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Voice Response System of Color and Pattern on Clothes for Visually Handicapped Person

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Abstract— **For visually handicapped people, a mental support is important in their independent daily life and participation in a society. It is expected to develop a system which can recognize colors and patterns on clothes so that they can go out with less concerns. We have worked on a basic study into such a system, and developed a prototype system which can stably recognize colors and patterns and immediately provide these information in voice, when a user faces it to clothes. In the results of evaluation experiments it is shown that the prototype system is superior to the system in the basic study at the accuracy rate for the recognition of color and pattern.**

I. Introduction

In recent years, visually impaired people who lost their eyesight are not supported enough, although the number of the patients who suffer diseases such as diabetes [1] and retinitis pigmentosa [2] are increasing. A physical support is necessary, for example an infrastructure equipment in a public area for those people to safely move, human support like guiding or taking care of them. In addition, a mental support is very important in order for them to be more independent in their life and more involved in a society. One of the problems is recognition of colors on clothes. They are always worried about their dresses and how they look to the others, even if they cannot recognize the color. However, there have been few studies about these support. Therefore we had proposed the basic system [3] which can recognize colors and patterns on clothes. If this system gets more practical, totally blind people will be able to go out more easily and with less concerns.

The prototype system based on the basic system is useful for visually impaired people because voice response can be output immediately by facing it to clothes. In this paper it is shown that: An expression of a color and pattern, a technology to recognize them regardless of the environment, a correction formula for a camera color space, and results in evaluation experiments.

II. Expression of Color and Pattern

A. Expression of Color

It is necessary to adopt the mode of intelligible expression of color for the totally blind person to be able to understand color only by an information from hearing. The Practical

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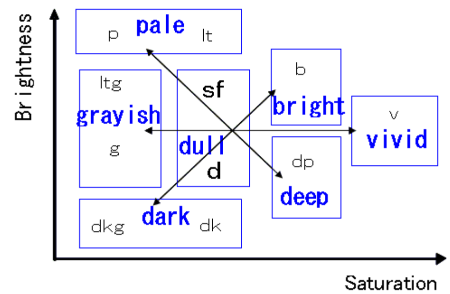


Fig. 1. Integration of tones.

Color Coordinate System(PCCS) [4] proposed by Japan Color Research Institute, can express color briefly with "tone" and "color name". The tone describes brightness and saturation. Eleven tones are used in the PCCS as illustrated in Fig. 1. Furthermore, tones are integrated so that the totally blind person can know their features using the system's voice response. All tones have been integrated into seven tones, as pale (p and lt), dull (sf and d), grayish (ltg and g) and dark (dk and dkg). The arrows in Fig. 1 show the relationship of complementary tones.

"Beige," a color often used for clothes, has been added to the eleven categorical colors which are red, green, yellow, blue, brown, purple, orange, pink, white, black and gray [5]. So "color name" is expressed with twelve colors.

B. Expression of Pattern

Figure 2 shows the five categories of pattern: "vertical-stripe," "horizontal-stripe," "checker," "plain," and "others," which frequently appear on clothing. The direction of the stripes in the pattern can be determined on the basis of the part of clothes touched by the user. Patterns that are neither "stripe" nor "checker" (whether regular or not) such as a pictorial pattern or a literal pattern are classified with "others."

To avoid detecting texture patterns, the input image is smoothed with a low-pass filter; hence, any unevenness on the surface of the cloth is disregarded, and the clothing image is treated as a two-dimensional pattern.

III. Proposed System

A. Hardware

The proposed system is shown in Fig. 3. The input unit consists of a USB camera and a ring light attached to the cover, which is used to shut out light extraneous to the proposed system. To reduce specular reflection of lighting

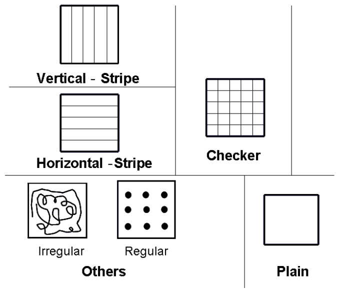


Fig. 2. Categories of Pattern.

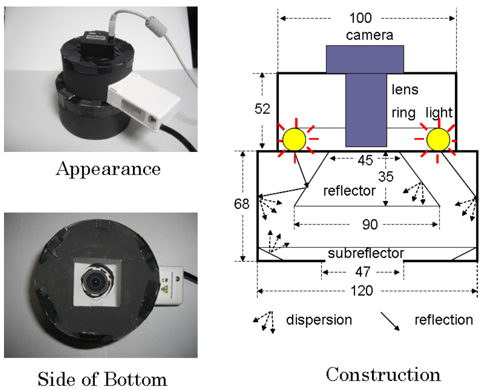


Fig. 3. Input Part.

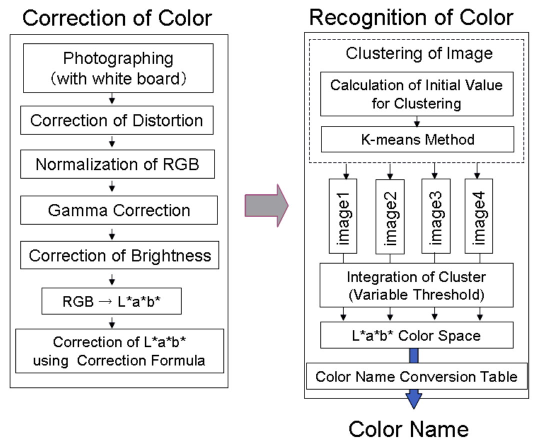


Fig. 4. Flow Chart; Recognition of Color.

light, which arises on an image, the light reflector and sub reflector are attached to the inside of the cover. The light reflector is a cone shape with the upper part opened. The light from the source is reflected by the mirrored surface and diffused onto the inner white surface. The sub reflector has a white surface and is housed in a ring along the inner circumference of the bottom of the cover. For normalizing the image luminance values, a standard white board [6] is attached on the edge of the inside bottom aperture. The image is taken together with a target cloth.

B. Information Processing Part - Recognition of Color

The flow of color recognition is shown in Fig. 4. Correction of distortion, normalization of RGB values and gamma correction is performed [7]. Brightness is corrected so that standard white may serve as a suitable benchmark. Subsequently, RGB values are converted into L*a*b* values, and these are then corrected by the correction formula of a camera color space.

The method of color recognition is as follows. The PCCS color chart data and the specimen image taken by the camera are mapped to L*a*b* color space, and the image is divided into less than four clusters by the K-means method. The initial clustering values are chosen as the point used as the image core. The three axes of the L*a*b* color space are quantified in 25 levels. The number of pixels is counted in each voxel, and the top four voxels are selected in terms of its numbers. Among these four voxels, the mid position of pixels is calculated and it is set as the initial value. Thereafter all pixels of the image are classified into four clusters in the proposed method.

Next, these pixels are reintegrated because the expression is too detailed to allow a speech-based indication of color when all the color names of four clusters are output. The distance between the center of cluster C_i and C_j is defined as D_{ij}, and the threshold value for integration of clusters is defined as H. If it is $D_{ij} < H$, C_i and C_j will be integrated into either C_i or C_j (whichever has more pixels). H is defined by the following formula.

$$H = n_1\sigma + n_2. \tag{1}$$

H is set up in conjunction with the standard deviation σ of the whole image to change dynamically. Thereafter, output of color names is made to suit the image which a person perceives. A suitable value is set as n_1 and n_2 by experiments.

In addition to 193 PCCS color charts, the data mapped into L*a*b* color space is added with the interpolation data of ten tones other than v tone, and the resultant total becomes 313. The matching rule between each cluster center P_i and the mapping data of the color chart is shown in Fig. 5. Circles with their center on the origin are drawn on the a^*-b^* surface of projection. The radius of the small circle is defined as $Neutral$ and the radius of the large circle is defined as Sat. These circles determine that the specimen image P_1 in the internal area of the small circle is an achromatic color, and does not match with a color chart. The specimen image P_2 in the area between the small and large circles is matched with a color chart by the nearest distance. The specimen image P_3 in the outside area of the large circle is matched with a color chart that has the nearest hue angle among three color charts with the nearest distance. The values of $Neutral$ and Sat are determined by experiments. Now the color can be recognized by the color name conversion table.

C. Information Processing Part - Recognition of Pattern

The flow of pattern recognition is shown in Fig. 6. As pretreatment, an image obtained by color correction is converted to grayscale and then smoothed to suppress the influence of texture. The image is filtered in a spatial frequency domain

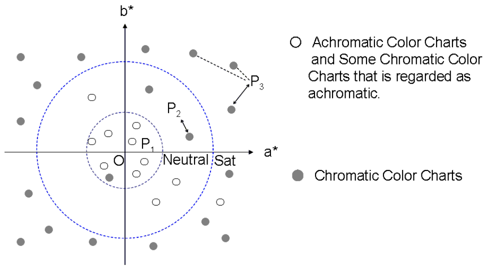


Fig. 5. Rules of Corresponding Color Name.

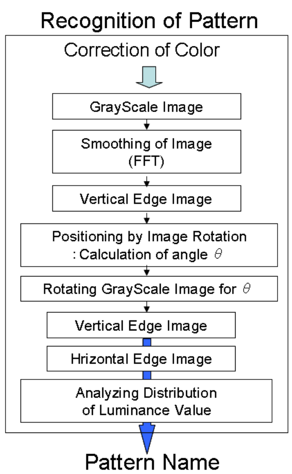


Fig. 6. Flow Chart; Recognition of Pattern.

using Fast Fourier Transform, and a smoothing image is obtained by Inverse Fast Fourier Transform. Then the Sobel operator is applied to the smoothed image and vertical edges are detected.

Standard deviation is calculated for a distribution of horizontal luminance values, rotating the vertical edge of the image by 1° counterclockwise. Thereafter, the system finds the rotation angle θ' with the maximum standard deviation. When there are stripes, the angle θ by an image can rotate more closely to either horizontal or vertical direction can be examined according to this θ'.

Again, the horizontal and vertical edges are separately detected using a grayscale image. The system investigates the respective distributions of luminance values both horizontally and vertically for these edges. Then the system judges on the basis of the threshold value whether an image has stripes and classifies the pattern.

D. Output

Generated clusters are set to C_1, C_2, C_3 and C_4. The color name of each cluster is denoted by C_{i_color}, and a pixel ratio of the pixels in each cluster to those in the original image is denoted by C_{i_ratio}. Pattern is expressed by $pattern$. C_{1_ratio}, C_{2_ratio}, C_{3_ratio} and C_{4_ratio} are sorted in the descending order. If the pixel ratio of a top cluster is more than 0.5, the system defines the color of the top cluster as "the background color of cloth". Cluster color names are output by a synthetic voice in the sorted order, and finally $pattern$ is output.

IV. Correction of Color

A. Normalization of measured value

Since the lighting intensity and the CCD sensitivity change over time, the measured RGB values of the center area have to be normalized. Therefore, the standard white board arranged to the neighboring area is photographed together with a specimen cloth.

X_{RGB}: Measurement of RGB values on the central area (a 350pixel square area).

Y_{RGB}: Measurement of RGB values on the neighboring area (four 100pixel square areas).

Z_{RGB}: Basic RGB values of the Standard White Board on the neighboring area.

The normalization luminance A_{RGB} of a specimen cloth for measurement can be calculated by the following formula.

$$A_{RGB} = X_{RGB}(Z_{RGB}/Y_{RGB}) \tag{2}$$

B. Correction Formula of Camera Color Space

The correction formula of a camera color space is derived by multiple regression analysis, so that the camera can correctly output the PCCS color from the chart used as the basis for color recognition. The color of the color chart images taken by the camera is corrected, and the L*a*b* values of these are calculated. These are called "Calculated Value". The L*a*b* values of color chart images measured by the spectral colorimeter are called "True Value". It is important that the Calculated Value is very close to the True Value, i.e., the color difference between these values is small, because of the construction of the color recognition system.

Then, the L*a*b* values of 193 color charts are measured using a spectral colorimeter. Using multiple regression analysis, the correction formula is derived, so that the Calculated Value may fit the True Value. However, 18 color charts of Vivid and Deep tone outside sRGB color space [8] are excluded.

Let L^*, a^* and b^* be objective variables (True Value), and let L, a and b be explaining variables (Calculated Value). The correction formula is defined as follows:

$$\begin{aligned} L^* &= K_{00} + K_{01}L + K_{02}a + K_{03}b + K_{04}La + K_{05}Lb \\ &\quad + K_{06}ab \\ a^* &= K_{10} + K_{11}L + K_{12}a + K_{13}b + K_{14}La + K_{15}Lb \\ &\quad + K_{16}ab \\ b^* &= K_{20} + K_{21}L + K_{22}a + K_{23}b + K_{24}La + K_{25}Lb \\ &\quad + K_{26}ab \end{aligned} \tag{3}$$

V. Experiments

In the color name conversion table, some of the chromatic color charts were judged to be achromatic colors when observed, and it was appropriate to treat them as achromatic (Figure 5).

The color difference adjusted by the correction formula (equation 3) is shown in Table I for every tone of PCCS.

In Vivid tone, the color difference is relatively larger since color charts of Vivid tone exist only half inside the sRGB color space. The average color difference of all color charts is 1.64. The multiple contribution ratio R_2 of this correction formula is 99% or more. Therefore, we can consider that this system is functioning appropriately.

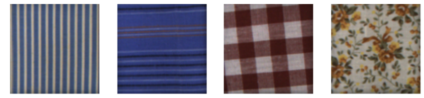
The instruments used and various preset values are shown in Table II. The specimen cloths used for the experiment were 38 types of cloths with various colors and patterns. The example images of specimen cloths are shown in Fig. 7. The outputs were as follows.

a. Beige Vertical-Stripes on Dull Blue Background.
b. Pale Blue, Dull Blue, and Dull Purple Horizontal-Stripes on Bright Purple Background.
c. Grayish Brown, Brown, and Pale Gray, Checker.
d. Dull Yellow and Gray Other Patterns on Beige Background.

We have conducted evaluation experiments for the system. Experiments compared the output accuracy between the prototype system and the basic system. Seventeen examinee looked at specimen cloths, listened to the voice responses and evaluated these in four steps. In the prototype system, the accuracy rate when considering the top two steps as the correct answer was 78.4 [%] (65.0 [%]) for the color and 94.4 [%] (91.3 [%]) for the pattern respectively. The inside of a parenthesis is in the basic system. The details are shown in Table III.

VI. Conclusions

We have developed "Voice Response System of Color and Pattern on Clothes for Visually Handicapped Person" based on the results from the basic study [3]. The technology to absorb the changing nature in a camera and a lighting has been developed, and the correction formula of a camera color space based on the spectrometry values of the PCCS color chart has been derived. In addition, we looked into the method of the expression and definition of the color which can be easily understood by the totally blind people, and we adopted it in the system. As a result, the accuracy of color correction has been improved and it can output more appropriate color names, which has resulted in the sufficient performance for the system. From now, we would like to investigate into how visually impaired people feel by using this system, and put this into practical use.



a. b. c. d.

Fig. 7. Output Samples.

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TABLE I
Average of Color Difference.

Tone	Number of Charts	Average of Color Difference
v	13	5.18
dp	5	3.31
dk	12	1.77
p	12	1.46
lt	12	1.98
b	12	3.41
sf	12	1.56
d	12	1.52
ltg	12	1.48
g	12	1.18
dkg	12	1.03
others	49	1.14
Total	175	1.64

TABLE II
The instrumens and the preset values.

Camera	Chameleon CMLN-13S2C
Ling light	StockerYale Model13
Spectral Colorimeter	Konica Minolta CM-2600d
Image resolution	W1280/H960[pixel]
Center measurement area	W47/H47[mm], 450/450[pixel]
Basic RGB values of the Standard White Board	$Z_R = 228.69, Z_G = 231.95$ $Z_B = 230.09$
The thresholds for integration of clusters	$H = n_1\sigma + n_2$ $n_1 = 0.33, n_2 = 2.7$
The thresholds for color recognition	$Neutral = 3.7, Sat = 5.0$

TABLE III
Accuracy Rate of Experiments in The Prototype System (%)

		Color	Pattern
Stripe		70.5	90.4
Checker		69.7	97.2
Plain		95.6	88.3
Others	Irregular	76.3	98.0
	Regular	86.2	100.0
Total		78.4	94.4