

# Development of a Coloration Support Tool for Making Web Page Screens User-Friendly for Color Blind

Michiko Anse and Tsutomu Tabe

Aoyama Gakuin University, Department of Industrial and Systems Engineering,  
5-10-1 Fuchinobe, Sagami-hara-city, Kanagawa, Japan  
{anse, tabe}@ise.aoyama.ac.jp

**Abstract.** Websites are providing more and more information because of their convenience. Information is often discriminated by color vision ability between individuals. Some people cannot discriminate information depending on the coloration. In these cases, information cannot be correctly discerned. Therefore, the development of a supporting tool for configuring screens is needed.

**Keywords:** color blind, web page, coloration support tool.

## 1 Introduction

Difference in color vision between individuals is caused by three types of nerve cells (cone cells that absorb different wavelengths). Persons who have normal chromatic vision perceive color with all three types of cone. Color deficient observers perceive colors at different levels depending on the status of impaired cone function. Color deficient observers include protanopes (red cone does not function), deutanopes (green cone does not function) and tritanopes (blue cone does not function), which, when only two colors are perceived, is called dichromatic vision. Color deficient observers account for 5% and 0.2% of East Asian males and females, respectively. They account for 8% and 4% of Caucasian males and black males respectively. According to the ratio, one out of 20 Japanese is color deficient, which is a considerable number [1, 2].

Information collection is indispensable in daily life. The spread of the Internet is allowing websites to provide more and more information. The use of colors is effective for emphasizing information to be provided because colors increase image discrimination. Therefore, colors are widely used in websites. However, information dispensed by colors may not be passed on correctly because color vision varies between individuals. We should thus use picturesque colors for passing information, and this information should be able to be understood even by color deficient observers.

## 2 Methods Offering Support to Make Color Web Page Screens That Can Be Discriminated by Color Blind

### 2.1 Methods to Simulate Color Vision

There are two main methods to simulate the vision of color deficient observers. The first method is to look through a filter to simulate imperfect color vision or to use a

liquid crystal display monitor with a color vision simulating function. The second method is to convert normal color vision to anomalous color vision via VsCheck software, etc, after reading a file on a personal computer. By these methods, we can see what normal color vision looks like when converted into abnormal color vision, allowing us to realize how color deficient observers see things and find our extensive use of colors confusing.

## **2.2 Methods for Detecting Confusing Colorations**

Uding (software) can detect confusing colorations displayed by simulation software and change the coloration [3]. ColorSelector (software) determines whether or not a specified combination of colors can be discriminated by color deficient observer [4]. They modify already existing files or determine whether two chosen colors can be discriminated or not. Therefore, they have a disadvantage in that they can be used only after files have been created or require time-consuming work to investigate whether two colors chosen from many combinations can be discriminated.

## **2.3 A Method for Supporting Coloring-Decisions When Making Web Page Screens**

Using a color vision simulator or ColorSelector for determining coloration when creating web page screens, is quite troublesome. Therefore, the author has devised a tool that supports the determination of coloration when making web page screens, and has created and verified the prototype.

# **3 Functions of the Web Page Screen Coloration Support Tool**

It should be provided as an add-in function of web page creation software. A user selects an area requiring the support of coloration during the creation of a web page. Then, the user calls up the coloration support tool. The functions of the tool consist of “Select color,” “Diagnose” and “Display.” The user can determine coloration with the consideration of color deficient observers by calling up this tool and reflecting the coloration on the screen.

This tool helps a user make colorations so that two colors on a background color can be discriminated by color deficient observers. This tool has two modes, one for characters and the other for illustrations only.

## **3.1 “Select Color” Function**

A user can select a background color and two colors on the background color from color palette tabs. Each color palette has 216 colors called web-safe colors that appear as almost the same color on both Windows and Macintosh. A user can specify a color he/she wants to use by clicking a color on the color palette or drawing a color out of the screen by using a dropper. A user selects a combination of colors, for example, “background and character color” whose coloration the user wants to evaluate. The color of any character which is inappropriate for the selected background color is

crossed out on the tab. Character colors which are appropriate for the selected background color, yet requiring some caution are checked with a triangular symbol. Color combinations which are deemed to be inappropriate for even one color vision out of the four types are also crossed out.

### 3.2 “Diagnosis” Function

In the “Select color” mode, the color palette displays whether color combinations are appropriate or not. After determining the background color, and colors 1 and 2, visibility by the four vision types is diagnosed. The result is displayed by circle (appropriate), triangle (Due consideration is required though it is not inappropriate) and cross (inappropriate).

The value of RGB of persons with normal color vision displayed on the color palette is converted to the value of RGB of the other three types of vision and saved in the table in order to diagnose colorations in the four types of color vision. The RGB value is used in the calculations listed below.

In the diagnosis, combinations of colors are determined to be appropriate if they meet certain standards (i.e., differences in brightness, luminance and color). Other combinations are determined to be inappropriate. Color combinations with a color difference of 500 or more and a brightness difference of 96 through 125 are determined that caution be exercised, though they are not inappropriate.

In WCAG, when the RGB of two colors is assumed to be (R1, G1, B1) and (R2, G2, B2), if the conditions listed below are met, the two colors are considered to be discriminated from each other concerning brightness and color difference. However, the WCAG standard is too strict and the number of usable colors becomes too small. Thus, in this study, among combinations of colors with a color difference of 500 or more, it was ascertained that the brightness difference can be alleviated to 96 in an experiment, expanding the range of options.

In WCAG, Brightness difference, Contrast ratio and Color difference are defined as these expressions (1), (2) and (3) [5].

$$\text{Brightness difference: } ((R1 - R2) * 299 + (G1 - G2) * 587 + (B1 - B2) * 114) / 1000 \geq 126 . \quad (1)$$

$$\text{Contrast ratio: } (L1+0.5) / (L2+0.5) \geq 5 . \quad (2)$$

Where

$$L1 = \max(((R1 / 255) ^ 2.2 * 0.2126 + (G1 / 255) ^ 2.2 * 0.7152 + (B1 / 255) ^ 2.2 * 0.0722), ((R2 / 255) ^ 2.2 * 0.2126 + (G2 / 255) ^ 2.2 * 0.7152 + (B2 / 255) ^ 2.2 * 0.0722))$$

$$L2 = \min(((R1 / 255) ^ 2.2 * 0.2126 + (G1 / 255) ^ 2.2 * 0.7152 + (B1 / 255) ^ 2.2 * 0.0722), ((R2 / 255) ^ 2.2 * 0.2126 + (G2 / 255) ^ 2.2 * 0.7152 + (B2 / 255) ^ 2.2 * 0.0722))$$

$$\text{Color difference: } (\max (R1, R2) - \min (R1, R2)) + (\max (G1, G2) - \min (G1, G2)) + (\max (B1, B2) - \min (B1, B2)) \geq 500 . \quad (3)$$

Fig .1. shows the methods of the diagnosis to appropriate combinations of colors.

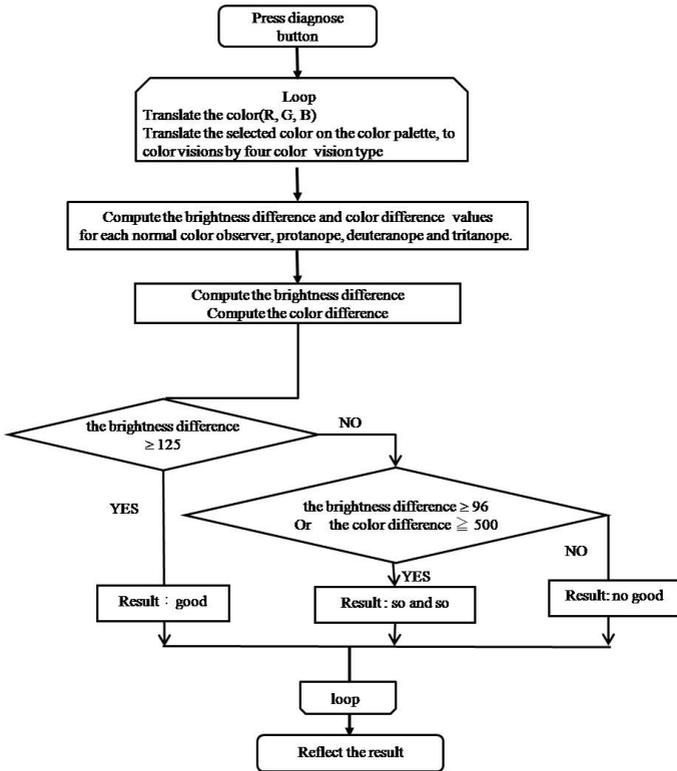


Fig. 1. The flow of the diagnosis to appropriate combinations of colors

### 3.3 “Display” Function

First, colors selected by the color palette are judged whether they are appropriate or not. Second, the vision of color deficient observers is simulated. Third, the coloration is determined to be appropriate or not. Finally, coloration of the selected area is replaced with a new one on the web page screen being created. The area that was saved is colored by the background color. The other two areas are colored by a new coloration. They are put to the original position to make an image with the new coloration.

## 4 Tools

This study has two types of coloration support tool. One is for the area including characters. The other is the area consisting of only images. The number of target areas is limited to three. If there are four or more areas, this tool must be used repeatedly. Each tool has tabs for each area. A tab has a color palette which displays whether the

coloration is appropriate or not. A user can select combinations of colors which are deemed to be appropriate from the color palette or select colors from the screen by using the dropper function. A user can understand the vision parameters of selected combinations of colors by the color deficient observers. He/she can understand whether the coloration on the selected areas is appropriate or not by the four vision types. Selected areas can be colored with the coloration.

#### 4.1 Tool for Characters

A user selects an area including a character string and background to be colored. Then, the user calls up the coloration support tool. The selected area is displayed on the tool. The coloration support tool has three tabs. The first tab is for the color of the characters. The second tab is for the background color which surrounds the color of the characters. The third tab is for the color which surrounds the background color. A user can specify a color from 216 colors from the color palette on the tab. A user can also use a dropper to select a color from the screen being created. After selecting a color, a user can display the vision seen by a normal color observer, protanope, deuteranope and tritanope by the “Reproduce defective color vision function.” The “Diagnose” function displays the evaluation (i.e., circle, triangle and cross) of the total color combination by the color vision. The “Reflect on screen” function draws the selected color combination on the selected area on the web page screen.

Fig. 2. shows the main and sub screens of the character coloration support tool.

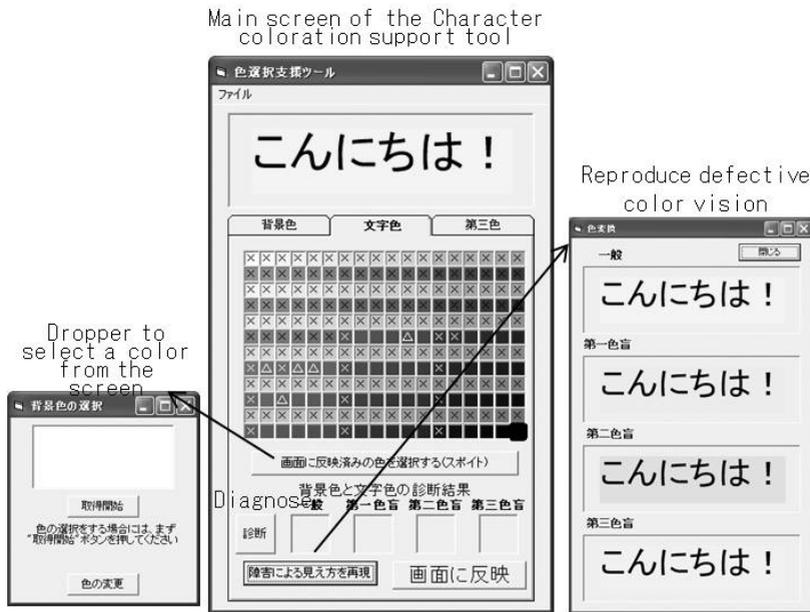


Fig. 2. Character coloration support tool

### 4.2 Graphic Drawing Tool

A user selects an area which he/she wants coloration support. Then, the user calls up the graphic drawing coloration support tool. The user selects the background color, and first and second color. Then, visibility of the two specified colors by the four color vision types is displayed on the tool. The originally selected image is displayed in a separate window. The window has three buttons denoting the defective color combinations above them. Pressing the button displays a window with the coloration corresponding to the “visibility” of each color combination. The user selects a tab and a new color to exchange with the first color. Then, selecting the second color tab displays compatibility with the new first color using symbols (no symbol, triangle and cross). The user selects a color other than the colors with the cross symbol. Presses “See all” to open a window with the selected coloration. Presses buttons in the window to check the vision by the color deficient observers. After determining a satisfactory combination, presses “Diagnose” to check the vision by the four color visions. If all color visions have no problem (circle), presses “Reflect on screen” to re-draw the coloration of the original graphic.

Fig. 3. shows the main and sub screens of the Graphic coloration support tool.

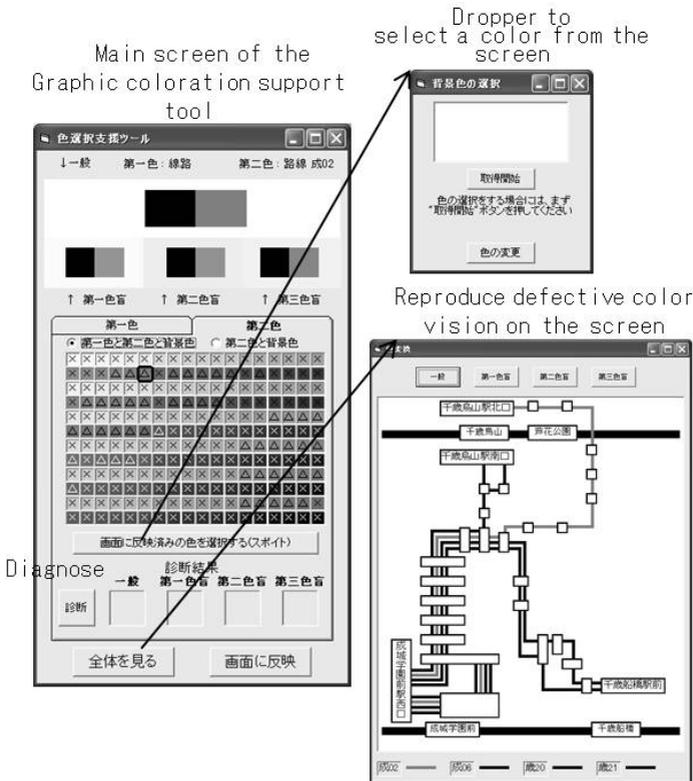


Fig. 3. Graphic coloration support tool

## 5 Verification of Effectiveness

A test was performed to draw graphics which can be discriminated by color deficient observers by using the character coloration tool and graphic drawing coloration tool. Subjects included 20 university students (males: 8, females: 12). Subjects were made to understand color vision deficiency by reading a manual. Then, they were ordered to make two screens by using the tools. After the test, the vision by color deficient observers was displayed by using a color vision simulator to check whether coloration that could be discriminated by color deficient observers was made or not. Two color deficient observers were ordered to view the screens made by all the subjects. It was proven that the coloration had no problem. Therefore, all subjects could make graphics which could be discriminated by color deficient observers. All subjects answered that the tool had supported them. Some subjects answered that the tool was difficult to use. As a result, the functions selected for developing this “web page screen preparation support tool in consideration of color deficient observers” are appropriate.

## 6 Conclusions

We are not really aware that color deficient observers account for approximately 5% of the total population. It is understood that normal color observers can enjoy rich expressions of various color while color deficient observers cannot enjoy them as readily. As W3C proposed, we should be careful not to express information that is dependant solely on colors. We should use easy tools to make coloration in consideration of color deficient observers, especially when creating highly public information websites. For that purpose, we should develop tools to support coloration in combination with existing software.

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