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Review of Color Blindness Removal Methods using Image Processing

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Abstract- **Color blindness is deficiency of color vision. Due to presence of color blindness, human eye becomes unable to differentiate colors with each other. Generally reason behind color blindness is genetic but sometimes it happens due to some damage and disorder in brain and eye. Color blindness is of many types like Red-Green, Blue-Yellow etc. Red-Green color blindness is most common type of deficiency in which person is unable to differentiate between red and green colors.**

Index Terms- **Color blindness, Image processing, color vision, red-green color deficiency, Ishihara color test, RGB, HSV.**

I. INTRODUCTION

Color blindness is a color vision problem where person is deficient to recognize colors like red, green and blue. To see something there are photoreceptors on retina of human eye, which pass information of light to the brain [1]. There are two types of photoreceptors: Rods and cones. Cones are responsible for color vision while rods are not sensitive to colors. There are three types of cones:

(i) S cones: Sensitive to short wavelength (Blue color).

(ii) M cones: Sensitive to medium wavelength (Green color).

(iii) L cones: Sensitive to long wavelength (Red color).

Due to abnormality of these cones there are three types of color blindness:

(i) **Monochromacy:** When a person has a single cone cell or no cone cells. This color blindness type is called total color blindness. It is very rare.

(ii) **Dichromacy:** When one of the three cone cells is missing.

(iii) **Anomalous Trichromacy**: When all three types of cones present but with shifted peaks of sensitivity for one of them.

Dichromacy and anomalous Trichromacy are of further three types:

(a) Protanopia: Due to absence or improper functioning of L-Cones.

(b) Deuteranopia: Due to absence or improper functioning of M-Cones.

(c) Tritanopia: Due to absence or improper functioning of S-Cones.

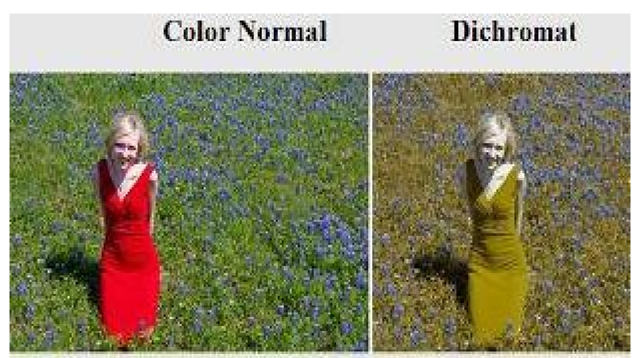

Fig. 1. Effect of Color Blindness

II. TEST METHODS

A. Ishihara Color Test

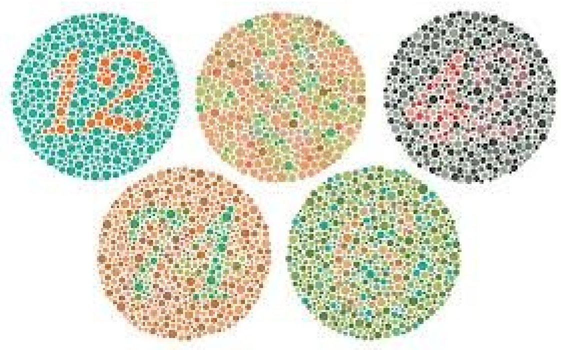

Fig. 2. Ishihara Color Vision Test Plates

This is the test for red-green color blindness, in this there are several ishihara plates consisting dots of different shapes and colors and a hidden number that is visible to normal color vision person and invisible to color deficient person. Full test includes 38 ishihara plates [2].

After Ishihara color vision analysis, the images are processed to remove the green and blue components leaving only the red component. This can be easily implemented in MATLAB using the imadjust command:

A=imadjust (IM,[0 0 0; 1 1 1],[0 0 0; 1 1 1],[1 0 0])

By filtering out these two colors components only the "weak" red component is remained. In the final improvement , red component is increased and the green and blue components are removed using following function:

A=imadjust (IM,[0 0 0; 1 1 1],[1 1 1; 0 0 0],[2 0 0])

The final generated filtered image was added to the original Ishihara test plate image. The hidden number within the plate become practically invisible to the normal vision subjects whereas some of the color blind subjects can see hidden value in the new image

B. RGB to HSV Conversion

As process starts first web contents are extracted from the websites and then out of these contents some images that are to be transformed are selected and saved. After saving these extracted images are passed through the color transformation process, by which unrecognized colors are transformed to recognizable colors to the color blind person. This research focuses on the red-green color vision deficient. Transformation process result as red is transformed to yellow and green is transformed to blue and blue is remaining same [3]. Green color's range is 120° because its hue value comes between 60° to 180°. Blue color's range is 180° to 300° because its hue value comes between 180° to 300° [4].

Green Ratio = (Hue - 60) / Green Range
Relative Blue = GreenRatio x BlueRange
After the transformation process, value of Hue = 180 + Blue Ratio.
After transformation hue value is divided by 360° for HSV to RGB conversion
Hue = Hue / 360

C. Gradient Map Method

This is an approach that is able to indicate regions that encounter the accessibility problem for colorblind viewers, the regions contain information that may not be well perceived by colorblind This method can be applied in different scenarios, such as checking the accessibility of designed images and to help designers to avoid the accessibility problem by making changes on the image. There are main two steps: inaccessible point detection and in-accessible region location [5].

(i) Inaccessible point detection: Inaccessible points are defined as the points around which the patches are not identifiable by color blind people, due to the loss of color information. For this estimation of the information loss as the difference of gradient maps of the original image and its protanopic or deuternopic views is calculated we may obtain several points that are still able to be recognized by colorblind viewers even if there exists significant information loss. Therefore, we also compute the full gradient maps of the colorblind views of the image, which is the sum of the gradient maps of channels, and its inaccessible point detection is accomplished.

(ii) Inaccessible region location: It is the region that covers inaccessible points.

D. Dalton Method

Color difference image has been found useful to visually inspect perceived color difference and additionally to build color remapping methods. Two color transformation methods are presented [6]. This research focused on two types of dichromacy (protanopy and deuteranopy). In this some methods are described as Image simulation, color transformation using color difference, color transformation using color difference scaling, and color transformation using red/green scaling.

LMS space plane is defined as: $\alpha L + \beta M + \gamma S = 0$.

The whole process is as:

(i) For each pixel do Gamma correction [R, G, B]= [R/255, G/255, B/255]^2.2

(ii) Scaling of color coordinates to color gamut using scaling factor=0.992052.

(iii) Transformation of RGB to XYZ to LMS:

$$\begin{bmatrix} L \\ M \\ S \end{bmatrix} = \begin{bmatrix} 17.8824 & 43.5161 & 4.11935 \\ 3.45565 & 27.1554 & 3.86714 \\ 0.0299566 & 0.184309 & 1.46709 \end{bmatrix} \times \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

(iv) Transformation of 3D LMS space to 2D spaces

(a) For protanopes:

$$\begin{bmatrix} L_P \\ M_P \\ S_P \end{bmatrix} = \begin{bmatrix} 0 & 2.02344 & -2.52581 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} L \\ M \\ S \end{bmatrix}$$

(b) For deuteranopes:

$$\begin{bmatrix} L_D \\ M_D \\ S_D \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0.494207 & 0 & 1.24827 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} L \\ M \\ S \end{bmatrix}$$

(v) Inverse transform $L_iM_iS_i$ to XYZ to RGB, i={P, D}:

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 0.080944 & -0.130504 & 0.116721 \\ -0.0102485 & 0.0540194 & -0.113615 \\ -0.000365294 & -0.00412163 & 0.693513 \end{bmatrix} \times \begin{bmatrix} L_i \\ M_i \\ S_i \end{bmatrix}$$

(vi) Inverse gamma correction [R, G, B]= 255*([Ri, G, B]^1/2.2).

This simulated image is used to take color difference from original image. This difference is used to analyze loss of color information perceived by dichromats. Then color scaling and remapping is used to make image visible to the dichromats. This method is used for both protanopia and deuteranopia deficiency.

III. CONCLUSION

This paper shows that color blindness is genetic problem associated with retina of human eye, in the presence of this human eye is deficient to see specific colors. There are different types of color blindness according to problem with cones of retina. There are some methods to detect and recover color blindness effect from the vision of image. First there is method ishihara test which shows how to detect color blindness effect present in human eye. Other method is to convert RGB to HSV image where hue, saturation and values are calculated. Next method is gradient color map method where inaccessible points and regions are calculated which are not visible to colorblind people and then recovered. Another method is dalton method where image daltonization is done. All methods are helpful to recover color blindness. To enhance quality of recovered image and to make clearer the difference between colors, segmentation can be done on images.

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