Rule Extraction from Images Using Neural Networks

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Abstract

*In this paper, as a method of extracting keywords, feature data is extracted from an image and a method using a Back-Propagation neural network for learning and classifying them is proposed. First, a bit map image in the RGB color space is transformed into the L*a*b* color space. Next, it clusters image pixels using the c-means method and domains are extracted by Labeling. Features, such as area of the obtained domain, color information, and coordinates of the center of gravity, are then calculated, which are input attributes to a neural network. Moreover, rule generation is carried out by extracting values in the hidden layer of each keyword after the learning of the neural network. The method of generating keywords using the rules is proposed and a comparison experiment is performed. Finally the validity of this method was verified by means of computer simulations.*

1. Introduction

In recent years, it has become the multimedia society where images play an important role, and the use of the Internet and image input apparatuses have spread. Nowadays, there is huge image data in our personal appearance with its spread. It is not easy to find an image suitable for one's purpose out of such a huge image data. Therefore, the technique of searching images is desired. For image retrieval from image database, suitable keywords are necessary in each image [1].

There is a technique of adding keywords to images beforehand, and searching by using a keyword based on them as a method of images retrieval. However, this can cause a problem that it is unmanageable if there is an immense quantity of images. In this case, automatic keyword extraction from images is important for image retrieval and to construct a large scale image archive. In this paper, therefore, a technique of performing keyword addition automatically to images is proposed.

First, in Section 2, a technique used is this paper is explained, and an experimental method which uses a neural network in Section 3 is described, and Section 4 shows a simulation result and consideration and conclusion in Section 5.

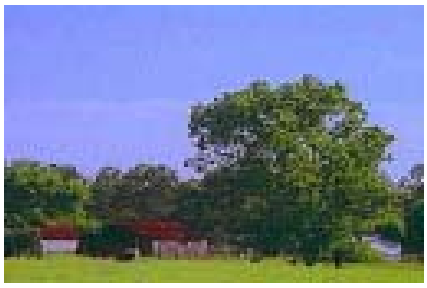

Figure 1. Sample of scenery image.

2. Feature extraction

2.1 L*a*b* color space

A L*a*b* color space is a front color system currently used for expressing an objective color most popularly in all fields. By the L*a*b* color space, intensity is expressed with L* and the degree of color which shows hue and saturation is expressed with a* and b* [2].

A conversion formula is shown below.

$$L^* = 116(Y/Y_n)^{1/3} - 16$$

$$a^* = 500[(X/X_n)^{1/3} - (Y/Y_n)^{1/3}]$$

$$b^* = 200[(Y/Y_n)^{1/3} - (Z/Z_n)^{1/3}]$$

$$X = 0.49000R + 0.31000G + 0.20000B$$
$$Y = 0.17697R + 0.81240G + 0.01063B$$
$$Z = 0.01000G + 0.99000B$$

($X_n = 95.045$ $Y_n = 100$ $Z_n = 108.892$)

$$X/X_n > 0.008856$$

However, $Y/Y_n > 0.008856$

$$Z/Z_n > 0.008856$$

When there is a value of 0.008856 or less in $X/X_n, Y/Y_n, Z/Z_n$, the term of the cubic root which corresponds to it in the upper formula is calculated by transposing it to the following formulas, respectively [9].

$$(X/X_n)^{1/3} \to 7.787(X/X_n) + 16/116$$
$$(Y/Y_n)^{1/3} \to 7.787(Y/Y_n) + 16/116$$
$$(Z/Z_n)^{1/3} \to 7.787(Z/Z_n) + 16/116$$

2.2 C-means method

The c-means method is a technique of clustering performed by adding a membership function to the k-means method [3][4][5][6].

Let $X = \{x_1, ..., x_n\}$ be n individuals with a p-dimensional vector to be clustered. Moreover, the number of clusters is set to c, the representative point of Cluster $i (i = 1, ..., c)$ is set to v_i, and it is decided with the membership function u_{ik} whether Individual x_k belongs to the Cluster i. Then, it is regarded as a problem which makes the criterion function J_m minimum by properly choosing Matrix $U = (u_{ik})$ and the representative point $V = (v_1, ..., v_c)$ for the problem of clustering.

In this technique, the membership u_{ik} is defined as the following.

In $x_k \neq v_i$

$$u_{ik} = 1 \Big/ \left[\sum_{j=1}^{c} \left(\frac{(d_{ik})^2}{(d_{jk})^2} \right)^{1/(m-1)} \right]$$

In $x_k = v_i$

$$u_{ik} = 1 \quad u_{jk} = 0 \quad (j \neq i)$$

Moreover, the center v_i of a cluster is computed as

$$v_i = \sum_{k=1}^{n} (u_{ik})^m x_k \Big/ \sum_{k=1}^{n} (u_{ik})^m .$$

The fundamental Algorithm is shown below.

FCM1. Initial values of U and V are decided suitably.

FCM2. U is fixed to the last value, the optimal

solution from $\min_{V \in R^p} J_m(U,V)$ is calculated, and it is referred to as a new V.

FCM3. V is fixed to the last value, the optimal solution from $\min_{V \in R^p} J_m(U,V)$ is calculated, and it is referred to as a new U.

FCM4. If this process converges on a proper value, it stops, otherwise, return to Step FCM2.

2.3 Labeling

Labeling is used to search for the coordinates of the area of each domain, an average RGB values, and the center of gravity in the image where domain division was carried out [7]. It is a operation which assigns a different label to a non-connected region and which assigns the same label to the same connected region. The processing procedure of Labeling used in this research is shown below.

<Algorithm>

Step.1. Label attachment is carried out using neighboring 8 pixels in each pixel.

Step.2. About the neighboring 8 pixels of a standard center, if it has the same pixel value as the standard pixel, the same label “i” is assigned.

Step.3. If there is a pixel with the same pixel value in the eight pixels, the same operation is carried out for the pixel with Label “i” and it is repeated.

Step.4. The whole image is operated until the same element is not found in neighboring eight.

Step.5. $i = i + 1$

Step.6. It is carried out to eight kinds of all quantization values in the same way.

3. Experimental method using a neural network

Conversion from a RGB color space to a L*a*b* color space is carried out by performing L*a*b* conversion to a bit map image. Five levels quantization using the c-means method to a* and b* which were obtained by the L*a*b* conversion is carried out (Figure.2). Next, three domains are extracted in order with the largest area by performing Labeling. The coordinates of the area of the domain obtained from this, color information, and the center of gravity were calculated, and they were made into a neural network's input signals.

Moreover, this technique uses a feed forward neural network as shows in Figure.3, and a Back-Propagation (BP) method as a learning algorithm. The model of the BP method has 6 units in the input layer, 10 units in the hidden layer, and units of the number of keywords in the output layer, as shown in Figure.3. Teacher data use 48 domains from a total of 43 scenery images, and the keywords in this study are "sky", "sea", "clouds", "plain", "dark green", and "rocks."

Next, the newly proposed if-then rule is explained. An If-then rule is a method of classifying based on the hidden layer's values at the time of classification. First, the values of a hidden layer of each key word are taken out from a trained neural network. Rule generation is performed to them. A rule in this case is based on combination of the hidden outputs. Each output unit can produce such a combination for each input. For instance, IF $H_1 = 1$ and $H_3 = 0$, then $class = 1$, where Hi indicates the output value of the first hidden unit. Based on generated rules, feature data are classified into each keyword in classification. That is, it is the

technique of classifying according to the hidden layer outputs. By this technique, the 1st place of a decimal is rounded off for every keyword, and the ten hidden layer's values are binarized to 0 or 1.

Comparison experiments between the neural network and the rules are performed.

Figure2.The quantization result by the C-means method.

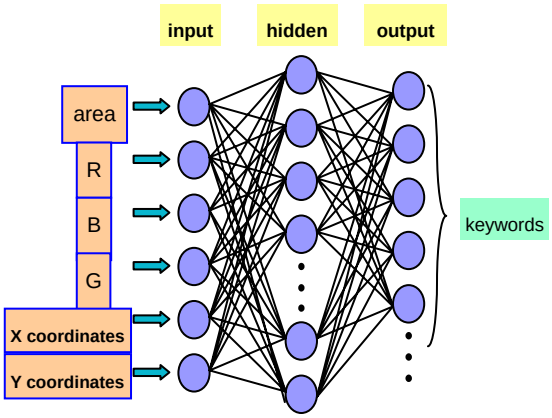

Figure3. A Neural Network Model.

4. Simulation and Consideration

The result classified into keywords using the BP method is shown in Table 1. Those rate shows accuracy which the neural network produced accurate keyword using the features of each region in images.

Table 1.BP method

sky	clouds	sea	plain	dark green	rocks
90%	67%	75%	70%	75%	80%

Next, the result obtained using If-Then rule for the hidden layer's values for every keyword is shown in Table 2.

Table 2.If-Then rule

sky	clouds	sea	plain	dark green	rocks
60%	45%	40%	50%	42%	58%

Compared with the results using a BP method, as for the rate of recognition, the results using the If-Then rule become worse in every keyword. This is due to approximation which transformed hidden layer's values into binary values simply.

However, although the sea can be incorrectly-recognized to be a sky by the BP method this time, the sea was not much incorrectly-recognized to be a sky using an If-Then rule. That is, when you want images of a sky, it is thought that only the image of a sky can be retrieved in many cases. However, more keywords and more kinds of images are necessary to construct a practical.

5. Conclusion

In this paper, the technique of keyword extraction from landscape images as the first phase which performs image retrieval was proposed. First, the feature domain was chosen by giving L*a*b* conversion, quantization by the C-means method, and labeling to the images, and the amount of features was extracted. Moreover,

the If-Then rule was generated and compared with the rate of recognition in the BP method.

Rule extraction method is improved in order to raise the rate of recognition in the If-Then rule from now on. Moreover, although the C-means method is used in domain division, it is considering a technique which can be divided still better.

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