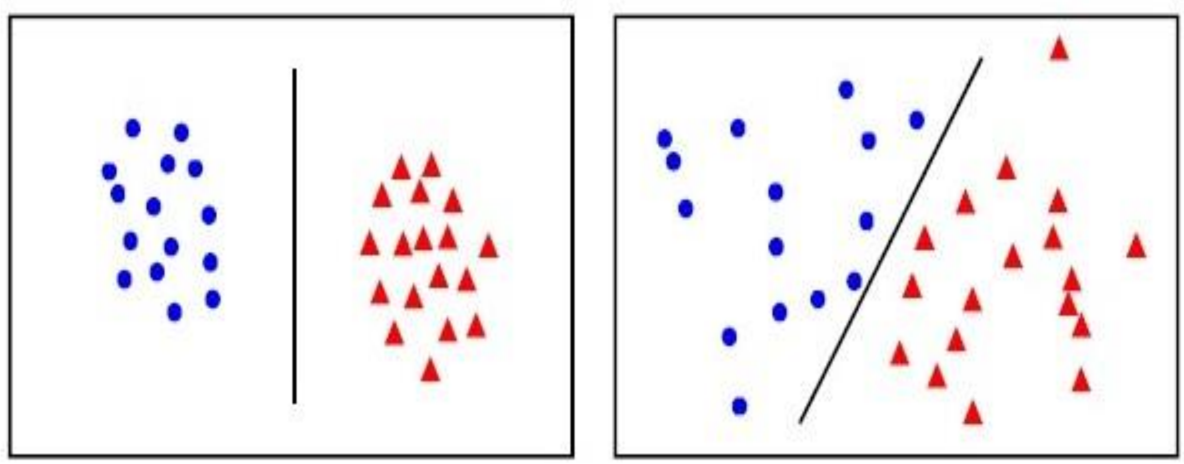


Fig 3.4: Dataset which shows linear separable

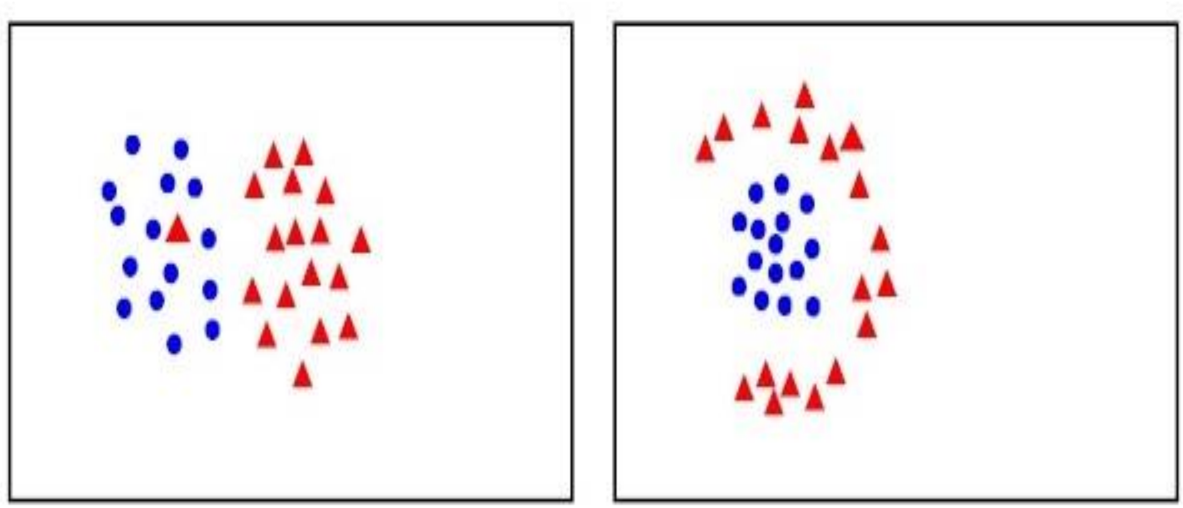


Fig 3.5: Dataset which shows linearly not separable

3.3 PEDESTRIAN DETECTION USING HOG-SVM DETECTOR

Histogram of oriented gradients (HOG) descriptor are the key features while detecting a pedestrians. These features are robust in nature. The HOG with combination of SVM detector has been give better results in detection of pedestrians.

3.3.2 System description:

This system consists of mainly three steps 1.segmentation and preprocessing 2.feature extraction 3.classificatiom. First an adaptive dual thresholds segmentation method was applied to an image for finding the objects, if needed preprocessing can be done in this stage. In the second step, features of the selected objects were extracted based on the application or objects to be find or recognition. Finally, in the classification step an SVM classifiers with HOG features are used here to train the system with positive and negative samples and further used for the classification of test images.

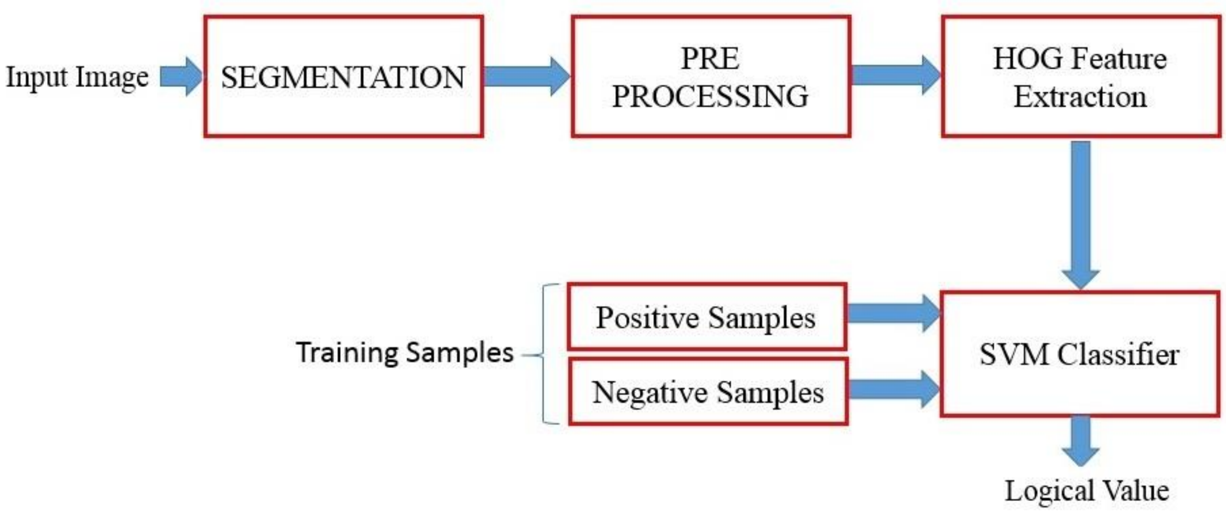


Fig 3.6: the over view of the pedestrian detection using HOG-SVM

Dual adaptive thresholds image segmentation

In earlier systems, a threshold algorithm of adaptive type is used for segmentation of images. This type of algorithm well performs when the view is clear without any noise and cluttering. But in the situation of pedestrian detection the background is moving that too in a dark environment where the background is highly complicated. At that type of situations this algorithms does not separates the objects from its background. It decreases the systems detection rate. For solving these type of problems, a dual adaptive threshold algorithm is applied for image segmentation. This algorithm consists two adaptive thresholds. These thresholds can be separately calculated by the following formulas:

$$T_{Low}(i,j) = \frac{\sum_{x=i-N}^{i+N} I(x,j)}{L} \tag{3}$$

$$T_{High}(i,j) = T_{Low}(i,j) + \theta \tag{4}$$

Where L=2N+1, L is width of the neighborhood &θ is a little positive number

The dual thresholds image segmentation algorithm follows the below condition

$$p(i,j) \in F, \; if \; I(i,j) > T_{High}(i,j) \; or \tag{5}$$

$$if \; T_{Low}(i,j) \leq I(i,j) \leq T_{High}(i,j) and p(i-1,j) \in F, \tag{6}$$

$$p(i,j) \in B, if \; I(i,j) < T_{Low}(i,j) \; or \tag{7}$$

$$if \; T_{Low}(i,j) \leq I(i,j) \leq T_{High}(i,j) and p(i-1,j) \in B, \tag{8}$$

Where, F represents foreground and B represents background.

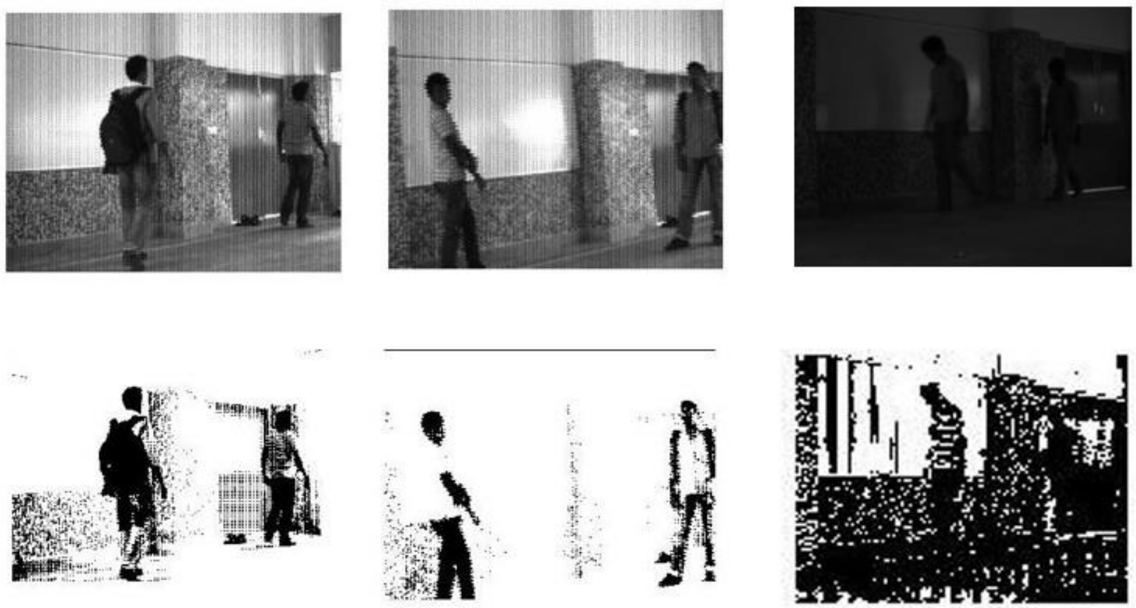


Fig 3.7: 1st row shows the NIR pedestrian images, 2nd row shows its respective segmented image

HOG Feature Extraction

After segmentation of images, HOG features were extracted from the resultant objects.

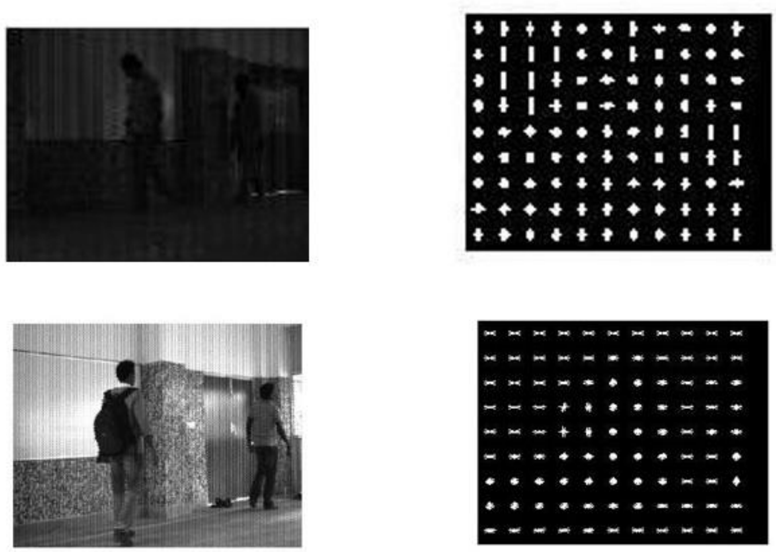


Fig3.8: NIR pedestrian images and its respective HOG Visualization

Detection using SVM Classifier

Fig 3.9: NIR Images given of Training and Testing data of SVM

CHAPTER 4

PEDESTRIAN DETECTION USING CASCADE CLASSIFICATION AND VALIDATION

Most of the pedestrian detection techniques were developed under day light environment with a normal visible camera. Compared to day time, chances of accidents are more at night time. Attending more interest in road safety, detecting pedestrians, while driving at night time had gained more importance. In recent years, there has been more research on detecting pedestrians in night time for assisting vehicle drivers with advanced systems [17-20]. In general, vision based cameras were used in surveillance applications where conventional background subtraction method is used for Region of Interest (ROI) generation which fails since it is a moving background. In night time, normal vision cameras cannot capture all the information needed since the background is cluttering and texture less. To overcome these type of situations, there has been extensive research on night time pedestrian detection based on near infrared images because of their merits than far infrared images [21], [22].

Here, night time pedestrian detection system with a cascaded classification and a part based validation stage in near infrared environment approach is described. The performance of classification of pedestrian with the help of Haar cascade detector and part based validation using HOG-SVM is implemented and analyzed. The part based pedestrian detection systems [23] build a robust validation of pedestrians compared to the other systems.

4.1 SYSTEM OVERVIEW

Fig 4.1: shows the overall view of the pedestrian detection system which has been proposed. The first stage of the system deals with detection of pedestrians using a scanning window with Haar cascade detector, which eliminates most of the non-pedestrians and second stage makes the system more robust by validating the detected pedestrians with part based HOG-SVM detector.

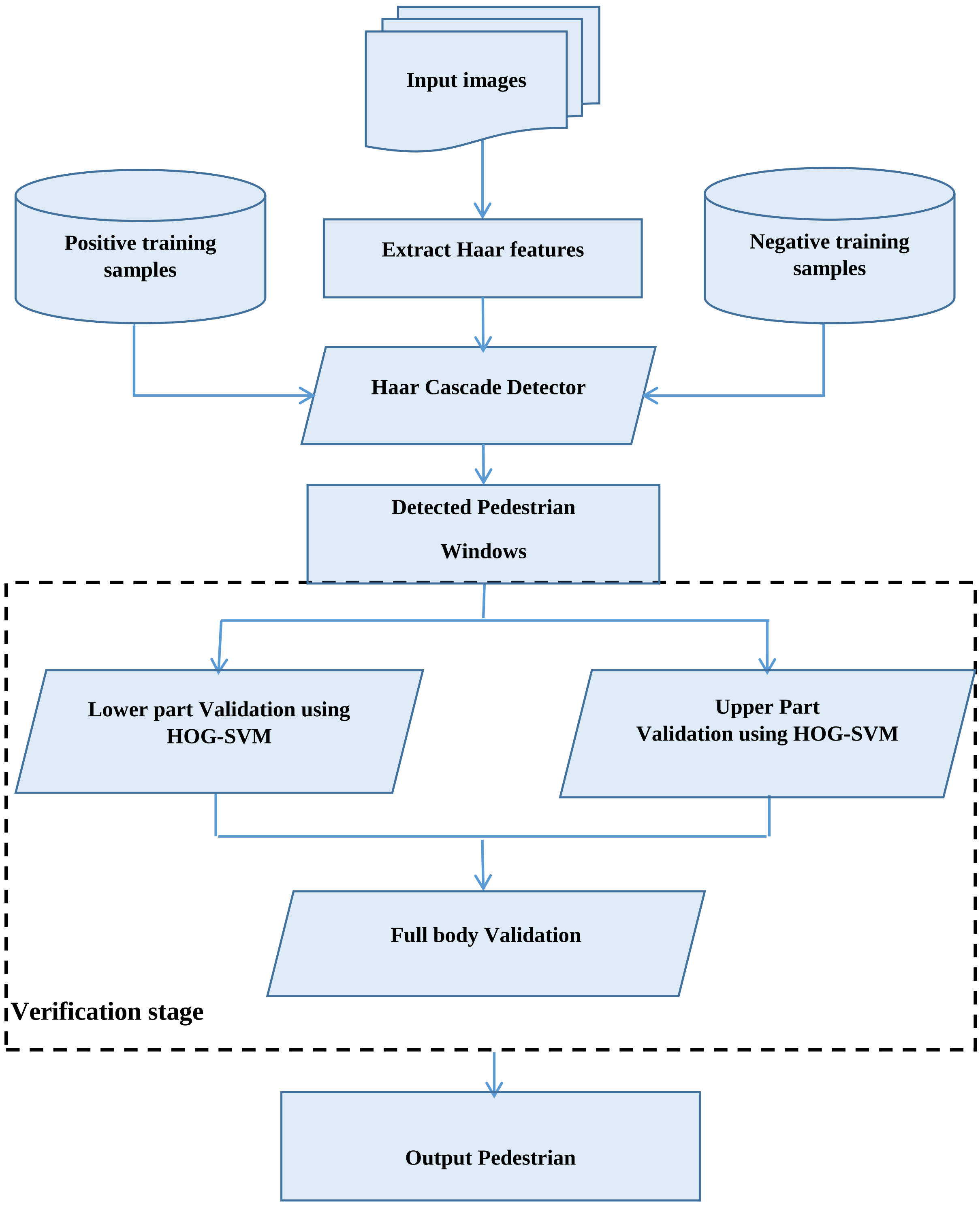


Fig 4.1 over view of the part based pedestrian detection system

4.2. DETECTION STAGE

In this stage, the system scans each window of the input image and extracts Haar features of that particular window, which is then used to compare with the cascade classifier. A boosting algorithm is used here to train a classifier with Haar features of positive and negative samples [24]. The structure of the cascade classifiers makes the system fast enough by filtering the most of non-pedestrian regions in the input image. The Haar feature based detection is used for rough classification of input image which focuses on non-pedestrian rejection and determines the pedestrian regions with bounding box

The set of parameters and its values used for training the cascade classifier with Haar features are given below

- Number of cascade stages used : 15
- Negative samples factor : 2
- Per stage true positive rate : 0.99
- Per stage false positive rate : 0.5

Fig.4.2 Output of the Haar cascade Detection stage which contains several False alarm.

Haar features extracted from intensity images has been used in many object detection modules such as car, face and pedestrian detection because they record the fine details of the object and have a fast algorithm. Fig.4.2 shows the output of the Haar cascade detector with bonding box representing pedestrians. Here, false alarm rate is higher but eliminates most of the non-pedestrian regions. Pedestrian detected output of the detector stage is processed with a part based validation module for the reduction of false alarm rate.

4.3. PART BASED VALIDATION

This module verifies each bounding box of previous stage by making it parts. Here, each pedestrian is divided into upper and lower body parts for verification. This system uses HOG features for detecting the parts. The HOG feature set significantly outperforms detection of pedestrian [4]. In recent years, HOG has more impact in pedestrian detection systems because of its robust feature set of orientation [25], [26].

The Optimal set of parameters for HOG descriptors are described by Suard and Broggi [27]. This paper implements the following set of parameters for HOG descriptors.

1. Cell size : 8 X 8 pixels
2. Block Size: 2 X 2 Cells
3. Block overlap: 2
4. Number of bins: 9

Fig.4.3 shows the upper and lower parts of bounding box where 1, 3 rows represent upper parts and 2, 4 rows represent lower parts. The HOG features of these parts has been extracted and compared with the pre trained SVM Classifier. SVM is a type of classifier which can be trained by positive and negative features to classify two distinct sets. Whenever the same class of data is given to the SVM, it classifies the data to which set it belongs. SVM is a popular classifier in combination with HOG. Training data can be any feature set or intensity image but the dimensions of feature set for training and testing data must be same

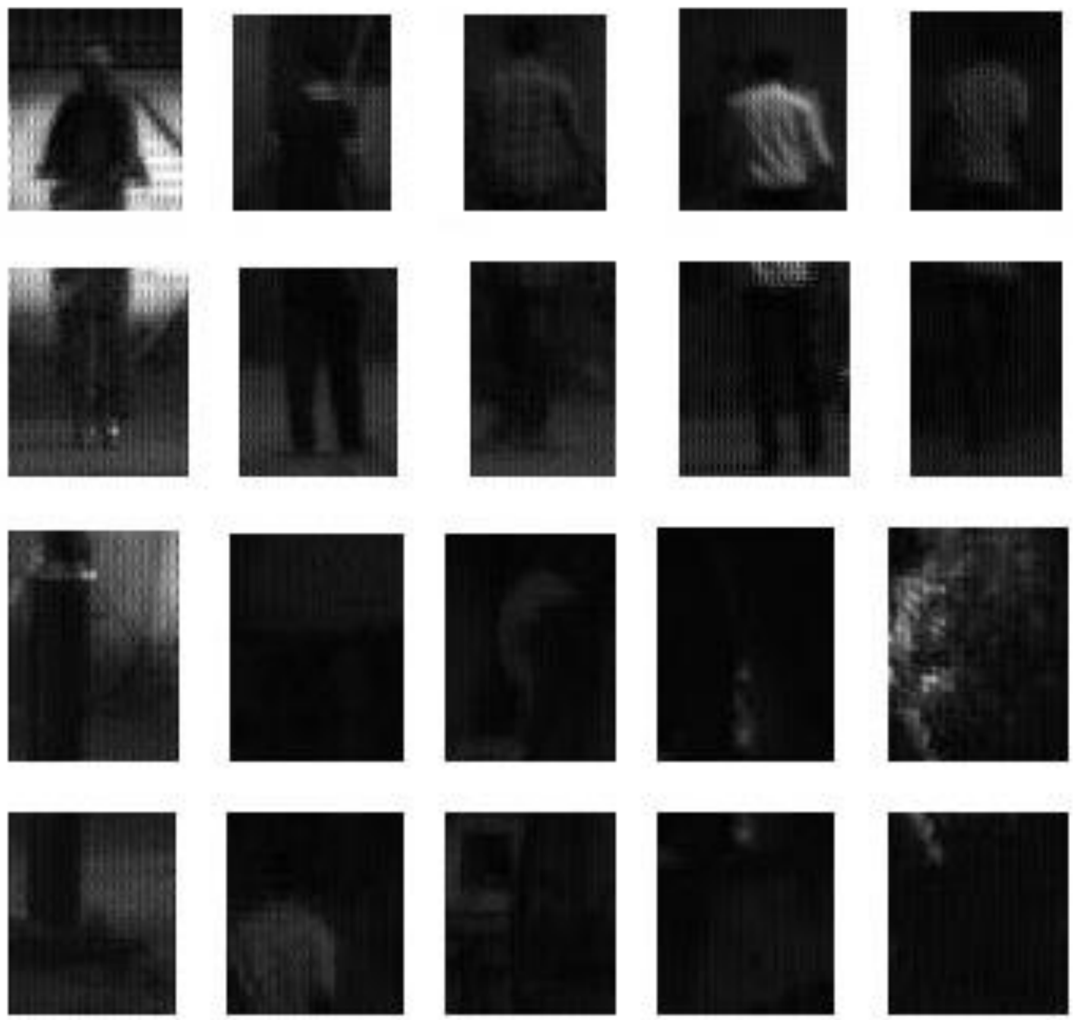


Fig. 4.3: Row 1, 2 represents the upper and lower body parts of the pedestrian bounding box.

Row3, 4 represents the upper and lower parts of the non-pedestrians of fig. 2

4.4 OVERALL VERIFICATION

Here, the system checks for the part based HOG-SVM output. If upper and lower body parts of the bounding box are validated correctly then the output pedestrian box appears at the end of second stage. Otherwise it checks for full body validation, if any one part of the pedestrian is validated correctly in previous stage. If both upper and lower body parts does not validate, then the system considers as a non-pedestrian or false alarm and removes it in that stage. Fig. 4.4 shows the pedestrians after removal of false positives in second stage.

Fig.4.4: Output after the part based verification stage

4.5 PERFORMANCE EVALUATION

The algorithm is having a high false alarm rate when it is detected only through Haar cascade detector. The missing chances of true positives is comparatively less when compared with other systems. The false alarm rate is reduced greatly when the system is tested with part based HOG-SVM detector. Whenever the two individual systems Haar cascade and HOG-SVM are evaluated, the false alarm rate is more when compared with the proposed technique. The false alarm rate with respect to true positive rate of the individual systems and proposed system is shown in the Fig. 4.5 and Fig. 4.6 respectively.

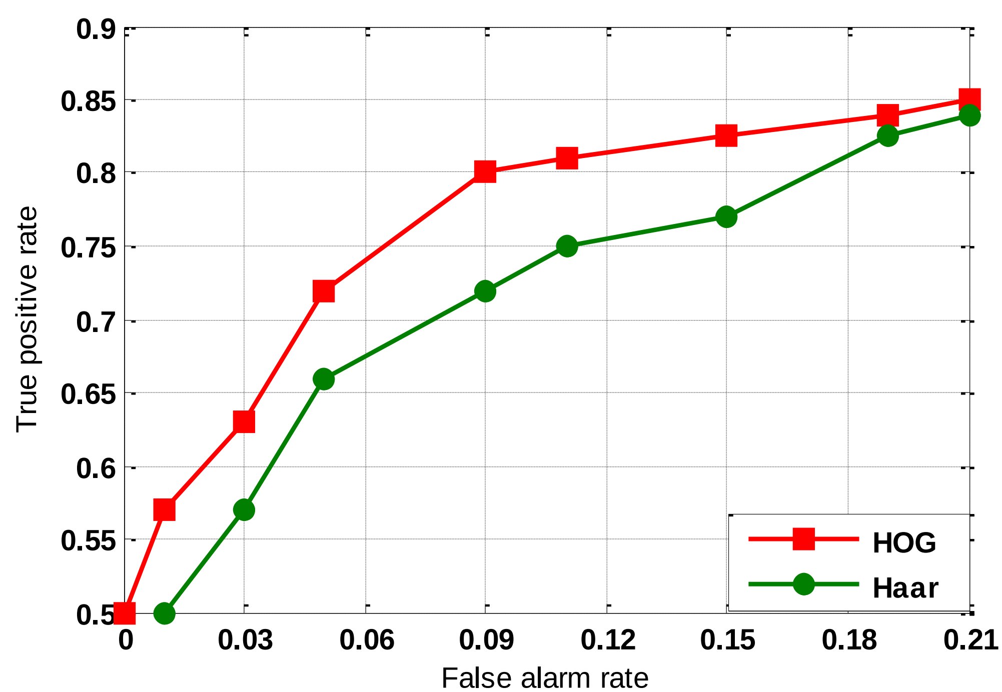


Fig. 4.5 Performance evaluation of individual systems HOG and Haar detectors

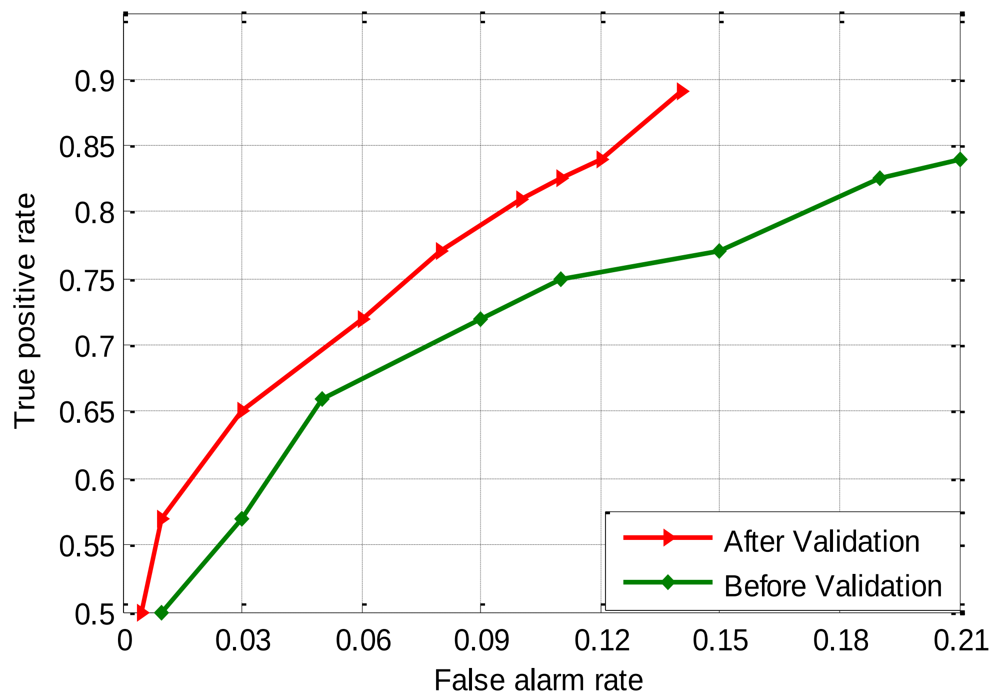
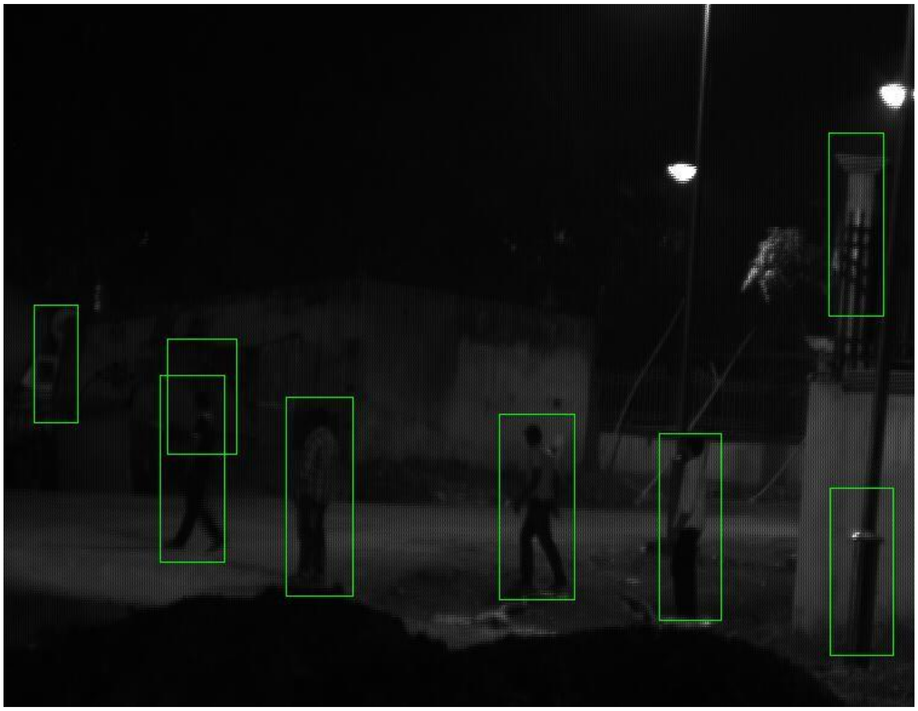


Fig. 4.6 Final performance evaluation before and after part based validation

4.6 DISCUSSIONS

The proposed method uses a combination of standard MIT pedestrian database, INRIA Database for pedestrian and our own NIR image database for training the system. Fig. 4.7(a) shows the pedestrians detected while crossing a road with high false alarm and Fig. 4.7(b) represents pedestrians with removed false positives which is from second stage of the presented system. Whenever occlusion occurs, the detection of pedestrians becomes difficult since the shape of the pedestrians is not clear.



(a)

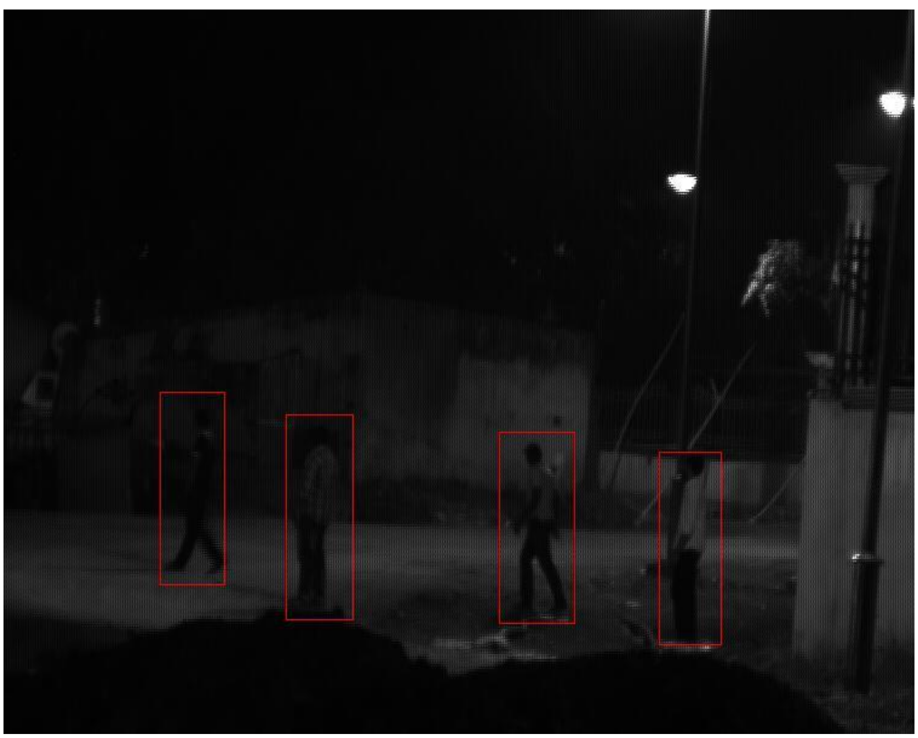


Fig.4.7: Detection of pedestrians (a) Output of the Haar cascade (b) Output after validation

CHAPTER 5

CONCLUSIONS

This chapter describes the conclusions of the overall research work and suggestions for the future scope of this work

5.1 CONCLUSIONS

In this research work, attention was drawn towards the recent trend of research in pedestrian detection techniques especially the use of HOG-SVM classifier is observed. The research work starts with the Image sensing technologies used in current trend of night vision pedestrian detection was studied. After that the best features (HOG and Haar-like) for detection of pedestrian were studied and implemented. Different types of classifiers such as SVM, AdaBoost techniques with the help of different feature extraction techniques were observed by training the system. Significance of HOG feature extraction based SVM classifier has been mentioned in chapter 3 with related results.

The HOG descriptor is one of the best features for detecting the objects especially pedestrians. A novel part based pedestrian detection scheme with cascade classification and validation was implemented in chapter 4. In night vision pedestrian detection, part based schemes are more robust since due to the invisibility. The Haar cascade detector detects the pedestrians by a scanning window and the resultant output was further validated by an HOG-SVM detector which performs well and good. While detecting pedestrians and eliminating non pedestrians in first stage using Haar features, false alarm rate is bit more in cluttering background situations, but in second stage, HOG-SVM combination with part based detection makes the system robust by reducing the false alarm rate.

The True positive rate vs False alarm of an HOG-SVM is comparatively good compared to Haar cascade detector. Whenever these two systems are cascaded the true positive rate increases slightly but the False alarm rate was reduced greatly.

5.2 SUGGESTIONS FOR FUTURE WORK

Regarding the future scope, there is a need of more research to reduce the false negatives and false alarm rate particularly in cluttering back ground, Occlusion and while crossing the road where the shape of the pedestrian was not clear. Efficiency should also be considered whenever needed to balance the robustness. This systems which we done in this research work are comprised to images, so that is enough to have a detection, but when coming to real time we need to work on videos where a tracking method also necessary to implement.

DISSEMINATION

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