

Application of a New Color Universal Design Method Based on the Color Appearance of Dichromats to a Campus Map

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Abstract

It is necessary to avoid using of confusion colors of dichromats in order to mediate information defined by color in visual materials to anyone. Such a color design method is called color universal design. Dichromatic simulators have been widely used for the color universal design. Recently, a new color universal design method without a dichromatic simulator has been proposed. Yoshitake et al. made a color sample set for the new color universal design method by the Natural Color System chips containing 1948 colors. We designed a campus map using their sample set in a campus barrier-free design project at Kyushu University. We show the results of the Kyushu University barrier-free design project.

Introduction

Typical human color vision is called “trichromacy”. Trichromacy is based on the responses of three types of cone photoreceptors. However, some individuals lack one of the three

cone photoreceptor types. These individuals’ color vision is known as “dichromacy”. Who has dichromacy is called “dichromat”. Dichromats cannot distinguish colors that cause different responses in only the lacking cone type. Such colors are known as “confusion colors”, depending on which cone type is lacking.

If visual materials contain information defined by combinations by confusion color of dichromacy, the information will not be communicated to dichromats. Therefore, color universal design (CUD) seeks to avoid using confusion colors in designing visual materials. To carry out CUD, color simulators of dichromacy have been widely used in order to check whether confusion colors are contained in visual materials.

Recently, a new CUD method, which does not require dichromatic simulation, has been proposed [1, 2]. This new method is constituted by two steps. In the first step, a color combination for dichromats is determined based on the colors dichromats can distinguish. In the second step, the color combination is modified

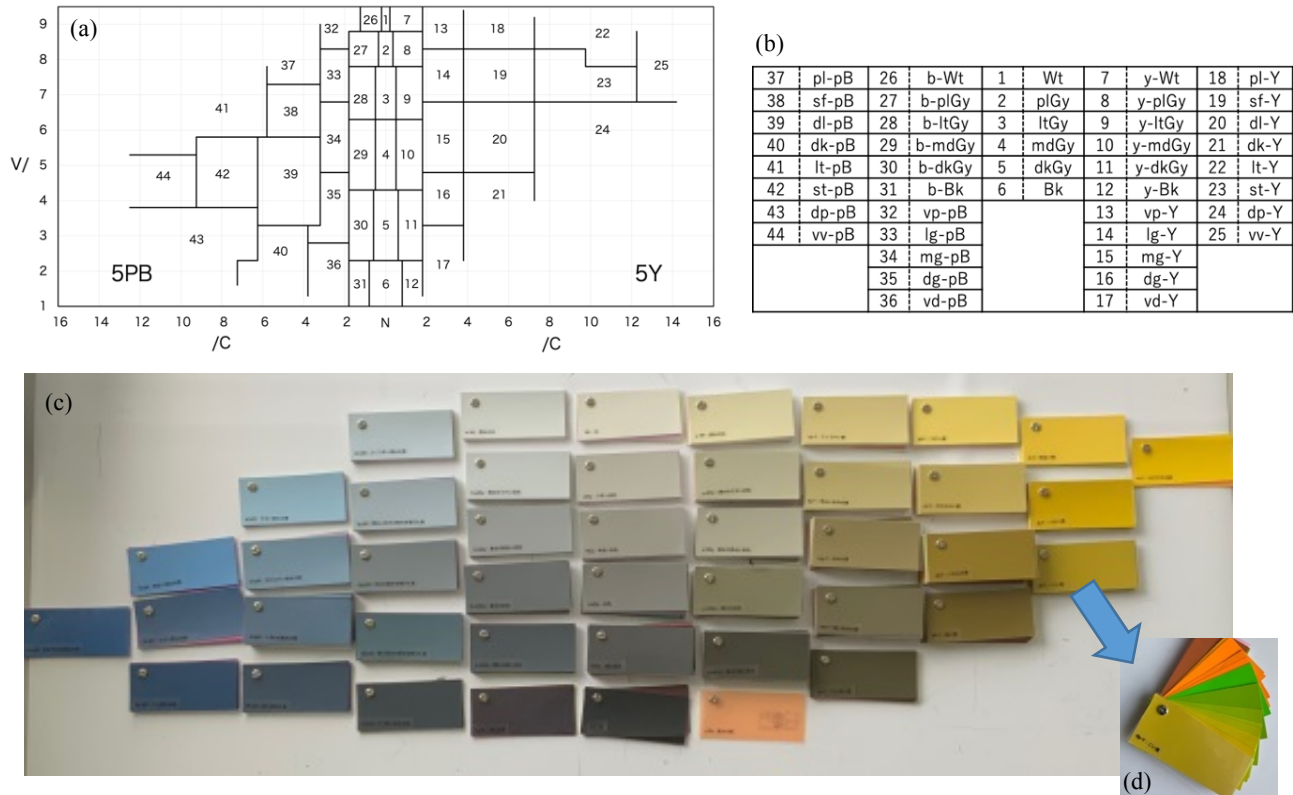


Figure 1. A Color Sample set was made by Yoshitake et al.
 (a) The region of the color name designation
 (b) The name of the color name designation
 (c) Yoshitake et al's color sample set (44 bundles)
 (d) Color chips in a category color bundle of color name designation

for trichromats by changing each color in the color combination to another color that is difficult for dichromats to distinguish. Despite these changes, the appearance of the color combination determined in the first step for dichromats is preserved, because of the color changes among the confusion colors of dichromats. However, because the protanopic and deuteranopic confusion lines do not agree, it is difficult to carry out CUD for protanopes and deuteranopes simultaneously. Although Sato has not mentioned about this disagreement of the protanopic and deuteranopic confusion lines [1], Sunaga et al. introduced an acceptable color shift based on the categories of color name designation from each confusion line in the second step [2]. Yoshitake et al. made a color sample set by the Natural Color System (NCS) chips containing 1948 colors to conduct the new CUD method [3]. The purpose of this paper is to introduce a design process of a campus map using their color sample set in a campus barrier-free design project at Kyushu University.

Features of a Color Sample set made by Yoshitake et al.

The color sample set, proposed by Yoshitake et al., was contained the 1948 NCS color chips. The CIE 2015 $x_{F}y_{F}z_{F}$ chromaticities of these color chips were calculated with the CMFs of CIE 2015 $X_{F}Y_{F}Z_{F}$ when they are illuminated by the illuminant D65.

Figure 1 shows a color sample set is made by Yoshitake et al. The sample set consists of 44 bundles. These bundles are classified by the category of the color name designation in the 5Y-N (neutral)-5PB Munsell Hue color plane. The covering color of each bundles is representative color that dichromats can perceive in each category.

The color chips contained in each bundle were separated into three parts. Color chips in one of the three belong to the identical color name designation region of both the protanopic simulation and the deuteranopic simulation. The total number of such color chips is 1107. Color chips in the second part belong in the corresponding color name designation region of only the protanopic simulation. Those in the third part belong in the corresponding region of only the deuteranopic simulation.

Application of a New Color Universal Design Method

Target Sign

Our target sign is a campus map of Kyushu university shown in Figure 2. This sign is at a main gate of Ito Campus, Kyushu



Figure 2. Target sign (the original sign)

University. The color of buildings is represented by a pale pink, the space around the building is indicated by a beige, the street is a white, the grass region is a light green, and the grove region is a vivid green.

Dichromatic Simulation of Target Sign

We applied the dichromatic simulator [4] to Figure 2 in order to check whether the CUD is conducted in the target map. Figure 3 shows the results of the simulation. The lower map of Figure 3 is the deuteranopic simulation of the original shown in the upper map. The contour of the building is obscure in the deuteranopic simulation. In addition, although the building is important information in this map, the color of buildings is not salient. Therefore, it is hard to say that the CUD has been conducted in the campus map.



Figure 3. The dichromatic simulated image
The lower map is the deuteranopic simulation of the original shown in the upper map

Coloring for Dichromats

We adopted the following two ideas as guidelines of coloring for dichromats in the first step of the new CUD method.

1. The distinction between figures (artificial objects) and grounds (natural objects) is represented by the difference in hue, that is, one is bluish, the other is yellowish.

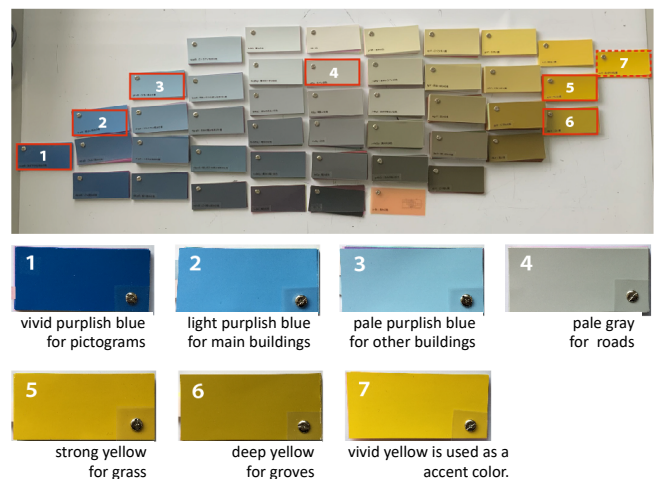


Figure 4. Assigned colors to coloring for dichromats

2. The importance of object is represented by the graduation of lightness or saturation of each hue.

As shown in Figure 4, we chose seven colors in coloring for dichromats. The bluish colors were assigned to artificial objects. The yellowish colors were assigned to natural objects, because most of natural objects was grass or groves. Yellowish colors assigned to grass or groves can be changed to greens which is the color of itself for trichromats. In addition, achromatic colors were assigned to paths and roads. The color appearance of achromatic colors is preserved to trichromats.

Change of Coloring for Trichromats

The second step of the CUD method is to determine the coloring for trichromats by replacing each color used in coloring for dichromats by other color in the identical bundle. The replacement of the colors for coloring of trichromats is shown in Figure 5. The bluish colors used as the colors of buildings were replaced by purplish colors. The yellowish greens instead of the yellowish colors were used in grass and groves. These colors were chosen the first part of each bundle. Therefore, the color appearance of the coloring for trichromats was almost preserved for both protanopes and deuteranopes. The colors of pictograms, roads, and accent were not changed.

There is one important point that we should pay attention in the second step. Because the bundles of #5 (#23 in Figure 1) and #6 (#24 in Figure 1) in Figures 4 and 5 are neighboring in the 5Y hue plane as shown in Figure 1(a), there is a possibility that the color difference between the changed colors for coloring for trichromats is not sufficiently maintained. However, in our case, the border of the #5 and #6 would be not so important because it represents the border between grass and groves.

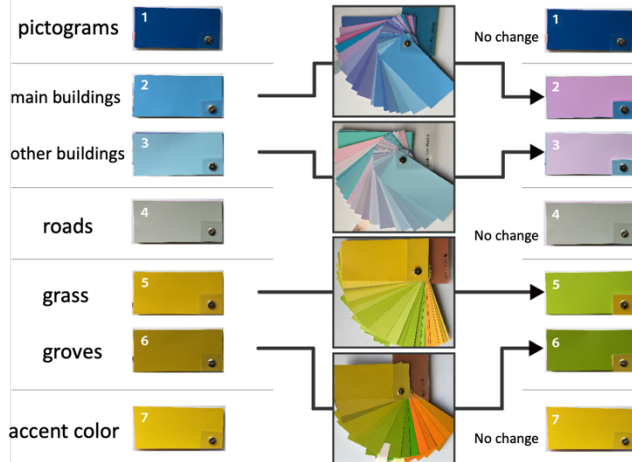


Figure 5. Replacements of colors for coloring for trichromats

Since the colors of the sample set made by Yoshitake et al. have been defined by the NCS notation, we converted the notations of fixed colors of coloring into color identification numbers of printing inks of the DIC corporation.

New Campus Map

Figure 6 shows a new campus map colored by the CUD method. The seven colors shown in Figure 7 were used in the new campus maps. In addition, a red color was used to indicate that “You are here.”

The dichromatic simulation was applied to the new campus map in order to check how dichromats perceive the new campus map.



Figure 6. The new campus map produced by the new CUD method

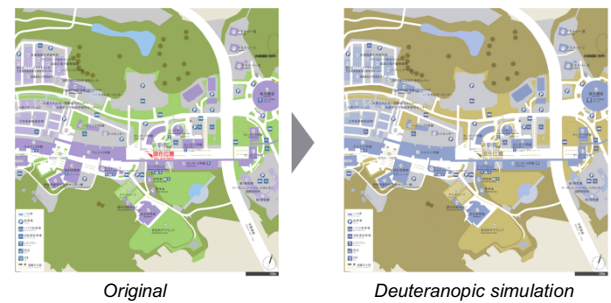


Figure 7. Verification of the new campus map by a dichromatic simulator

The result of the deuteranopic simulation is shown in the right panel of Figure 7. Any color in the map has well-defined contours. Moreover, the difference between figures (artificial objects) and grounds (natural objects) is also distinct. Each color in the simulated image are similar to that of Figure 4 or Figure 5. This suggests that the coloring for dichromats was preserved in the coloring for trichromats.

Conclusions

As an example of a campus map, we described a design process with the CUD color sample set proposed by Yoshitake et al. in this paper. We can conclude that the CUD method and the color sample set proposed by Yoshitake et al. is very useful and easy to conduct CUD. However, it is hard for ordinary designers to get the CUD sample set. Now, we are planning to develop a software which conducts this CUD method.

The campus map sign was selected to the Sign Design Association Award 2020, Japan.

Acknowledgement

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Author Biography

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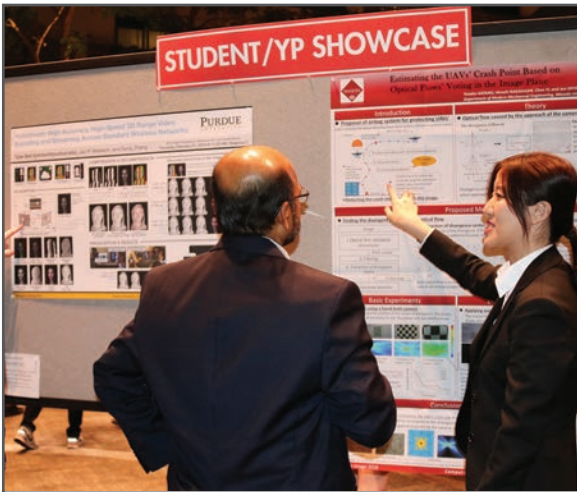
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