AN ADVANCED NUMBER PLATE DETECTION METHOD FOR REAR-END COLLISION AVOIDANCE SYSTEM

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Abstract

THE Design of a new car moves from real car prototype to software based virtual design methods, see e.g. [1]. These methods accelerate both the design and the development of new functions. Especially safety functions are of interest. The rear-end collision, which is typically caused by other drivers, is an accident that cannot be easily controlled by the ego driver. In the case, a rear-end collision takes place, a fast detection of the status and a fast evacuation are needed. This paper classifies the rear-end collisions and proposes methods of avoiding the accident and if this is not possible of minimizing the damage. Rigorous and accurate evaluation of the risk of the coming collision by fast and real-time processing and reliable detection of accidents should be realized. To improve the reliability, the integration of several detecting elements is needed. At the detection of the collision, it is necessary to minimize false positive and permit false negative identifications. Then, logical AND of results of detection elements is used to exclude the false positive error.

The types of the ego-car positions in rear-end collisions are running and stopping in a traffic jam. Types of driver’s behaviours in following vehicles are e.g. look away, inattentive, careless, dozing, etc. Types of situations are e.g. poor visibility in snow, in the fog, insufficient vehicle distance, etc. The collision should be detected at least two seconds or 50 meters before the accident at the difference speed of 100 km/h. The evacuation may be indicated to the following car by light and sound signals or electric impulses. To judge that the collision shall surely occur, the moving object must be identified as a real vehicle. Detection elements to identify real vehicle are the number plate, vehicle symmetry, the tires, the windscreen, the face or the eyes of the driver etc. In this paper, among the above elements, the number plate detection is deeply improved. The method presented is mainly developed to improve correct detection rate in comparison with conventional methods. The features of the number plate are many vertical and horizontal lines combined to numbers with horizontal to vertical aspect ratio in the order of the detected rectangle of the number plate. Additionally there is a relatively high luminance of background of number plate area. In this paper, in addition to these features, an advanced sobel filter is introduced to adapt to the size variation of the number plate depending on the distance between two cars. The basic coefficients of the original sobel filter is (1,0,-1). The proposed advanced sobel filter is (1,0,0,-1). By using the original and the advanced sobel filters, larger plates and smaller plates will be detected adaptively. The resulted rear-end collision avoidance software will be integrated and tested in the virtual system design approach. maximum 500 words
INTRODUCTION

Technology development and feasible experiments using vehicles with automated driving assistance system (ADAS) are widely proceeding. Research for investigating which should have the authority of operating a vehicle between a human and a machine and consequently switching criterion of judgment and efforts is performed [2]. The research paper presented the necessity that a human should drive for a while taking the authority of the operation instead of a machine when the machine gets into a difficult situation for automated driving. This event is called “arbitration” because a human and a machine may fight to obtain the authority of operation, which means it is not a simply switching but could be a serious battle of taking the right of operation.

In the current automated driving assistant system, it is assumed that the vehicles and other things around the ADAS car are all favourable to the ADAS car, which was referred to in the presentation of [3]. It would be a more difficult task for the ADAS car if the surround vehicles do not act in favour. For example, when an ADAS vehicle goes in a constant speed obeying the law of a speed limit, and when another car comes into the front lane of the ADAS car, the ADAS car would keep sufficient distance between the coming car and the ego car by reducing the speed of the ADAS car as a machine thinks itself. The front part of the ADAS driving lane is not the space for the ADAS’s but the space for all the other vehicles to be donated from the ADAS car. The ADAS has no right at all for the front part of itself. For the both side areas, for example, when the ADAS car detects an obstacle in the left hand, the ADAS car will make judgments to move right hand to keep safe distance between the ego-car and the obstacle. This means that the ADAS car has no right to use the left hand area as a spare room for safety and the space is programmed to get off to others if necessary. So is the same as for the right-hand area.

How about is it for the rear area? As for rear area, no action is mentioned except that blind spot detection will keep the car going straight and avoid changing lanes. The ASAS car assumes that other cars surely reduce the speed or stop to avoid collision similarly as the ADAS car if the distance between two cars becomes short. However, in the case that the other cars do not equip such intelligent system nor switching off the ADAS function, whose case that the driver in the following car manually drive having authority of operation, it is not assured that the following car does reduce its speed or stop when the distance between two cars is getting short.

From the consideration above, the current ADAS car does not practically have a right to run in the front lane, both side lanes and it has no protecting equipment for rear direction. In this paper, focusing this dangerous status in the rear direction, we will consider to cope with the any types of accidents caused by the vehicles in the rear direction. To detect the vehicles in the rear direction without error is the first point. What to do before the moment of collision is the second problem.

RELATED ITEMS

Driving ways of driving between human driver and a machine driving system are different. There is a great gap between human way of driving and machine. We have been considering the problems caused by manually driving following vehicles. If the detection result is sufficient reliable, we consider to act to make a dangerous evacuation even paying a large risk As the first stage for that system, reliable vehicle detection methods are proposed in this paper.

Rear-End Collision Avoidance System
The rear-end collision, which is typically caused by other drivers, is an accident that cannot be easily controlled by the ego driver. In the case, a rear-end collision takes place, a fast detection of the status and a fast evacuation are needed. This paper classifies the rear-end collisions and proposes methods of avoiding the accident and if this is not possible of minimizing the damage. Rigorous and accurate evaluation of the risk of the coming collision by fast and real-time processing and reliable detection of accidents should be realized. To improve the reliability, the integration of several detecting elements is needed.

The types of the ego-car positions in rear-end collisions are running and stopping in a traffic jam. Types of driver’s behaviours in following vehicles are e.g. look away, inattentive, careless, dozing, etc. Types of situations are e.g. poor visibility in snow, in the fog, insufficient vehicle distance, etc.

The collision should be detected at least two seconds or 50 meters before the accident at the difference speed of 100 km/h. The alert indicates to the following car by light and sound signals or electric impulses before evacuation. The evacuation methods are moving the car either to the left or to the right by turning the steering wheel or rotating the car position if low cost realization is possible.

There is a long-term method which detects all vehicles and tracks them for a long period and then analyzes the behavior of the vehicle to find dangerous factors. This paper focuses the instance of collision. Tanaka et al tried to detect vehicles using rear-camera based on perspective transformation of the rear images [4]. They uses 3D processing to obtain top-view improves measuring distance between cars. However, it is better to measure the distance by radar system than vision system. Balcones et al presented real-time vision-based vehicle detection for rear-end collision mitigation [5]. Rear lane detection followed by entropy evaluation and detecting symmetry are tried. The results of detection rate depend on video sequence from 87.5% to 100.0%. Tsuchiyu et al presented real-time vehicle detection for a blind spot warning system [6]. They did not detect following vehicles straight in rear direction, but in a diagonally backward. Kim presented high-speed target detection by fusion of spatial and temporal detectors [7]. The paper detect moving target in the space assuming there is no obstacles other than enemies in military use. Backover Crash avoidance technologies are surveyed and reported by National High-way Traffic Safety Administration (NHTSA). The report includes rear-end collision and large scale experiments to provide images to a driver during driving using rear cameras [8].

In this paper, we would like to reconstruct the vehicle detection in the rear direction in high precision.

SYSTEM

Figure 1 shows the proposed whole number plate detection system, white lane detection, vehicle detection, head-light detection and the number plate detection. Conventional number plate recognition software using openCV [9] can detect the number plates that are in large sizes such as taken in parking area. In a situation at driving on a highway, detecting the number plates in high precision is needed [10].

The total detection will be carried out by combining devises as possible such as radar for measuring distance, though the structure in Figure 1 only shows image processing. In this paper, sobel filter and Hough transform at the last part will be presented among the whole image processing.

The region of the number plate is usually detected using horizontal and vertical edges, because there are several numerical characters on the number plate with a plain background [11]. This method apply a horizontally differential filter to an input image, then making a histogram by accumulating 1 values horizontally of binarized data of absolute values of the differentiated data. It is considered that high-frequency parts of the histogram are caused by the characters on the number plate. By scanning the histogram vertically, we can extract a horizontal belt with a specific height. Next, within this horizontal belt, we detect a candidate
interval by scanning another vertical histogram of vertical differentiated results. Some confirmation procedures are applied.

Lin et al presented rear obstacle detection using fish-eye camera to obtain a wide angled image [12]. The fish-eye camera image is undistorted by calibration. Lane detection, ROI extraction, sobel edge detection and Wavelet transform and SVM methods are integrated to detect rear vehicles. It detects both the following vehicle and overtaking one in an adjacent lane simultaneously in small traffic scene.

**Advanced Sobel Filter: zero-extended sobel filter**

Extended sobel filters [13,14] usually have the size of 5x5 or 7x7 filtering matrix, while the original sobel filter has 3x3 filtering matrix. Also, there is another example with extension in diagonal direction [15]. Here, we considered an advanced sobel filter with increased zero coefficients in the centre part, which we call zero-extended sobel filter. Zero coefficients at the centre part make effect to produce larger absolute values of filter output when the input image resolution is low. Resolution of rear camera image at a large distance will be low when the auto focus function could not pursuit the situation. In such case, the number of zeros will contribute to the detection of strong edges. For the simple example of the original coefficients are,

\((-1 \ 0 \ +1)\).

And coefficients of the advanced sobel filter are,

\((-1 \ 0 \ 0 \ +1)\).
To judge that the collision shall surely occur, the moving object must be identified as a real vehicle. Detection elements to identify real vehicle are the number plate, vehicle symmetry, the tires, the windscreen, the face or the eyes of the driver etc. In this paper, among the above elements, the number plate detection is deeply improved. The method presented is mainly developed to improve correct detection rate in comparison with conventional methods.

The features of the number plate are many vertical and horizontal lines combined to numbers with horizontal to vertical aspect ratio in the order of the detected rectangle of the number plate. Additionally there is a relatively high luminance of background of number plate area. In this paper, in addition to these features, an advanced sobel filter is introduced to adapt to the size variation of the number plate depending on the distance between two cars. The basic coefficients of the original sobel filter is (1,0,-1). The proposed advanced sobel filter is (1,0,0,-1). By using the original and the advanced sobel filters, larger plates and smaller plates will be detected adaptively. The resulted rear-end collision avoidance software will be integrated and tested in the virtual system design approach.

### Rectangle Hough Transform

As the number plate is the shape of a rectangle, a Hough transform method of line detection is modified only to detect horizontal and vertical lines. A method to detect rectangle in any directions was presented [16]. Pairs of Parallel lines and orthogonal conditions were introduced in Hough transform. But the method assumed that there is an origin at the centre of the rectangle.

We modified the conventional Hough transform for detecting a rectangle of the number plate shape. Figure 2 shows a rectangle Hough transform. At a voting of Hough transform for each edge pixel is restricted for angles of 0 and 90 degrees. By this restriction, other slanted lines are excluded from the voting stage. The Hough transform result has only horizontal and vertical lines. The processing speed would increase by skipping other candidates. After detected lines, we apply a rectangle test that horizontal width and vertical height are in an appropriate rate or not. Finally an average luminance level of the detected plate region is tested at an appropriate level.

![Rectangle Hough transform for the number plate region detection.](image)
Experiments

Figure 3 shows effects of the proposed advanced sobel filter for horizontal differential case. Zero-extended filter with the 5-7-taps shows strong edges for the image with the original size. For the half sized image, 3-6-taps results show stronger edges than the results of 3-tap.

Using Hough transform together, several results are shown in Figure 4. Figure 4(a) shows results only using average luminance information after sobel filter without using Hough transform. Figure 4(b) shows a result using sobel filter and Hough transform and luminance level test. The rate of width versus height of the detected rectangle is 2 for Japanese cars and 3 for Germany cars.
Figure 4(a) Detection using sobel filter and average luminance level.

Figure 4(b) Detection using sobel filter and Hough transform and average luminance level.
Figure 4(c) Number plate searching area given by the preceding stage.

Figure 4(d) Detection using sobel filter and Hough transform and average luminance level.

Figure 4(d) Detection using sobel filter and Hough transform and average luminance level.
Conclusion

Using an advanced sobel filter and rectangle Hough Transform, we can detect the number plate region correctly. The rectangle Hough transform detects the horizontal and vertical lines effectively and reduce the searching time. For the Japanese number plate rate of width vs. height is about 2. For the Germany case the rate is about 3.

Further study

To integrate total detection software and how to use the detected alarm signal to avoid rear-end collision from the following vehicles.


