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Research paper

Homogeneity Property Based Two Wheeler Detection Research Using Histogram of Oriented Gradients and Soft Computing

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Abstract

We describe an algorithm to detect two-wheelers with various shapes and viewpoints using the homogeneity property and Histograms of Gradients (HOG). The typical shape of a two-wheeler is can be divided into two parts: human body (upper area) and assembled complex components (bottom). The upper area is substantially homogeneous, because the front and rear body views are simple, whereas the bottom part consists of complex shapes and shows little homogeneity. And the bottom area has very little homogeneity, because it is consisted of complicated shapes. Our algorithm using HOG features based on homogeneity to the upper and lower parts separately and uses Adaboost as the classifier. Furthermore, this paper applied the Adaboost algorithm to classify the objects as the soft computing. Our improved algorithm correctly identified more than 84% of the hardest case tested – motorcycles leaning at 60º - and more than 98% of all types of two-wheelers at 90º.

Keywords: *Object detection; Histogram of oriented gradients; Homogeneity; Adaboost; Two-wheelers.*

1. Introduction

Nowadays, the technological improvements are changing our society very fast. In the past, studies related to human safety have been concentrated mainly on the detection rate of pedestrians and vehicles in video images. Currently, the range of the survey to protect vulnerable road users (VRUs), such as small cars, has been expanding [1, 2]. Since pedestrians and cyclists are very weak objects in the VRU. Therefore it is an enthusiastic challenge for the intelligent transportation system fields. A wide variety of sensors are used for real-time detection and tracking, such as NIR, FIR, LIDAR, radar, laser scanners, fusion systems.

Among VRUs, pedestrians move slowly compared to others. On the other hand, two-wheelers have complicated shapes with variations in the rider's dress, hair style, whole body attitude, forms and patterns of loading and various two-wheeler structures - further complicated by the viewing angle, so a stronger algorithm handling these variations is needed.

Intelligent vehicles research have been focused recognizing and detection of pedestrians, automobiles and road signs by advanced researcher [1]. The two-wheeler in the following means a combination of a person and a machine. As described above, the detection of a two-wheelers on the road is similar to the detection of a pedestrian on the road. And feature extraction for pedestrian detection is classified into single property, multiple property, whole property and zone property according to the purpose of property [3]. Especially, HOG feature and modified features are generally used in object detection and target tracking for the vision area. In [4], Zhao and An used HOG characteristics to improve the detection rate and speed based on the block normalization method. Further, Watanabe et al. [5] used co-occurrence HOG characteristics, and Wang et al. [6] improved the human detection accuracy using the HOG and LBP for input images. Mikolajczyk et al. [7] divided into whole body detection and body parts detection as the local features. The advantage of using part-based research is that it can deal with variation in human appearance due to body articulation. However, the draw of using this method is that it is more complicated to pedestrian detection and difficult to calculate.

The main idea of this paper is as follow. First, studies on the two-wheeler detection system researches are still at low level. On the contrary, it means that the research need much time investment and it is valuable to study to find good algorithm. Second, we are accustomed to pedestrian detection with accuracy and efficiency of still and video images. However, this is one of the most difficult tasks due to environmental conditions, complex backgrounds and complex objects as well as various shapes of posture (depending on the angle of camera, it shows different shapes than people). Therefore In this paper, we propose a new detection algorithm for bicycle and motorcycle that is easy to reach the most dangerous situation on the road.

The rest of this paper consists of the following: In Chapter 2, basic algorithm configuration, feature extraction method and normalization process for detection rate are explained for the histogram of oriented gradients and homogeneity. Chapter explains the mechanism for Adaboost, which is used only in object classification. The evaluation of the experimental results of the two-wheeler detection and the proposals are discussed in Chapter 4. The conclusion states in the Chapter 5.

2. Feature Extraction

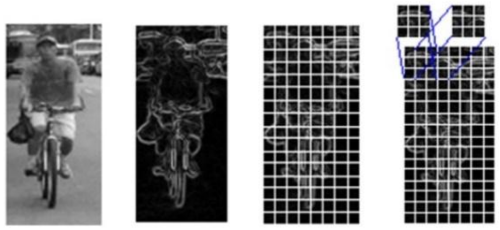
2.1. Histogram of Oriented Gradients (HOG)

HOG [8] shows the distribution of local brightness in directional vector form by using size, direction and histogram. The gradient values in all image pixels are calculated using the derivatives $f_x = |f(x-1) - f(x+1)|$ and derivatives $f_y = |f(y-1) - f(y+1)|$.

Magnitude *m(x, y)* and orientation $\theta(x, y)$ of a given image are computed using Eq. (1) and (2).

$$m(x,y) = 2\sqrt{f_x(x,y)^2 + f_y(x,y)} \tag{1}$$

$$\theta(x,y) = \arctan\left(\frac{f_y(x,y)}{f_x(x,y)}\right) \tag{2}$$



(a) (b) (c) (d)

Fig. 1: The example of two-wheelers HOG normalization. (a) Input image (b) magnitude vector image (c) image cells (d) image blocks.

Each cell (Fig. 1 (c)) is composed of 8x8 pixel and includes nine bins with [0 °, 180 °] range. Each cell containing directional information about brightness is normalized into a block of 3x3 cells. Cell step interval is one cell and the direction is right side to lower side, as shown Figure 1 (d). The feature vector quantity of the *k-th* block can be expressed as $B_k = [F_1, F_2, \cdots F_9]$. Each block generated is normalized using 3x3 cells. This is done by accumulating the histogram feature values for the local region, and the motion interval is 1 cell. This paper used Dalal and Triggs [11] method using L2-norm normalization as:

$$\Pi = \frac{f}{\sqrt{\|f\|_2^2 + \varepsilon^2}} \tag{3}$$

where ε is the small constant.

2.2. Homogeneity Operator

The extraction of edge is very important works to make features from input image. The homogeneity operator is simplest and quickest edge detector. It subtracts each pixel on the outer edge of the 3x3 window from center pixel using equation (4)

$$I'(x,y) = \max\{I(x,y) - I(x+i, y+j)\}_{i,j=-1,0,+1} \tag{4}$$

where *I* is center pixel and *I'* is new image. The edges extraction in the original image will be well represented by this operator, as shown in Figure 2 [9] and 3.

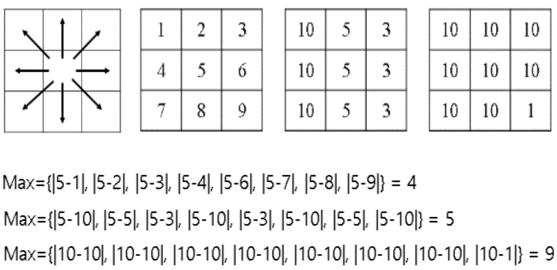
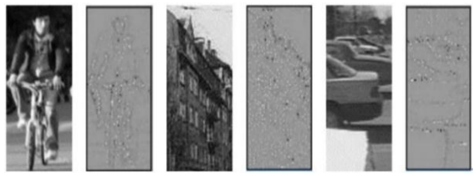


Fig. 2: An example of the Homogeneity Operator.



(a) (b) (c)

Fig. 3: The result of homogeneity operator for the positive and negative images, (a) positive (two-wheeler), (b) negative image (building), and (c) negative image (road vehicle).

3. Classifier – Adaboost

Extracted features can be reached the final decision stage by the classifiers. Adaboost is a simple algorithm that learns to make a strong classifier from weak classifier using the weight of classifiers. AdaBoost refers to a particular method of training a boosted classifier method. The Adaboost training process gives a weak classifier a lot of weight and combines them to create a strong classifier. This paper will follow the algorithm proposed by P. Viola [10]. This algorithm uses the learning set where each domain and label belongs to some domain and label set as below:

Input a training set: $(a_1, b_1) \cdots (a_n, b_n)$ where each a_i belong to some domain *A*.

Label set: b_i is in some label set *B*.

Given training set: $(a_1, b_1) \cdots (a_n, b_n)$
where $a_i \in A$, $b_i \in B = \{+1, -1\}$

A. Initialize weights:

$$w_{1,i} = \frac{1}{2m}, \frac{1}{2l} \text{ for } B = \{+1, -1\}$$

m : positive images (+1)

n : negative images (-1)

B. For t=1 $\cdots T$:

(a) Weights normalization

$$w_{t,i} = \frac{w_{t,i}}{\sum_{j=1}^{n} w_{t,j}}$$

so that $w_{t,i}$ is a probability distribution of *i*th training image for *t*th weak classification

(b) *j-th* classifier h_j which is limited by a single feature. The error is calculate by w_i

$$\varepsilon_j = \sum_i \omega_i |h_j(a_i) - b_i|$$

(c) Choose the classifier, h_t, with the lowest error ε_t

(d) Update the weights: $w_{t+1,i} = w_{t,i}\beta_t^{1-\varepsilon_i}$

where $\varepsilon_i = -1$, +1.If example a_i is classified correctly, $\varepsilon_i = +1$ otherwise $\varepsilon_i = -1$ and $\beta_t^i = \frac{\varepsilon_t}{1-\varepsilon_t}$.

C. The final hypothesis:

$$H(a) = sign\left(\sum_{t=1}^{T} \alpha_t h_t(a)\right)$$

where $\alpha_t = \log(1/\beta_t)$

The final hypothesis *H* is obtained after the weight value of the *T-th* weak hypothesis is given.

In step 1, the initial input value a represents the feature value of the input image for training, and b represents the positive and negative classification labels. Step 2 initializes and updates the weight value, selects the weak classifier with the minimum error, and generates a weak classifier that imposes the weight on the classifier.

4. Experimental Results

The proposed evolutionary algorithm was applied to improve the detection rate using the homogeneity operator and Adaboost algorithm. The experiment was performed in a typical user computer environment consisting of Intel Core i7 and Visual Studio 2015 C ++ programs. The two-wheeler data image used in the experiment consists of the image taken by the user directly on the road and the image downloaded from the Internet. The two-wheeler data image used in the experiment consists of the image taken by the user directly on the road and the image downloaded from the Internet. And it shows various shapes according to viewing angle. The data used in this paper are front (about 90 °, marked 90 °) and slightly tilted (about 60 ° and 60 °) for the front and rear view of the motorcycle when viewed in the car. We extracted 2353 two-wheeler images normalized to 128 × 64 (width × height) from obtained 640 × 480 (width × height) images, and divided them into training images and experimental images. Non-two-wheeler images (negative images) were randomly extracted from a general building, road, mountain, and field. The acquired images are divided into two types: training images and test images. In this experiment, 3,000 pictures of negative image (street and building) were used. Some of our dataset examples used in this paper shows in Figure 4. Negative and positive image ratios for training were 1:1 and 1:2. Table 1 shows the number of training and test images for the positive image according to the experimental angle. In the first experiments, the performance of the traditional HOG feature has shown in Figure 5.

Table 1: The number of obtained total images

Type \ Angle		60°	90°	60°+90°
B	Training	340	845	1185
	Test	305	863	1168
M	Training	96	234	330
	Test	80	219	299
MB	Training	436	1079	1515
	Test	385	1082	1467

Fig. 4: Positive and negative images for training and test.

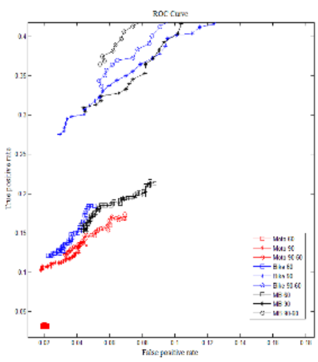


Fig. 5: Experimental Result of an ordinary HOG Method (serialized feature data saving method).

The threshold ranges were used between -20 and 20 for the classification. In this paper, the confusion matrix, TPR (True Positive Rate) and FPR (False Positive Rate) are calculated using equation (5) to analyze the experimental results for each angle. The results of the ROC curves [14] describing the degree of detection are shown in Figure 5.

$$TPR = \frac{TP}{TP + FN}, \quad FPR = \frac{FP}{FP + TN}, \quad Accuracy = \frac{TP}{TP + FP} \tag{5}$$

where "TP" is True Positive", "FP" is False Positive", "TN" is True Negative and "FN" is False Negative. The ROC shows better performance as the result values are gathered at the upper left corner (True positive:1.0, False positive:0.0). However, the Figure 5 using general HOG method not close to the upper left corner. And the True positive values are marked very low value. In Figure 5, "MB" means mixed test including motorcycles and bicycles and "90-60" means mixed test including 90 degree and 60 degree.

The proposed algorithm results using homogeneity property are presented higher detection rate than ordinary HOG method, as shown in Figure 6.

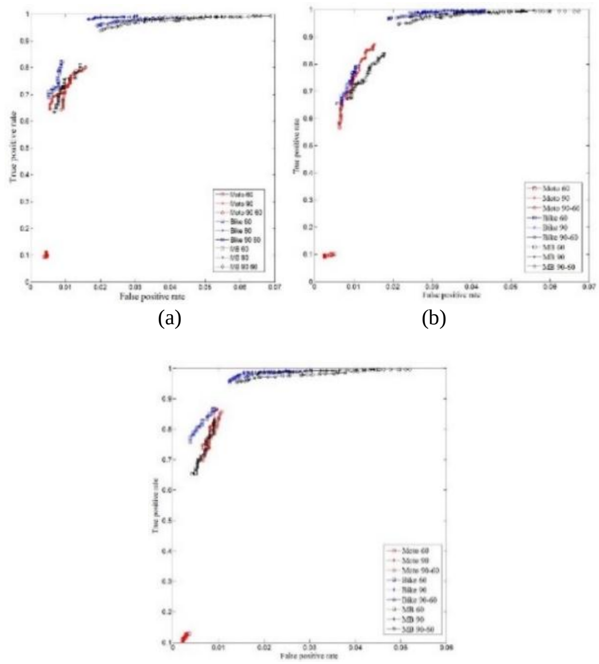
The motivation of the proposed method is high homogeneity value for edge pixels and low values for non-edge pixel. Therefore, we applied new magnitude calculation for the HOG, as follow

$$m\_h = \begin{cases} m \times Ho & \text{if} \quad m > th \\ m / Ho & else \end{cases} \tag{6}$$

$$F\_U = \begin{cases} m\_h & \text{if} \quad upper\ area \\ m & else \end{cases} \tag{7}$$

$$F\_L = \begin{cases} m & \text{if} \quad upper\ area \\ m\_h & else \end{cases} \tag{8}$$

where m is gradient value, Ho is homogeneity value and th is threshold value. th is obtained by experiment. In this paper, m is 2.0, th is 50 from equation (6). In equation 7, F_U means upper area HOG feature in Table 1 HU_HOG and in equation 8, F_L means lower area HOG feature in Table 1 HL_HOG.



(a) (b) (c)

Fig. 6: Experimental results for the proposed algorithms (a) Results of whole body homogeneity HOG algorithm, (b) Results of the upper area homogeneity HOG, (c) Results of the lower area homogeneity HOG by applying the suggested algorithm.

Table 2: Accuracies for traditional and proposed methods (%).

Angle \ Method		HOG	H_HOG	HU_HOG	HL_HOG
60	***M***	61.1	81.7	80.1	84.1
	B	71.2	97.4	96.9	97.9
	MB	76.7	96.4	96.5	97.1
90	***M***	74.9	97.2	97.8	98.2
	B	78.3	98.3	97.9	98.5
	MB	76.1	97.4	97.5	98.2
90-60	***M***	77.8	97.7	96.4	97.7
	B	75.5	97.5	97.8	98.3
	MB	73.1	97.0	97.1	97.8

Training uses the Adaboost algorithm for the upper and lower HOG feature vectors of the proposed method for positive and negative images. The final strong classifier (final hypothesis) can be obtained as in Section III. Table 1 shows the result of applying the same feature extraction procedure to the input image and then applying it to the strong classifier. As shown in Table 1, proposed method presents higher detection rate than general method. Moreover, HL_HOG and HU_HOG has higher detection rate than H_HOG. As shown in Figure 6, the cells of two-wheelers area are showing different type of characteristic than other area, such as background or road area (bottom). Then we emphasize that our paper proposed an innovation methods based on shape information; upper and lower to calculate the homogeneity. The highest accuracies for each of the methods were calculated with (7) and the results are listed in Table 1.
Table 2 shows that bicycle single items exhibit higher accuracy than motor bicycle single items and mixed database use. This is highly dependent on the nature of the motorcycle. The motorcycle can be said to have more impact because it can load more loads behind people. It is shown that the proposed method shows higher accuracy than the conventional method in the two kinds of motorcycle mixing experiments. For the miss classification In table 1, the HU_HOG and HL_HOG presents not only higher accuracy rate than the traditional HOG for training rate and all degree but also less calculation time than the HOG due to using half image. In the case of false detection, 90 degrees showed less than 60 degrees. 90 degrees is almost similar to a person, but it is considered that the complexity increases gradually as the angle decreases, resulting in a large number of detection errors.

5. Conclusion

This paper provides a more efficient algorithm for detecting two-wheelers that can be highly exposed to the risk of accidents on the road and using homogeneity features of objects. It has the problem that two-wheelers move faster than the pedestrian on the road. So it has very valuable research to protect the human life and to avoid the accident. To solve this problem, we proposed that homogeneity property used a sliding window approach has outstanding detection result than previous algorithm. The method based on the Adaboost classification has been found to be able to obtain successful results in the search of two-wheeled vehicles, constituting the subject of the study, which can be searched with two wheels. It has been experimentally demonstrated that HL_HOG and HU_HOG show better classification results than other traditional methods through ROC curve and Table 2. As a future task, we will spell over the including partially occluded object, the shapes of various view angles, weather, night environment, etc.

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References

[1] Jung H, Ehara Y, Tan JK, Kim H, and Ishikawa S, Applying MSC-HOG Feature to the Detection of Human on a Bicycle, *International Conference on Control*, (2012), pp: 514-517.
[2] Cho H, Rybski PE, and Zhang W, Vision-based Bicyclist Detection and Tracking for Intelligent Vehicles, *Intelligent Vehicle Symposium*, (2010), pp: 454-461.
[3] Yu L, Zhao F, and An Z, Locally Assembled Binary Feature with Feed-forward Cascade for Pedestrian Detection in Intelligent Vehicle, *Int. Conf. on Cognitive Informatics*, (2010), pp: 458-463.
[4] Zhu Q, Yeh MC, Cheng TK, and Avidan S, Fast human detection using a cascade of histograms of oriented gradients, *IEEE Conference on Computer Vision and Pattern Recognition*, (2006), pp: 1491-1498.
[5] Watanabe T, Ito S, and Yokoi K, Co-occurrence Histogram of Oriented Gradients for Detection, *Advances in Image and Video Technology(LNCS)*, (2009), pp. 37-47.
[6] Wang XY, Han TX, and Yan S, An HOG-LBP human detector with partial occlusion handling, *International Conference on Computer Vision*, (2009), pp:32-39..
[7] Mikolajczyk K, Schmid C, and Zisserman A, Human detection based on a probabilistic assembly of robust part detectors, *in Proc. Eur.Conf. Comput. Vis.*, (2004), pp: 69-81.
[8] Dalal N and Triggs B, Histogram of Oriented Gradients for Human Detection, *IEEE Conference on Computer Vision Pattern Recognition*, (2005), pp: 886-893.
[9] Homogeneity, https://en.wikipedia.org/wiki/Homogeneity_and_heterogeneity#Homogenity (accessed September 2018).
[10] Viola P, Jones M, and Snow M, Detection pedestrians using patterns of motion and appearance, *ICCV 2003*, (2003), pp. 153-161.
[11] Receiver operating characteristic, http://en.wikipedia.org/wiki/Receiver_operating_characteristic (accessed September 2018).