Proposal a Vehicle Speed Measuring System Using Image Processing

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***Abstract*—This research proposes a new vehicle speed measuring approach based on image processing technique. This approach is aimed to improve the vehicle speed measuring accuracy at night. Ordinarily, it is difficult to take a clear image at night by using a low profile digital camera. Thus the image based vehicle speed measuring system for dark environment was not developed by now. In this research, the disadvantage of low profile camera is used for speed measuring. By controlling the shutter speed of camera, a bright line comes from the headlamp of a moving vehicle is appeared in the picture. In this work, an algorithm depend on this feature is developed. Experiment result shows a reasonable measuring value.**

***Keywords*-Image, processing, Low profile camera, vehicle speed measurement, shutter speed, line of light.**

I. Introduction

As the amount of traffic increases, the car accidents due to the over speed are occurring frequently. The annual report distributed by Police Traffic Bureau of Japan shows that the 36.2% of fatal traffic accident comes from the over speed. Therefore, it is very important task to make an effort to prevent the over speed car accident occurrence. In the past 30 years, an automatic speed violation control device called ORBIS has been applied. Such a kind of system using loop coil or radar needs a high deployment costs and maintenance cost, and has a drawback that misdetection occurs in some certain situations. Furthermore, many aged devices are fault and left without repairing[1]. In this situation, recently, image processing based vehicle speed measuring techniques are developed actively[5]. Image processing approach can gives a picture record logs, and can helps the analysis of the cause of the accident efficiently. But image processing based speed measuring system also have problems. Especially for a dark circumstance, the pictures cannot be taken clearly and the measuring accuracy becomes low. In this research, a very new idea is attempted to speed measuring task in the night environment. What we need is a low profile camera, a microcomputer board, and some camera depend parameters like focus depth, imaging area size, etc. Such a construction can yield a low cost system so that it can be applied worldwide. Especially for the newly developing countries, which show a significant increasing rate of vehicle. The main purpose of this research is to improve accuracy of measuring car speed in the night environment. But in a dark circumstance, it is impossible to take a clear and a sharp picture by using a high shutter speed with a low profile camera. Therefore, we take an opposite operation, take a picture of the moving vehicle first by the setting the camera's shutter speed to 1 second. Thereby, because the camera is fixed and the vehicle is moving, the headlight of vehicle observed in the picture becomes a light line as showed in Figure. 1. Next, the positions of the light lines are detected by using an automatic threshold decision algorithm, and then the line are extracted from a picture by using a labelling method. After that the length of the light line is detected. The vehicle speed is calculated from this length finally.

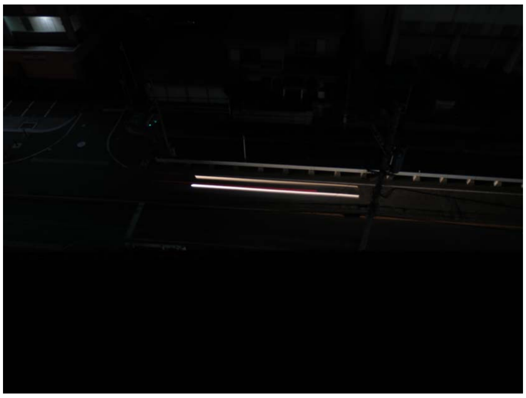

Figure 1. Filmed image of sample.

II. Theory and Method

This section explains how to extract the line of light and how to calculate the real distance from the light line length derived from the image.

A. Length of the light line

The flowchart light line extraction is shown Figure. 2. Figure. 1 is an experimental example that taken in a real night circumstance. The following explaining of proposed method is performed on this picture. In this study, we developed an automatic threshold decision method by using a histogram.

1) Calculate a histogram of the image and its weighted average histogram: A histogram is calculated from the picture. With the original BGR histogram shown in Figure. 3 whose values are changing violently in local area, it is difficult to decide a threshold value. To solve this problem, a Gaussian distributed weight function is utilized to get a smoothed histogram. Figure. 4 shows the result of Gaussian weighted histogram of Figure. 3.

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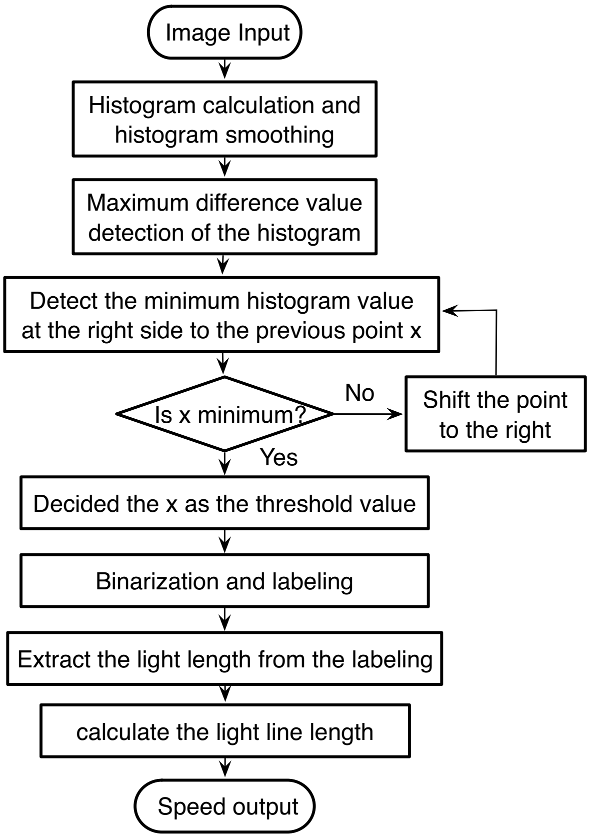

Figure 2. flowchart.

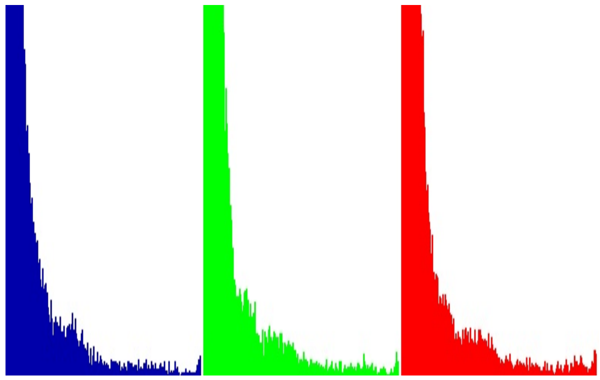

Figure 3. Histogram of Figure. 1.

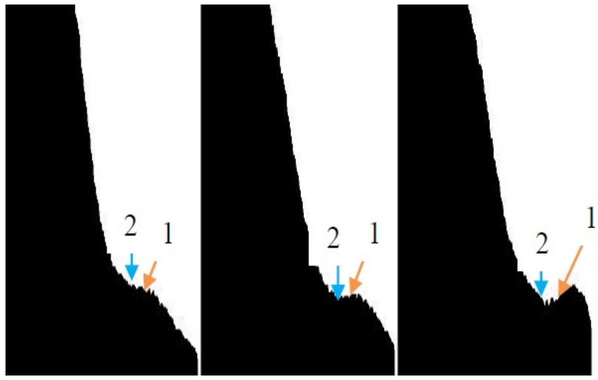

Figure 4. Histogram of weighted average.

2) Detect a maximum difference value point: Applying a Differential processing to the weighted average histogram, we can get the highest difference value. This means the maximum slope of the histogram is found, and we use this slope value and its position for threshold value decision. In Figure. 4, the positions pointed by arrow "1" are maxima derivatives of B, G, R colour channels respectively.

3) Decide a threshold: As we known, the light line has a higher brightness value than other area of the picture. Therefore, we inspect the Gaussian weighted histogram from right side to the left side, and finding the first minus difference value position at the left side of the found maximum difference value in previous step, then decide the luminance value there as a threshold value. The luminance values pointed by arrow "2" shown in Figure. 4 are decided as threshold values of each colour channel.

4) Binarization and labelling: In order to get rid of non-light line area and detect the light line length, the binarization and labelling processing are performed. Figure 6 shows the threshold processing result. In Figure. 6, several non-light lines appeared on the picture area. By labelling each separated area, the real running light line can be selected correctly. A purple line in Figure. 6 is the line selected as the light line of vehicle. By calculate the length of the labelled light area, the vehicle speed can be derived.

B. Calculate a real dimension of captured picture's width

For calculating the real dimension, the relationship of position between the camera and the vehicle shown in Figure. 5 is needed. In Figure. 5, h is an altitude of the camera from ground, θ is an elevator angle of the camera, f is a focus distance of the camera, and k is a width of an image sensor of the camera. Using these parameters, the real dimension of captured picture width can be calculated by the following formula. First, the Scaled width of image is calculated by following formula,

$$x = 2L \tan \theta_x \tag{1}$$

where

$$L = \frac{h}{\cos \theta} \tag{2}$$

$$\theta_x = 2 \tan^{-1}(\frac{k}{2f}) \tag{3}$$

Scaled distance per pixel is obtained from the following equation,

$$pk = \frac{x}{m} \tag{4}$$

where m is the horizontal pixel number of the imaging sensor. Finally, the vehicle speed v is calculated by the following formula,

$$v = pk \times d \tag{5}$$

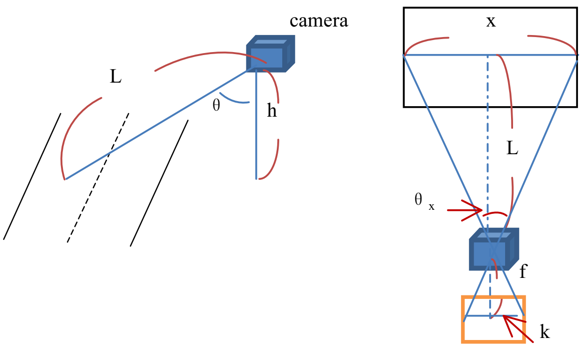

Figure 5. Camera Setting information.

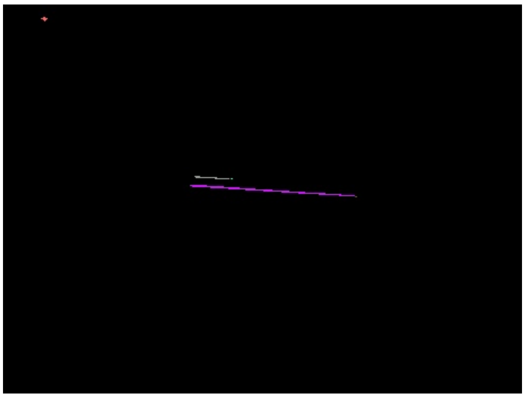

Figure 6. Threshold-processed image of Figure. 1.

III. Simulation

In order to test the performance of this proposal, a simulation experiment was performed under the following conditions. The system setting informations are $h = 18[\mathrm{m}]$, $\theta = 45[\mathrm{degrees}]$, $k = 6.2[\mathrm{mm}]$, $f = 4.3[\mathrm{mm}]$. Figure 1 is used as the test picture. By the threshold-processed image shown Figure. 6 and the camera informations, the vehicle speed is derived. We also measure the vehicle speed by using a traditional stopwatch method for evaluation. The distance for stopwatch measuring is $30[\mathrm{m}]$. The comparing result is shown in Table I. It seems that the proposed speed measuring approach gives a reasonable value, and it is thought can be used for a practical application.

IV. Conclusion

In this research, a new approach for vehicle speed measurement was proposed. This method is especially developed for night environment using. This system could yields a low cost and portable speed measuring equipment. We hope it could contribute to reducing the fatal car accident. But now the picture is taken manually, we still have a lot of future work like making an automatic photo taking function by installing an object detection sensor for shutter timing trigger. We also plan to make a system for the daytime, and to develop a small device which can measure the vehicle speed all time.

Table I
Phantom ratio before improvement

	The speed measurement by the system[km/h]	The speed measurement by the stopwatch[km/h]
speed	41.6508	42.1

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