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Vehicle classification by estimation of the direction angle in a mixed traffic flow

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Abstract

The application of Intelligent Transportation System (ITS) is very important in developing societies nowadays. Vehicle monitoring is one of the primary tasks of ITS, where vehicles are classified by lanes for traffic management, especially in case of a mixed flow of motorcycles and other automobiles in the transport system of Vietnam. This paper proposes a new approach in vehicle classification, which is based on evaluation of the direction angle of the first primary axis of each coming vehicle detected in the captured video sequence and map into the predetermined database to mark it as motorcycle or automobiles instead of consideration of vehicle size. The experimental results show that the classification performance is promising, especially for motorcycles and cars, and therefore is applicable in detection of vehicle penalties moving in wrong lanes.

Keywords

vehicle, estimation, classification, direction, angle, mixed, traffic, flow

Disciplines

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Vehicle Classification by Estimation of the Direction Angle in a Mixed Traffic Flow

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Abstract— **The application of Intelligent Transportation System (ITS) is very important in developing societies nowadays. Vehicle monitoring is one of the primary tasks of ITS, where vehicles are classified by lanes for traffic management, especially in case of a mixed flow of motorcycles and other automobiles in the transport system of Vietnam. This paper proposes a new approach in vehicle classification, which is based on evaluation of the direction angle of the first primary axis of each coming vehicle detected in the captured video sequence and map into the predetermined database to mark it as motorcycle or automobiles instead of consideration of vehicle size. The experimental results show that the classification performance is promising, especially for motorcycles and cars, and therefore is applicable in detection of vehicle penalties moving in wrong lanes.**

Keywords—ITS; vehicle classification; motorcycle; car

I. INTRODUCTION

In developing countries such as Vietnam, a vehicle traffic mainly consists of motorcycles and cars which is characterized by a heterogeneous mix of vehicle types and by a lack of lane discipline [1]. In order to investigate the behaviour of these vehicles for traffic management and vehicle monitoring, the task of vehicle classification becomes very important in the current transport system. The vehicle classification can help monitor traffic flow on the roadway lanes corresponding to each type of vehicle. An approach using magnetic fields and radio waves studies the vehicle size, where cameras are mounted in each lane to monitor vehicle behaviour and therefore this solution seems to be expensive and inappropriate for multiple line roadways, and unwieldy operation [2]. Another method in [3][4] also investigate vehicle size, however applicable for car or non-cars only and not including motorcycles.

Vehicle classification used magnetic sensor as in [5] is also quite accurate, but the disadvantage of this approach is that the method cannot be classified as multiple-lane roads, this method is only suitable for charging stations. System used a sensor dual-axis Anisotropic Magnetoresistance magnetometer for detection of the vehicle length from its side view, and used for vehicle classification.

Authors in [6][7] exploit the combination of k-Nearest Neighbour, Histogram of Oriented Gradients features and Support Vector Machines for a shape-based and gradient-based analysis to categorize automobiles in a highway. This solution demonstrates high efficiency when the traffic light system and mounted surveillance cameras are standardized.

Since the mixed vehicle flow of motorcycles and other means is typical in the transport context of Vietnam, there is the need to classify vehicles motorcycles out from automobiles in a multiple lane roadway. Therefore, this paper utilizes of the Direction Angle (DA) of the First Primary Axis (FPA) for each coming vehicle detected in the video sequence captured by the surveillance camera, which is able to arbitrarily mounted in a given roadway. The background subtraction [8] is first performed for the captured frame sequence and then each vehicle is located and the DA of FPA is evaluated for decision making in classification task. The experimental results demonstrate high classification performance and imply that this approach is applicable for traffic management in developing countries likely Vietnam, where a large number of motorcycles participate in traffic multiple lanes together with automobiles.

The structure of this paper is as follow. The detailed description of the proposed classification method is next presented. In the next session, the experimental results are demonstrated to verify the performance and followed by the discussion and future work.

II. SYSTEM IMPLEMENTATION

A. Mount camera

For video acquisition, a CCD camera working with frame rate of 30fps and frame size of 640 x 480 is mounted at the elevation of 6.25m from the road surface so that the view angle to the horizontal line is 30 degrees as shown in Fig. 1.

B. Vehicle detection

The vehicle detection is based on background subtraction [6], known also as foreground detection, which is a widely used approach for detecting moving objects in videos sequence to remove the background. The rationale in the approach is that of detecting the moving vehicles from the difference between the current frame and a reference frame, often called a background image. As the result, the vehicle objects are detected as shown in Fig. 2 and ready for the classification stage.

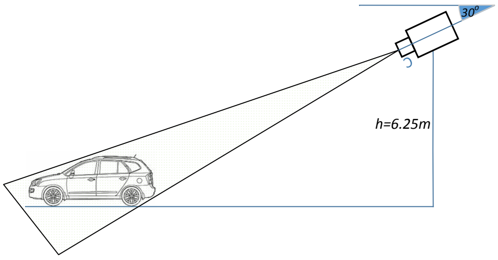

Fig. 1. Camera setup in the proposed classification system.

Fig. 2. Background subtraction algorithm
a) Original frame, b) Foreground detected

C. Vehicle classification

The vehicle classification utilizes specific features of vehicles. For examples, most of car objects are square bounded, while motorcycles typically are rectangular bounded. As illustrated in Fig. 3, the DA to the FPA within the bound detected is evaluated and used to classify vehicles. The DA denoted by *a* is obtained by the vertical line passing across the bound centre and the first primary diagonal and is evaluated by the following equation:

$$a = \arctan\left(\frac{width}{length}\right) x \frac{180}{\pi}. \quad (1)$$

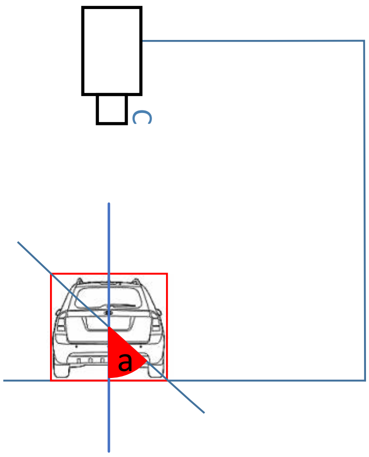

Fig. 3. Illustration of DA of FPA

III. Experimental Results and Discussion

Fig. 4 is a collection of detected cars branded Sedans, SUV, Mini-van and Pickup, which are located by rectangular bounds after background subtraction algorithm.

Fig. 4. Detected cars

Fig. 5 demonstrates the detected bounds and corresponding DA for 80 car samples of Sedan, SUV, Mini-van and Pickup. One can see that even though the bound sizes are quite different, the DA vary in a small tolerance from 39.92 degrees to 49.42 degrees, and therefore DA is shown to be a suitable feature for car classification as depicted in Tab. I.

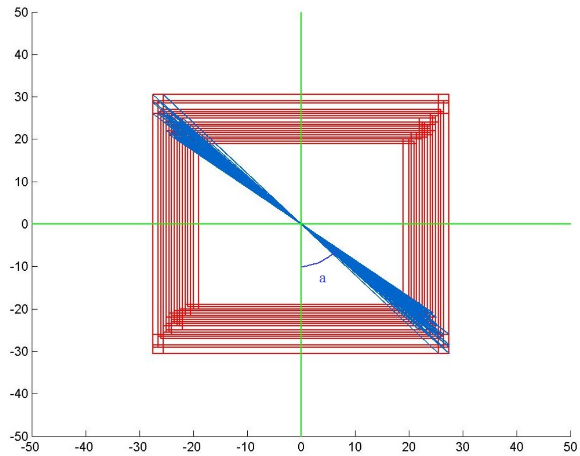

Fig. 5. A set of 80 detected cars with square bounds and the corresponding DA.

TABLE I. DA values of Sedan, Mini-van, SUV and Pickup

Min DA	Max DA	Average
39.92	49.42	45.92

In this study, the largest DA goes to sedan, next to the mini-van, the smaller to SUV, and finally the smallest to the pickup.

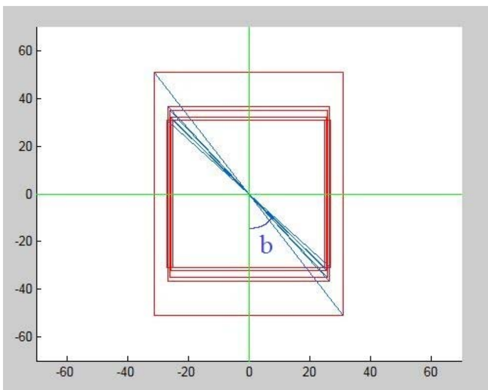

Fig. 6. A set of 7 buses and trucks with bounds and the corresponding DA.

In the similar manner, Fig. 6 shows statistics of 7 large size samples including buses and trucks. The corresponding DA of these vehicles ranges from 31.31 degrees to 41.08 degrees as given in Tab. II.

TABLE II. DA VALUES OF BUS AND TRUCK

Min DA	Max DA	Average
31.31	41.08	37.08

The main point of interest in this study is motorcycle classification. Fig. 7 demonstrates the set of 80 different motorcycles which have been detected and bounded for DA evaluation. One can see that the sizes are not uniform despite being taken out from the same camera view, because of different types of motorcycles.

Fig. 7. Detected motorcycles

As represented in Fig. 8, the corresponding DAs for each detected bound is performed similarly as in case of car. However this time, the DA values vary only from 20.71 degrees to 27.77 degrees with the average value of 23.68 as shown in Tab. III. Fig. 9 demonstrates a set of 80 detected motorcycles with rectangular bounds and the corresponding DAs with small difference.

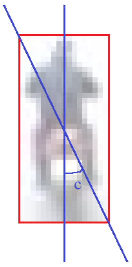

Fig. 8. DA for the detected motorcycle

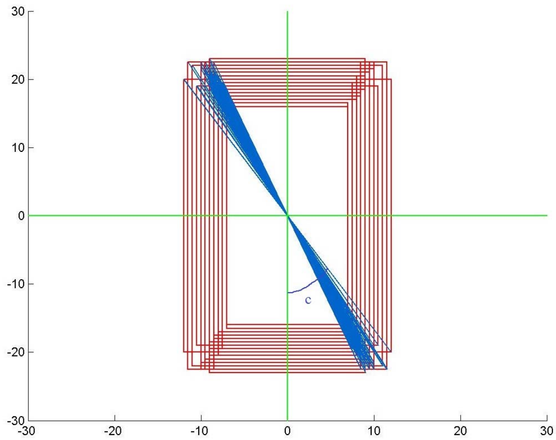

Fig. 9. A set of 80 detected motorcycles with rectangular bounds and the corresponding DA

TABLE III. DA VALUES OF MOTORCYCLES

Min value	Max value	Average
20.71	27.77	23.68

Tab. IV summarizes the DA of different vehicles appearing in the test video captured by the surveillance camera for easy subjective comparison of this feature.

TABLE IV. DA VALUE STATISTICS FOR VEHICLES

Vehicle	Cars	Buses and Trucks	Motorcycles
DA	49.92 - 39.92	41.08 - 31.31	27.77 - 20.71

Tab. V lists the number of car and motorcycles appearing in the captured video sequence for a given period of time, and the actual number of classified vehicles using the proposed DA feature.

TABLE V. DETECTION VEHICLES

Vehicle	# counted	Classified #	Accuracy
Car	50	50	100%
Motorcycle	55	51	92.72%

One can see that the accuracy for motorcycle classification is relatively less than that of cars, because the motorcycles move very close each to other with similar speed. In addition, motorcycles typically carry goods in the back seat, and therefore the DA may be changed, and it may lead to misclassification.

IV. CONCLUSIONS

This paper has presented an simple but efficient approach to classify vehicles including motorcycles and other types of automobiles which is based on the detection of vehicles and evaluation of the direction of angle. The future work will focus on more stable detection and classification of motorcycles carrying cargos which can be widely seen in the transport of Vietnam.

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