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A Study of Color Transformation on Website Images for the Color Blind

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***Abstract*—**In this paper, we study on color transformation method on website images for the color blind. The most common category of color blindness is red-green color blindness which is viewed as beige color. By transforming the colors of the images, the color blind can improve their color visibility. They can have a better view when browsing through the websites. To transform colors on the website images, we study on two algorithms which are the conversion techniques from RGB color space to HSV color space and self-organizing color transformation. The comparative study focuses on criteria based on the ease of use, quality, accuracy and efficiency. The outcome of the study leads to enhancement of website images to meet the color blinds' vision requirements in perceiving image detailed.

***Keywords*—**Color blind, color transformation, HSV (Hue, Saturation, Value), RGB (Red, Green, Blue).

I. Introduction

A. Color Blindness

ACCORDING to Oxford dictionary, color blindness is the inability to distinguish certain colors under bright illumination. Even though color works well for most of the people, there are around 8% of males and less than 1% of females have faulty color perception from birth [4]. Many people think that those who are color blind people can only see black and white, just like the old days watching black and white movies [1]. This thinking is a very big misconception and it is not true at all. This is because it is extremely rare to be totally color blind.

There are many types and degrees of color blindness. It is more accurately called color vision deficiencies. The most common category of color blindness is called red-green color blindness such as protanopia, protanomaly, deuteranopia and deuteranomaly [3]. It cannot be concluded that these group of people cannot see the red or green color. They just have the difficulty in differentiating between these two colors because not all reds and greens are distinguishable. For example, they can easily tell the difference between light green and dark red. But it would be hard and confusing for them to tell the difference if the red color is approximately as dark as the green. Another problem with red-green color blindness people is they see red and green color as yellow, orange and beige in color. Therefore, they will confuse whether the color is the real yellow, orange and beige color or is the red and green color. The least affected color is the blue color.

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B. Background of the Problem

Nowadays, there is color blind glasses which are the main instrument prescribed for color deficiencies people [3]. The function of these glasses is a very simple way of filtering the colors to help them to differentiate certain specific colors such as red and green color. Although these glasses seem like can be easily helping them to see the colors, it can cause other color confusion.

Besides that, Color Vision Assist System helps color blind people in recognizing the color of the traffic lights. The system consisted of a small camera, image processing unit and wearable display which can monitor real-time like a single eye-glass [4]. The image is captured in RGB color space and then converted into HLS color space. For example, the red color of the traffic lights is captured by the camera and the system converts the color to become magenta color. Therefore, when red-green deficiencies people look at the lights, they can see the blue color and they know that the red color light is on.

Visual Auxiliary System also helps those who have color vision deficiencies to improve their color vision. It will undergo a compensation processes such as linear or nonlinear image scaling, edge and contrast enhancement, color coordinate transformation and histogram modification [2]. The compensation processes are done depends on the types of color deficiencies the users are. Therefore, the output of the image will based on the types of deficiencies that users suffer with.

C. Statement of the Problem

A major problem of color blind people during assessment on the websites is color differentiation. This is because they cannot differentiate between certain colors such as red and green color or blue and yellow color. For example, they cannot even recognize anything on an image with red color text on green background.

The main reason they face with difficulty during assessment of websites is because color blindness is mostly neglected by public. Many people do not consider being color blind is a serious problem [1]. This is because they still can see things in this world. In fact, color blind people are classed as disability group of people. Therefore, there is not much concern put on their situation and difficulty.

Another reason is that people are concerning about the safety of these group of people especially in traffic lights recognition more than web accessibility. Most of the researches are done in the traffic lights applications. Less works are done in website application for color blind people. Therefore, they still face difficulty during assessment of the websites.

Other than that, during the website development, developers care much more on the design of the website. Usually the website is a colorful design in order to make it more attractive to people. They are less likely to think about the difficulty of the color blind people to see the colors during their assessment of the websites.

D. Objectives

The main objective of this study is to do comparative study on two color transformation techniques that are the conversion technique from RGB color space to HSV color space and self-organizing color transformation.

E. Importance of the Research

This study is important to show concern on color blind people so that these groups of people would not feel they have been neglected or ignored by public. It helps to let public know the difficulty of them when dealing with colors. Besides, this study also helps to remind the website developers to concern about them while developing the websites.

The study plays an important role in helping color deficiencies people to have a better visibility on colors on the images in the websites. It helps them to see less beige color on the image because these colors will be transforming into other visible color for them. The image will become more attractive as beige color looks very dull compare to other colors.

F. Scope of the Research

The study mainly focuses on the color transformation techniques. These techniques transform the colors of the image into visible color space for different types of color deficiencies people. It is due to different types of color deficiencies have different visible color space.

The technique of converting RGB color space to HSV color space requires sequence of steps. First, the algorithm searches the color space which color blind people unable to differentiate the colors. For example, it searches for red and green color space for red-green color blindness or blue and yellow color space for blue-yellow color blindness. Then, it scans pixel by pixel of the image to detect the color space. Once the color space is detected, the algorithm determines the RGB value of that pixel and transforms it into other color space that is visible to the color blind people.

G. Contribution

The comparative study determines a better algorithm which will be implemented on websites to help color deficiencies people to be more accessible on the websites. Even though the system cannot improve the visibility of color deficiencies people perfectly, but at least it can improve their visibility on colors as they can differentiate the colors.

H. Limitation and Assumption

Many people think that being color blindness is not a serious problem, therefore it is not been highlighted enough in this area. There is not much works are done in improving the vision of color deficiencies people. The function basically is applied on the traffic lights recognition but not on the website application.

There are some existing algorithms in this area such as the conversion technique from RGB color space to HSV color space and self-organizing color transformation. But there may be some other algorithms which researchers did not publish their papers or journals.

II. Literature Review

A. Introduction

A Visual Auxiliary System helps color blind to see an image clearer. The system transfer different colors to the color gamut that these groups of people can identify. It is a user-friendly, portable and integrated visual function aid system that can co-operate multiple visual compensation subsystems for vision defects. With the real-time image processing algorithms, the system is able to detect and construct the user's perceptual model and then meet their vision requirements by compensating the input visual information thus to fit their vision models [2]. Experimental results for this technique show that it deed help color blind and weak color level identification people in perceiving the image detailed. The system structure and algorithm help them to improve their life quality and have a better communication with the world especially in this IT era.

Self-organizing color transformation helps color blind people to discriminate colors better. This technique utilized the redundancy of color information and change the colors of the image into identifiable by color blind people. The self-organizing map (SOM) algorithm is used to build a nonlinear color map, maintaining the neighboring relations between colors [3]. The results of this method show that it can effectively enhance the color discrimination for color blind people.

B. Conversion Technique from RGB Color Space to HSV Color Space

This conversion is used to transfer different colors to the color gamut that the color blind people can identify by using color level conversion. There are high-saturation colors, mid-saturation colors and low-saturation colors in an image. The area with high-saturation color is reserved and the area with mid-saturation color is replaced with the originally mistaken saturation to help color blind people identify the difference.

C. Self-organizing Color Transformation

The output color of the transformation is set by users themselves based on their preference. The output color is set in the SOM network. After the self-organizing process, the weights of the SOM networks are fixed and they are called 'codebook vectors' or 'reference vectors' [3]. Each codebook vector corresponds to one color in the original color space. On

the other hand, a new color space is created with the same size and resolution as the codebook color space. It has black and white color in two opposing corners and a smooth interpolation in between. Then the codebook color space is rotated to make its corner colors most closely related to the corresponding corner colors of the new color space.

D. Variable of Conversion Technique from RGB Color Space to HSV Color Space

The RGB colors are converted into HSV colors for color gamut transfer and separate adjustment of hues and saturation as described as follows

$$H' = H + \Delta H; \quad S' = S + \Delta S; \quad V' = V$$

where H', S' and V' indicate the corrected hue, saturation and brightness values to replace the original mistaken color's attributes HSV respectively, and $\Delta H / \Delta S$ is the hue/saturation displacement value [2] [5].

In color vision assist system, the RGB color space can be converted to HLS color space to enhance color difference depending on the defective color type [4]. For the defective area in HLS color space, the defective color space is transform to visible color space by

$$H' = H / 360 * 270 + 45$$

E. Variable of Self-organizing Color Transformation

Self-organizing color transformation flow is as shown in Fig. 1.

F. Summary

The conversion technique from RGB color space to HSV color space and self-organizing color transformation are applied in traffic lights signal recognition as researchers are more concerning about the safety of color blind people. The algorithms can be applied to website to make it more accessible to color blind people.

III. Evaluation Criteria

A. Research Procedures

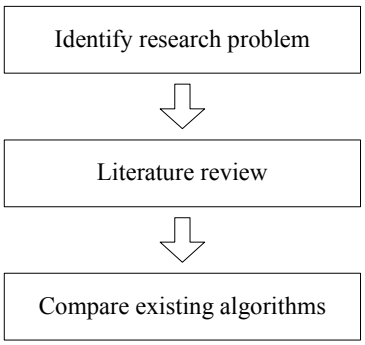

Fig. 2 Methodology

The first step of the study is identifying the difficulty of color blind people during their assessment on the websites. Their difficulties are studied through the existing researches or papers and get further information from the websites. They are unable to recognize certain color space. It would be very difficult for them to deal with colorful images.

The study continues with studying on the existing algorithms that are the conversion technique from RGB color space to HSV color space and self-organizing color transformation. These algorithms are applied in traffic lights signal recognition. They help color blind people to enhance their visibility on colors.

The comparative study focuses on criteria based on the ease of use, quality, accuracy and efficiency on the existing algorithms. The outcome of the study for each criterion will be discussed in the next section.

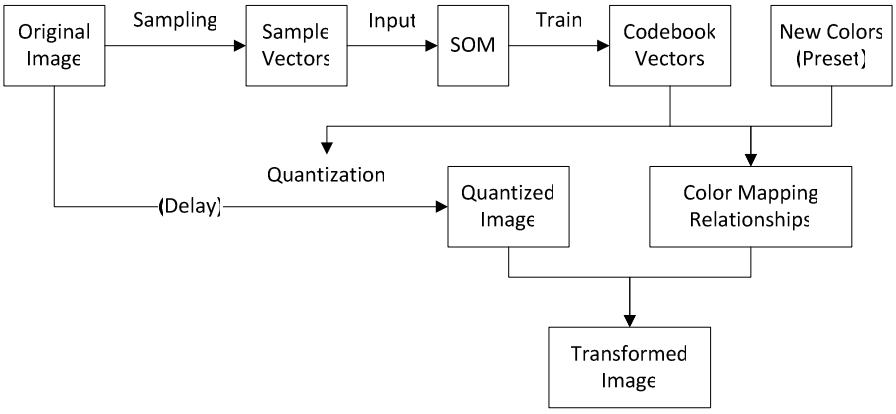

Fig. 1 The flowchart of the self-organizing color transformation [3]

B. Outcome of the Study

TABLE I
COMPARISON BETWEEN TWO TECHNIQUES

Criteria	Conversion technique from RGB color space to HSV color space	Self-organizing color transformation
Ease of use	Both algorithms are easy to use. This is due to the reason that both algorithms come to the same purpose that is helping the color blind to improve their color visibility. Both algorithms make the images easy to see for the color blind.	
Quality	The color image produced is clear. The color blind can see the signal of the traffic lights clearly.	The color image produced is clear. The color blind is able to recognize the edge between two different colors on the images because they can differentiate the colors.
Accuracy	This algorithm is accurate for normal people because the red color and magenta color almost the same. It is not accurate for the color blind because they see red as beige and magenta as blue.	This algorithm has same accuracy for both normal and the color blind. They see the images in the same result. The algorithm makes the color become weird for normal people, but they can know the way the color blind look at the images.
	Both algorithms do not produce high accuracy images. This is due to the conversion made has change the nature of the color. For example, the color blind see the red roses become blue roses.	
Efficiency	This algorithm is efficient on traffic lights signal only. Therefore it is less efficient on more complex color images.	This algorithm is more efficient because it helps the color blind to have a better vision on more complex color images.

IV. CONCLUSION

From the outcome of the study, self-organizing color transformation algorithm is better than the conversion technique from RGB color space to HSV color space algorithm. It is more suitable to deal with more complex color images especially from the websites.

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