Number Plate Detection System by Using the Night Images

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Abstract: License plate recognition is very important in an automobile society. This is because, since plate detection accuracy has large influence on subsequent number recognition, it is very important. However, it is very difficult to do it, because a background and a body color of cars are similar to that of the license plate. In this paper, we propose a new thresholds determination method in the various background by using the real-coded genetic algorithm (RGA). By using RGA, the most likely plate colors are decided under various lighting conditions. First, the average brightness Y values of images are calculated. Next, relationship between the Y value and the most likely plate color thresholds (upper and lower bounds)are obtained by RGA. The relationship between thresholds decided from RGA and brightness average is aproximate by using the recursive least squares (RLS) algorithm. In the case of plate detection, thresholds are decided from these functions.

Keywords: license plate detection, threshold, template matching

1. Introduction

TMuch work on number plate detection with a digital computer has been done actively, and applied to car counting or the recognition of number plate of cars. For these demand, there are methods based on the color histogram. However these methods cannot cope with a change of back ground color (light condition). It is very difficult, by using nothing but the color information to extract a specific object from an image. People can recognize color information using various color characteristics. Objects are normally not monochrome except those made intentionally. Good results can be obtained by threshold obtained from binarization for a given image. However the results are not so good when several images are used, because of the variation in lightings, orientation etc [1]-[3]. In this paper, the best thresholds for every image are found using RGA. It can be automatically decided using RGA.

By this method, the thresholds (upper and lower bounds) of a number plate are determined using RGA out of the strange images from which brightness and a type of a car differ. Next, the relation between this thresholds (upper and lower bounds) and brightness of car domain are changed into a function using a least-squares method. In the case of plate detection, thresholds are calculated based on this function. For this reason, the time to determine the thresholds is saved. Therefore, the calculation to detection also decreases. Moreover, in order to determine thresholds based on the brightness of a car domain, also to change of lighting conditions that it is effective. In addition, the images used for the simulation of this paper are photoed with the digital camcorder.

2. Image processing

In this paper, images that photoed car while running an outdoor road with the digital camcorder are used. Photography conditions are as having been shown in Table. 1.

Table 1. Photography conditions

Shutter speed	1 / 30 [sec]
Picture size	length 340 pixel width 240 pixel
Picture form	24bit color
Environment	rainy day
Photography time	from 18:00 to 19:00

2.1. Car area extraction

2.1.1 Frame difference

The continuous image of ten per car is used for a simulation. First of all, difference is taken to the image of two sheets followed in ten sheets. Next, in this difference, change asks for the large portion and makes the value the graph of length and a transverse direction [4]. The portion that exceeds a threshold in length and a transverse direction in this graph is extracted as a car domain. This situation is shown in Fig. 2.1.2In addition, the portion in which cars are not contained in the stage of extraction, and the portion with a small plate are removed beforehand.

2.1.2 Headlight consideration

The method of frame difference is effective car extraction on the day time image in our current research [5]. However, in the night time image, it is difficult by the image. In rainy day, the road wetting, so light of headlight is refrect from the road. Because, we cannot perform the frame difference to accuracy.
Then, we detect car domain from the headlight. The headlight is lit in the night. Therefore, in the result of frame difference, the change of the domain around the headlight is large. It means we can detect car domain easily. The result of this procedure is shown in Fig. 2

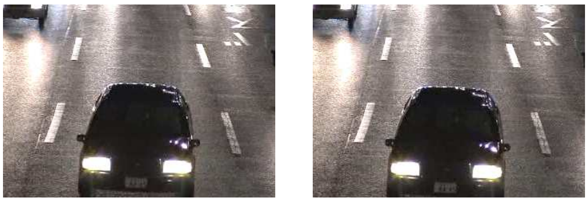
2.2. Color systems

To obtain optical features of color information from color images, each attribute in a color system is used. Examples

(a) The original image

(b)A result of difference (c)An extraction result

Fig. 1. Car domain extraction



(a) The original image

(b)A result of difference (c)An extraction result

Fig. 2. Car domain extraction(Consideration headlight)

of color systems are RGB, YC_rC_b, YIQ, etc. In this paper, the Y, C_r, C_b color system is used, which reflects the most color perception property of human beings. In particular, the value Y is used for the purpose of understanding the light concentration. A transform formula with the RGB table color is shown in the following.

$$\begin{pmatrix} Y \\ C_r \\ C_b \end{pmatrix} = \begin{pmatrix} 0.29900 & 0.58700 & 0.11400 \\ 0.50000 & -0.41869 & -0.08131 \\ -0.16874 & -0.33126 & 0.50000 \end{pmatrix} \begin{pmatrix} B \\ G \\ R \end{pmatrix}$$

Where Y is brightness, and C_r, C_b are colors. Note that, only Y is used in this paper. The method using thresholds can recognize objects at high speed.

2.3. Thresholds

How to choose the thresholds for the plate detection is a difficult problem. It is because a threshold changes by the condition of the light. Therefore, detection accuracy changes significantly with varying threshold value. In this paper, appropriate thresholds of plate detection are found by using RGA under the condition of an unknown Y value, which is calculated by the above equation.

The plate domain for samples is extracted from a car domain by viewing. The example of a car domain and the extracted plate domain is shown in Fig. 3. When calculate the thresholds, these images are used.

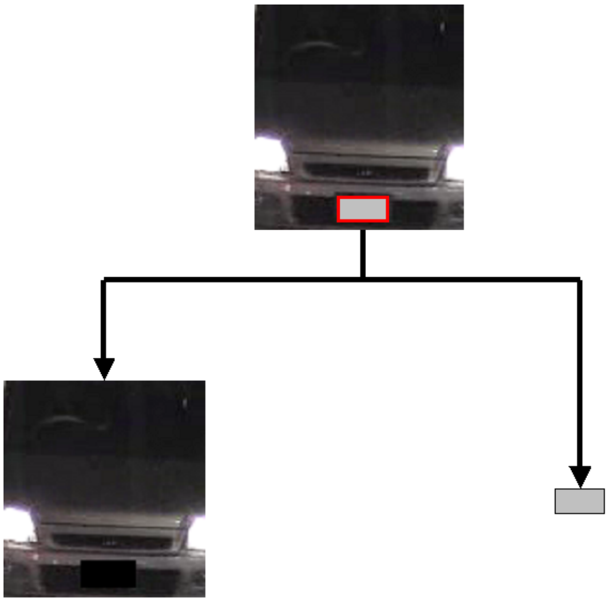


Fig. 3. A sample of a plate extraction result

B (MIN)	B (MAX)	G (MIN)	G (MAX)	R (MIN)	R (MAX)

Fig. 4. A sample of chromosome

2.4. Genetic Algorithms

On the problem with which it deals in this paper, we have to change the thresholds for plate detection for each image. The images from which brightness differs are also stabilized and a plate position must be detected. However, when a thresholds (upper and lower bounds) changes, the results after processing may differ greatly. In this paper, the genetic algorithm that used real numerical value coding (RGA) is adopted as optimization algorithm. When design variable value is the continuous function optimization problem, which is the real number, RGA can be efficiently taken over to a parent individual's feature. Therefore, as compared with GA, which used the bit string for the chromosome, efficient search is possible [6].

2.4.1 Chromosomes

n this paper, since a parameter was a thresholds (upper and lower bounds), it has set as the form that shows the form of a chromosome in Fig. 4.

2.4.2 Fitness functions

In this paper, the degree of adaptation was set up as follows.

if $\quad RECOG_{PLATE} < 0.20$

$$fitness = RECOG_{PLATE}$$

else $\quad fitness = \frac{RECOG_{PLATE}}{RECOG_{CAR}} * B_{RESULT} * G_{RESULT} * R_{RESULT}$

if $\quad (B_{MAX} - B_{MIN}) \quad , \quad (G_{MAX} - G_{MIN}) \quad , \quad (R_{MAX} - R_{MIN}) > 80.0$

$(< 80.0) \quad B_{RESULT}, G_{RESULT} \; , \; R_{RESULT} = \frac{1.05}{(MAX-MIN)^{0.01}}$

else $\quad (\{(B_{MIN}, G_{MIN}, R_{MIN}) + 1.0\}, \{(B_{MAX}, G_{MAX}, R_{MAX}) - 3.0\})$

$B_{RESULT}, G_{RESULT}, R_{RESULT} = \frac{1.05}{(MAX-MIN)^{0.01}}$

$RECOG_{PLATE}$: The rate of the number of pixels which exists in the threshold (maximum and minimum) value determined by GA to thetotal number of pixels in a plate domain

$RECOG_{CAR}$: The rate of the number of pixels which exists in the threshold value (maximum and minimum) determined by GA to all thepixels in a sample cars domain

$B_{MIN}, G_{MIN}, R_{MIN}$: The minimum of the threshold value of B, G, and R which were determined by GA

$B_{MAX}, G_{MAX}, R_{MAX}$: Maximum of the threshold value of B, G, and R which were determined by GA

By using a thresholds function, the rate of recognition is high and what has as small the range of a threshold value as possible is chosen. Therefore, it is thought that it is expectable to obtain a desirable result to the method proposed in this paper.

2.5. Thresholds function

The relation between the thresholds (upper and lower bounds) and the average of the brightness in a car domain are used to calculate of the thresholds function to (upper and lower bounds). The thresholds function of the upper and lower bounds are shown in Fig. 5.

The value calculated from this function is effective to the difference of light conditions or car color. Because, it has calculated based on the brightness of the whole car domain. Moreover, the thresholds of the plate detection in a strange image are determined based on the calculated function. That is, the threshold value, which detects the plate position in an image, is determined only calculating the brightness of an image. Therefore, the amount of calculation, which is needed for detection, can also be reduced.

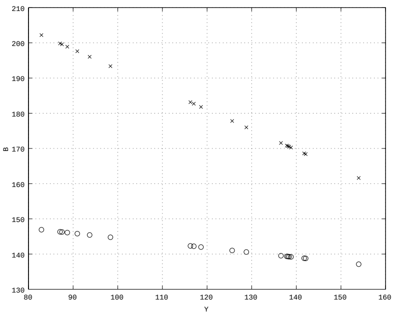


Fig. 5. The estimated threshold line by using RLS algorithm(B, upper and lower bounds)

3. Domai specification

3.1. Symmetry

If a domain is extracted only with a thresholds function, a domain, which has similar thresholds of a plate, may also be chosen. In this case, which domain finally is determined as a plate domain poses a problem. The method of determining a domain with many pixels, which exist within the limits of thresholds as a plate domain, is considered as one. However, by this method, a possibility of causing incorrect recognition in a plate domain, which has similar thresholds, becomes high.

Then, in this paper, the degree of symmetry is proposed and it is used as the domain specification method. The degree of symmetry shows as the following equations.

$$Symmetry = \frac{Sim}{Pixel * 2} \tag{1}$$

Sim : The degree of similar of two points which is applicable (difference of pixel value)

$Pixel$: The number of pixels of the half of a chosen domain

By using this method, the area chosen as a plate domain is equally divided into two first at length or a transverse direction. Next, the concentration value of the pixel, which becomes symmetry to a division line in two domains, is compared. Finally, the symmetry of a domain is measured by breaking the total of the value by the value of the half of the number of pixels of the whole domain.

3.2. Domain position

The plate position is different for each car. However rough position is can be predictable. Therefore, we use the distance from center of the width and more below than the center of vertical width in the car domain to decided domain as the feature.

3.3. Template matching

To detect the exact plate position, we perform the template matching for all the decided position pixels. In this process, we perform template matching for only decided domain pixel. Therefore, processing time is a little.

Moreover, when we perform the template matching, we improve template image for each image. The equation of improvement is following.

$$f(x,y) = T_{min} + \frac{T_{max} - T_{min}}{256} * f_t(x,y) \qquad (2)$$

$f(x,y)$: Pixel value after improvement
$f_t(x,y)$: Pixel value of template image
T_{min} : Minimum threshold
T_{max} : Maximum threshold

By this equation, we can obtain the responded template image for each image. The example of improvement is shown in the Fig. 6.

Y = 130 (a)Original image   Y = 155 (b)Template image   Y = 135 (c)Improved image

Fig. 6. Template improvement

4. Processing flow

The process in the case of actual plate detection is shown below.

4.1. Preprocessing

First of all, the cars domain that has brightness and cars color differ is prepared, and these image are formed into 2 values images using difference between frames. In quest of length and the number of pixels of a transverse direction, it graph-izes using this 2-value image. In these graphs, determine the domain beyond a threshold value as a cars domain. Next, a plate domain is started from the extracted cars domain. The upper and lower bounds of thresholds for each image calculates by the real numerical value GA using the plate domain image and cars domain image. Finally, the thresholds function calculates from the relation between the average value of the brightness of car domain and threshold value, which is calculated from RGA.

4.2. Detection processing

First of all, an inputted image is formed into 2 values image using difference between frames. Graph of length and transverse direction pixels calculate from 2 value pictures. In both these graphs, the domain beyond thresholds is determined as a cars domain. Next, the average value of the brightness in the determined cars domain is calculated. Each R, G, and B thresholds (upper and lower bound) are determined from thresholds function using car domain average. The number of pixels in a cars domain, which exists within the limits of the thresholds, is calculated. Graphs (length and transverse direction) calculate based on the pixel, which exist within the car domain and limits thresholds. By using these graphs (length and transverse direction), determine the domain beyond a threshold value as a plate domain. When two or more selection domains exist in the case of plate domain determination, in addition to the rate of recognition, the degree of symmetry of a selection domain is also used, and, the thing most in character with a plate domain is determined. Finally an exact position is determined by performing template matching to the inside of the determined domain [7], [8].

5. Computer simulations

In this section, in order to show the effectiveness of the proposed method, computer simulations are done by using the 119 car area images.

5.1. Simulation conditions

When computer simulation has done, parts where dose not contain a car are deleted. The deleted parts are part upper of original image and outside centerline. The number of the individuals, the generation shift number of times, crossover probability, mutation percentage in RGA is shown in Table 2.

Table 2. The parameters used in RGA

The number of individuals	200
The number of generations	1000
The number of elite preservation	20
Occurrence probability of crossover	0.60
The rate of mutation	0.07

5.2. Simulation results

When more than 70 % of plate areas made contained in the square of result, the detection is succeeding. The results of the detection are shown in Table **??** and the example of this simulation results are shown in Fig. 7.

Table 3. Simulation Result

	Detection accracy (%)	Processing time (sec)
Method1	70.2	0.18
Method2	80.7	0.18
Method3	86.6	0.18

CPU PentiumIII(500MHz)

Method1 : Frame difference and one template
Method2 : Frame difference and improved template
Method3 : Headlight consideration and improved template

The one, which succeeded in the detection, can be extracted the plate area from these results correctly. Moreover, we can detect the plate domain regardless of the color of the car.
In the failure detection, the road where light is hit is detected as plate domain. In this result, two reason is considered. One is that the car domain extraction is failure. Second is that the brightness of the road where light is hit is very high compared with another position of road. Therefore, brightness average is near to the plate domain.

6. Conclusions

In this paper, we propose the new thresholds determination method in the various background by using the RGA. In the conventional thresholds detection method is not robust for the changing background. That is, in the conventional method, we determine the thresholds, if the background color is changed, the detection accuracy is getting worse. However in this paper, determined the thresholds are changed adaptive by using thresholds function. Therefore, if

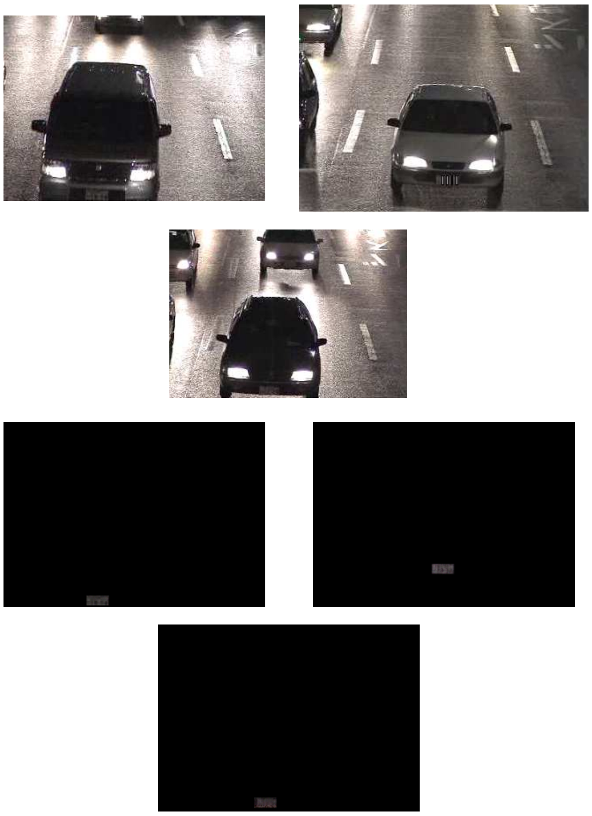


Fig. 7. Detection result (The example of failure of a simulation)

the background is changed (for example, rainy day thresholds and day time thresholds), we can obtain the suitable thresholds by using RGA. Then, we can obtain the good detection accuracy. In order to show the effectiveness of the proposed method, we show the simulation. In the simulation, we show the effectiveness the proposed a new thresholds determination method using RGA.

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