NIR Image based Pedestrian Detection in Night Vision with Cascade Classification and Validation

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***Abstract*—Pedestrian detection is one of the vital issues in advanced driving assistance applications. It is even more important in nighttime. This paper presents a robust algorithm for a nighttime pedestrian detection system. 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 paper 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.**

***Index Terms*—Haar-Cascade, histogram of oriented gradients, support vector machine, pedestrian detection**

I. INTRODUCTION

Pedestrian detection is one of the most challenging and significant tasks in the computer vision 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.

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 [2]. The main aspects in both types of night-vision systems are capability of pedestrian detection, effectiveness for avoidance of collision, and the commercial attractiveness. 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, but an NIR system is highly resistant to environment. 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.

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 on the roads, 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 [3-6]. 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 textureless. 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 [7], [8].

In this paper, 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 [9] build a robust validation of pedestrians compared to the other systems.

This paper is organized as follows: Section II is about system overall view. Section III is about results and discussions. Section IV is all about performance evaluation of the system and section V concludes the paper.

II. SYSTEM OVERVIEW

Fig. 1 shows the overall view of the pedestrian detection system which has been proposed. The first stage of the system deals with the 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.

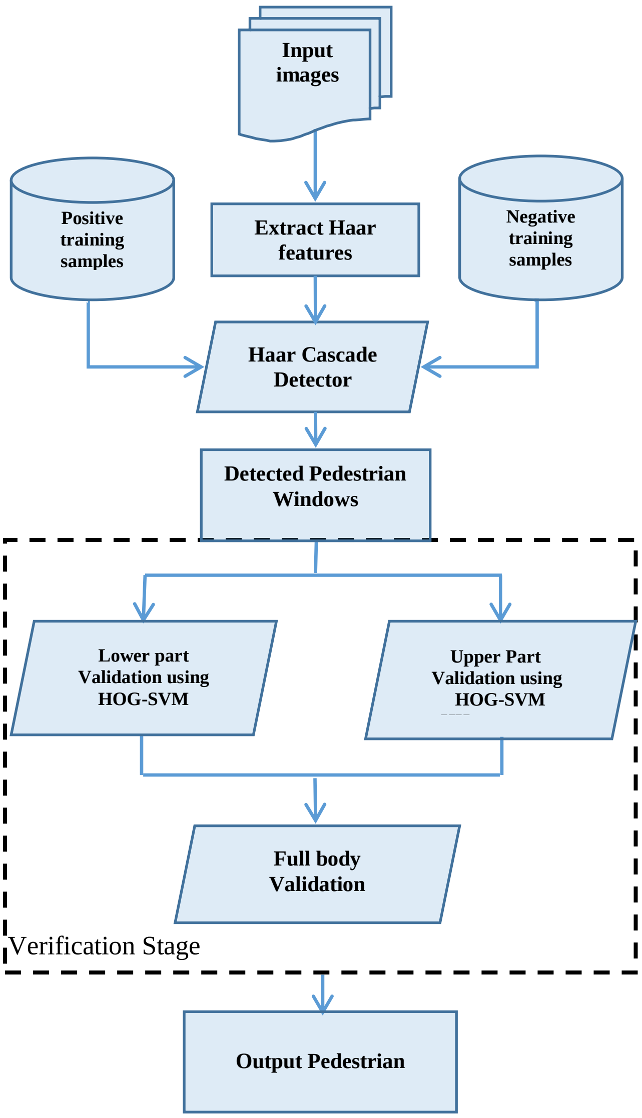


Fig.1 Structure of the pedestrian detection system with detection stage and part based validation stage.

A. 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 [10]. 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.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.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. To reduce the false alarm rate, pedestrian detected output of the detector stage is processed with a part based validation module.

B. 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 [11]. In recent years, HOG has more impact in pedestrian detection systems because of its robust feature set of orientation [12], [13].

The Optimal set of parameters for HOG descriptors are described by Suard and Broggi [14]. 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.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. 3 Row 1, 2 represents the upper and lower body parts of the pedestrian bounding box. Row 3, 4 represents the upper and lower parts of the non-pedestrians of fig. 2

C. Overall Verification:

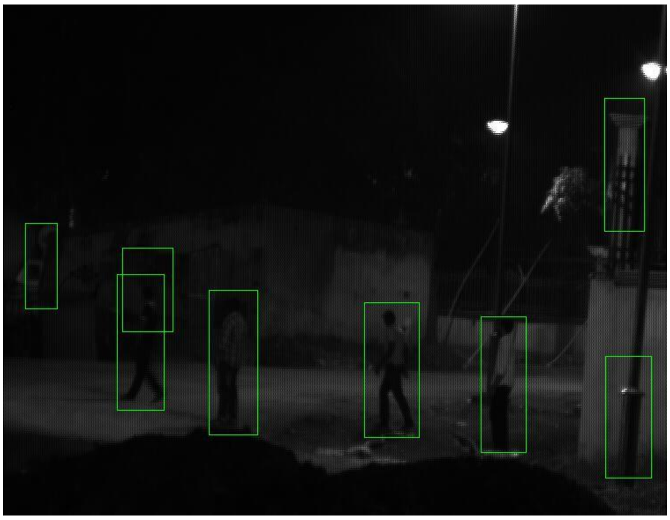
Here, the system checks for the part based HOG-SVM

Fig.4 Output after the part based verification stage

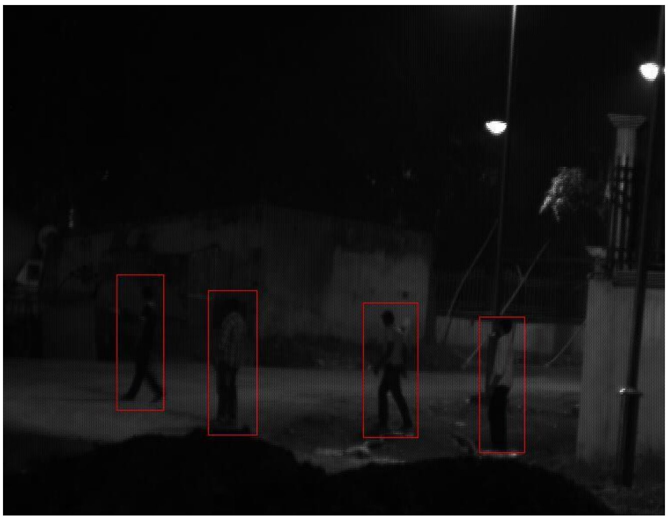
output. If upper and lower body parts of the bounding box are validated correctly then the output pedestrian box appears at the end of second stage. Otherwise it checks for full body validation, if any one part of the pedestrian is validated correctly in previous stage. If both upper and lower body parts does not validate, then the system considers as a non-pedestrian or false alarm and removes it in that stage. Fig. 4 shows the pedestrians after removal of false positives in second stage.

III. RESULTS AND 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. 5(a) shows the pedestrians detected while crossing a road with high false alarm and Fig. 5(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)



(b)

Fig.5 Detection of pedestrians while crossing the roads
(a) Output of the Haar cascade (b) Output after validation

IV. 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. 6 and Fig. 7 respectively.

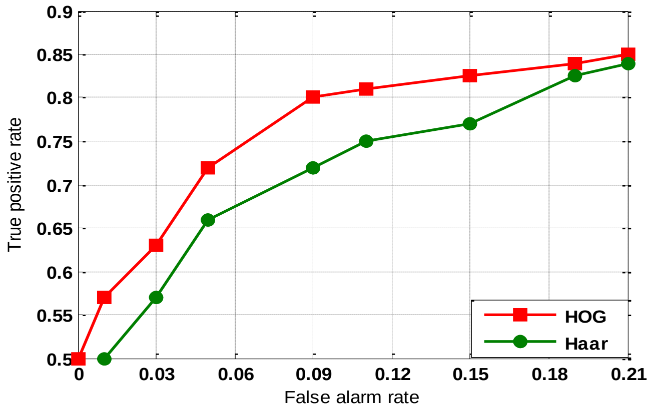


Fig. 6 Performance evaluation of individual systems HOG and Haar detectors

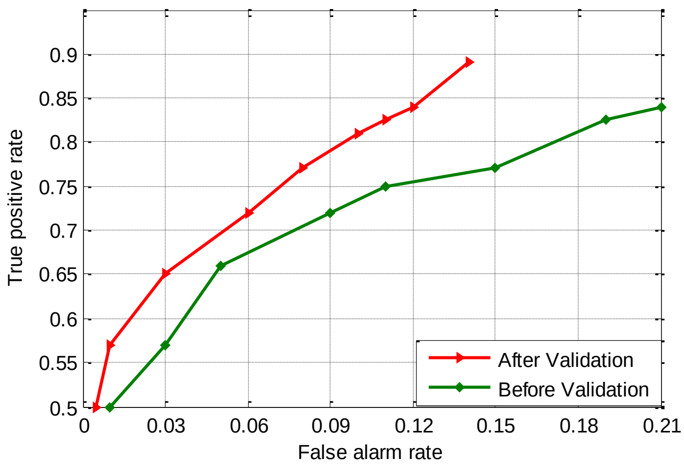


Fig. 7 Final performance evaluation before and after part based validation

V. Conclusions and Future Work

This paper presents a robust algorithm which detects the pedestrians at nighttime using near infrared images. Here, it combines both Haar features and HOG features in Cascade to classify and validate the pedestrians. 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.

Regarding the future work, 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.

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