A Skin and Clothes Matching Seeded by Color System Selection

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Abstract

This work has designed an automated system to recommend clothe for people based on their skin. Skin colors from various races were related with a variety of clothing colors to obtain their harmonization value. This research involve 30 respondents through questionnaire to provide initial views to a variety of colors to match the skin color variation. Input from the respondents is then analyzed to choose the right color system to be linked with skin color. To determine the relationship between skin color and clothes color fuzzy logic rules were used. The system was then tested again to 30 respondents. The results showed that variations in skin color and clothing are best on a combination of Cr and Saturation.

Keywords: skin color, clothes color, harmonization

1. Introduction

The clothe colors chosen and sed by person can indicate many things. For instance: it can support someone's appearance, make the skin become more brilliant, make a person feel more relaxed and can be used as one aspect in determining one's personality

Currently, the harmonization of clothe and skin colors is determined by conjecture aspects, or propriety that the accuracy is still relatively low. In that case, harmony in clothes could be matched according to someone but it looks tacky by others. Therefore, it required a certain method in determining the compatibility with a system that can be used to accurately and are universal. Since the difference of human skin color will have a different level of harmony to any color of his clothes, this technology was adapted to the characteristics of human skin color.

Two important points to create the suitability of one's clothing were skin color classification and human race determination. Skin color identification and the determination of a person's race can be done by several methods such as region-based methods [1], skin color clusters using neural network [2, 3], and neural fuzzy [4]. Subsequently, the suitability of clothes colors can be determined using least square fitting method [7], making the design of intelligent systems to create an efficient and effective clothes [8] and production automation in a corporate fashion garment using fuzzy logic [9].

The purpose of this research was to determine the level of compatibility of clothes colors with one's skin color. We made an automated system to determine the highest levels of color suitability between skin and clothing. The new approach offered in this research was: the connectivity between the fuzzy membership functions of skin color and clothing. The system will recommend an appropriate color of clothes when the type of skin color was detected by input camera. In this research, we used fuzzy logic method to match the variation of skin color input with its appropriate clothes. We analyzed a lot of data input from 30 respondents that gave their valuation by questioner sheet to determine the suitability color space model. Then, we created a fuzzy membership function of this color model and design its correlation with skin color membership function by fuzzy rule systems. Finally, we obtained three of the most harmonious clothes colors for each skin color.

2. Research Method

This study consisted of several stages: The first stage was human skin color classification. In this stage, 30 skin color samples of human were tried out to classify them into three races based on their color models. We fixed the YcbCr color model. From, these race classification, the fuzzy membership functions was determined to make a rules of fuzzy.

The suitability of skin color variation was designed with clothes as a second stage. A questionnaire was distributed that contained a lot of images of various human races with a wide variety of clothes colors to 30 respondents. Each respondent was given 30 variations of a common color of clothing worn by the people for each type of skin color. Respondent gave ratings of 1 to very mismatched and 10 for very harmonious. The three highest score results of total respondents was ranged as a dominant color of each skin color.

The third stage was the relationship design between human skin colors with the color of clothing. The selected color model (RGB, HIS or YCB Cr) which is suitable for the clothes, then created each of its fuzzy membership function and the appropriate rule for this system. Finally, the relationship of fuzzy rule between fuzzy membership function of skin color and clothes were designed to get the best suitability index. This index is needed to select an appropriate clothes color with the various insert skin color. The suitability index was differentiated between men and women clothes.

2.1. Color Models and Skin Color

Color models provide a standard way to specify a particular color, by defining a 3D coordinate system, and a subspace that contains all constructible colors within a particular model. Any color that can be specified using a model will correspond to a single point within the subspace its defines.

2.1.1. RGB

The most commonly used and popular color space is RGB. However, this space presents some limitations: (i) the presence of a negative part in the spectra, which does not allow the representation of certain colors by a superposition of the three spectra, (ii) the difficulty to determine color features like the presence or the absence of a given color, and (iii) the inability of the Euclidean distance to correctly capture color differences in the RGB space.

A color in this space is represented by a triplet of values typically between zero and one and is usually scaled by 255 for an 8-bit representation. Each color can be broken down into its relative intensity in the three primaries corresponding to the spectral response of one of the three types of cones present in the human eye: red, green and blue. The space is easily represented as a three dimensional cube where each axis represents the strength.

2.1.2. YCbCr

YCbCr is a family of color spaces used as a part of image pipeline in video and digital photography B and CR are the blue-difference and red-difference chroma components. Y (with prime) is distinguished from Y which is luminance, meaning that light intensity is non-linearly encoded using gamma correction [12]. The Y in YCbCr denotes the luminance component, and Cb and Cr represent the chrominance factors .In YCbCr, the Y is the brightness (luma), Cb is blue minus luma (B - Y) and Cr is red minus luma (R - Y) [5]. If R, G and B are given with 8 bit digital precision, then YCbCr from digital 8-bit can be obtained from RGB coordinate using a transformation matrix as illustrated in Equation (1). When representing the signals in digital form, the results are scaled and rounded, and offsets are typically added. For example, the scaling and offset applied to the Y component per specification results in the value of 16 for black and the value of 235 for white when using an8-bit representation. The standard has 8 bit digitized versions of Cb and Cr scaled to a different range of 16– 240 [4].

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 64.481 & -37.757 & 112 \\ 128.553 & -74.203 & -93.786 \\ 24.996 & 112 & -18.214 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \tag{1}$$

2.1.3. HIS

The HSI color model is also based on the characteristics of the human's visual system. I denotes the light intensity, H denotes the hue that indicates the measure of the color purity, S is the saturation (the degree of a color permeated the white color). If a color is with high saturation value, it means the color is with the low white color. The relationship between HSI and RGB can be described as [15]:

$$\theta = \cos^{-1} \left\{ \frac{\frac{1}{2}[(R-G)+(R-B)]}{[(R-G)^2+(R-B)(G-B)]^{\frac{1}{2}}} \right\} \tag{2}$$

$$I = 1 - \frac{3}{(R+G+B)} \tag{3}$$

$$S = 1 - \frac{3}{(R+G+B)}[\min(R,G,B)] \tag{4}$$

2.1.4. Skin Color

The aim of skin color pixel classification is to determine if a color pixel is a skin color or non-skin color. Good skin color pixel classification should provide coverage of all different skin types (blackish, yellowish, brownish, whitish, etc.) and cater for as many different lighting conditions as possible.

Skin color is one of the characteristics of human identification and human race classification. Skin color has a high sensitivity to changes in light. Therefore, the alteration of skin color image from RGB space to YCbCr model was very suitable for detecting skin color due to the influence of luminance can be eliminated during the image processing [10, 11].

In general, human skin can be grouped into 3 main races: skin blackish, brownish and whitish [9]. But in this research, the skin color are classified into caukcsoid, mongoloid and negroid. The Skin-color distribution and Gaussian distribution in Cg-Cr space are shown Figure 1.
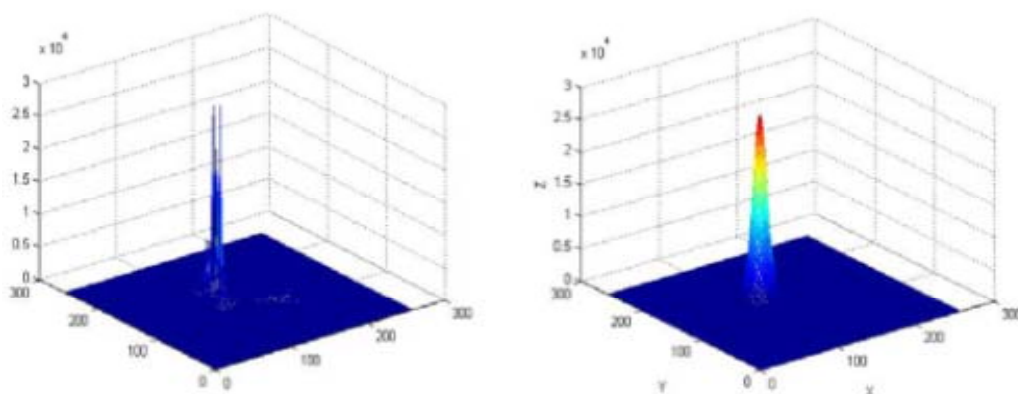

Figure 1. Skin-color distribution and Gaussian distribution in Cb-Cr space [14]

Commonly, the harmonization of skin and clothes color indicated the compatibility of a person's appearance.

2.2. Fuzzy Logic

Fuzzy logic has a continuous value, which can be expressed in degrees of a membership. The membership functions used in this research was the triangular membership function curve which was shown in the following equation [13]:

$$f(x,a,b,c) = \begin{cases} 0 & x < a \\ \dfrac{x-a}{b-a} & a \le x \le b \\ \dfrac{c-x}{c-b} & b \le x \le c \\ 0 & x > c \end{cases} \qquad (5)$$

This fuzzy membership function was illustrated in Figure 2 below:
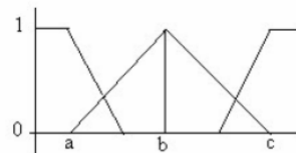

Figure 2. Triangular fuzzy membership function

3. Results and Analysis
3.1. Skin Color Range
Skin color range was obtained by analyzing of 30 skin color samples, as shown the table below. This result was somewhat different from previous studies [4, 6].

Table 1. Range of skin color in the YCbCr color system

Type of skin	Y	Cb	Cr
kaukasoid	180-216	197-250	189-200
mongoloid	134-186	160-203	155-192
negroid	80-140	100-166	100-165

Furthermore, from these values, we created their fuzzy membership function as illustrated in Figure 3 below:
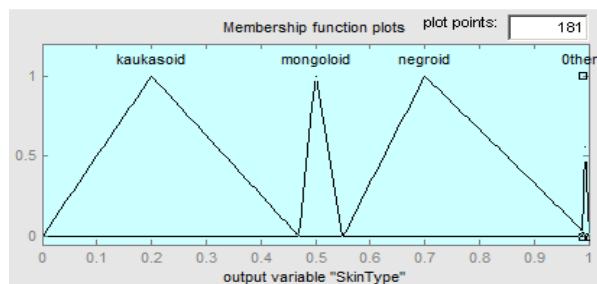

Figure 3. Skin color fuzzy membership function [6]

3.2. Questionnaire Results
Five highest score of harmonization between skin color and clothing from 30 respondents described in Figure 4 and 5 below.

Three higest score form each condition described by Figure 4 and 5 were used to analize of harmonization color between clothe and human skin. From the graph above, there are differences in harmony clothing color for male and female on the same type of race. This can be understood as the level of propriety clothes between female and male is different. The dominant clothing color for female in black in the harmony of the various races. For male, the blue clothing color was dominant in the harmony of the various races. These colors become a reference for creating fuzzy membership functions in each gender.
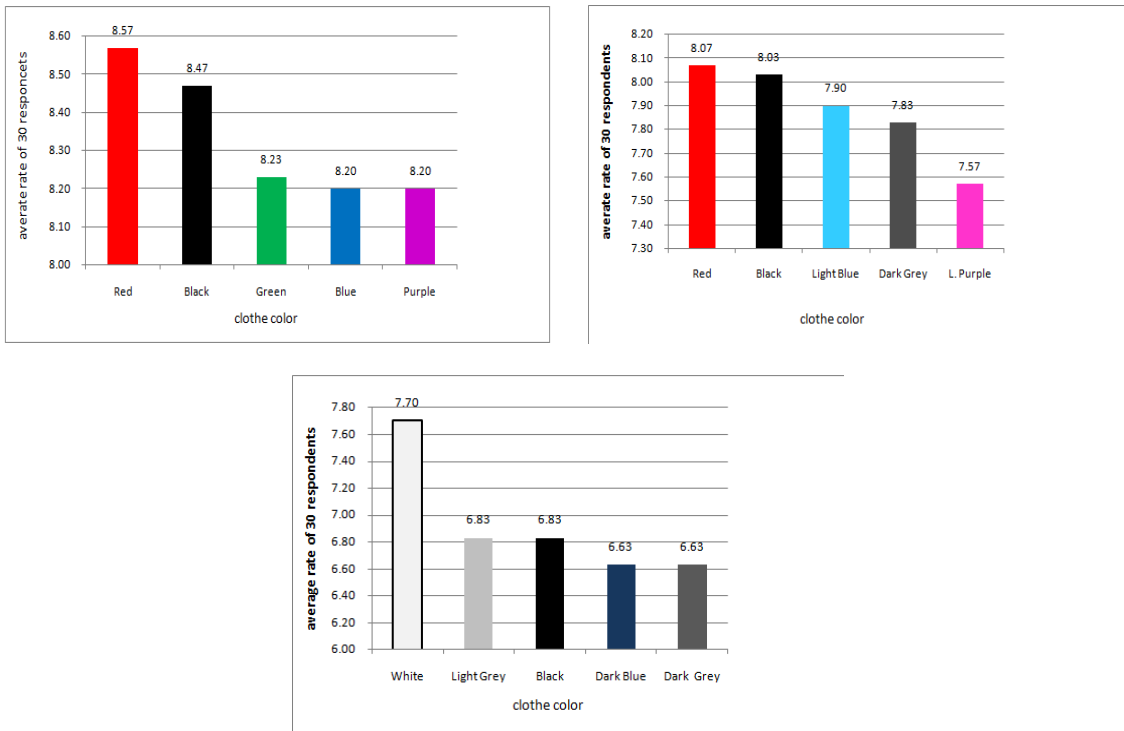
Figure 4. Five highest score of harmonization between clothing and female (a) caucasoid, (b) mongoloid, (c) negroid
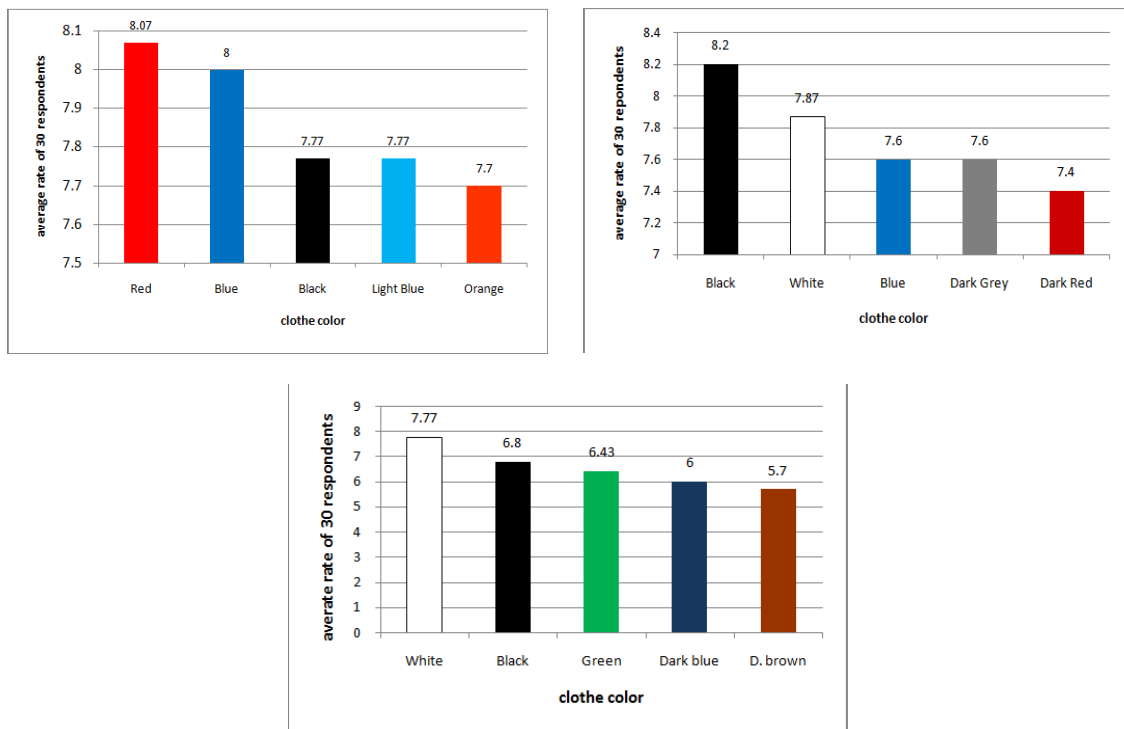

Figure 5. Five highest score of harmonization between clothing and male (a) caucasoid, (b) mongoloid, (c) negroid

3.3. Clothing Color Model Selection

We analyzed a harmony level of skin color and clothing that obtained from respondent by calculating the clothe colors distribution in each color model (RGB,HSI, YcbCr). Then, we select an appropriate color model to relate with skin color. The results were shown as Table 2 and 3.

Table 2. Various female clothes color model

Skin Type	Textile Color	R	G	B	H	S	I	Y	Cb	Cr
	Red	206	18	51	350,532	80,01	92	84	151	208
Kaukasoid	Black	35	37	34	100,0000	3,79	35	47	143	128
	Green	46	130	67	134,4240	43	81	100	158	128
	Red	206	18	51	350,5320	80,01	92	84	151	208
Mongoloid	Black	35	37	34	100,9080	3,79	35	47	143	128
	Darkgrey	95	102	110	211,8960	18,63	163	103	176	128
	Black	35	37	34	100,9080	3,79	35	47	143	128
Negroid	White	239	241	238	100,9080	0,56	239	222	232	128
	Light grey	151	147	158	233,9280	3,23	151	143	198	128

Table 3. Various male clothes color model

Skin Type	Textile Color	R	G	B	H	S	I	Y	Cb	Cr
	Red	206	18	51	350,532	80,01	92	84	151	208
Kaukasoid	Blue	3	67	132	209,988	96,27	67	64	186	128
	Orange	241	88	48	11,412	61,781	126	127	149	198
	Red	206	18	51	350,532	80,01	92	64	186	128
Mongoloid	Black	35	37	34	100,908	3,79	35	47	143	128
	White	239	241	238	100,908	0,56	239	222	232	128
	Black	35	37	34	100,908	3,79	35	47	143	128
Negroid	White	239	241	238	100,908	0,56	239	222	232	128
	Light grey	151	147	158	233,928	3,23	151	143	198	128

From the sixth figures above, HSI color system had a regular value obtained between the results of the color groups according to the type of skin colors for both women and men is the HSI color space, while in another color space values are not regular and overlap. In that case, the color of clothes in this research were converted into HIS.

3.4. Fuzzy Rule

A rule of fuzzy was fixed based on range of the output fuzzy system membership function index. In this research we obtained the caucasoid skin color had the output fuzzy system membership function index in the range of 0 up to 0.5. The mongoloid skin color had the output fuzzy system membership function index in the range of 0.5 up to 0.7. Finnaly, the negroid skin color the caucasoid skin color had the output fuzzy system membership function index more than 0.7. For example if we had pixel skin with Cb = 167 and the output fuzzy system membership function index of clothes color saturation = 0.5, so it would get the value of output = 0752. This value indicated that the relationship between skin color Cb = 167 and clothes at saturation = 0.5 will be suitable for negroid skin color. The complete rule fuzzy system was shown in Figure 6.
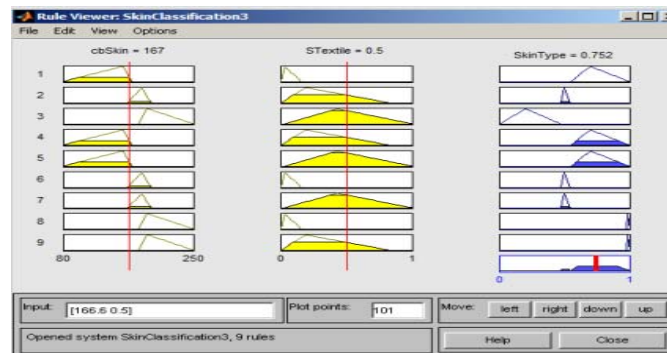

Figure 6. Fuzzy rule output system [6]

3.5. Index of Harmonization
The harmonization index of skin color to color clothes in the system was illustrated in Figure 7 and Figure 8.
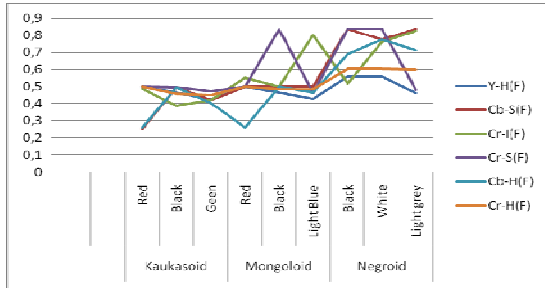

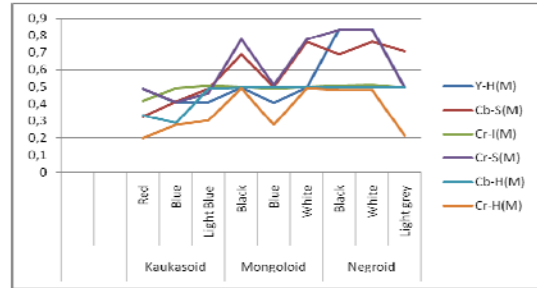Figure 7. Harmonization index of female [6]

Figure 8. Harmonization index of male

From the figures, the most stable system is the combination of Cb-S. The best result of the system was obtained if we set the skin color in Cb membership function and clothing color in saturation membership function on their relationship. Otherwise, poor result is the combination of Cr-I color matching system. This result occurred because the range values of Cr was not stable for all skin tones while the values of Intensity clothes color almost the same for all condition.

3.6. System Evaluation
System evaluation was performed by inserting 24 other various skin colors. We obtained a suitable clothing color closed to experimental result. The results of this evaluation were shown Figure 9.
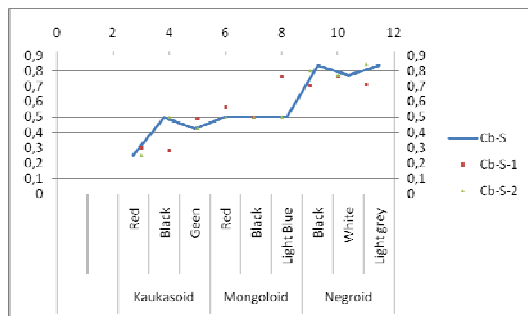
(a)
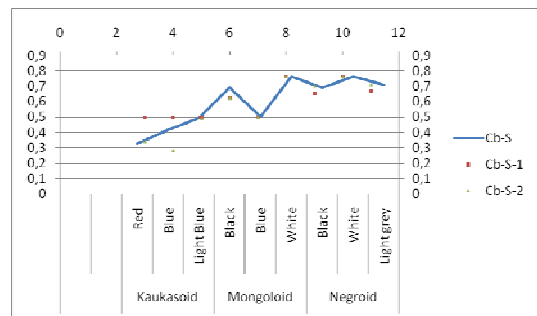
(b)

Figure 9. Evaluation result (a) female [6], (b) male

The evaluation results showed that the system was run well. It can be seen from most of the output value is in the range desired output.

4. Conclusion
This work has proposed an automatic correlation system of skin color variations to recommend the appropriate color of clothing. The system also successfully managed to separate the compatibility level clothes by sex. Relative element and subjective assessment in this research were eliminated by the number of respondents who used the results of research and testing back to the respondent.

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