Proceedings of the 11th
KACC, October 1996

Traffic Flow Measurement System Using Image Processing

○Takaaki HARA*, Kageo AKIZUKI* and Mamoru KAWAMURA**

* Department of Electrical, Electronics and Computer Engineering, Waseda University,
55N-401B, 3-4-1, Ohkubo, shinjuku-ku, Tokyo, 169, Japan.
Tel:+81-3-3207-7143; Fax:+81-3-3207-7143; E-mail: hara@akizuki.elec.waseda.ac.jp
** Japan Radio Co, Ltd. 5-1-1, Shimorenjaku, Mitaka, Tokyo, 181, Japan
Tel: +81-422-45-9337, Fax: +81-422-45-9751

Abstracts: In this paper, we propose a simple algorithm to calculate the numbers of the passing cars by using an image processing sensor for the digital black and white images with 256 tone level. Shadow is one of the most troublesome factor in image processing. By differencing the tone level, we cannot discriminate between the body of the car and its shadow. In our proposed algorithm, the area of the shadow is excluded by recognizing the position of each traffic lane. For real-time operation and simple calculation, two lines of the tone level are extracted and the existences of cars are recognized. In the experimental application on a high-way, the recognition rate of the real-time operation is more than 94%.
Key words: Real-time operation, A simple algorithm, The elimination of shadow

1. INTRODUCTION

In this paper, we will describe the traffic measurement system. In this system, a simple algorithm should be applied, because the system operates in real-time. The sampling period of the system must be less than 100 msec. At first, a line on which cars passing is chosen. The tone-level on the line becomes as shown in Fig. 1 .

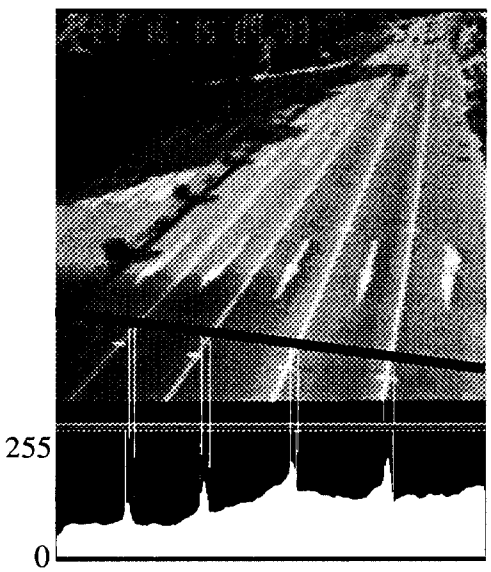


Fig. 1. The tone-level on a chosen line.

The cars are moving in one way, and there are some traffic lanes. We find in which traffic lane cars exist by the difference of the tone-level on a chosen line. First we get the tone-level from an image without cars. The tone-level are called " the base tone-level ". Then, we get the new tone-level of a real-time image from a video camera for some milliseconds as shown in Fig. 2. They are called " the real-time tone-level ".

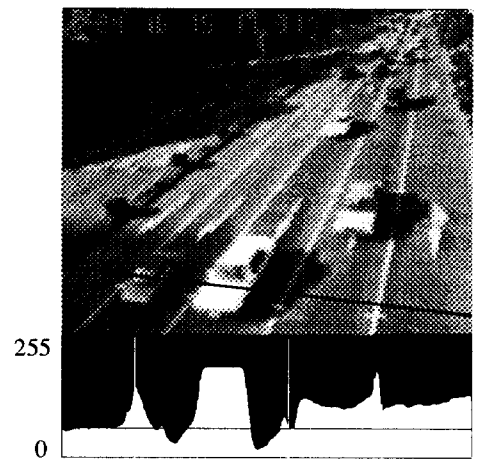
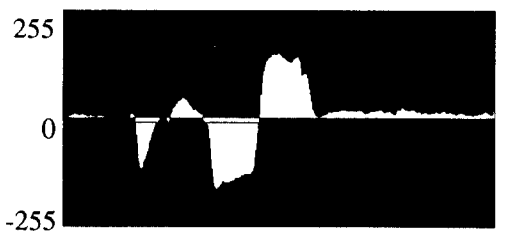


Fig. 2. The tone-level obtained from a real-time image.

We subtract the base tone-level from the real-time tone-level, which is called " the subtracted tone-level ". The subtracted tone-level shown in Fig. 3 shows the difference between the tone-level of the cars and that of the road. In each point the subtracted tone-level has values between -255 to 255. In Fig. 3, minus value of the tone-level means light, on the contrary plus means dark.



$$S(x) = B(x) - R(x)$$

S(x) : the subtracted tone-level
B(x) : the base tone-level
R(x) : the real-time tone-level

Fig. 3. The subtracted tone-level.

2. AN ELEMENTARY JUDGEMENT OF EXISTENCE OF CARS

In this section, we use the subtracted tone-level for the recognition of cars. To find the region of the prospective car's existence from Fig. 3, we divide the figure of the tone-level into many blocks by vertical lines. Each block consists of 15 image elements width as shown in Fig. 4.

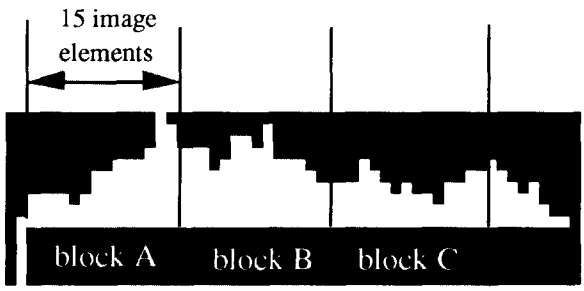


Fig. 4. An enlarged figure of Fig. 3.

We calculate the squared area of each block as the following equations.

$$\begin{aligned} &\text{Block A}: \quad A = a_1^2 + a_2^2 + a_3^2 + \cdots + a_{15}^2 \\ &\text{Block B}: \quad B = b_1^2 + b_2^2 + b_3^2 + \cdots + b_{15}^2 \qquad (1) \\ &\qquad\qquad \vdots \end{aligned}$$

The " a " and " b " show the tone-level of the image elements, respectively.

We decide whether the car exists on each block or not according to the size of the values which are calculated by the above equations. In this research, we take 2500 as the threshold-value. Then, we join some prospective regions to their neighbor block which has more than 2500 value as shown in Fig. 5.

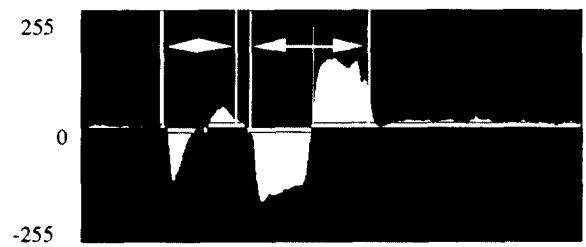


Fig. 5. The region of prospective car's existence.

When all blocks don't have the value more than 2500, we regard as no car on the road, and we update the base tone-level to the new tone-level, because the tone-level of the roads is changing, according to time, weather, etc.

3. THE ELIMINATION OF SHADOW

The areas of the subtracted tone-level of the existing cars are not so small that we must consider to eliminate small noises. So, we assume that the shadow by the car is the only noise effect in recognition. To eliminate the shadow , we propose the following three procedures.

3.1 The shadow elimination by using the difference of tone-level

This method is effective for cars with high tone-level. We can easily recognize the difference of tone-level , when a white car exist on the line as shown in Fig. 6. In this figure, the minus tone-level comes from the car, and the plus one from the shadow. In detail, if the image elements whose tone-levels are lower than -150 occupy more than 50 point in width, we judge that cars exist, and otherwise the image elements come from shadow.

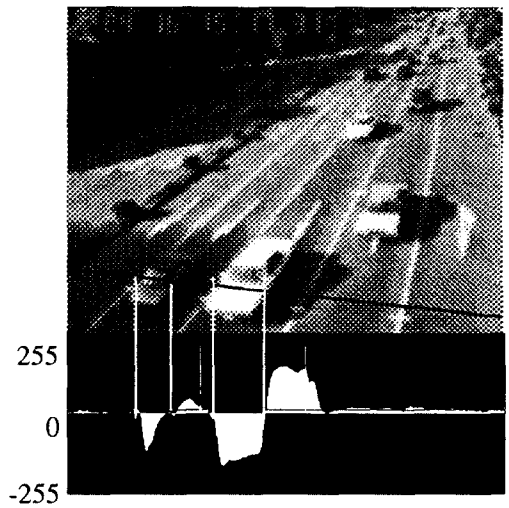


Fig. 6. The subtracted tone-level of a bright car.

3.2 The shadow elimination by using the location of the white traffic-lines.

Using the procedure mentioned in 3.1, we can eliminate the shadow of a bright car, but not that of a dark car. So that, we propose the second method to eliminate the shadow by using the subtracted tone-level correspond to a white line dividing traffic lanes.

We can recognize the location of the white-lines as shown in Fig. 1, because they have higher tone-levels than the other position. Even if the shadow covers the white-lines as shown in Fig. 7(A), we can still find the location .

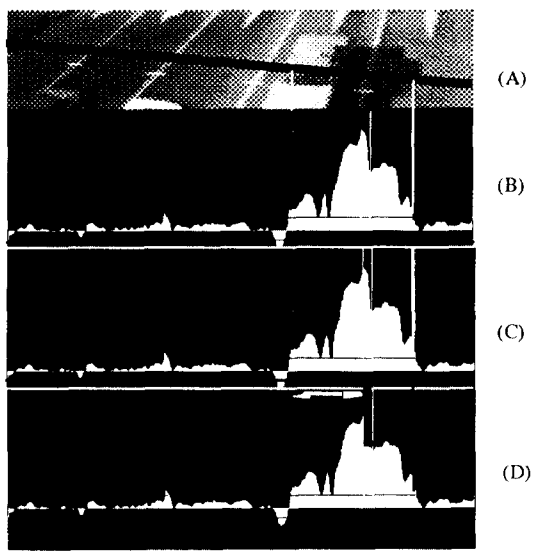


Fig. 7. The shadow elimination by using the white traffic lines.

In Fig. 7(B), we can expect a car's existence, because the subtracted tone-level has a large area. From the sharp peak of the tone-level, we can find the location of the white line as shown in Fig. 7(C). So that, we can conclude that the region of prospective car's existence includes the shadow. We separate the area into two blocks by the location of the white-line. In this case, the right-hand side area of the white-line is too small to be considered as a car. As a result, we can judge that a car exists only at the left-hand side as shown in Fig. 7(D).

3.3 The shadow elimination by finding the darkest point

Using the procedures shown in 3.1 and 3.2, we can eliminate the shadow and find the existence of the car, but the exact location of the car cannot be found. To find the exact location of the car, we find the darkest point in the prospective region as shown in Fig. 8. It corresponds to the border line between the body of the car and its shadow.

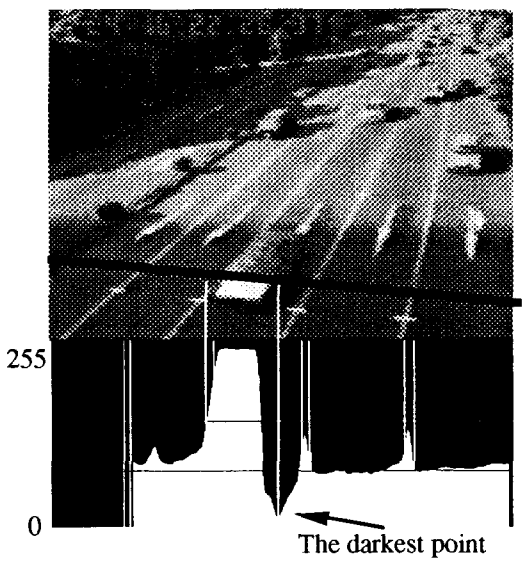


Fig. 8. The darkest point in the subtracted tone-level.

By applying the above three procedures (in 3.1, 3.2 and 3. 3), we can remove the shadow and get the exact position of the car.

4. EXPERIMENTAL RESULT AND SOME IMPROVEMENTS

Now, using this recognition system including the procedures described above, we can judge whether a car exists on each lane or not. Getting an image every 50 msec, we can count the passing cars by the judgement of the change fr om " CARS EXIST " to " NO CAR " at each traffic lane . The result becomes as shown in Table 1.

Table 1. The experimental result.

	The real number of passing cars	The counted number of passing cars
Day time	151	125
Twilight time	158	134

As shown in Table 1, some mistakes in count up the passing car take place. Most of these mistakes are caused by an over-sight owing to two reasons. One is that some cars move too fast to be counted, another is that the windshield of the cars exist on the line. We cannot discriminate between the tone-level of the windshield and that of the road because of similarity. To remove the miscounting, we set another judgement line which is apart from the previous judgement line by 25 image elements.

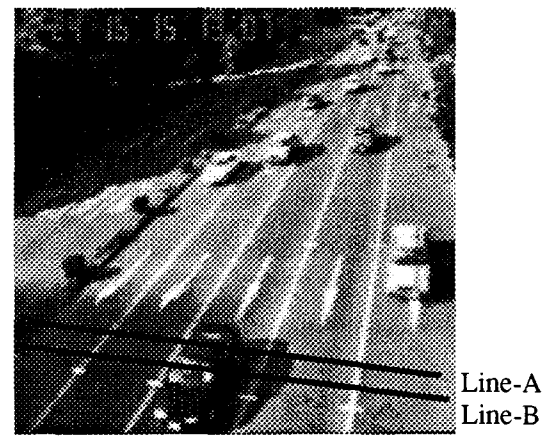
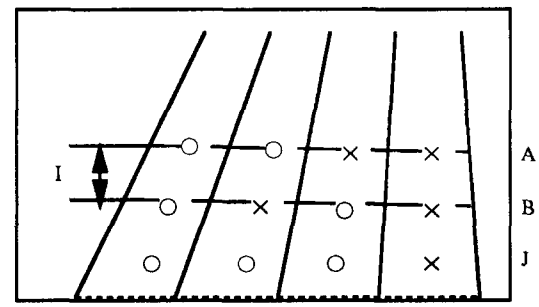


Fig. 9 The new judgement lines.

For these two judgement lines, we apply the recognition procedure mentioned above. Only if the case that the existence of a car is not recognized in both lanes, we judge as "NO CAR".



A : The judgements of Line-A
B : The judgements of Line-B
J : The total judgements
I : 25 image elements intervals
○: Car exist ×: No cars

Fig. 10. The judgement using recognition results on two lines.

We show the revised result by this improvement in Table 2. We can get the recognition rate for more than 94%.

Table 2. An experimental result by the revised judgement of two lines.

	The real number of passing cars	The counted number of passing cars
Daytime	151	144
Twilight time	158	155

5. MISTAKES THAT CANNOT BE IMPROVED

A mistake occurs when a big car is passing as shown in Fig. 11. In Fig. 11, the shadow covers some traffic lanes. In case there is no car next to the bus, we can remove the shadow by the procedures in 3.1 -3.3, then our proposed algo rithm will work correctly. But in contrary, if there is a car next to the bus, we also remove the car, unfortunately. Though it is rare case, we cannot get around the mistake by using the procedures mentioned above.

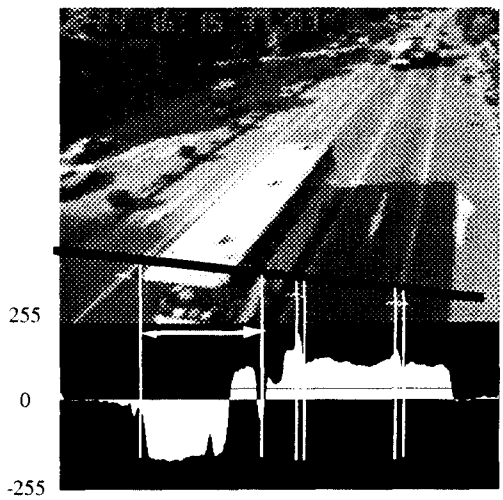
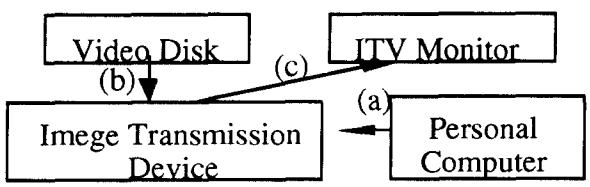


Fig. 11. The mistake image.

6. THE REAL-TIME OPERATION

We use the following devices for real-time operation, and the system is shown in Fig. 12

The name	The maker	The type
Personal Computer	NEC	PC-9821Ne2
Image Transmission Device	JRC	NDC-925
Video Disk	SONY	EV-S2200
ITV Monitor	SONY	KV-14MD1



(a) Feed the program which calculates the passing cars
(b) Fetch a real-time image every 50 msec.
(c) Output the result and the real-time image every 50 msec.

Fig. 12. The real-time operation system.

This system are able to recognize the white lines automatically. So this system can adapt for the location of the white lines which are different from the monitoring stations or the numbers of the traffic lanes.

7. THE RESULTS OF REAL-TIME OPERATION

We test the real-time operation at Tomei high-way in Japan (See Fig.13). In Fig. 13, we can see two numbers " 0 " or " 1" at each traffic lane. The number of the upper side shows the judgement on the line-A, and the lower one on the line-B's. "0" means "No cars", and "1" means "Car Exist". From this figure we can recognize there is a car at the middle traffic lane. The numbers at the middle part of this image show the total numbers of passing cars at each lane.

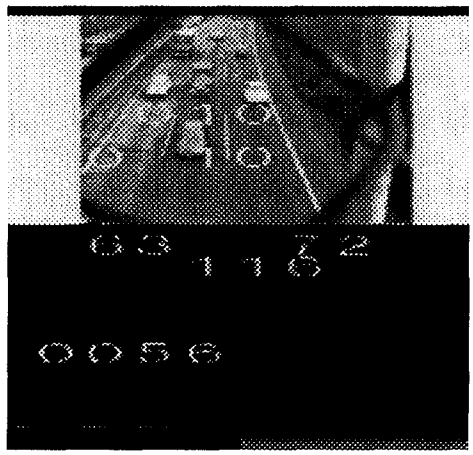


Fig. 13. One of the operated image at Tomei high-way.

Table 3. The result of real-time operation.

passing cars	counted cars	oversight cars	over-counted cars
972	994	0	22

We have no oversight, but we still have an over-counted in this real-time operation. We consider this resu lt to be very good, since we can achieve the recognition rate for more than 94%.

8. CONCLUSIONS

We construct a simple recogn ition algorithm which is able to operate in real-time, and get the recogn ition rate for more than 94%. But this system operates only in daytime. To apply this system in night-time, there are some problems. Moreover we want to calculate the speed of a car, these are the problems which confronts us after this.

REFERENCES

[1] Translated by Makoto Nagao,
Digital Picture Processing, kindai-kagakusha
[2] Tadashi Akimoto and Kageo Akizuki "A Watching System of a person entering a restricted area by Image Processing" , KACC'94 IS-01-2 pp 6-12