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# Classification of Road Signs Using Shape Feature Coefficient and Color Rate for Simple Layered Neural Networks

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**Abstract**—At the present day, the study of detection and recognition of road sings has been recognized as an important research field of ITS(Intelligent Transportation Systems). These studies, detection and recogniton methods of the road sings indicating the limited speed from a monochrome road image have been proposed(e.g.[1]). Other methods using layered neural networks has developed to fix road sings from a color image[2]. However, it is not too much to say that these methods do not give satisfying results at present state.

To improve these methods, we use layered neural networks for distinguishing red, blue, yellow and other colors [3]. For these results, we can define a shape feature confficient, which is calculated by the components of low frequncy of the Fourier descriptor. In this paper a new approach for detecting and recognizing road sings by integrating the shape feature coefficient and the color rate derived from an object domain is proposed.

As results of experiment, we have over 90% as a success rate in recognition in case of standard patterned images. Besides, we have about 80% rate in case of actual road sing images.

## 1. Introduction

The technology in the field of ITS (Intelligent Transportation Systems) makes remarkable developement in the recent years, and the image processing is one of the key technologies to supply real time information for a driver. Neural networks are also used as intelligent tools for the image processing in ITS [1, 2]. In this paper, small and simple structured neural networks are used as key tools for the proposed system of the road sign detected from a natural color image.

The first, color pixel is discriminated using a neural network(Color NN) in the color image. At the use of the result which detected the color, form recognition (Shape NN) by the Neural Network is performed. And, the method of recognizing road signs has been proposed using template matching inside a road sign[3].

In order to quantify the amount of form features, we newly define a shape feature coefficient derived from the Forier descriptor.

For that purpose, it is necessary to improve in a performance of color detection. Then, the technique using the input data double complementary color of Color NN is proposed first, and performance comparison with other techniques are investigated.

By using the Fourier descriptor as an amount of the form features, utility of proposed method is examined.

## 2. Detection process using 2 types of layered Neural Networks

The outline of the detection process is shown in Figure 1. The original color image is firstly reduced the relevant area by LOG filter. Secondary Color NN classifies each pixel whether the pixel belongs to a road sign or not. Then a Shape NN outputs whether each sub-region in the reduced area contains an object with the shape of a road sign. If a shape similarity is higher than a certain threshold value, then a template matching is done for the final recognition. There is also an additional process of the redetection for the region which is rejected by the previous steps. The details of each steps are described in the next sections.

**step 0** Loading Original image consist of 24-bit color

**step 1** Masking the irrelevant region for the road sign detection by LOG filter

**step 2** Selection of the relevant region using Color NN for matching the color

**step 3** Selection of the relevant region using Shape NN for matching the shape

**step 4** Matching with the temple for the final recognition

**step 5** Auxiliary Selection from the previous rejected region

Figure 1: Outline of the proposed detection method

### 2.1. Masking the region by LOG filter

Before discriminating a color, in order to restrict an area, processing shown in Figure 2 is investigated. It is possible

**step 1-1** Transformation of a 24-bit color image into an 8-bit brightness image

**step 1-2** Application of LOG filter

**step 1-3** Transformation into binary image using Discriminant Analysis Method

**step 1-4** Removal of noisy areas

**step 1-5** Masking the original color image by the obtained binary image

Figure 2: Masking process (step 1 in Figure 1)

by making large regions with little concentration change, such as empty, into the outside of an object by this to attain improvement in the speed of color discernment and increase in efficiency.

### 2.2. Selection of relevant pixels by Color NN

Plenty of techniques for color detection have been proposed. A technique is various and the same is said of the table color system space which discriminates. The complementary color structure is used for the table color system used by this research in a preliminary experiment. Conversion from an *RGB* table color system to a complementary color system is shown below:

$$O_{(R-G)} = R - G \tag{1}$$

$$O_{(Y-B)} = Y - B, \tag{2}$$

where $Y$ denotes a yellow compornent, which can be obtaind by Eq.(3):

$$Y = \min(R, G). \tag{3}$$

In our previous study, we proposed color Neural Networks(Color NN)[3], which have special use of color detection. Characteristic point of this Color NN is to stop its learning halfway to cope with uncertainness on the classification.

This neural network (Color NN) shall output four kinds of the colors currently used for the road signs of the color besides red, blue, yellow, and an object. Since the structure of Color NN assigned these four to each unit, it made the number of output layer units four pieces. Moreover, the number of input layer units is made into three parts, $O_{(R-G)}$ of a complementary color, $O_{(Y-B)}$, and luminosity $b$.

The data used when making Color NN learn is the color pixels extracted from the road sight picture. Moreover, it restricts to Color NN, the green of a forest is also extracted, and it learns as a color besides an object. The judgment considered the layer which takes the maximum among four outputs as the output. The output of all data and an error with teacher signals make study end conditions under 10%. It applies to an actual road sight picture using Color NN which study completed. To the application result of Color NN, labeling processing is investigated and removal specification area outside is investigated.

### 2.3. Selection of relevant regions by Shape NN

At the use of template matching, to lessen influence of a noise, the method of using Neural Networks has been proposed.

In the former, since the figure pattern is considered as the input as it is , the size of a figure needed to be changed, and there is a fault of distortion and being influenced of a noise by this operation.

This is considered as the input of Shape NN, using the ingredient ratio of the Fourier descriptor as an amount of the form features. It is expectable that the problem of the modification accompanying rotation of a figure and regularizing of the size of a region is solvable with this.

Generally there are the Fourier descriptor by the method of Zahn[4] and the method of Granlund[4] among the Fourier descriptor.

It can express with the method of Zahn[4] that the Fourier series expansion of the change of distance with the circumferential when making the center of gravity of a certain region into $(x_0, y_0)$ is carried out as follows:

$$z(t) = \sqrt{(x(t) - x_0)^2 + (y(t) - y_0)^2} \tag{4}$$

$$C_n = \frac{1}{T} \int_0^T z(t) e^{-j\omega t} dt, \tag{5}$$

where $T$ is the circumferential number of pixels. Generally, $T$ degree of rotation $\theta$ is used in many cases. In this research, it expects that better result is obtained by using the number of pixels of the parimeter. Next, a closed curve is expressed in the method of Granlund[4] as $z(t) = (x(t), y(t))$. $z(t)$ denotes the point that only distance $t$ progressed the closed curve top from a certain starting point.

$$C_n = \frac{1}{T} \int_0^T u(t) e^{-j\omega t} dt \tag{6}$$

These $C_n$ are used in many cases as amounts of the form features. However, if this technique is used, FFT will be unapplicable in many cases, and it will take processing time too much. Then, the work which reduces the number of data is done in applying FFT.

$T' = \log_2(T)$ is computed to all circumferential length $T$. It is an integer which rounded off the first place below the decimal here. FFT will be used after sampling to this number of data of $T'$ pieces. Let what computed even $C_n$ and investigated regularization by $C_0$ be the amount of the form features. Let $C_n$ be input data of Shape NN from $C_1$ among this shape feature coefficient.

Moreover, by inputting into Shape NN the result which computed the color rate from the result which investigated color discernment by Color NN, it builds so that all the

signs of three colors may be classified according to one Shape NN. It asks for the color rate of red, blue, yellow, and white or black which is in the inside of a region from the result of Color NN.

Here, with white and black, the pixel recognized as other colors is complemented with Color NN to white or black by the color rate in a region in the inside of a region.

The structure of Shape NN set the number of input layer units to the five amounts of the form features, and a total of 9 of the color rate 4. Moreover, the number of output layer units was set to 8 in consideration of the color, the meaning of a form and a sign, etc. in the data used in an experiment this time. The study method is the same as that of Shape NN proposed in the past.

We decided to perform template matching of the sign applicable to the unit which outputted maximum among the outputs of Shape NN, and decided not to set a threshold as the output of Shape NN.

After template matching processing, since it is the same as that of technique [3] proposed until now, it omits.

### 2.4. Template matching

The size of a figure, and since it corresponds to rotation, template matching which used polar-coordinates conversion is proposed.

From the result which applied Shape NN, matching processing for recognizing the meaning of a sign is investigated. The output of Shape NN is classified into eight groups according to the technique proposed this time. Matching processing is investigated for the region which has a sign candidate in the template of the selected group.

A sign candidate's region is changed into a complementary color. And polar-coordinates conversion is investigated focusing on the center of gravity of a sign candidate's region.

The picture after conversion creates $x$ axis on a rotation square $\theta$, and creates the $y$ axis in the size of $128 \times 64$ as a distance $d$ from the center of gravity. Where, the number of samplings of a rotation angle $\theta$ is the number of pixels of the perimeter a sign candidate's region $T$, and it is made regular so that the maximum $d_{max}$ of the distance $d$ from the center of gravity may turn into the maximum 64 of the $y$ axis. The point $(x, y)$ of a region when considering as the center of gravity $(x_0, y_0)$ paying its attention is computed by the following formulas:

$$x = x_0 + d_{max} \times \cos\theta \tag{7}$$

$$y = y_0 + d_{max} \times \sin\theta. \tag{8}$$

After changing of polar-coordinates, 1-dimensional FFT is applied to the following formula:

$$C(y) = O_{(R-G)}(y) + jO_{(Y-B)}(y). \tag{9}$$

$C(y)$ is calculated the whole horizontal sequence and made into a picture.

## 3. Performance comparison experiment

### 3.1. Color discernment

Originally, the technique to propose performs color detection after the processing which limits a domain. However, since he wants to perform evaluation by the performance of only color detection, a domain is not limited in this experiment.

Table 1: ROC curve region

| Technique | Rate of area |
|---|---|
| color map | 92.94% |
| distribution function of a color | 96.81% |
| Color NN | 98.33% |

Two complementary color map using the study data of ColorNN as algorithm for comparison of performance evaluation of ColorNN and the distribution function of pixcel value, are used. And the ROC curve was drawn as an index of performance evaluation. The rate of area of a ROC curve is shown in Table 1. Table 1 shows that Color NN also has few mistakes and highly efficient.

### 3.2. Pattern classification

Only the form of a technique the easiest as a form pattern classification and popular performs template matching, and compares Shape NN with the technique of classifying a form pattern. It carries out to this Shape NN about the technique using the amount of the form features proposed technique [3] proposed in the past and this time. It carries out also about the case where two of the amounts of the form features used as an input of the new proposal technique, the method of Zahn[4] and the method of Granlund[4], are used, respectively.

A pattern picture is first used for the experiment picture used here, and it performs it. The number of sign patterns is 44 in all. A size and rotation have five steps of pattern pictures of a total of 25 sheets about one kind of pattern.

To the technique of four kinds of form pattern classifications, the picture of 1100 form patterns was inputted and the discernment experiment was conducted. The result is shown in Table 2. Shape NN at the time of using the method of Zahn[4] and the method of Granlund[4] as an amount of the form features was as prediction rate of correct answer 100%. Since other two techniques had been influenced of rotation of a pattern etc., they were 85% grades.

Table 2: The rate of correct answer of a form pattern (1100 sheets)

| Technique | The rate of correct answer |
|---|---|
| Template matching | 85% |
| Conventional Shape NN | 88% |
| Shape NN(Zahn) | 100% |
| Shape NN(Granlund) | 100% |

Next, the thing made distorted arbitrarily is also inputted to this form pattern. The result is shown in Table 3.

Table 3: The rate of correct answer of a form pattern (5500 sheets)

| Technique | The rate of correct answer |
|---|---|
| Template matching | 75% |
| Conventional Shape NN | 82% |
| Shape NN(Zahn) | 100% |
| Shape NN(Granlund) | 94% |

By this experiment, the performance difference of each technique appeared clearly. Although there are problems, like the method of Zahn[4] has slow convergence of the Fourier series expansion, when using as an amount of the form features of ShapeNN, in order to take only a low frequency ingredient into consideration, it is thought that it is completely satisfactory. It is thought that the method of Granlund[4] has made a judgment which was mistaken in response to the influence by distortion.

Using the Fourier descriptor as an amount of the form features, even if it had rotation and a similarity relation in the simple figure by inputting into Shape NN, the good result is able to be obtained from these two experiments. Moreover, when distortion of a figure was made an issue of the method of Granlund showed that the method of Zahn[4] was effective.

Next, the same recognition experiment is conducted from a road sight picture to 275 pictures which started the sign portion. The result is shown in Table 4.

Table 4: The rate of correct answer of road sight pictures (275 sheets)

| Technique | The rate of correct answer |
|---|---|
| Template matching | 61% |
| Conventional Shape NN | 65% |
| Shape NN(Zahn) | 75% |
| Shape NN(Granlund) | 79% |

From this result, these four techniques are less than rate of correct answer 80%. It is because the information on a color that four techniques detected very important as the reason. Since it is difficult to discriminate a yellow lozenge and the square of red and blue when the method of Zahn[4] is used especially, and a color rate collapses, the rate of correct answer is low from the method of Granlund[4].

### 3.3. Template matching

In this section, we examine the influence of changing of coodinate. It is reported that the change of polar-coordinate often causes distortion or noise on the image. In Table 5. we compare performance between simple template matching and proposed method.

In a standard size, three techniques prepare as a template 44 pictures which are not rotating, and are investigated to the picture of a total of 1100 sheets which changed rotation and the size to five stages. It turns out that the proposed method is superir to the simple template matching method.

Table 5: The rate of correct answer of selection of a road signs

| Technique | The rate of correct answer |
|---|---|
| Simple template matching | 77% |
| Change of polar-coordinates | 86% |

## 4. Conclusions

To contribute the promotion of ITS, a new procedure for detecting and recognizing of road signs is proposed.

This procedure consists of three parts, first we use layered neural networks to distinguish colors for color images, and to determine the detected region for monocrome images. Second we successfully can classify road sign patterns by using both of the shape feature coefficients and the color rate. Finally, recognized pattern is determined as one of the road sign using a changing of coodinate template matching.

On the classification of the pattern picture, it is obtained that the rate of correct answer exceeds 90%. This outstanding results are due to use low frequency component of the Fourier descriptor to avoid distortion caused by condition of picture-taking.

However, it remained to the road sight picture in the second half of 70%. Moreover, since it is difficult to discriminate a yellow lozenge and the square of red and blue when the method of Zahn[4] is used, and a color rate collapses, the rate of a correct answer is low from the method of Granlund[4]. When seen generally, the performance of color detection of the system which used as the base the color picture proposed in the past by this research, and a form pattern classification enhances.

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