A Vehicle Detection Algorithm for the Application of Road Safety

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***Abstract*—Preventing road accidents from happening can be done by using the protective features available in vehicle such as seat belt and air bag. However, an act of prevention does nothing in reducing the rate of death on the road. An industrial camera is used to capture the image of the target vehicle in front of the vehicle installed with the camera in this paper. The method introduced inside the paper will be applied onto the raw data obtained from the camera. With the data obtained displayed inside the software MATLAB, the mathematical calculation of distance estimation is carried out inside the vehicle detection algorithm, thus, assisting the driver in the process of driving on the road. The reliability and the accuracy of the vehicle detection algorithm for the application of road safety can be further boosted by applying method of image processing onto the data obtained through the industrial camera.**

***Index Terms*—image processing, vision-based, vehicle detection**

I. Introduction

Technology involving autonomous vehicle is quite a popular topic nowadays. Autonomous vehicles are equipped with a lot of sensors such as cameras, radar and LIDAR. By using one or two cameras, humans have enough information to perceive and able to drive on the road. A single moving camera is used to carry out the task of detecting vehicle in this paper. However, data from dynamic scenes cannot be yielded by a single camera quickly and easily without the aid of stereo camera or sensors. Apart from that, there are numerous amount of vehicle variations that are difficult to be modeled or learned [1]. Known initial position and easily detectable vehicle target are assumed by many tracking algorithm [2].

Advanced Driver Assistance Systems (ADAS) such as Adaptive Cruise Control (ACC) and Cruise Control (CC) has also been developed to aid the driver in the process of driving on the road [3]. Driver Assistance Systems (DAS) has the basic technology to track and detect vehicles using sensor [4]. Furthermore, with the ever changing environment of the road such as distribution of vehicle on the road, shape of vehicles, condition of the weather and change of illumination during day and night, an image processing algorithm that is important needed to be developed in order so that the DAS could detect vehicle reliably and extract effective information [4]. Appearance-based approach and feature-based approach are two branches in detecting vehicle on the road [4]. The most commonly used method for the purpose of vehicle detection is optical flow, background subtraction and lastly frame subtraction [5]. The method of background subtraction is the most famous and used technique at present [5]. Not only that, tailnight pair can be used for detecting vehicle in the night [6]. Texture descriptor [7], Haar filters [8], and some other method can also be used in detecting vehicle on the road. In this paper, a vehicle detection algorithm that can be applied onto the vehicle on road during broad daylight is presented.

The aim of the research is to create a vehicle detection algorithm that can improve the safety of the driver and passenger and to minimize the number of accidents happening on the road.

This paper is organized as follows: Methodology used in this paper in order to obtain the distance estimation algorithm is presented in Section II. The results obtained from the distance estimation algorithm and some discussion as to address the results obtained in this paper are presented in Section III. Section IV presents the conclusion and some future work of this paper.

II. Methodology

In this paper, an industrial web camera with the brand of Logitech model C525 is employed to capture the input video or rather the raw data of the algorithm. The camera is set up with the frame rate of 30 frames per second. A more accurate data processing can be obtained from the video or raw data captured at this frame rate. Fig. 1 shows the camera being used in this paper and the basic parameter of a camera in a 2 dimension projection.

A background scene is generated beforehand instead of taking the difference between current frame and previous frame from the raw data or input video to detect the moving object. The conventional way of detecting object by taking frame difference is not suitable for this algorithm because it limits the detection to moving object and vehicles might not be detected if they are moving in lower speed or not moving on the road. Thus, an initial frame is taken as the background scene.

The next step being carried out in this research will be the removal of noisy pixel. The removal of noisy pixel is carried out by either using erosion filter or dilation filter. This will somehow minimize the number of noisy pixel in

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the frame of images obtained from the raw data or input video.

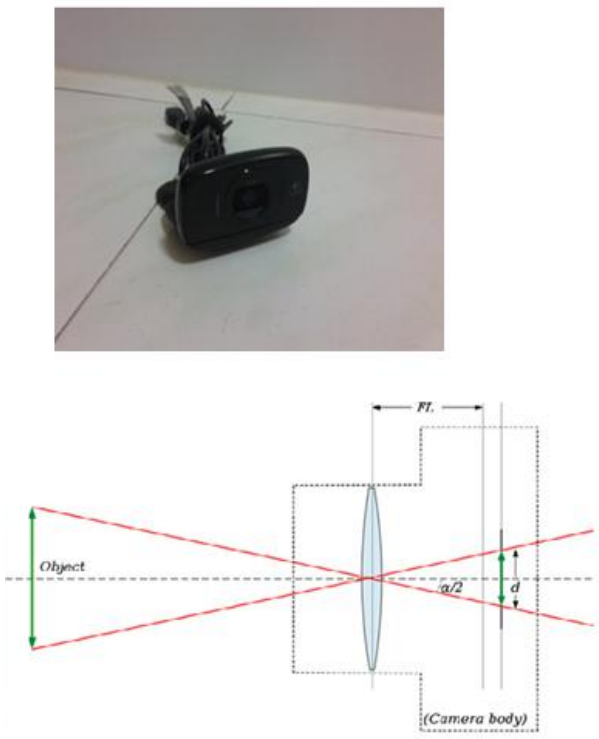

Figure 1. The camera being used and the basic parameter of a camera.

With the noisy pixel removed from the processed image, the current image obtained will only have a distinctive pattern or shape of target vehicle currently being detected by the algorithm in it. The calculation of number of pixel in the area of the target vehicle will be obtained by using the specific mathematical function inside the MATLAB. Apart from that, the region of interest of target vehicle or rather blob made from the resulting process of image segmentation are labeled accordingly. This is carried out in order to identify the specific blob of interest together with its corresponding mean intensity and other data pertaining to it such as the area of the blob, the centroid of the blob and so on. Then, the number of pixel of white colour and black colour are calculated accordingly before the process of obtaining the area of interest of target vehicle is computed. This is to ease the tabulation of data to be carried out in the later part of the experiment.

By obtaining the area of interest of target vehicle that is computed using the function BoundingBox in MATLAB, the mathematical equation can be obtained from the graph plotted using the area of interest of target vehicle versus the known distance from the sample. The mathematical equation is then applied back onto the frame of images of known distance taken from the samples to estimate the distance between the target vehicles with the host vehicle. Once the vehicle is detected, the position in terms of distance between the host vehicle and target vehicle will be known. The movement path of the target vehicle is captured and recorded for analysis purpose.

With the movement path of the target vehicle recorded information as in position of the target vehicle and distance between target vehicles with host vehicle are gathered and analyzed. Position of the target vehicle is identified by using the video stream recorded using the industrial camera. The distance between target vehicles with host vehicle is calculated by using the function of BoundingBox in the MATLAB. The BoundingBox' function is to trace the region boundary which is the region of interest of the target vehicles in this research.

Thus, the value of estimated distance between targets vehicles with the host vehicle can be compared with the actual value of distance being measured using meter rule or measuring tape. The difference in distance estimated from the target vehicle to the host vehicle with its respective known distance from the target vehicle to the host vehicle are used to compute the percentage of error and the percentage of absolute mean error in the experiment.

Fine-tuning and adjustment of parameters are done to eliminate the unwanted segmented foreground objects included the moving objects on the road such as the shadow and leaves. The purpose is also to make the application more robust to the unforeseen situation such as sudden change of light condition or the existent of the cloudy day. After a clear frame with only the target vehicle appearing as a region of interest is obtained, the detection of target vehicle can be done easily. The movement path of the target vehicle through the video frames can be seen.

Overall, the methodology involved in this experiment can be summarized into details shown in Fig. 2. Fig. 2 shows the flowchart of the vehicle detection algorithm.

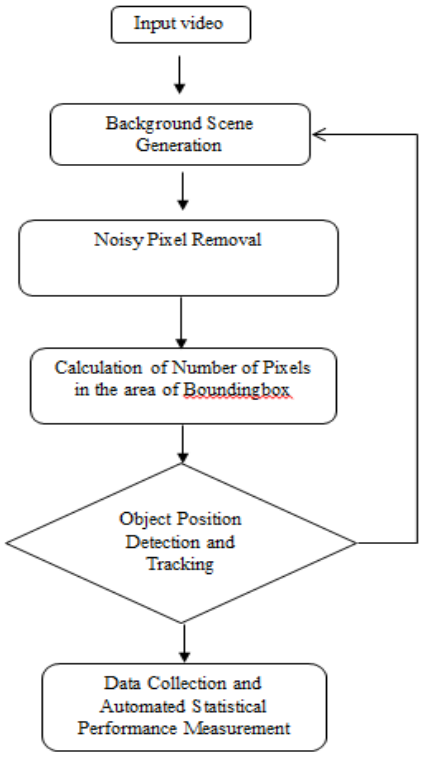

Figure 2. The flowchart of the vehicle detection algorithm.

III. Results and Discussion

The result of the area of interest of target vehicle by using the mathematical function in MATLAB is generated in this part of the experiment. They are several models of vehicles being used in this experiment. Hence, there will be 1 general mathematical equations generated from the graph of area of interest of target vehicle versus the known distance of target vehicle from host vehicle being installed with the camera. The conversion of value of pixel to distance will be calculated using the generated mathematical equation. The equations of the vehicle detection algorithm for estimating the distance between the target vehicles with host vehicle being installed with the camera are shown below:

$$y = 997.4x^{-0.517} \quad (1)$$

where y = the distance estimated between the target vehicle with the host vehicle and

x = the area of the vehicle obtained in MATLAB

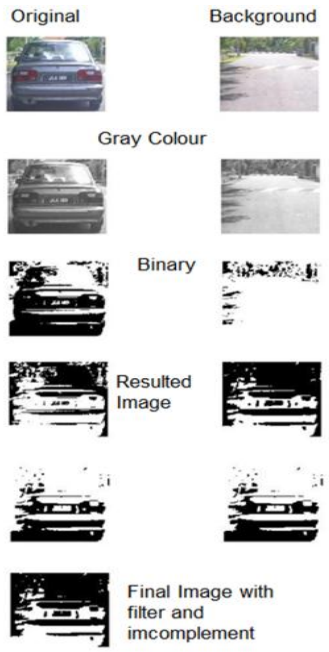

Figure 3. The result of detected vehicle by vehicle detection algorithm.

Fig. 3 shows the result of the images obtained from the camera undergo the process of vehicle detection algorithm whereas Fig. 4 shows the graph plotted using the data obtained and the mathematical equation generated from the collective samples of data obtained. Fig. 5 shows the distance estimated between target vehicle and the host vehicle with the camera being installed in it obtained and displayed clearly on the data obtained.

The result obtained shows relatively low percentage of error though there are some random spikes in the readings itself. The readings are within the expected boundary of error due to the fact that the position of the target vehicles on the road is dynamic. The robustness of the vehicle detection algorithm needed to be further improved.

Environment also plays a role in the improvement of the value or hampering it resulting in less accurate readings. Illumination and shadow are one of the few causes that can truly inhibit the accuracy of the data being obtained in this experiment. Apart from that, the dependency of the camera being installed in the host vehicle is one of the factors that can also somehow improve or deteriorate the readings of data being obtained in this experiment.

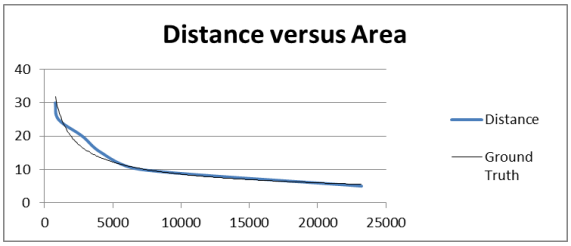

Figure 4. The graph plotted using data obtained.

Figure 5. The distance estimated is displayed clearly on the data obtained from the vehicle detection algorithm.

IV. Conclusion

In the conclusion, the method proposed inside this paper is verified by comparing the calculated distance inside MATLAB with the real distance measured in real time by the mean of measuring tools. Apart from that, the percentage of error can be further minimized by improving the qualities of the equipment being used in this paper. Not only that, there is some error in the method proposed that is due to the limitation of the industrial camera being used in this research. Though the method proposed had been verified in this paper, the methodology used in the vehicle detection algorithm can be further improved.

In regard to the future work of the vehicle detection algorithm, there are some recommendations that can be implemented in it. One of the recommendations that could be implemented is the usage of laser sensor. Laser sensor could make the process of obtaining data from the industrial camera much more easily.

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