Fast Pedestrian Detection Based on Haar Pre-Detection

Wenfeng Xing, Yong Zhao, Ruzhong Cheng, Jiaoyao Xu, Shaoting Lv, and Xinan Wang

***Abstract*—We proposed a simple but efficient way to accelerate the traditional pedestrian process without decrease the detection accuracy. Haar/adaboost is one of the fastest ways in pattern recognition, and HOG/libSVM is an accurate way to deal with pedestrian detection. Haar/adaboost can work fast using low resolution images, but HOG/libSVM, which was proposed by Dalal in 2005, is much slower due to the high resolution detection window and complicated feature extraction. Inspired by the above results, we combine these two most popular ways to develop a better pedestrian detection system. And due to the fast small scale Haar/adaboost pre-detection, experiment result shows that the time our method consumed is about one third of the original HOG/LibSVM method, while maintaining almost the same detection rate.**

***Index Terms*—Small scale, HOG, HAAR, fast pedestrian detection**

I. Introduction

Pedestrian detection has been paid more and more attention in recent years, and European Commission has funded project PROTECTOR (Preventive Safety for Unprotected Road User) [1] during 2000-2003 and SAVE-U[2] (Sensors and System Architecture for Vulnerable road User protection) from 2002 to 2009. Though a lot of progresses have been achieved, the detection speed is still too slow to meet the demand of actual application.

In this paper, we propose a typical coarse-to-fine detection system, while the coarse detection has a high speed and PPR (Positive Positive Rate), and the fine procedure has a relative low FPR (False Positive Rate), which make the whole coarse-to-fine system a high detection rate and low FPR.

This paper is arranged as follows: related work will be briefly introduced in section 2; in section 3, we describe our method in detail; and experiment results will be shown in section 4; and conclusion will be delivered at last.

II. Related Work

Several pedestrian detection approaches have been proposed in the literature. Gavrila and Giebel use chamfer system [5] to locate desired objects, then a texture classification is involved to verify the chamfer system detections [1]. Viola and Jones proposed a simple feature known as haar wavelet feature and a boosted cascade classifier to achieve rapid object detection [3]. Papageorgiou and Poggio [6] studied the haar wavelet in combination with SVM classifier in object detection. Dalal and Triggs present a novel pedestrian descriptor which derived from SIFT features, called histograms of oriented gradients (HOG) [7], and with a trained SVM classifier, the detection result turned out to be relatively good. Zhu et al. modified the Dalal's original HOG feature to make it fit well into integral image [3] approach, which can efficiently compute histograms over arbitrary rectangular image regions [8]. Based on the Dalal's detection method, Xu et al. [9] proposed an edge factor for coarse detection, which could filter out some windows that have less edges and gradients.

Among all of the pedestrian approach, HOG/libSVM has been proved to be one of most successful methods, but this method proposed by Dalal is very time consuming. And haar feature has been proved that it is not suitable for pedestrian detection theoretically, since it depends on the statics of the gray pixel value and pedestrian can wear different color clothes. But during our experiments, we found the Haar/adaboost method can get a very high PPR along with an acceptable FPR, so we take advantage of the Haar/adaboost's high detection speed and HOG/libSVM's high accuracy to make a more efficient pedestrian detection system.

III. Overview of our Method

There are two major steps during our detect process: coarse detection and verification. Also we do some preprocess work: converting the color image to grey scale image, Histogram Equalization and image zooming. And the flowchart of our system is illustrated in Fig.1.

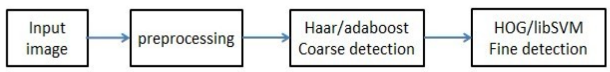

Fig. 1. The flowchart of our system

A. Pre-Process

In order to decrease the computational work, first we convert the input color image to grey scale image; and then use histogram equalization to enhance the image contrast; at last we zoom in the image to the half size of the original scale for the coarse detection. In this case, the pixels that we need to compute decrease to one fourth of the original amount.

B. Coarse Detection

Haar feature is a kind of rectangle filter which could be computed very fast with the application of "Integral Image". Viola and Jones [3] developed the haar feature to haar-like feature in 2001, and Lienhart and Maydt [10] introduced the idea of tilted haar-like feature, which is also used in our coarse detection. Fig. 2 shows the haar feature that we used

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in our detection.

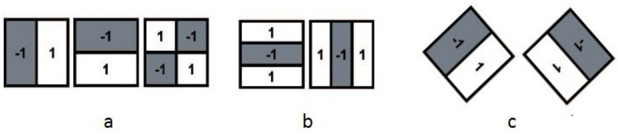

Fig. 2 a) Haar feature b) Haar-like feature c) Tilted haar feature

For the classifier training, we created several videos taken from the camera in the front of a running vehicle, then we clipped thousands of samples (which size are 100*200 pixels) from the videos for the training process. We use about 7000 positive samples (normalize to size 20*40) and more than 100,000 negative samples as our training dataset. Fig.3 shows some positive samples we used in the training process. With the help of openCV library, we got a cascaded classifier with 12 stages and more than 500 weak classifiers. Finally, we use this classifier to select the most pedestrian-like ROIs.

Fig. 3. Some positive pedestrian samples

C. Fine Detection

HOG feature was proposed by Dalal and Triggs in 2005, and was successfully used for human detection. But unfortunately, this method can only process 320 * 240 images at 1FPS using a very sparse scanning methodology [8]. Though Zhu [8] used "integrated image" to accelerated the detection process, we found it to create nine integral images is very computational expensive either. So we decided to use the original HOG/libSVM in the verification stage.

The resolution of the ROIs that we got from the coarse detection may either higher or lower than the HOG/libSVM's detection window size, so we clipped the ROIs from the original image and normalize the ROIs to size 64*128. In this case, we might detect the smaller pedestrian which the original HOG/libSVM would have missed.

IV. Experiment Results

Fig.4 shows the details of our trained classifier which we used in the coarse detection. And Fig.5 a is an example of the coarse detection results with half size input images, b shows the results after fine detection.

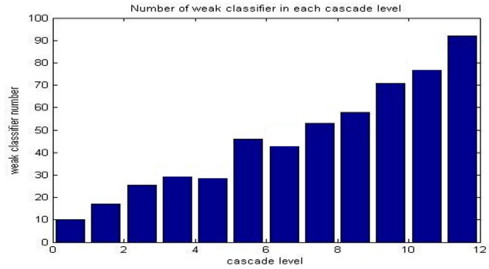

Fig. 4. The number of weak classifier in each level

(a) (b)

Fig. 5 a) Results of coarse detection using haar/adaboost under low resolution

b) Final results of the fine detection using HOG/Libsvm under high resolution

We test our detection system on the test dataset, and compared our results with the original HOG/libSVM method and the Haar/adaboost method. We test these three methods on 120 images (704*576) we take from the urban areas, including 167 pedestrian in the images and using a dual-core Intel 2.7G CPU. The details results are shown in Table I.

TABLE I: Detailed Detection Results of the Three Methods

	Detected Num	False detections	Detection Rate	Time used(s)
Haar/adaboost	163	47	97.6%	7.37
HOG/libSVM	144	3	86.2%	26.66
Haar + HOG (our method)	141	4	84.4%	8.97

From the above results, we can see that Haar/adaboost has a very high detection rate but a very high false detection, and HOG/libSVM achieves very high detection accuracy but with a very low detection speed. And our proposed method takes advantages of both Haar/adaboost and HOG/libSVM, experiment shows that we achieve a 13.3FPS processing speed on 704*576 images while maintaining almost the same detection rate as HOG/libSVM.

V. Conclusion

In this paper, we proposed a simple but efficient way to accelerate the traditional pedestrian process without decrease the detection accuracy. The main contribute is that we use low resolution images and the fast Haar/adaboost for the coarse detection. As most of the detection windows are rejected by the coarse detection, the computational work of the fine detection process is dramatically reduced.

For future work, we will further study the HOG feature and try to make it easy to extract. And we also want to use depth information in the pedestrian detection. With depth information provided by other device we may locate the ROIs faster and accurately.

ACKNOWLEDGEMENTS

This work was supported by the Hong Kong government as part of the project "Pedestrian Warning and Pedestrian Protection System", and we would like to thank the HKPC (Hong Kong Productivity Council) for providing us the training dataset and the test dataset.

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