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IMAGE PROCESSING WITH COLOR COMPENSATION FOR COLOR VISION DEFICIENCY

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ABSTRACT
The commonly known vision defect in human eyeball is Color vision deficiency (CVD). It is color blind type deficiency caused due to the excretion in our eyeball; this is either in the form of defect or sometimes completely missing of certain photoreceptors. Due to defect, photo receptors are unable to detect color with certain spectrum. By virtue of this people will see the different colors in the image from the real colors. For example, some people in CVD can see a red color object might appear as yellow. This is also known as red green color blindness. Furthermore, according to one report on global analysis, almost 10% men have color deficiency. The most common deficiencies are the protanopia for red-weakness and deuteranopia for green. Person who suffers from these kind of color deficiency have very hard time to distinguish between red and green color. This causes them lots of problems in their day to day activities. The objectives of this proposed research are to achieve a versatile solution for allowing researchers to test different deficiency about color vision models and to test the possibility of the three most accepted reasons for the hypotheses in dichromatic vision.

KEYWORDS: Anomalous trichromacy, backlight control, color blindness, color vision deficiency (CVD), daltonism, deuteranomaly, LCD, protanomaly.

I.INTRODUCTION
There is sufficiently great number of people with CVD in the world. The severity among peoples impairment may differ depending upon the extent of the shift in wavelength of color distinction. The shift of more than 20 nm in spectral response of a cone is essentially equivalent to the complete blindness in the color that is received by that specific cone. CVD is a common among human population as seen in Table 1 [2], [3]. Although CVD is the common disability between the human populations there are lots of other issues resulting from color blindness. People with color blindness are not eligible to do some jobs like defense, military, police etc. In some countries CVD people are not allowed to drive vehicles because severe CVD prevents them from distinguishing different colors on the traffic light.

Table 1. Incidence of CVD among different Ethinic groups

Ethinic Groups	Incidence of RED – GREEN CVD (%)	
	MALE	FEMALE
Caucasians	7.9	0.42
Asians	4.2	0.58
Africans	2.6	0.54

Different devices are being developed to help people with CVD. Samsung's Galaxy phones (From Galaxy S4) now have a built-in CVD system, and some computer games including World of War craft and League of Legends have color blind mode [4]. In further effort to help people with CVD, we present an image processing method for people affected by CVD, so that they can perceive the colors similarly as the normal people do. Also tritanomaly is very rare among human population, we can consider image processing for only deuteranomaly and protanomaly.

II. LITERATURE REVIEW

The cones (photoreceptors) present in human eye retina are responsible for color vision which is known as trichromatic. It is activated by the reception of light in three subsets of cones, whose highest sensitivities is observed in the long - range wavelength (L), middle-range wavelength (M) and short-length wavelength of the spectrum. Manipulation in of one of three subsets of the cone pigments specifies Color Vision Deficiency (CVD). Primarily there are three types of Color Vision Deficiency. The first type is called dichromacy also called as anomalous trichromacy. There can be an extreme case, named achromatopsia.

In this paper, only dichromacy has been specified and after studying thoroughly about the deficiency of dichromacy, it has been observed that there are three basic types of dichromacy which are protanopia, deuteranopia and tritanopia. All colors are visible for trichromacy in normal vision and are shown as two monochromatic hues. In protanopia the spectrum observed in tones of yellow and blue and in deuteranopia where the confusion is about red and green.]. As an example, a color image with various vision defects is shown in figure (1).

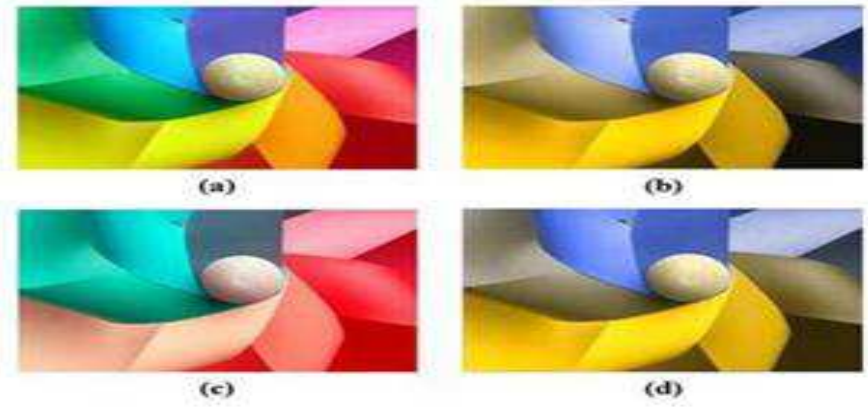

Fig 1: The figure of a color image with different vision problems (a) Normal color vision, (b) Green-blindness (Deuteranopia), (c) Blue-blindness (Tritanopia) and (d) Red-blindness (Protanopia).

It is passed from mother to son on the 23rd chromosome, the sex chromosome, and thus the frequency range of red-green CVD is significantly higher for male population[2][4]. Unlike red/green CVD, blue color blindness is extremely rare (only well-nigh 0.003% of the population is unauthentic by it); tritanomaly that causes verisimilitude defect in blue is not carried on genetically. Human verisimilitude perception is unswayable by a set of photoreceptors (cones) in the retina [6]. Once stimulated, they activate signals to the human brain and there by interpreted as verisimilitude sensation. Individuals with normal verisimilitude vision present three kinds of cones tabbed red, green, and blue, which differ from each other by having photo pigments that are sensitive to the low, medium, and upper frequencies of the visible electromagnetic spectrum, respectively. Changes in the cones photo pigments are caused by natural variations of some proteins, causing them to wilt increasingly sensitive to a variegated wreath of the visible spectrum, when compared to a normal vision person [11]. Such individuals are tabbed queer trichromats. In specimen one kind of cone is missing, the subjects are tabbed dichromats, and can be remoter classified as protanopes, deuteranopes, and tritanopes, depending whether the missing cones are red, green, or blue, respectively [14].

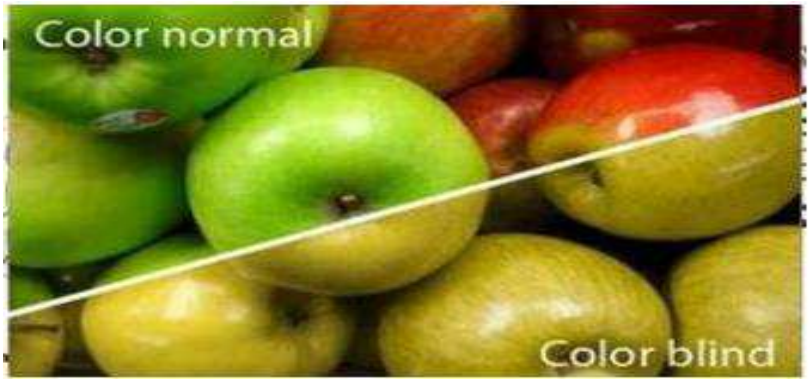

Fig: 2 (a) Ordinary color vision and (b) Color blind vision

Table: 2 Types of Color vision deficit

Medical terms	Deficiency type	Deficiency Degree	
		Textual	Numerical
Protanomaly	Red deficiency (Mild)	Mild	0.1-0.9
Protanopia	Red deficiency (Severe)	Severe	1
Deuteranomaly	Green deficiency (Mild)	Mild	0.1-0.9
Deuteranopia	Green deficiency (Severe)	Severe	1
Tritanomaly	Blue deficiency (Mild)	Mild	0.1-0.9
Tritanopia	Blue deficiency (Severe)	Severe	1
Incomplete Achromatopsia	Complete color blindness Mild	Mild	0.1-0.9
Complete Achromatopsia	Complete color blindness Sever	Severe	1

III.METHODOLOGY

III.I) SYSTEM BLOCK DIAGRAM:

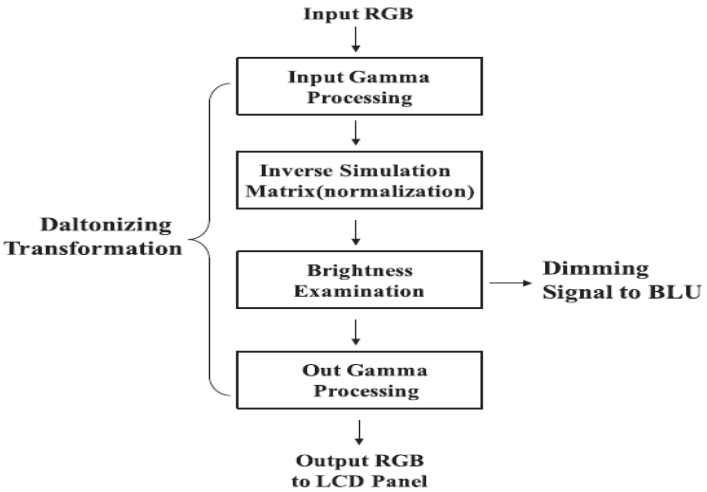

Fig (3.a). Algorithm to manipulate an image for people with CVD.

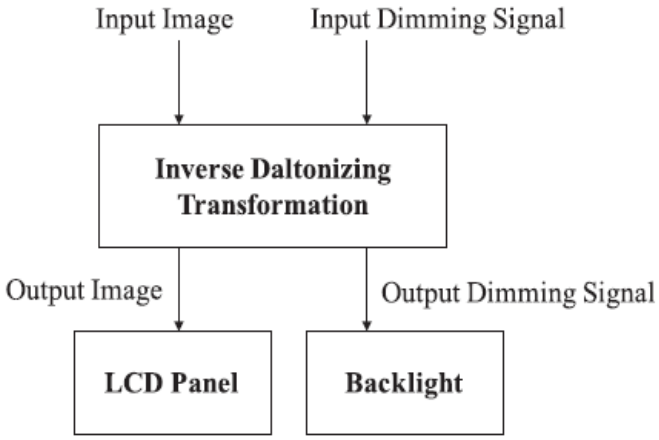

Fig (3.b). Backlight control system and control process.

III.II) STEPS:

A. DYSCHROMATOPSIA

In general, people perceive object's color and brightness when photons are reflected because of an object's surface and are identified by visual cells. A visual cell is composed of cone cells and rod cells; there are approximately over 60 lakhs of cone cells and over 90 million rod cells in human retina. Rod cells simply distinguish light and shade, and cone cells perceive a more specific shape and color. Cone cells sense light that is over 0.1 lux. Human normal vision requires few kinds of photoreceptors: L, M, S cones. Each cone is used to receive lights of different wavelength, and the spectral response of each kind of cone is defined by

the specific type of photo-pigment it contains. According to the intensity of the perceived light, information in respective cone cell combines to perceive chromatic and achromatic colors. A situation where there is a variance of proteins that comprise a given light-pigment is defined as anomalous trichromacy. If the changed photo pigment is the one associated in normal color vision exclusively with the L, M or S cones, the condition can be further classified as protanomaly, deuteranomaly, and tritanomaly, respectively.

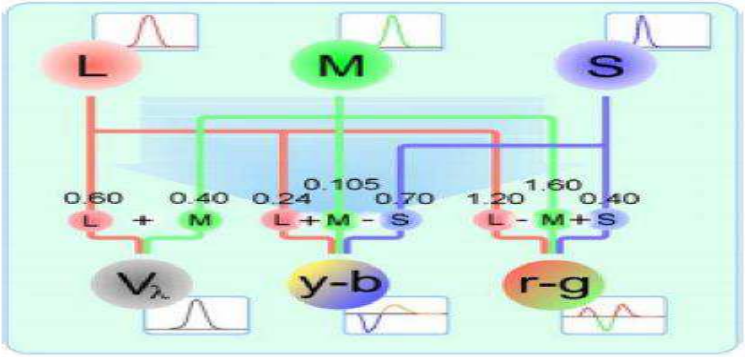

Fig. 4.Ingling and Tsou's two-stage model of human color vision. The output of the photo reception stage (L,M, and S cones) is proportionally joint in the opponent stage [6], [7].

B. DYSCHROMATOPSIA MODEL

Gustavo simulated color vision deficiency treating the change of spectral absorption of cones' photo pigments [6]. From LMS spectral sensitivity function which displays intensity of a wavelength range that causes certain cone cell's response, the function was linearly converted into an opponent stage by using at two stage model with the shift of CVD absorption wavelength [7]. Equation (1) describes two stage theory transformations and Fig. 4 represents how the cones' output signals are united into the spectral response function of the adversary channels V, y-b, and r-g.

$$\begin{bmatrix} V\lambda \\ y-b \\ r-g \end{bmatrix} \begin{bmatrix} 0.600 & 0.400 & 0.000 \\ 0.240 & 0.105 & -0.700 \\ 1.200 & -1.600 & 0.400 \end{bmatrix} \begin{bmatrix} L \\ M \\ S \end{bmatrix} \qquad (1)$$

Anomalous trichromacy can be explained by a shift in the spectral sensitivity purpose of the cones and the spectral sensitivity functions of the anomalous cones are represented as

$$\begin{aligned} \mathrm{L_a}(\lambda) &= \mathrm{L}(\lambda + \Delta\lambda_{\mathrm{L}}) \\ \mathrm{M_a}(\lambda) &= \mathrm{M}(\lambda + \Delta\lambda_{\mathrm{M}}) \\ \mathrm{S_a}(\lambda) &= \mathrm{S}(\lambda + \Delta\lambda_{\mathrm{S}}) \end{aligned} \qquad (2)$$

According to the CVD model, the simulation of the perception of individuals with CVD is given by a uni-matrix multiplication [8].

C. CVD COMPENSATION ALGORITHM

The light intensity of RGB received by people with CVD could be drawn by the CVD alteration matrix. Algorithm was developed with an assumption that the inversion of the transformed matrix will allow people with CVD to recognize colors as normal trichromats do. If an image is transformed with the algorithm in order, an adjusted image is produced. Inverse CVD uni-matrix outcomes in intensification of the weaker colors, and therefore it is common to have spill over in RGB gray level. The normalization of the image reduces the overall brightness of the image, so the backlight of LCD has to be controlled to compensate for the decrease in brightness as shown in Fig.3.a.

D. BLU CONTROL ALGORITHM

By using the method of inverse simulation matrix with the original image, weak CVD will be amplified. Brightness of each RGB is normalized based on the maximum value of RGB When any one of RGB exceeds a certain data level the screen can clutch. Brightness of every color including white is reduced. As shown in

the compensation section, the brightness is decreased to 59.68% of original image's brightness, and the brightness is decreased to 61.00%. Earlier than normalizing the RGB data of the inversed image, we saved the maximum intensity in the form of brightness. Maximum brightness after the normalization was obtained, and the maximum brightness before the normalization was divided by the one after as shown in (3). This value is represented BL gain and that value; backlight compensated the brightness of the normalized image.

$$BL\ Gain = \frac{Maximum\ Data(Before\ normalization)}{Maximum\ Data(After\ normalization)} \quad (3)$$

The output of pulse width modulation , When backlight brightness is adjusted with compensated dimming value. People with CVD will recognize not only the same colors but the same brightness as the regular person views the image.

$$Output\ BL\ Value = Original\ BL\ Value * BL\ Gain \quad (4)$$

For example, if an algorithm is controlled within 10 bit brightness resolution and the maximum luminance of 1600 before the normalization and 1023 after the normalization, backlight boost has to be 1600/1023 times brighter than the original image.

IV. CONCLUSION

Research above presented an algorithm of color vision deficiency compensation for people with both deuteranomaly and protanomaly, and has shown how the adjusted image amplifies different colors accordingly for different kinds of color vision deficiency. This methodology can be useful for the people with tritanomaly by the same process used for protanomaly and deuteranomaly .The model achieved here are true under such condition by strengthening defected colors. However, this led to a trouble where the RGB value crosees above the RGB data level that an LCD display can produce. Therefore, there should be normalization of the entire RGB data based on the highest data rate of RGB data.

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