Modifying Image Appearance for Improvement in Information Gaining For Colour Blinds

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Abstract--- Color blindness is a color perception problem of human eye to distinguish colors. Persons who are suffering from color blindness face many problem in day to day life because many information are contained in color representations like traffic light, road signs etc. Daltonization is a procedure for adapting colors in an image or a sequence of images for improving the color perception by a color-deficient viewer. In this paper, we propose a re-coloring algorithm to improve the accessibility for the color deficient viewers. In Particular, we select protanopia, a type of dichromacy where the patient does not naturally develop "Red", or Long wavelength, cones in his or her eyes. This algorithm when applied to the original image and after some processing provides satisfactory output image that is distinguishable by color deficient viewers.
Keywords: Color blindness, LMS color space, color segmentation.

I. INTRODUCTION

Color blindness affects roughly ten present of human males. Woman can be color blind but however, most color blind individuals are men because the main form of color blindness manifests as a defect in the X chromosome. Of those diagnosed with color blindness, over ninety-nine present of them suffer from some sort of red-green deficiency, where they are unable to distinguish well between red and green. Dichromacy is a general term for a person's lack of ability to perceive one of the three wavelength groups perceptible to non-color blind persons. The three types of receptor cones in the normal human eye are often referred to as red, green, and blue (RGB); it is more correct to describe them as receptors of long, medium, and short (LMS) wavelengths. All simulation and calculation is performed in MATLAB.

II. COLOUR MODELS AND COLOUR VISUAL SPECTRUM

A. RGB color model

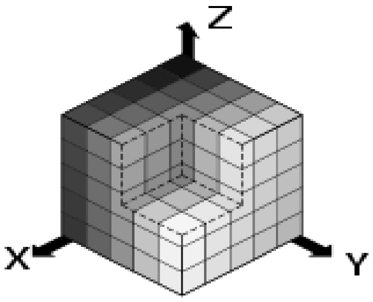


Fig. 1

Light transmitted by media i.e., Television uses additive color mixing with primary colors of red, green, and blue, each of which is stimulating one of the three types of the color receptors of eyes with as little stimulation as possible of the other two. Its called "RGB" color space. Mixtures of light are actually a mixture of these primary colors and it covers a huge part of the human color space and thus produces a large part of human color experiences. That's because color television sets or color computer monitors needs to produce mixtures of primary colors.

Other primary colors could in principle be used, but the largest portion of the human color space can be captured with red, green and blue. Unfortunately the proportion of the red, green and blue colours is not exact, so the same RGB values can give rise to slightly different colors on different screens.

B. HSV and HSL Color Models

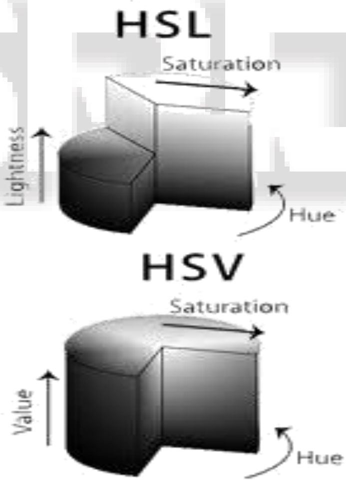


Fig. 2

As the geometry of the RGB model is poorly aligned with the color-making attributes that are recognized by human vision; computer graphics researchers developed two alternate representations of RGB, HSV and HSL (*h*ue, *s*aturation, *v*alue and *h*ue, *s*aturation, *l*ightness). By doing the improvement on the color cube representation of RGB, there is a representation of HSV and HSL color space models. Its done by arranging colors of each hue in a radial slice, around a central axis of neutral color. It ranges from black at the bottom to white at the top. Now in a color wheel, the saturated colors of each hue lie in this circle.

HSV models itself as a paint mixture, where its saturation and value dimensions are looking like mixtures of a brightly colored paint with, respectively, white and black. HSL is a more perceptual color model. Here the fully saturated colors are placed in a circle of lightness ½, so that lightness 1 always represents white, and lightness 0 always represents black.

C. *CMYK color model*

A large range of colors seen by humans, are possible to achieve by combining cyan, magenta, and yellow colors on a white substrate. These three colours are called the *subtractive* primary colors. To improve reproduction of some dark colors, fourth colour black is added. This is called "CMY" or "CMYK" color space.

The cyan ink is absorbing red light and transmitting green and blue, the magenta ink is absorbing green light and transmitting red and blue, and the yellow ink is absorbing blue light and transmitting red and green. The transmitted light is reflected back to the viewers from the white substrate. Because the CMY inks which are suitable for printing also reflect a little bit of color, which makes a deep and neutral black impossible, the K (black ink) component that is usually printed last, needs to be compensated for their deficiencies. When a lot of black content is to be printed, the use of a separate black ink is also economically driven, e.g., in text media, where the simultaneous use of the three colored inks is to be reduced.

D. *Color Vision Spectrum*

The visible spectrum is the portion of the electromagnetic spectrum that is visible to (can be detected by) the human eye. In this range of wavelengths, Electromagnetic radiation is called visible light. Wavelengths from about 390 to 700 nm will be responded by a typical human eye. This is actually corresponding to a band in the vicinity of 430–790 THz, in terms of frequency. A light-adapted eye is having its maximum sensitivity at around 555 nm (540 THz), in the green region of the optical spectrum (see: luminosity function). All the colors that the human eyes and brain can distinguish are not contained by the spectrum. Unsaturated colors i.e., pink, or purple variations such as magenta, are absent, because they are made only by a mixture of multiple wavelengths. Pure colors are the Colors contain only one wavelength.

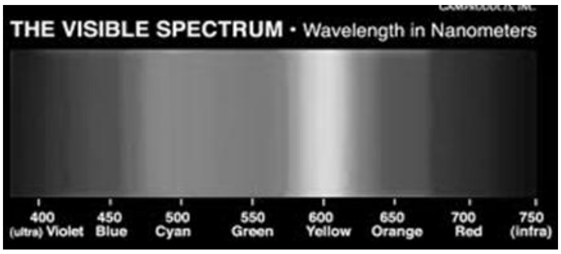


Fig. 3

Visible wavelengths pass through the "optical window" which is the region of the EM spectrum that allows wavelengths to pass largely unattenuated through the Earth's atmosphere. Clean air is scattering blue light more than red wavelengths, and thats the reason why the midday sky appears blue.

III. TYPES OF COLOR BLINDNESS

A. *Monochromacy*

If there is no cone or only one type of cone present at retina of eye then it is called Monochromacy. In Monochromacy person is unable to see any color. All things seem to be black, white and gray.

B. *Dichromacy*

If there are only two types of cones present at retina of eye then it is called Dichromacy. In Dichromacy any one type of cones is missing. So the information carried by that particular wavelength is lost. Dichromacy is again of three types according to missing cone:

C. *Protanopia*

If missing cone is L-cone then it is called protanopia. Due to protanopia that is due to long wavelength. Color information is lost so the person suffering from protanopia is unable to see red color. This is called 'Red blindness'.

D. *Deuteranopia*

If missing is called Deuteranopia .Due to deuteranopia medium wavelength color information is lost so the person suffering from deuteranopia is unable to see green color. This is called 'Green blindness'.

E. *Tritanopia*

If missing cones is S-cone then it is called Tritanopia .Due to tritanopia short wavelength color information is lost so the person suffering from tritanopia is unable to see blue color. This is called 'Blue blindness'

F. *Anomalous Trichromacy*

In anomalous trichromacy all three cones are present but one of these cones perceives color slightly out of alignment, so perceived image is not as the actual one. It is of three types depending upon which cone is working improperly:-

1) *Protanomaly*

In this type L cones are defective and do not function properly and sensitivity to red hue is lower. This is called 'Red Weakness'.

2) *Deuteranomaly*

In this type M cones are defective and do not function properly and sensitivity to distinguish red and green hue is lower. This is called 'Green Weakness'.

3) *Tritanomaly*

In this type S cones are defective and do not function properly and sensitivity to distinguish blue and yellow hue is lower. This is called 'Blue Weakness'.

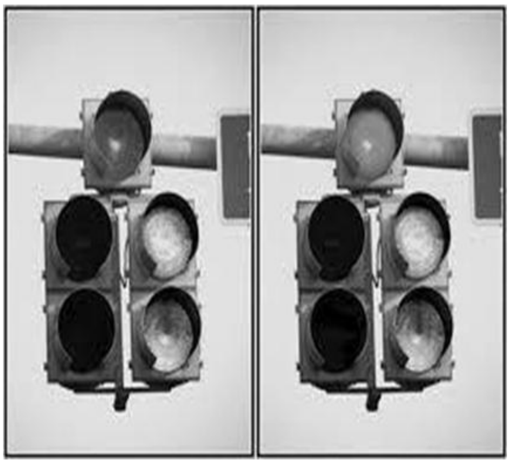


Fig. 4

4) Red-green color blindness

Red-green color blindness is a type of CVD where sensing of red and green color is weak.

Types of Red-green color blindness are Protanopia, Deuteranopia, Protanomaly and Deuteranomaly.

5) Blue-yellow color blindness

Blue-yellow color blindness is a type of deficiency of color vision where sensing of blue and yellow color is weak. Types of Blue-yellow color blindness are Tritanopia and Tritanomaly.

IV. SIMULATING PROTANOPIA WITH IMAGE PROCESSING

Colour difference image has been found useful to visually inspect perceived colour difference and additionally to built colour remapping methods. Here we have presented two colour transformation methods. Here the focus is on two types of dichromacy (protanopy and deuteranopy). Here some methods are described as Image simulation, color transformation using color difference, color transformation using color difference scaling, color transformation using red/green scaling LMS space plane is defined as: aL + ßM + γS = 0.The whole process is as:

1) For each pixel do Gamma correction [R, G, B]= [R/255, G/255, B/255]^2.2
2) Scaling of color coordinates to color gamut using scaling factor, which is taken 0.992052
3) Transformation of RGB to XYZ to LMS:

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

4) Transformation of 3D LMS space to 2D spaces for protanopes.

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

For deuteranopes:

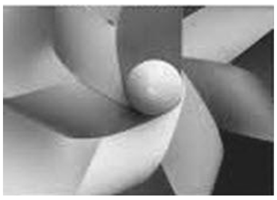
$$\begin{bmatrix} L_D \\ M_D \\ S_D \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0.494207 & 0 & 1.24827 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} L \\ M \\ S \end{bmatrix}$$

5.) Inverse transform LiMiSi to XYZ to RGB, i={P, D}:

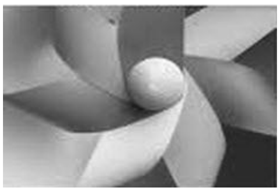
$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 0.080944 & -0.130504 & 0.116721 \\ -0.0102485 & 0.0540194 & -0.113615 \\ -0.000365294 & -0.00412163 & 0.693513 \end{bmatrix} \times \begin{bmatrix} L_i \\ M_i \\ S_i \end{bmatrix}$$

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

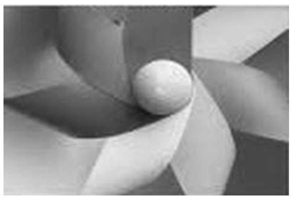
V. RESULTS AND CONCLUSION:



(a) Original Image



(b) Image Viewed by Color Blind Viewers



(c) Modified Image Viewed By Color Blind Viewers

Fig. 5(a), (b), (c)

CONCLUSION

This project gives us the opportunity to see the world through the eyes of someone suffering from color blindness and explores the effectiveness of different attempts to improve their world. It is exciting and humbling to have this opportunity to learn from the perspective of others and help the people who are suffering from the color blindness. This result shows that the process can successfully modify the images for colour blind. The colour confusion between red and green is clearly solved. The color Blind viewers can easily distinguish red and green color. The process takes very less time to execute and is a very simple procedure.

VI. FUTURE WORK

A. Future Work:

The program modifies images for Deuteranopians; it can be extended for Protanopia and Tritanopia. The program can be improved to modify images with various shades of red, to provide complete error free image that can be useful to various Colour Deficient Viewers. Also we can modify the Videos, so that the Color Blind Viewers can see the world more clearly than before and distinguish between various colors.

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