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Distance Estimation with Car Detection Algorithm for Lane Change Assist System

Assadayooth Ruangkumhai[1], Nuksit Noomwongs[1]

[1] Faculty of Engineering Chulalongkorn University, Phayathai road Patumwan, Bangkok 10330, Thailand
Assadayooth.Ruangkumhai@gmail.com, Nuksit.N@eng.chula.ac.th, 02-218-6610

Abstract

In recent years, there are many types of research for the car-safety system. The lane change assist system is one of many popular systems in this research field. This system will detect a car in target lane. Then, the system will warn the user when they changing the lane in dangerous conditions. The car detection sensor and distance estimation sensor are importance for this system. The camera is the most efficiency sensor because it has the lowest cost and many applications. However, distance estimation algorithm for camera sensor is the big challenge. This research was purposed the estimation function for estimate the distance between user car and a car in a target lane. The experiment was showed the potential of car detection system with the estimation function for car detection and distance estimation. The result shows that this system can detect a passenger car from 8 meters up to 25 meters from the sensor. Moreover, the R-Squared value of the distance estimation function is about 92%.

Keywords: Car detection system, Distance Estimation, Lane change assist system.

1. Introduction

Road accidents are the most important problem for many years. NHTSA report shows that the lane changing accident is contributed for 15% of all of the road accident in the United State of America [1]. The main cause is the human error of driver for estimating distance and relative velocity of a car in the target lane [2]. The lane change assist system is the system which detects the car at the side lane of the user's car. This system will warn the user when they try to change the lane in dangerous conditions.

Nowadays, many Lane Change Assist systems work with the car detection system which using a digital camera as a sensor. However, there is no method to estimate the distance between user's car and a car in the target lane which is not in the blind-spot area.

The Lane Change Assist System in this research has the process as in Fig. 1. The image of a car in a target lane was taken by the camera sensor. Then, the car's location was located by The Car Detection System for locating a car in an image. The car's location in an image was used to calculate the distance between the sensor and a detected car. The Minimum Safety Spacing (MSS) [3] can be evaluated by using the information from The Distance Estimation Algorithm. The Minimum Safety Spacing was used for warning decision. This system warns the user when the user changes the lane while the distance between the user car and the detected car is less than the Minimum Safety Spacing. The scope of this work is to evaluate the maximum and minimum range of a system and find the Distance Estimation Function for Distance Estimation Algorithm which is showed in Fig. 1.

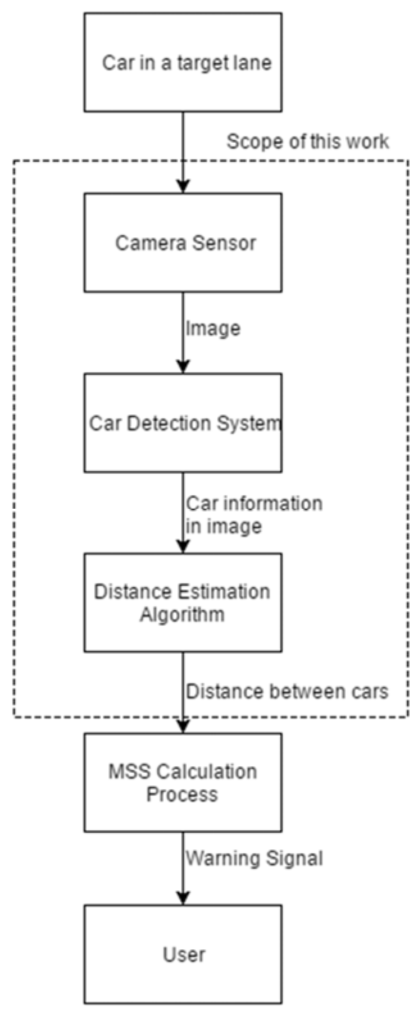

Fig. 1 Process of Lane Change Assist System

2. Literature Review

There are many types of research about car detection system in present day. The sensor for this system can be divided into 2 groups. The first group is an active sensor (e.g. laser scanner, radar, sonar etc.). Another type of sensor is a passive sensor such as a camera. The passive sensor is more suitable for car detection system than the active sensor because the information (picture) from this sensor can be applied in many ways such as identify the type of a detected car or other object etc. Moreover, the passive sensor has a lower cost than active sensor [4]. Image processing techniques are important for car detection system with the camera as a sensor. The car detection progress can be divided into 2 steps. The first step is hypothesis generation (HG). In this step, the system will find the area in a picture which may be a car which is called Region of Interest (ROIs). The second step is hypothesis verification (HV). The system will verify the ROIs from HG step which is a car [5] and draw the rectangle around the car in a picture. The process of Car Detection is shown in Fig. 2.

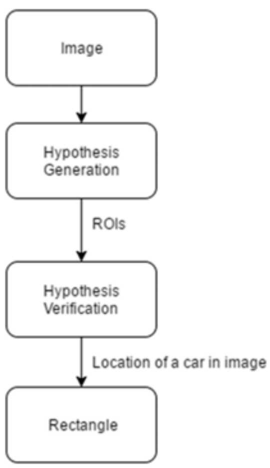

Fig. 2 Car Detection Process

The popular techniques to find ROIs in HG step are shadow-base detection and edge detection. These methods use Haar-Like feature algorithm for mark the location of ROIs [7], [8].

The ROIs from HG step will be inspected by the classifier in HV step. The classifier was made from machine learning techniques. There are 2 methods of machine learning that use to create a classifier for car detection. The first method is Support Vector Machine (SVM). The classifier which created by this method is called SVM classifier. The ROIs will be transformed to higher dimension by Kernel Function. Then, the vector line will be created to classify the data. This method needs high computer performance and too hard to use with the real-time system [8]. Another method is Boosted Classifier. The boosted classifier with Haar-Like feature algorithm is called Haar-Cascade classifier. The plenty of data which called samples was used to train this classifier. The ROIs will be classified by comparing with trained database. The accuracy of this classifier depends on the number of samples. This method uses lowest computational time and computer performance [7]. Car detection system will detect a car in a target lane then draw a rectangle around the detected car. The range between sensor and a detected car are related to the size of the rectangle of a detected car in an image [9]. The system can estimate the distance between the user's car and the detected car by using the similarity of the triangle (eq1).

$$\frac{h}{f} = \frac{H}{Z} \tag{1}$$

Where

- Z is the range between car and sensor
- f is the focal range of a camera
- H is range between sensor and the ground
- h is the size of a rectangle of a detected car

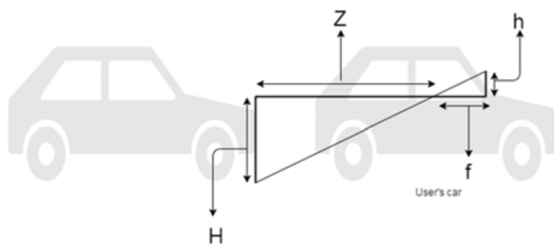

Fig. 3 applying the similarity of triangle with lane change assist system

However, the size of the rectangle of a detected car is the same at some ranges. So, the system is lacked accuracy in range estimation.

In this research, we enhanced the car detection system by create the Estimation function for estimating the range between car and sensor. This function was created from the relationship between sizes of a car in the image for any range.

3. System Design

The car detection system in this work is using a digital camera as a sensor with a car detection program. The procession of this system was shown in Fig. 4. An image from the camera was sent to the car detection program. The car detection program is combined with HG and HV process. In HG step, we used edge-detection to create the ROIs. The ROIs will be classified by Haar-Cascade classifier. This classifier was created from 300 of positive samples and 500 of negative samples. Next, the created program draw the rectangle around the location of a detected car.

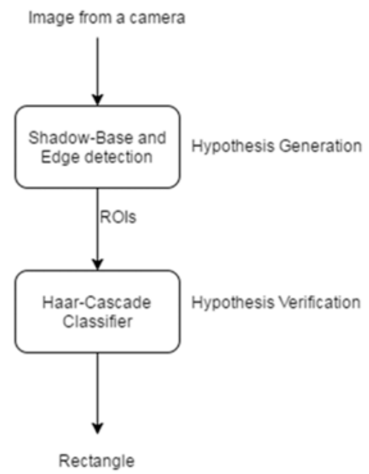

Fig. 4 The car detection process

The program was created in C# language by using Microsoft Visual Studio 2015 and EmguCV library. We use the digital camera from uEye-IDS. The specification of this camera was shown in Table. 1.

Table. 1 Camera specifications

Model	UI-1220LE
Connection	USB 2.0
Dimension	752 x 480
Optical Class	1/3"
Focal Length	infinity

The system is operating in a laptop computer and the specifications were shown in Table. 2.

Table 2 Computer Specifications

Type	Laptop
Operating system	Windows 8.1
CPU	Intel Core i7
RAM	8 GB

4. Experimentations and Experimental Results

4.1 Maximum and Minimum range of the system

This experiment was set to evaluate the limit of this system. The maximum range is the distance between a sensor to the front of a target car. The experimentation was set as follow

1. Setting up the camera sensor on the tripod with 120 centimeters height which is the height of side mirror
2. Connecting the sensor to a computer via USB cable
3. Start up the program
4. Stop a car in front of the sensor at any distance to find the maximum and minimum range

The created system can detect a car from 8 meters as in figure 6 up to 25 meters as in figure 7 from the sensor.

Fig. 5 car detected at 8 meters from the sensor

Fig. 6 car detected at 25 meters from the sensor

4.2 The estimation function evaluation

We tested the car detection system from 8 meters up to 25 meters from the sensor to find the relationship between the high from top of the image to the bottom of the rectangle of a detected car (h) and the distance between the detected car and a sensor (Z). The experimentation was set as following.

1. Setting up the camera sensor on the tripod with 120 centimeters height height which is the height of side mirror
2. Connecting the sensor to a computer
3. Start up the program
4. Stop a car in front of the sensor at any distance between 8 meters up to 25 meters from the sensor

The result was shown in Table. 3. We found the relationship between data in Table. 3 as in Fig. 5.

Table. 3 the height from top of the image to the bottom of the rectangle of detected car and a distance relationship

Z(meter)	h(pixel)
25	316
20	329
15	348
10	403
8	418

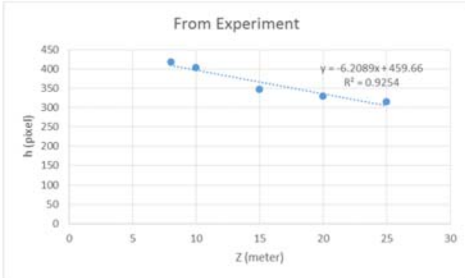

Figure 7 The relationship between the high from top of the image to the bottom of the rectangle of detected car and a distance

In Fig. 7, we found that the height from top of the image to the bottom of the rectangle of detected car and a distance have the linear relation. The linear equation can be used to estimate the range between the sensor and a car as in equation below (2).

$$Z = \frac{459.66 - h}{6.2089} \tag{2}$$

The R-Squared value of the equation (2) is about 0.9254.

5. Conclusion and Future Work

The goal of this research is to find the Estimation Function which use to estimate the distance between the sensor and a detected car. We created the Car Detection System which using a digital camera as a sensor with the Haar-Cascade Classifier for detecting a car in a picture from a digital camera. Then we found that the relationship between the high from top of the image to the bottom of the rectangle of a detected car (h) and the distance between the detected car and a sensor (Z) is linear and describe in the equation (2). The R-Squared value of the equation (2) is about 92%. It implies that the calculated distance from (2) is closetable to the real world distance measurement.

We will develop the equation (2) for our lane change assist system. The equation will be modified for real-time usage to calculate the relative velocity by using the different distance at each frame. The Minimum Safety Spacing can be determined by using the acquired relative velocity. Then, we can create the condition for warning the user.

6. References

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