Personal Color Decision System Using Fuzzy Logic [1]

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Abstract

This paper, which is based on the research in the personal color diagnosis system, uses the fuzzy logic. We propose the method which constructs more systematic color selection system using personal color database and fuzzy logic. This paper will refer to this system as FPCS (Fuzzy logic Personal Color System). The FPCS program proposed in this study is able to produce rapid and accurate results without the complex processes of existing color diagnosis therefore it is convenient and can save time and money.

Keywords: Personal Color System , Fuzzy Logic

1. Introduction

The color diagnosis system that is currently being used universally mainly uses the draping method of using color diagnosis fabric which is done by a trained color analyst along with a basic questionnaire.

However, because the basis of diagnosis has not yet been unified and the diagnosis is done based on the subjective view or unclear data of the person conducting the diagnosis, the probability of an incorrect analysis is significant.

When season color type is decided based on improper analysis, its feasibility test also becomes difficult, decreasing reliability of the decision and its accuracy.

This study, as a way for improving such problems, aims to present a more accurate and specific color diagnosis rules through a test applying the Fuzzy logic based on data gathered from the first questionnaire program. In addition, increase of objective objectivity was also intended by analyzing and certifying the designed and realized program.

1.2. Scope of study

This study computed the membership degree of RGB values for each body color of individuals and used objective data as its basis by defining the fuzzy membership function whose style used in this study was a non parametric estimation method using the nearest neighbor algorithm.

The validity of FPCS was secured through a validation test by a professional, which in this study was the χ^2 test.

2. Related Studies

2.1. personal color

The personal color system as the study of systematization already from the West Europe long time ago, was introduced in Japan since about 20 years[1].But In our country, recently the research to be advanced by some specialists, is tendency of revitalization with supplying in rapid pace as the interest of multitude is concentrated.

Johannes Itten, the professor, and the scholar of the color of the Bauhaus, as the synthetic moulding school in Germany, has found that the preference color of the students is related to their unique color, namely, the color of skin, hair, eyes etc. as their own, and paid attention to the relationship between the appearance and the subjective view of chromatic in 1928, It is becoming known as the beginning of color analysis[2].

Our human body show each different skin color like some people are yellow, another are more red than the others, and some people are darker than the others etc. for effect of 3 kinds of pigments like carotene, the hemoglobin and the melanin[3].

The personal color is decided with proper color which

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individual keeps, namely, the color of skin, hair, eyes, etc. among those 3 elements, the skin color became the most important element. (Table1. 1 explains the point of reference like this).

The personal color is made by the 4 seasonal color analysis as the spring, summer, autumn, winter which is harmonized with each personal proper body color after diagnoses the proper color which individuals were born, especially it classifies 4 seasonal color types with dividing color of skin, hair, eyes.

All of colors could be divided with cold color and warm color, the basic background color of pattern of spring, autumn is yellow and gold color as warm color, it has the feeling of movement, clearness, deepness, elegant, and the basic background color of pattern of summer, winter is blue, black color, and it has the images of soft, thickness, romanticism, clearness, urban, dynamic image [3].

The skin color of the human being is accomplished with 3 kinds of pigments, namely, melanin, hemoglobin, and carotene, generally the black race has more melanin, the white race has more hemoglobin, and the yellow race has more carotene contents compared to the other pigments, and the thing that the each skin color is shown differently though same race is the result following to the component ratio of these 3 kinds of pigments[4].

Our skin could be divided in 2 types largely, as warm type skin of ivory, yellow, copper color, and gold and cool type skin of white, pink, red, and blue[5].

Cool color means the color which includes white, blue, black in every color.

Especially the color which includes white and blue is called summer type color, and the color which includes blue and black is called winter type color.

Warm color is the color which includes yellow and gold in every color. Especially the color which yellow is basic background color, is called spring type color, and yellow and gold become a basic background color that is called autumn color. [5].

(Table1. Cool class color & warm class color)

Colors of cool class	Colors of warm class
The bright skin which with color is lingering	Bright yellowish skin
The middle tone skin which is canescent color	Yellowish skin of middle tone
The skin which is little bit red and canescent.	Yellowish skin which red tint is lingering.
The dark tone skin which is canescent	Yellowish skin which brown color is lingering.
Uran, cold, sharp image	Warm, healthy, familiar image

Because of the skin color of spring type people is yellowish, transparent and thin, it's the type which the spots like freckle could be appeared in the face easily. The eyes color is yellowish, the hair wears the light brown color. The image of the spring person is bright and vivid so there are many style which looks younger than age and cute. .

The skin color of summer type person is white and green light goes round or the pink light circles round, and does not burn well in the sun and to be red. The eyes color is the soft brown, the hair is the brown which wears gray and is a dry lackluster type. The image of summer type is somewhat cold, romantic and feminine.

The skin color of autumn type person is yellowish, lackluster and white-livered. It's easy to be burn in the sun, the face color changes to brown easily. The hair is lackluster dark brown, eyes color is umber which gives peaceful and fluffy. The image of the autumn person is warm and soft which gives intimate and comfortable feeling, it has natural and classic image

The skin color of the winter type person is cold and pale, the eyes and hair color is deep gray-brown or black so it's contrasted with white skin and gives polished image. The image of the winter person is cold and intense, keeps the intellectual impression.

2.2 Use of Personal Color

When the 4 season color image classification approach is observed, it is closely related to color image scale [6].

The 4 season image classification and color image scale classification have very similar in their logical connection.

Their only different characteristic is the difference in the concept of warm colors and cool colors. The color image scale classifies red tones as warm colors and blue tones as cool colors, and in contrast, the 4 season colors view all colors to have warm shades and cool shades.

In other words, in the color red, there is a warm red to which a yellow shade is added and a cool red to which a white tone is added. The same applies also for blue tones.

2.3 Images and harmonious colors of the 4 season type

• Spring type: Bright and cute

Representative colors of spring give off a warm feeling with yellow hues added in all colors.

Spring colors are clear and soft, and they are groups with high level of brightness and chroma, and include a broad range of colors.

(Fig.1 harmonious colors of the Spring type)

•Summer Type: Bright and elegant

All summer colors include blue and white colors. They give off a soft and cool feel, and include ranges of pink tones and pastel tones that do not clash. Types of colors are also somewhat diverse.

(Fig.2 harmonious colors of the Summer type)

•Autumn Type: Deep autumn tones

All autumn colors have yellow tones in them and therefore give off a warm feeling.

They are not glossy or shiny, and clothes that display the quality of the fabric project depth. .

There are many ranges of brown tones. They include golden yellow, and colors of fields, autumn forests, and autumnal tints.

(Fig.3 harmonious colors of the autumn type)

• Winter type: Classy and urban

Colors that represent winter are mostly blue tones and are colors that stand out with clarity. They include lemon yellow, blue green, indigo, deep blue, black, and wine.

(Fig.4 harmonious colors of the winter type)

2.4. Fuzzy Theory

Fuzzy is the theory which could appear fuzzy intellection of human being that couldn't divide with only dichotomy in the computer with mathematical function, as compared with the logic circuits of computer moves by the absolute standard like 0 and 1, this theory is the method which let the computer executes the thought, studying, self-development, etc. that the intelligence of the human being could do [7-8].

3. Fuzzy Logic Design

3.1 Data Collection

This system aims to statistically formulate a fuzzy logic based on data gathered from specialists.

In order to gather the necessary data, first questionnaire was conducted with 212 subjects in the age bracket of 20 - 50 years over 2 months, from August to September of 2008.

A total of 212 data were collected and the male to female ratio was 62 male respondents to 150 female respondents.

Of the gathered information, skin, hair, and eye colors were used and the diagnosis program was designed based on this collected data by determining the preference order of the 4 seasons (order by season).

3.2 Questionnaire

The program for the questionnaire was designed to determine the 4 ranks by selecting 1. basic characteristics, 2. skin factor check, 3. color mix.

3.3. Fuzzy Logic Design

The fuzzy function was defined by computing the membership degree of RGB value for each of skin, hair, and eye colors that determine the 4 season type and based on this, a fuzzy based

personal color system was formulated and a more scientific and systematic color diagnosis method was presented. Determining season type

● **Season Type**

When skin, hair, and eye colors are each unique colors, the season type is predetermined.

Ex) when skin=(255, 233, 204), hair=(180, 154, 102), eye=(126, 93, 50), season type is "Spring"

A total of 9 dimensions are expressed by expressing three dimensionally(RGB) the color feature space for identification of season type with three colors.

Season types were marked as "Spring", "Summer", "Autumn", and "Winter."

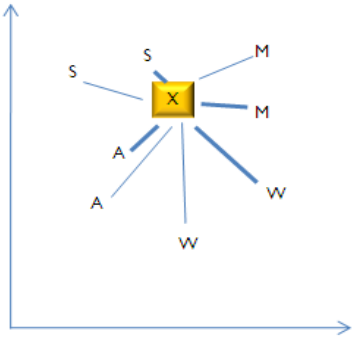
$$Y : C \rightarrow t \quad C \in [0..255]^9 \quad t \in T = \{S, M, A, W\}$$

When physical colors of a specific person are skin =(255, 233, 204), hair=(180, 154, 102), and eye=(126, 93, 50), the fuzzy function determines the season type for the applicable physical colors as "Spring".

· ● **Calculation of Distance from Season Type**

The distance in feature space between colors of the predetermined season type and color in question is computed.

At this time, if more than two season types are predetermined, the distance to the nearest season type is defied as the applicable season type distance.



(Fig. 8 . Distance from Season Type)

$$D_T(x) = \min_{\{c_t^i | t=T\} \in C} dist(x, c_t^i)$$

Distance between (x) in question and applicable season(T)

Physical color of (x) in question

Physical color applicable to season in question among collected data

$dist(x, c_t^i)$ c_t^i: distance between one () among collected data and a specific physical color (x). It is defined as Weighted Euclidean Distance between the two points within the 9 dimensional feature space that express physical colors.

$c_t^1 c_t^{212}$ c: Sum of all gathered data. When 212 data are collected, it will have a total of 212 elements from to .

$\{c_t^i | t = t^*\} \equiv C_{t^*}$ t^*: Partial sum containing data applicable to a specific season() among collected data (C). For example, when =S, among the collected data, those that responded "spring" as color preference are expressed.

$D_{t^*}(x)$: Distance between physical color (x) of the person whose season type is to be diagnosed and the applicable season (t). For calculating the distance, Weighted Euclidean distances between physical color (x) and each data collected for applicable season in the feature space were computed and distance with the nearest neighbor was used.

$$dist(x, c_t^i) = \sqrt{\sum_{m=\{Skin, Hair, Eye\}} \left(\alpha_m \sum_{n=\{R,G,B\}} (x(m,n) - c_t^i(m,n))^2 \right)}$$

Physical area (Skin, hair, eye).

α_m α_{skin} α_{hair} α_{eye}: Weight by physical color. By determining the weight skin(), hair(), eye(), the weight each physical color takes up when determining the distance can be controlled differently.

$x(m,n)$ $c_t^i(m,n)$ c_t^i, : Among the specific physical color (x) and collected data, one color() signifies one dimension among each of the colors that is expressed in 9 dimensions (three color types and three RGB).

m signifies the type (among 3) of physical color, and n signifies one of RGB (among 3).

● Estimating Season Type for Query Color

Fuzzy membership function was designed by using the logic that the closer the distance between query color and season type sample in feature space, the higher the degree of membership will be.

Fuzzy membership function was used by fixing the reciprocal of distance with each season type as the sum of all reciprocals.

Also, a coefficient (α) that controls sensitivity was used to decrease the risk of the fuzzy membership function placing weight on a single specific sample.

$$p(t^* \mid C) = \frac{\left(\frac{1}{D_t(C)}\right)^{\alpha}}{\sum_{t \in T}\left(\frac{1}{D_t(C)}\right)^{\alpha}}$$

$p(t^* \mid x)t^*$: A fuzzy membership function for a single season type () for a specific physical color (x) of the individuals. Fuzzy membership function was used by expressing the reciprocal of the distance between each season type as the sum of all reciprocals.

Also, a coefficient () that controls sensitivity was used to decrease the risk of the fuzzy membership function placing weight on a single specific sample.

4. Experiment and Results Analysis

4.1 FPCS test

Fuzzy function style used in this test is the non parametric estimation using the nearest neighbor algorithm.

(Fig. 5. FPCS Simulation)

4.2. FPCS Results Analysis

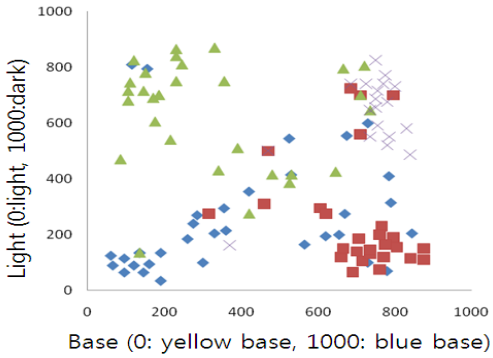
Based on the logic that personal color elements, which are colors of the individual, are determined by skin, eye, and hair colors the following experiment was conducted in order to verify that skin color has discrimination in determining the color mix of the 4 season type by comparing those that were diagnosed by the FPCS system and the three elements that were diagnosed using their eyes.

For FPCS system test analysis, Leave-one-out Cross-Validation technique was used[9].

This is a verification method of using each collected sample in the training set with the exception of the applicable sample.

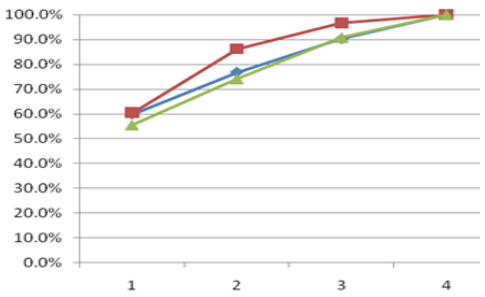
The result of analysis using this method revealed that when distribution of skin color by 4 season types is observed, skin color distribution is grouped uniformly based on the person's season type as seen below.

(Table 3.Skin color distribution by season type)



The horizontal axis signifies the base color, and the vertical axis signifies brightness.

(Table 4. Accuracy of season type diagnosis)



When these season type color mix decision results are observed, rank 1 season type percentiles were 60.3% for the specialist 1, 55.6% for the specialist 2, and 59.8% when all data were used.

Also, when cases upto rank 2 are observed, the percentiles were 82.6% for the specialist 1, 74.1% for the specialist 2, and 76.8% when all data were used.

(Table 5 Season type diagnosis result)

Data Rank	Use of All (112)	Specialist group 1 (54)	Specialist Group 2 (58)
1	59.8%	60.3%	55.6%
2	76.8%	86.2%	74.1%

3	90.2%	96.6%	90.7%
4	100%	100%	100%

When above results are examined, it experimently verifies that skin color has discrimination in determining the season type color mix.

4.3. Comparison of existing method and FPCS

The result of analysis using this method revealed that when distribution of skin color by 4 season types is observed, skin color distribution is grouped uniformly based on the person's season type as seen below. When the FPCS proposed in this study and existing color diagnosis system are compared and analyzed, existing personal color diagnosis system has low functionality, affordability, originality, and reliability, but familiarity between the person conducting the diagnosis and one receiving the diagnosis is high.

In contrast, FPCS of this study has high functionality, affordability, originality, and reliability, but it is difficult to expect familiarity between the program and the user.

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5. Conclusion and Future Study Objective

The FPCS program proposed in this study is able to produce rapid and accurate results without the complex processes of existing color diagnosis therefore it is convenient and can save time and money.

Also, it can not only be used by specialists but also by anyone for basis personal color self diagnosis.

If additional study is conducted, database of sufficient size is built through testing, and based on it, further studies are accomplished, a more effective development of diagnosis system can be anticipated.

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