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Development of Vehicle-to-Infrastructure Systemusing Image Processing Technique

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Abstract. Road safety has become an important issue and gained much attention for many years. The vehicle-to-infrastructure is one of the traffic intelligent systems which are developed to communicate with driver.This article presents a development of vehicle-to-infrastructure system using image processing. It focuses to develop of overtaking analysis system to gain higher efficiency when overtaking on a two-lane highway while driving during night-time. The depth of field and stereo vision techniques are used to determine the car distance. The zigbee standard is used to communicate between the vehicles to infrastructure. The result shows that the processing time needs only 0.54 second and it need at least 250 meters to overtake a car with the speed 40km/hr.

Keywords:vehicle-to-infrastructure, depth of field, stereo vision

1. Introduction

Road safety has become an important issue and gained much attention for many years [1-3].To reduce traffic accidents, researchers have proposed several vehicle-to-vehicle (V2V) collision warning systems CWS) to avoid vehicle collisions and vehicle-to-infrastructure (V2I). The V2V collision warning system can be categorized into three classes based on the employed technologies: radar-based, camera-based, and radio-based. The radar-based and camera-based collision warning systems are mainly designed to avoid forward collisions of vehicles on the same lane due to the line-of-sight limitation resulting from the radar and camera technologies [4]. The radio-based collision warning system is more capable of avoiding vehicle collisions in off-sight scenarios, such as the four corners of an intersection. Vehicle to Infrastructure communication allows the vehicle to send messages to the infrastructure about the state of the vehicle, and to a limited extent using on-board radar and other sensors, about the immediate roadway environment[5].

From fig. 1, a function-level technology may be composed of several hardware, software, or activity elements that together deliver a cohesive function or service. This research is investigated and focused to using the Zigbee communication technology with real time image processing for the V2I system [6]. It focuses to develop of overtaking analysis system to gain higher efficiency when overtaking on a two-lane highway while driving during night-time. The study will identify the distance of the oncoming opposite lane car and its velocity which results in the overtaking decision by using 2 images. The benefit with the investment cost is not expensive; the use of an existing cars original equipment camera can be selected. The step of processing starts from the vehicle specification by using the provided algorithm structures. Inside these algorithms, there are several vehicle specifications and their simulation models constructed. After knowing the vehicle specification, the proper equation with the real condition will be applied. Finally, the overtaking decision by the database of computer vision will be exposed.

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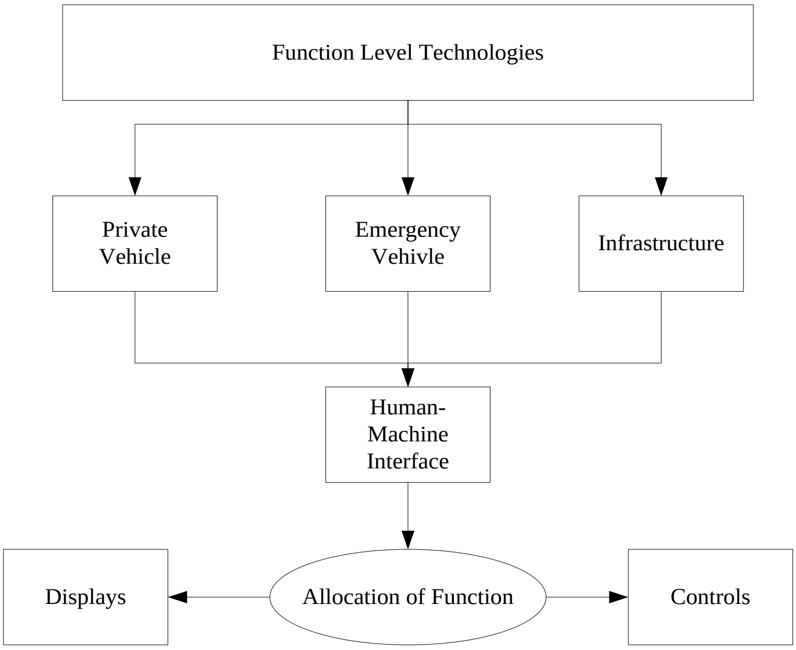


Fig. 1: Levels of V2Itechnology

2. Depth of Field (DOF)

Depth of Field (DOF) is the distance between the focused object to the film plane. Depth of Field is proportional to the square of object distance as in Equation .

$$DOF \propto (Object\ Distance)^2 \tag{1}$$

That means if the distance of the object increases twice, Depth of Field will be four timeincrease. However, theincrease of the distance will affect the decrease of the objectsize and its perspective will change.From Fig.2, the figure shows the model of the cars' motionprocess. The car installed the camera will be at bottom-end.The image on the top right displays the depth of field of theimage and the image on the bottom right shows theperspective view.Where

$$\frac{a}{b} = \frac{c'}{d'} \tag{2}$$

$$\frac{z}{\lambda} = \frac{c'}{d'} \tag{3}$$

$$\frac{a}{b} = \frac{z}{\lambda} \tag{4}$$

$$z = \frac{\lambda a}{b} \tag{5}$$

a = a real distance of the headlight
a'= the horizontal distance from the left headlight to the center of the camera
b = the perspective size of a in the image plane
b′= the perspective size of a′in the image plane
c = the hypotenuse size of the right triangle with the Z leg and the a +a′leg.
c′= the hypotenuse size of the right triangle with the Z leg and the a′leg
Z = distance between the object and the camera
λ= focal length of the camera

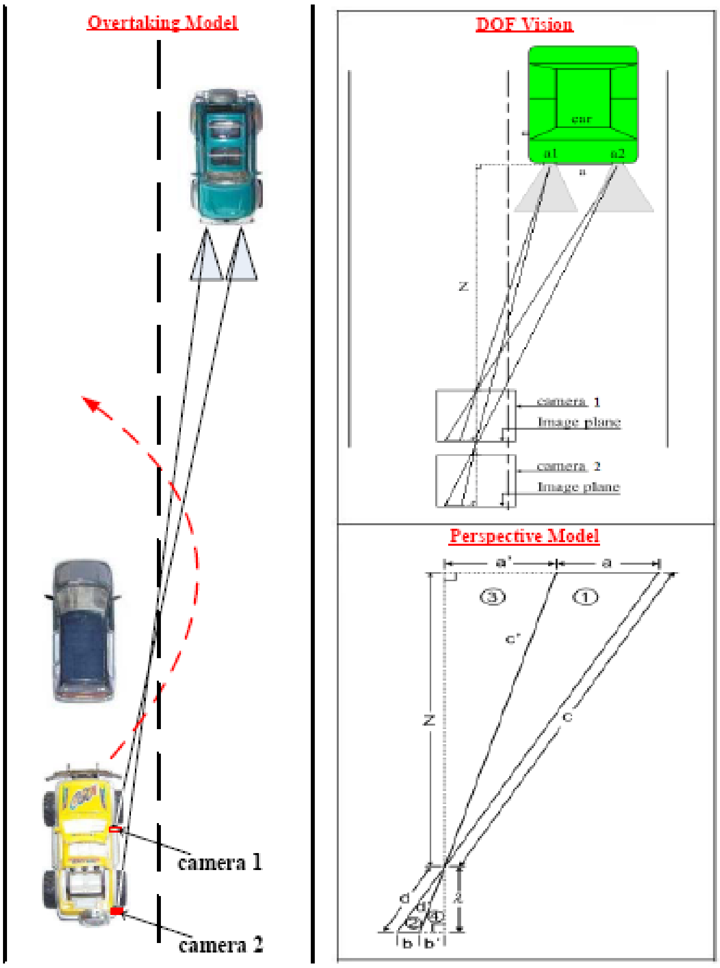


Fig.2: The principle analyses

The image of DOF is then pass through the Blob Coloring to calculate the centroid by using equation (6)-(8).

$$S = \text{Regionprop}(Ybw,\text{"Area"},\text{"Centroid"}) \quad (6)$$

$$\text{Distance} = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2} \quad (7)$$

$$\text{Distance} = \sqrt{(Centroid\_x_1 - Centroid\_x_2)^2 + (Centroid\_y_1) - Centroid\_y_2)^2} \quad (8)$$

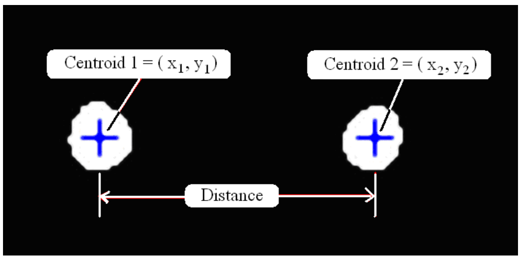


Fig. 3: the front light of a car

3. Methodology

The process of this experiment is shown in Fig. 4.

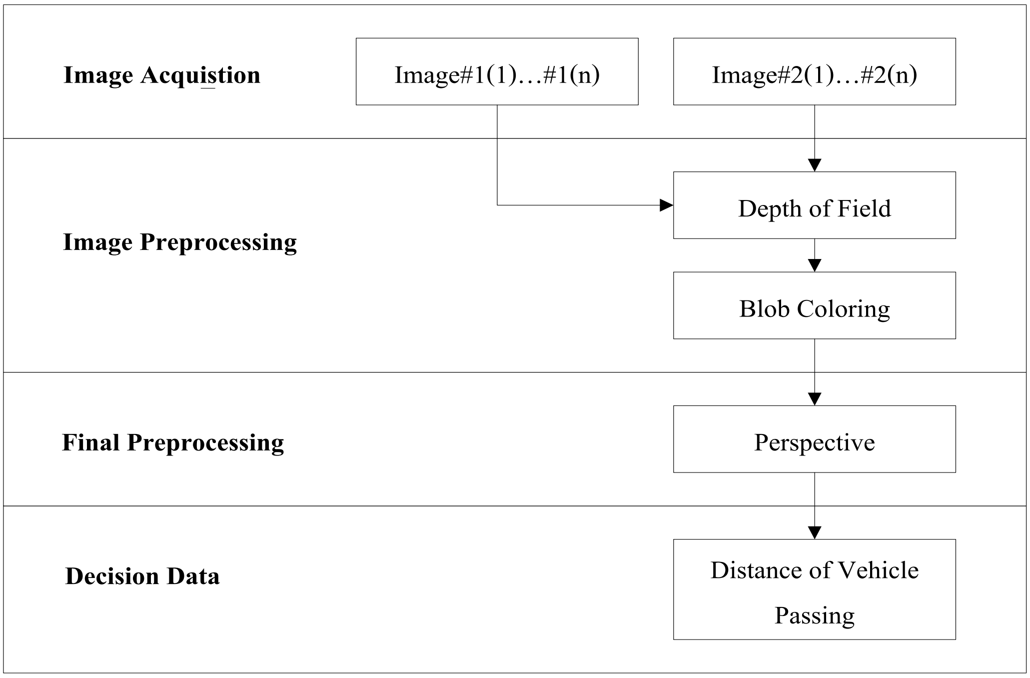


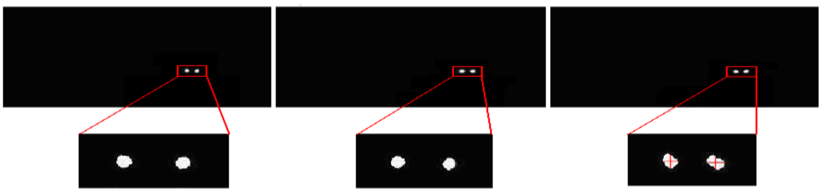
Fig. 4: process of this experiment

1) Video Acquisition - For record the moving pictures from digital camera (real time recording)
2) Frame Grabber - For convert a moving file to digital-still-picture. In the research, it is necessary to consider every frame for data analysis. For usability ,the camera can be set up to cupture images in real-time .However, practically, this step can be neglected.
3) Image Preprocessing - For evaluate a distance between headlight by DOF and Blob Analysis.
4)Final Processing - For process the data by virtual perspective technique.
5)Decision Data - It is a data output used for taking a decision (depending on vehiclespeed, distance between vehicle and digital camera.

4. Experiments and Results

This research used 10 cars to investigate and adjust the experiment.

meters	Day time image	Night time image
30		



(a) (b) (c)

Fig.5: Method to find the center of the vehicle headlight from 2 cameras

Figure 5 expresses the concept of finding the averagevalue of focus point from 2 cameras, which are (a) the imagefrom the first camera, (b) the image from the second cameraand (c) the combination of 2 image which carries out focus point of white light group with correctness and accuracy, byusing the equation (1).

5. Conclusion

This article presents a development of vehicle-to-infrastructure system using image processing. It focuses to develop of overtaking analysis system to gain higher efficiency when overtaking on a two-lane highway while driving during night-time. The depth of field and stereo vision techniques are used to determine the car distance.The processingtime needs only 0.54 second, in the process to stop overtakingand by considering the image only 2 frames after theidentification of headlight distance. The advantage ishigher efficiency for driver's decision at night-time period.The velocity 40 km./hr. must do the overtakingdecision distance more than 250 meters. However there is an error ofdetermination of vehicle size and the difference betweenmoving images from non-smooth road, affecting the irregularof the light. In addition, the factor of moving car's velocity stillneeds further development in the future.

6. Acknowledgements

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