Neurocomputing 173 (2016) 450–461

Contents lists available at ScienceDirect

Neurocomputing

journal homepage: www.elsevier.com/locate/neucom

Vision-based two-step brake detection method for vehicle collision avoidance

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A R T I C L E I N F O

Article history:
Received 1 August 2014
Received in revised form
9 March 2015
Accepted 8 April 2015
Available online 5 September 2015

Keywords:
Vehicle accidents
Brake detection
Color space
SVM

A B S T R A C T

Nowadays with the growing popularity of vehicles, traffic accidents occur more frequently, causing lots of casualties. In this paper, in order to avoid the accident where a vehicle collides with the one ahead, we present a novel vehicle brake behavior detection method by using a colorful camera or mobile device fixed on the windshield of the test car which utilized to capture the front vehicle information. The brake behavior detection in our work includes two procedures, brake lights region detection and brake behavior decision. For the first procedure, we use threshold segmentation and proposed horizontal–vertical peak intersection strategy to filter and generate the credible rear-light regions of the front vehicle in the YCrCb color space converted from the original RGB color space. For the second procedure, the sophisticated SVM classifier is trained to detect the brake behavior of the front vehicle. In this procedure, we extract discriminative features of the rear-light regions generated from the first procedure and then the features are used as the input of the pre-trained classifier. Extensive experiments on various real-world vehicle datasets demonstrate the effectiveness and real-time performance of our proposed brake detection strategy.

1. Introduction

With the popularity of vehicles in recent years, traffic accidents are becoming more frequent and lots of casualties have been caused. Therefore, how to avoid the accident has drawn growing attention in the research communities at present, such as vehicle detection, brake detection and vehicle distance calculation, as well as the correlational research of manless driving.

Many existing vehicle detection methods can be divided into two parts, sensors-based methods and vision-based methods [1]. In our work, we focus on the vision-based methods to implement the brake detection. Some of the vision-based methods are mainly based on the rear-light detection and localization at nighttime to implement vehicle detection [2–7]. As analysis, the rear-light is an important feature of vehicles which usually shows white color in the center with surrounding ring of red color. And many works have been done on brake detection and distance measure for preventing vehicle collision during the nighttime [8–12] by using this distinctive feature, as feature is very important in machine learning, feature representation methods have been proposed to obtain the optimal feature for learning [13,14]. The characteristic of rear-light is illustrated in Fig. 1, (a) is an example of brake behavior in the daytime, and (b) is an example of brake behavior in the nighttime. Both show white color in the center, surrounded by red color, which is a useful feature for brake-light detection.

As we know, many research works have been done on vehicle detection, but few works have been done on vehicle brake detection, fewer even utilized on mobile device (such as windows phone). Therefore, in this paper, we propose a two-step brake detection method used on mobile device (such as windows phone) which is also a vision-based method. The framework of our method is illustrated in Fig. 2. There are two important processing steps in the framework: brake-light regions generation and brake behavior decision. In the first step, we present a novel strategy to localize the brake-light regions of the front vehicle, including candidate brake-light regions generation in the YCrCb color space, soft spatial filtering and horizontal–vertical peak intersection verification. Compared with the methods in [5,12] illustrated in Table 1, our method has less threshold for brake-light regions localization, which could improve the robustness in different traffic environments. In the second step, we utilize the sophisticated SVM classifier for brake behavior decision with the distinctive feature extracted from the located brake-light regions. We extract six different features used for the SVM classifier to detect the brake behavior of the front vehicle. The output of the classifier is brake or non-brake, and with this result, we could define the current brake behavior state of the front vehicle as brake or non-brake.

In the era of economic development, we believe that our work has the potential in producing economic and social benefits, due to the following contributions.

http://dx.doi.org/10.1016/j.neucom.2015.04.117
0925-2312/

Fig. 1. (a) The example of brake-light in the daytime. (b) The example of brake-light in the nighttime.

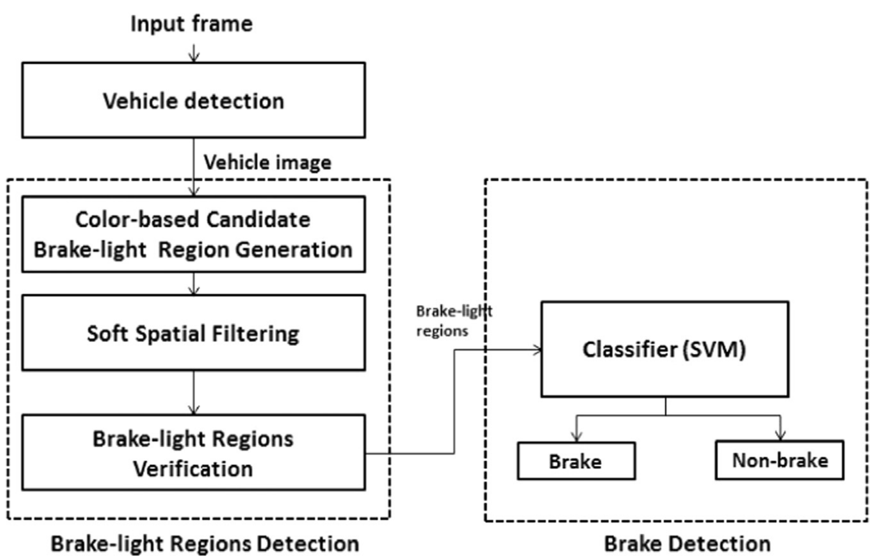

Fig. 2. The framework of the two-step brake detection.

Table 1
The threshold parameters in our work and related works.

Our	Work [5]	Work [12]
Adaptive T	W_{min} W_{max} d	T_o T_{sh} T_n

1. We propose a novel strategy to generate the brake-light regions from the candidate light regions which is called horizontal–vertical peak intersection verification method. We demonstrate that this strategy has the anti-jamming ability to the noisy light regions such as street-light region and reflected light region.

2. We utilize the sophisticated classifier method in machine learning to detect whether the front vehicle has brake behavior or not. We believe that this method is more effective than the methods where a lot of parameters need to be set while detecting the vehicle brake behavior.

3. As there are no complex calculations in our method, we believe that our method could be used on the mobile device (such as windows phone) to detect the brake behavior and avoid the risk of accident by alerting the driver.

The rest of the paper is organized as follows. Section 2 reviews related work. In Section 3, we describe the details of the brake-light regions detection. In Section 4, we give the decision of brake behavior. The experiment results are reported in Section 5. Finally we conclude this paper and give the future work in Section 6.

2. Related work

The research of vehicle detection and vehicle lights detection could be divided into two parts, detection based on sensors methods and detection based on vision methods. To a certain extent, vehicle lights detection could be regarded as auxiliary for vehicle detection.

One most common approach in vehicle detection is using sensors, such as lasers, millimeter-wave radars or optical sensors. The first two are called active sensors and the optical sensors are called passive sensors [1]. Though active sensors have shown promising results, there are also some drawbacks, such as slow scanning speed and low spatial resolution. A big problem is that the cost of a laser or radar is high. Compared with the active sensors, the optical sensor has the advantage of low cost. Optical sensors can be used for tracking vehicles, lane detection or object identification. There are also some complex situations such as