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AN INTELLIGENT PREDICTION SYSTEM FOR PEDESTRIAN CROSSING DETECTION

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ABSTRACT

In recent computer vision research, the importance is given to the practical applications such as automation, surveillance and Advanced Driver Assistance Systems (ADAS). While entering into automation field, the task which is in existing system processed by human intervention is to be changed and make it effective. In this research the two main tasks were made: initially the detection of pedestrians crossing the road is to be evaluated as soon as possible. This video is in dynamic due to camera shake and irregular vehicle movement hence it resulted as blurry videos, to avoid this, a mean filter is used to enhance the captured video. This process helps to improve the performance of the video by reducing the blurry effect. While improving these factors, the system is able to detect and indicate the sudden pedestrians crossing and it helps to avoid unwanted accidents.

Keywords: pedestrian detection, enhancement, SVM classifier, optimization.

INTRODUCTION

All over the world the traffic accidents occurs due to pedestrians becoming an increasing one, due to high population density, rapid urbanization and due to overrule the traffic regulations by drivers and pedestrians. Pedestrians Detection is very essential factor in surveillance for safety purpose. Several challenges were occurred while detecting the pedestrian's, such as style of clothing appearance, different transition and frequent occlusion between pedestrians. In some traditional detection methods the detectors are trained to find the pedestrians in the video frame by scanning full video. Two practical requirements such as high accuracy and real time speed for detection is needed.

Griffiths *et al.*, (1984) stated a delay in pedestrian's crossings. Several studies were made about this issue, and in some cases the driver's behavior and pedestrians interactions at pedestrians crossings also discussed by Katz *et al*., (1975). A multinomial logit mode is presented by Himanen and Kulmala (1988), it state the probabilities of a driver braking and pedestrians response are identified with some calculation of distance and size of the movable object. The considerations were made based on the traffic condition and probability of pedestrian crossing, these analyze is made at different instance. Hakkert *et al*., (2002) made an experiment that detects the pedestrians near the crosswalk zone and to warning the drivers about pedestrian's presence. This system were analyzed by considering four different locations. Based on the recognition of the system the implementation varies. Cheng *et al*., (2015) made a research based on pedestrian collisions due to vehicle which is captured in cameras. The footage is recorded in High Definition format that determines the speed and exact points of impacts.

Katoh and Tanahashi (2013) made a pedestrian collision detection system with the help of wireless mobile communication. This method is totally based on the wireless communication that satisfies the condition between pedestrian and the vehicle user. Angelova *et al.*, (2015) modeled a Real-time pedestrian detection that addresses deep-learning-based classifiers with an efficient cascade classifier frameworks. In traditional methods the Deep Neural Network (DNN) models were used but it seems to be very slow. The performance of pedestrian detection methods based on accuracy versus speed axis, which is indicated in Angelova *et al*., (2015). It shows the existing methods measured on challenging Caltech pedestrian detection benchmark which is cited by (www.vision.caltech.edu/ Image_Datasets / Caltech Pedestrians/).

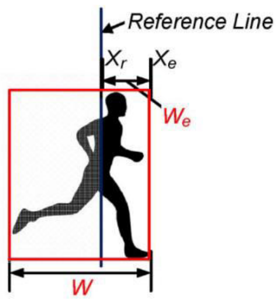

Figure-1. Notation for a pedestrian crossing event [8].

Xu *et al*., (2012) described the notation of pedestrian crossing event which is shown in figure 1. They described the event as a spatiotemporal volume that encompasses within a range of pedestrian visibility that enters into the camera. The pedestrian entering ratio is defined as

$$\alpha = \frac{X_e - X_r}{W},$$

where, X_e is the X axis value of the right edge of the pedestrian's bounding box.
X_r is the X axis value of a vertical reference line, and
W is the horizontal width of the bounding box.

From entering ratio equation the entering width is also defined as We = Xe – Xr.

In this section, the different approaches were analyzed this paper concentrates on detection, and process/filtering the resulted video to enhance the original strength to avoid blur effect that occurs due to the movement. The remaining paper is organized as follows. In section 2 states the detailed description of traditional pedestrian crossings detection methods, functions that is used to perform this task and some limitations were analyzed. In section 3 the problem definition of fully surveyed is made. In section 4 the proposed design described with the Caltech pedestrian dataset based on the problem which is identified in section 3. Finally the results were concluded in section 5.

LITERATURE SURVEY

In machine vision, many ongoing researches were made for detecting the Pedestrian crossing. In this section each detection and several protocols that applied in the detection units were analyzed. Pedestrian detection is stated in Dollar *et al*., (2012) with three ways, initially the well-annotated and realistic dataset is considered, proposed a refined per-frame evaluation methodology and finally the performance of sixteen pre-trained detectors across six datasets were evaluated. Ess *et al*., (2007) addressed a problem of detecting Pedestrian simultaneously. This method is estimated in the busy Pedestrian zone. It uses robust stereo cues and ground-plane estimation for detecting using graphical model. Here single video frame is considered for robust detection. The evaluation of estimate scene geometry and object locations based on the input from detection and dense stereo. In order to evaluate the problem the object is correctly tracked and the overlapping that occurs due to the same pixels presented in the image. The problem is rectified by two iterative process. To interface the ground plane and object bounding the belief propagation is made. The graphical model is stated by them is shown for fusion of object and ground plane detection.

Junejo *et al*., (2004) presented a Multi Feature Path Modeling for Video Surveillance. The problem stated here is detecting the nonconforming trajectories of objects in a motion recording. To solve this issue the spatial features were used in existing methods such as Zheng *et al*., (2009), Chung *et al*., (2010), Jalalian *et al*., (2012), Liu *et al*., (2013). For path detection several path detection algorithm were made by Grimson *et al*., (1998) and to show the vision system that monitoring the activity in site with respect to the time. Makris *et al*., focused on video sequences of natural outdoor scenes. It is discussed the problem about learning the routes or paths by Pedestrian walking through outdoor scenes. The task is held for context of multi-camera video surveillance network. The retrieved video contains both overlapping and non-overlapping fields of view. The results were discussed with a single camera dataset. Route updating is made by Node updating, Route extension and Route resampling. Felzenszwalb and Huttenlocher (2006) presented a Markov random field models for robust and unified framework in vision problems. Several algorithms were made to improve run time of the loopy belief propagation algorithm. It proves that the proposed algorithm is accurate when compared it with the other global methods such as Middlebury stereo benchmark.

Table-1. Pedestrian detection survey.

S. No	Citation	Method used for detection	Merit	Performance improvement
1	Oren *et al.,* (1997) [19]	Wavelet templates	It is Computationally efficient algorithm and also an Effective learning scheme.	It is used to detect the static images of cluttered scenes
2	Enzweiler, M., & Gavrila, (2009) [20]	Combined shape-based detection and texture-based classification.	Performance is enhanced by incorporating temporal integration	By using cascade approach the pixels were overlapped
3	Zhao and Thorpe (2000). [21]	Stereo-based segmentation and neural network-based recognition	It can detect pedestrians in various poses, shapes, sizes, Clothing and occlusion status.	The system is robust but false version is varies
4	Tuzel *et al*., (2008) [22]	LogitBoost, GentleBoost, and AdaBoost classifiers algorithm with two datasets INRIA and DaimlerChrysler	Computational Complexity is reduced	Need some extra block to solve computer vision problems
5	Xu *et al*., (2005) [23]	Support Vector Machine (SVM) designed especially for Night detection	Effective approach designed for night Vision and it is feasible.	The appearance of pedestrians is not clear compared to that of day-time images; hence complexity in the system increases.

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Paisitkriangkrai *et al.*, (2014) presented an extract low level visual features based on spatial pooling for pedestrian detection. Here spatial pooling is applied in sparse coding for generic image classification problems. Several benchmarks such as INRIA, ETH, TUD-Brussels, Caltech and Diamler data sets were analyzed with that method. The optimization is made with the partial area under ROC curve measure, which concentrates on detection. Gandhi and Trivedi (2007) described an enhancement of pedestrian safety with its Issues, Survey, and Challenges. Here the survey details about both detection made by using non visible light and visible light. Based on the sensors it describes with multiple sensors and time-to-flight sensors. Based on the classifiers several mechanism were considered. Super vector Machine (SVM) used to detect the boundary based on the maximizing the minimum separation between classes. Vazquez *et al*., (2014). The adaboost classifier is also used for pedestrian detection that integrates image intensity and motion information. The Viola *et al*., (2005) combined both sources of information in a single detector which is efficient and low resolution.

Hu *et al*., (2015) presented a global–local information pedestrian detection algorithm for outdoor video surveillance. It focused for fully exploits global information to improve the recognition performance. In this case the Gaussian Low-Pass Filtering (GLPF) is used for noise suppression. The Gaussian filtering is used to suppress the background interference and discriminate the global interference. In some applications the video sequence watched by consumer devices such as digital cameras and camcorders. In videos the blurring occurs due to the movement or motion effect. The deblurring algorithm is used to reconstruct the blurred frame. The ringing artifacts is the another effect made by conventional deconvolution. Du *et al*., (2014) made a privacy preserving scheme for data security. Due to Unknown blurring kernel, inaccurate foreground content, mask and distributed video stream storage.

Based on the training dataset several analysis were made to detect and used it for many applications. In this research the Caltech Pedestrian Testing Dataset is to be considered and processed. This section began with an overview of detection methods and datasets which is related to the Pedestrian crossings. Various detection algorithms were reviewed and summarized. This study helps to understand the basic algorithms that applied in various process of Pedestrian crossing.

PROBLEM STATEMENT

This research investigated about the operation of Pedestrian crossing detection and deblurring system. The detection system is used to monitor and identify the elements that lead to change in the motion. In some cases the detection system captures the motion picture far away from the original object, hence the distance, area and counts were to be made effectively. While capturing the image through a camera, the motion field estimation is to be made, then the motion based detection and shape based people detection were important in this task.It has an implications about identification and characterize the key shape of pedestrian information. Finally to overcome the limitation which is faced by the existing detection and provide enhanced result without changing its originality. To provide better result this research focused on motion filter in detection unit and this unit is tested by using Caltech Pedestrian Testing Dataset. The corresponding sections provides detail explanation of dataset and the prediction system.

The main objective to develop this system is given below:

- To improve automated detection technologies based on false activation rate and missed detection rate.
- To increase their effective use based on counting pedestrians with respect to the speed.
- To manage the device with environmental issues such as precipitation, lighting, sun angles.

METHODOLOGY

In video sequences the detection part consists of enhancement, segmentation followed by detection. The main contribution is to establish a standard detection unit with recent advancement. Initially the new feature based In evaluation process the Caltech Pedestrians dataset is considered.

Video enhancement

In video research the enhancement is the major issue which is faced while processing. Its main objective is to process and improve the appearance of the video. The simple representation of enhancement is represented in Figure-2.

In this research the self-enhancement and frame-based fusion enhancement were considered. In self enhancement the contrast enhancement is used to process the local contrast in different regions of the given images. The transformation of original pixel values represented in transform function.

$$g(x, y) = T[r(x, y)]$$

Where g(x,y) and r(x,y) are the output and input pixel values in image position.

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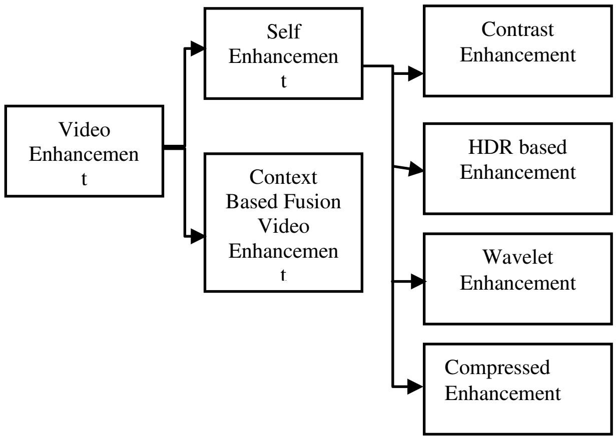

Figure-2. The block diagram of video enhancement categories.

Histogram equalization is used for contrast enhancement. The main aim is to achieve a uniform distributed histogram by using the cumulative density function of the input image which is represented in Rao and Chen (2012), Abdullah *et al*., (2007).

Pedestrian segmentation

Tracking an object or a person in a video is an important task for human operator. In machine vision process the designed system is able to extent and executes the task. To create a robust system with respect the human perception, the results with the video clarity, illumiance and some non-occluded scene is made a success. The segmentation process is particularly difficult if the analyze is made in crowded area. In this research, the segmentation is a process of tracking the individuals in the videos. Hence, while tracking single person the effective rate of computation is improved and the system becomes efficient. Iwasaki *et al.*, (2012) made a segmentation process over a crowd. Some existing methods like Appearance-based and model-based approaches are not effective due to the change in shape caused by occlusion and deformation. The motion based methods were discussed in Brostow and Cipolla (2006), Brox and Malik (2010), Kratz and Nishino (2010), Rabaud and Belongie (2006), Sugimura *et al*., (2009). The advantages of this method are robustness to shape variance, because the target shape is not assumed. Since two limitations were identified such as trajectory gets longer and occlusion happens more frequently.

The segmentation Process work flow is shown in the Figure-3.

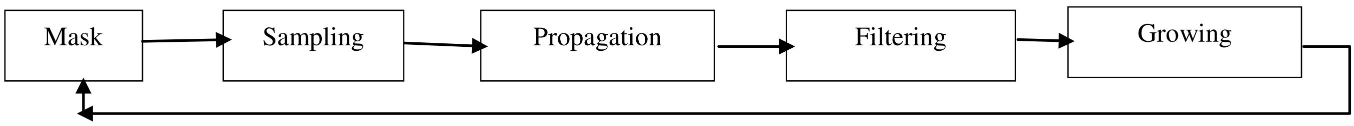

Figure-3. Work flow for segmentation.

The Mask is the first approximation in pedestrian segmentation by generating points similar to the previous frame work to the current frame. The masked image is sampled and given to the filtering. To eliminate the noise due to the translation direction the filtering process is needed. Finally the super pixel expansion called as grows made to propagate the points which is tracked and processed by the edge detection. The segmentation is grown by merging the interior of all segments. The super pixels' merging is considered that the cost of merging horizontally is twice that of cost of merging vertically.

Initial Segmentation is a process of collecting the sub images from the given original image near the corner with the help of original image as reference. Colour image were treated by considering the red component from the RGB band. In this research histogram-based methods considered as very efficient when compared to other segmentation methods because it requires only one pass through the pixels. Histogram-based approaches easily adapted to apply in multiple frames. The histogram can be done in multiple fashions when multiple frames are considered. The approach that is taken with one frame can be applied to multiple, and after the results are merged, peaks and valleys that were previously difficult to identify are more likely to be distinguishable. It is also applied in a per-pixel basis, where the resulting information is used to determine the most frequent color for the pixel location. This approach segments based on active objects and a static environment. It is also useful in video tracking.

Feature descriptor and estimation

Histogram of Oriented Gradients (HOG) is one of the detection methods in computer vision process. This system is similar to that of edge detection and shape contexts. It counts the occurrences of gradient orientation in some local portions of image. This method is differing from other because it uses overlapping local contrast normalization to improve the accuracy. Dalal and Triggs (2005) described these HOG descriptors. In that work they initially focused on static image detection and tests were expanded to human detection in videos. The advantage of HOG descriptor is it operates on local cells and it is invariant to the geometric transformations. Some challenges of HOG are large variation in appearances and speed for mobile vision. It is needed because the shape and object appearance can be characterized by distribution of local intensity gradients or edge directions. The process is initially the image window is divided into small spatial

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regions called cells. These cells may be either rectangle or radial shown in the Figure-4.

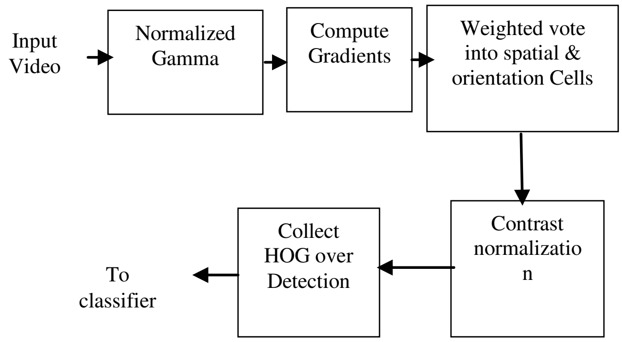

Figure-4. Block diagram for normalization process in histograms of oriented gradients.

To improve the illumination the local response made to be contrast-normalize. To reduce the storage, latency and transmission feature compression is needed. The algorithm for HOG feature detectors in image pre-processing is stated as follows:

Gradient computation

Step 1: To ensure normalized color and gamma value
Step 2: Compute the gradient value
Step 3: Apply the 1 Dimensional centered to the both lines horizontal and vertical.
Step 4: Filtering the color or intensity with the kernals [-1, 0, 1] for horizontal and [-1, 0, 1] T for vertical.

Orientation binning
Step 5: Creating the cell histograms and perform gradient computation.

Descriptor blocks
Step 6: to made a changes in contrast and illumination the normalization is required by grouping the cells

Block normalization
Step 7: Improve the non-normalized data
Step 8: Object recognition using HOG to feed the descriptors based on supervised learning.

Based on the algorithm the dynamic image is processed and normalized and the detector window is tiled with the grids of overlapping blocks in which the Histogram of Oriented Gradient feature vectors are extracted. The combined vectors are further processed by SVM classifier for object and non-object classification.

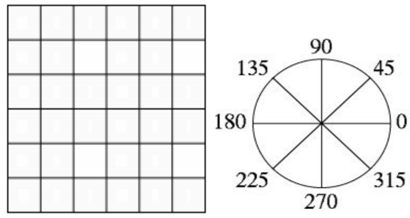

Figure-5. Region splitting and weighted local 1-D histogram of gradient directions.

Pedestrian detection

Support Vector Machine (SVM) is an algorithm that was developed for pattern classification. It is applied to various optimization problems such as regression and the data classification. The basic idea is shown in Figure-7. The data points are identified as being positive or negative, and the problem is to find a hyper-plane that separates the data points by a maximal margin.

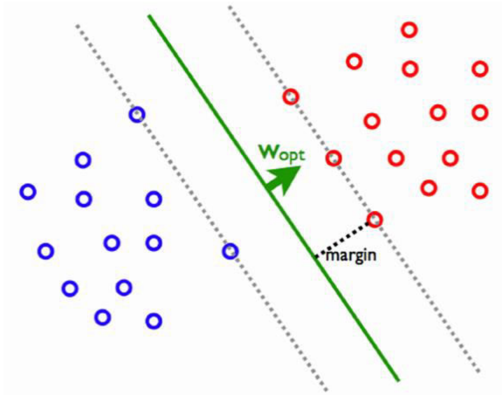

Figure-6. SVM classification problem, [45] Huang *et al*., (2008).

The above figure only shows the 2-dimensional case where the data points are linearly separable. The points are classified in three categories such as $y_i f(xi_i) > 1$, for point is in outside margin, there is no contribution loss. $y_i f(xi_i) = 1$, Point is on margin and no contribution to loss. $y_i f(xi_i) < 1$, Point violates margin constraint and contributes to loss. The mathematics of the problem to be solved is the following:

$$\min_{\vec{w},b} \frac{1}{2}\|w\|,$$

$$s.t \quad y_i = +1 \Rightarrow \vec{w} \cdot \vec{x}_i + b \geq +1$$
$$y_i = -1 \Rightarrow \vec{w} \cdot \vec{x}_i - b \leq -1$$

The identification of the each data point xi is yi, which can take a value of +1 or -1 (representing positive or negative respectively). The solution hyper-plane is the following:

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$$u = \vec{w} \cdot \vec{x} + b$$

SVM is a useful technique for data classification. It is easier to classify the data and it involves testing for some data instances. The objective of SVM is to produce a model which predicts target value of data instances in the testing set which are given only the attributes. A step in SVM classification that involves the identification as which are intimately connected to the known classes which is called feature selection or feature extraction. The objective is to find classifier with largest margin between closest positive and negatively labelled support vectors. Normal vector for optimal separating hyper plane wopt is found using a quadratic optimization procedure.

Training and evaluation

The dataset is considered for training/ testing sets and made analyze between Enhanced Histograms of Oriented Gradients (EHOG) and normal Histograms of Oriented Gradients (HOG). The data was captured over a 11 sessions. The data is roughly divided in to half of the original set; it is represented as sessions such as 6 sessions namely (s0 to s5) and 5 sessions (s6 to s10). The images from s0 to s1o is available in public. Detection unit can be trained by using Caltech training data (S0-S5) and other external data by (s6-s10). It is made by four scenario described as follows:

Scenario ext1: Train on any external data, test on s6-s10.

Scenario cal0: Perform 6-fold cross validation using s0-s5.

In each phase use 5 sessions for training and the 6th for testing, then merge and report results over s0-s5.

Scenario cal1: Train using s0-s5, test on s6-s10.

Here the ext 0/ Ext 1 used for evaluating the pertained detectors. While cal0 and cal1 involve training using the Caltech training data (S0-S5). Based on the large dataset the system is to be re-trained and evaluate under cal0/cal1. During detector development ext 0/cal0 is considered. After finalizing the parameters the evaluation made in the scenarios ext1/cal1.The Caltech dataset properties are listed: It contains color images, per-image evaluation, video sequences, temporal correlation and occlusion labels.

EXPERIMENTAL RESULTS

The overall prediction system is summarized based on the individual results that made by enhancement, segmentation and detection units. For effective result SVM classifier is used because it trained by solving a constrained quadratic optimization problem. The video frames are effectively classified based on the shape of the object or human.

Caltech pedestrian dataset

The Caltech Pedestrian Detection Benchmark is considered in the video processing made in Pedestrian detection. It is consists of approximately 10 hours of 640x480, 30Hz video taken from a driving in urban area. The frames are about 137 approximately minute long segments about 250,000 frames with a 350,000 bounding boxes and 2300 unique pedestrians were annotated.

The performance of the proposed prediction system with video segmentation, detection and enhancement unit were analyzed. The evaluation is made by

$$ErrorRate = \frac{ErrorPixelCount}{FrameSize}$$

Where, the error pixel count is the number of pixel obtained from the reference plane.

To compare the proposed detectors, the miss rate against false positives per image (using log-log plots) by varying the threshold on detection confidence is shown in the Figure-7. The hit ratio is the fraction of accesses which are a hit. The miss ratio is the fraction of accesses which are a miss. It holds that miss rate=1−hit rate.

Miss rate indicate the memory overheads experienced by the run time. These miss rates are used as inputs by the algorithms used to better predict run-time and more accurately. The performance of pedestrian detection has some improvement in low resolution. The miss rate is depends upon the dynamic scenes by camera motions and due to pedestrians. The miss rate performance measures were improved by using structural SVM. The overlap threshold shows the detection confidence. The log average miss rate helps to summarize the detector performance. Per-window versus full image evaluation on the Caltech pedestrian dataset is shown in Figure-7. Full image results obtained by evaluating the same pedestrians but within their original image context, which is shown in the Figure-8. While Pre Window and full image performance are somewhat correlated, the ranking of competing methods is substantially different. From the analysis of miss rate and false positive the lower curves indicate better performance. There is an upper limit on the acceptable false positives per image (FPPI) rate independent of pedestrian density.

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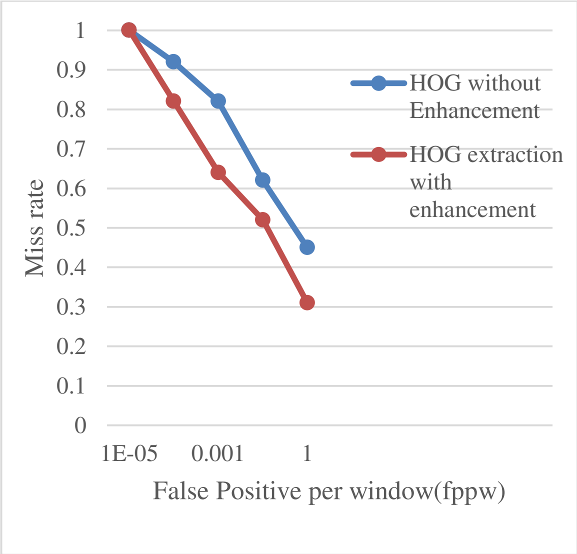

Figure-7. Per window results reproduced from original sequence.

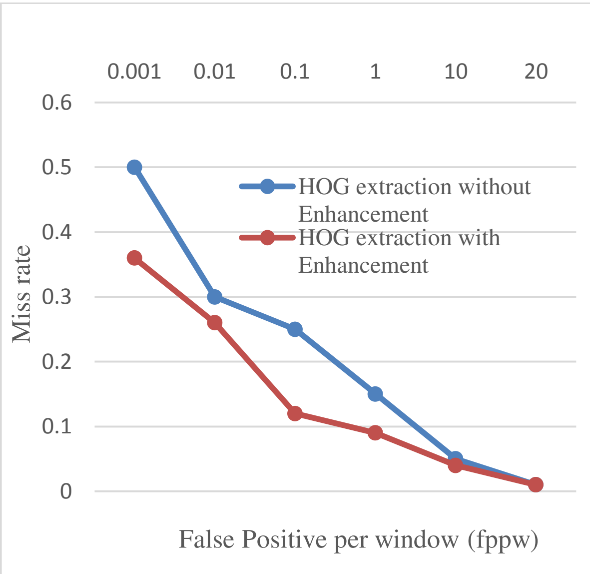

Figure-8. Full image results obtained by evaluating on the same pedestrians but within their original image context.

From the graphical representation the values in enhanced HOG extraction shows the best performance among normal extraction. The average miss rate is indicated in Figure-9, the threshold value below the value 0.5 reduce the log average miss rate and the performance of the proposed deign Enhanced Histograms of Oriented Gradients (EHOG) and histograms of Oriented Gradients (HOG) were more or less similar in threshold value for overlapping. However, increasing it over 0.6 results in rapidly increasing log-average miss rates as improved localization accuracy is necessary.

CONCLUSIONS

Detection of pedestrian is an open challenge in computer vision. This paper presented a pedestrian detection in different backgrounds and different in motion.

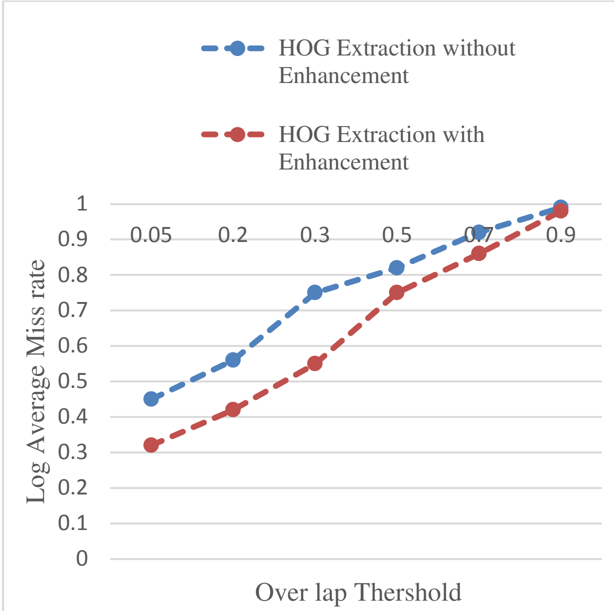

Figure-9. Log-average miss rates on overlap area.

The capturing may varies from stationary or some unpredictable changes were occur. The detection unit consists of video segmentation, Histograms of Oriented Gradients based feature extraction and SVM based classifier. The non-linearly separable and dynamic input is classified and produces accurate results with the help of SVM classifier. This research focused the segmentation and enhancement of Caltech Pedestrian dataset. From the results it is noticed that the proposed system helps to detect and enhance the captured input with minimum error rate and miss rate. The future development of this research may focus in detecting the movable objects such as animals, transport vehicles and so on. Test the data and implement this proposed EHOG Model with several datasets.

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