International Interdisciplinary Virtual Conference on
'Recent Advancements in Computer Science, Management and Information Technology'
International Journal of Scientific Research in Computer Science,
Engineering and Information Technology| ISSN : 2456-3307 (www.ijsrcseit.com)

# Image Processing and Modification for Improving Perception of Color-Blind Viewers

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**ABSTRACT**

About 8% of men and 0.5% women in world are affected by the Colour Vision Deficiency. As we observe the statistics, we can find that there are nearly 200 million colour blind people in the world.CVD affects their ability to effectively executecolor and visualization- related tasks. A colour vision deficient will not be able to attain every critical aspect of information present in the image or video. But with the help of Image processing, many methods have been developed that can modify the image and make it suitable for viewingby the person suffering from CVD. This paper focuses on some of the methods of modifying images such that viewers suffering from deuterenopia are able to better perceive image detail and color dynamics.

**Keywords:** Deuteranopia, Dichromacy, CVD,LMS Daltonization, RGB ColorConstrasting, LAB Color Correction.

## I. INTRODUCTION

In last few decades, multimedia has significantly increasedthe use of colors to convey the information. The Color vision deficient people cannot distinguish the multimedia contents as a normal person can do. As stated by William Woods[1], Color blindness affects roughly ten percent of humans. About ninety-nine percent of this ratio suffer from some sort of red-green deficiency, where a person cannot differentiate efficiently between red and green. Dichromacy is a general term for a person's lack of ability to perceive one of these three wavelengths.

**Types of colorblindness:**

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 not able to see any color other than 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 about that particular wavelength is lost. Dichromacy is again of three types according to the missing cone:-

1) *Protanopia*
2) *Deuteranopia*.
3) *Tritanopia*

**C.** ***Anomalous Trichromacy***- In this condition all the types of cones are present but they are not aligned properly. Hence, the sensitivity to a particular color is reduced. Depending upon which cone is not aligned properly it is further divided into:

1) *Protanomaly*
2) *Dueteranomaly*
3) *Tritanomaly*

In this paper, we have focused on deuteranopia, a type of dichromacy where the patient does not naturally develop “green”, or medium wavelength, cones in his or her eyes. For this we have considered three algorithms for image processing; : LMS daltonization, Color contrast enhancement, and LAB color adjustment. Two separate processing algorithms are also included to evaluate the effectiveness of these adjustment techniques. We simulate deuteranopia on both the original and processed images to see effects of algorithm from the perspective of a color blind viewer. We calculate the delta E value between the two images in order to assess how greatly the image changes from the perspective of a non-colorblind viewer. Color contrast enhancement provides the greatest advantage to color blind viewers, but also changes the image most significantly for non-color blind viewers. LAB coloradjustment has the least effect in both cases, and LMS daltonization falls in between the other two techniques.

## II. LITERATURE REVIEW

This report presents the techniques of simulation and modification to solve the main limitations of the basic techniques. Both techniques were successfully integrated into a visualization system, which allowed the practical validation of its results. Both works were published in visualization journals (MACHADO; OLIVEIRA; FER NANDES, 2009; MACHADO; OLIVEIRA, 2010).

## III. PROPOSED SCHEME

Approximately 200 million people worldwide are affected by Color vision deficiency (CVD),compromising the ability of these individuals to effectively perform color and visualization-related tasks. This has a significant impact on their private and professional lives.This project presents a model for simulating color perception.

Besides modeling normal color vision, it also accounts for the hereditary and most prevalent cases of color vision deficiency (i.e., deuteranopia).This model is based on the stage theory of human color vision and is derived from data reported in various studies. It is a model to efficiently consider normal color vision and dichromacy in a unified way.

The proposed model was validated through an experimental evaluation involving groups of color visiondeficient individuals and normal color vision ones. It can provide insights and feedback on how to improve visualization experiences for individuals with CVD.This report also presents an image-recoloring technique for enhancing color contrast for dichromats.

Unlike previous approaches, this technique preserves temporal coherence and, so it is suitable for image recoloring. This project demonstrates the effectiveness of the proposed technique by integrating it into a visualization system and showing high-quality recolored visualizations for dichromats.

## IV. IMPLEMENTATION

### I. SIMULATING DEUTERANOPIA

In order to assess the effectiveness of the algorithms, we have to simulate an image through the eyes of a person suffering from deuteranopia[7]. A simple conversion method can be considered where the image is first converted into the LMS color space. Theimread function of Matlab reads images in the RGB color space, so we convert it from RGB to LMS.

This is a simple linear matrix multiplication operation.

$$\begin{matrix} L \\ M \\ S \end{matrix} = \begin{matrix} 17.8824 & 43.5161 & 4.11935 \\ 3.4565 & 27.1554 & 3.86714 \\ 0.02996 & 0.18431 & 1.46709 \end{matrix} * \begin{matrix} R \\ G \\ B \end{matrix}$$

This operation is applied to every pixel of the image and it results in a new set of pixels whose information is now defined for the LMS color space. Now the image exists in the LMS color space, we remove information associated with the M cone and replace it with information perceived by L and S cones[7]. It can be seen below that the M information is removed, however the M component of the new pixel is not empty. It is filled with a proportion of information from the L and S cones because that M light is seen by the eye but perceived as being from the L and S wavelength bands instead. This requires another matrix multiplication operation.

$$\begin{matrix} L_{deut} \\ M_{deut} \\ S_{deut} \end{matrix} = \begin{matrix} 1 & 0 & 0 \\ 0.49421 & 0 & 1.24827 \\ 0 & 0 & 1 \end{matrix} * \begin{matrix} L \\ M \\ S \end{matrix}$$

The medium wavelength information has been removed from the image and the new M pixel is filled appropriately, thus deuteranopia has been simulated. In order to view the results, we simply convert back to the RGB color space by performing matrix multiplication again on each LMS pixel where the matrix is the inverse of that found in above equation.

### II. DELTA E

The second tool required for assessing the impact of color blindness compensation techniques is Delta E. Delta E is a popular metric for measuring color difference. We choose this metric in order to help determine the extent to which the algorithm in question changes the original image, i.e. negatively affecting the image as seen by viewers without color blindness. The Delta E algorithm is another simple operation, calculated for each pixel of an image. This function takes intwo images in order to evaluate the color difference between them. Both images are first converted from RGB to the LAB color space. Matlab has a built in function which allows the user to convert between these two color spaces; no such function exists for the prior RGB to LMS conversion. LAB pixel values hold lightness, L, and color coordinates A and B, based on a compressed version of the standard XYZ colorcoordinate space. The actual Delta E value for each pixel is calculated as follows.

$$\Delta E=\sqrt{(l_2-l_1)^2+(a_2-a_1)^2+(b_2-b)^2}$$

A recent study suggests that the Delta E value for a just noticeable difference is approximately 2.3. This will be worthy of consideration while assessing our results.

## THE COMPENSATION ALGORITHMS

Many algorithms are designed to adjust images in such a way that color blind viewers are able to attain the detail originally lost due to their color blindness. However we choose to examine only these three in order to provide useful results while still maintaining a reasonably limited scope for the project. These ultimately strive to compensate for color blindness and each is performed in a different color space and thus provides some amount of theoretical diversity.

*A. LMS Daltonization*

*B. RGB Color Constrasting*

*C. LAB Color Correction*

### A. LMS Daltonization

LMS daltonization uses the information lost in the deuteranopia simulation in order to improve the original image. The lost information from the original simulation is converted from the LMS color space to RGB and then mapped to wavelengths perceptible to the viewer, in this case long and short wavelenghts, mostly red and blue. This lost information, now shifted to colors the viewer can see, is then added back to the image. The fact to be considered is how to convert from LMS to RGB color spaces. The lost information, now as RGB pixels, is mapped using the following matrix multiplication.

$$\begin{pmatrix} R_{map} \\ G_{map} \\ B_{map} \end{pmatrix} = \begin{pmatrix} 1 & 0.7 & 0 \\ 0 & 0 & 0 \\ 0 & 0.7 & 1 \end{pmatrix} * \begin{pmatrix} R_{lost} \\ G_{lost} \\ B_{lost} \end{pmatrix}$$

It is clear that this operation does nothing to the lost red and blue information, but shifts the lost green partially into red and partially into blue. These new mapped RGB components are added to the original image. Finally, the image is checked and concatenated to ensure that no pixel value rises above one or below zero.

### B. RGB Color Constrasting

This algorithm adjusts an image's RGB values in order to enhance contrast between red and green and, in general, make green pixels appear to be bluer. The process begins by halving every pixel in the original image in order to provide room for pixel values to be increased. For each pixel, three operations occur. The first step is to increase the value of the pixel's red component relative to pure red. Reds further from pure red are increased significantly while reds already very close to pure red are only marginally increased. The green component of each pixel is manipulated next by applying exactly the same logic as that used on the red components. Finally, for pixels that are mostly red, the value of the blue component is reduced. For pixels that are mostly green, the blue component is increased. The scaling values here are determined through experimental eviden.ce found through trial and error with color blind subjects

### C. LAB Color Correction

This algorithm modifies reds and greens of an image to increase color contrast and clarity for a color blind individual This process is different from RGB Color Contrasting as it is performed in the LAB color space. The algorithm generally operates as follows.

The original image pixels are converted from RGB to LAB color space. The first operation is on each pixel's A component, where a positive A means it is closer to red and negative A means it is closer to green. Just as in RGB Color Contrasting, this A value is adjusted relative to its maximum, making positive values a bit more positive and negative values a bit more negative. Again, in each pixel the B component is adjusted relative to how green or red it is in order to bring out blue and yellow hues in the image. Finally, L, the brightness of the pixel, is also adjusted relative to the pixels A value. The image is converted back to the RGB color space and concatenated to ensure pixel values lie between zero and one. As with RGB ColorContrasting, this algorithm lacks clear theoretical basis. It is also based upon experimental procedures relying mostly on trial and error in the presence of a color blind viewer.

## V. EXPERIMENTAL RESULTS

This study approaches different methods of modifying and adjusting images so that the persons suffering from dichromacy are able to better perceive image detail and color dynamics in a better manner[7].

The image to be considered is to be simulated and algorithms are applied. The algorithms include:

a) LMS Daltonization,
b) RGB Color Contrasting and
c) LAB Color Correction.

For the purpose of implementation of the algorithms, we have considered an image of flowers.


**Fig 5(a)**


**Fig 5(b)**

The result of implementation of these methods is expected as shown above. Here the original image and image seen by a deuteranopia patient are shown in Fig 5(a) and Fig 5(b) respectively. The original image consists of different colors which are orange red, green, yellow and blue. It is observed that a normal person can distinguish these different colors but a person affected by deuteranopia can't distinguish red and green. So first this original image is taken in RGB color space shown in Fig 5(a), then it is simulated so as to understand the perception of a deuteranopic viewer, it is shown in Fig 5(b).



**Fig 5(c)** **Fig 5(d)**

Image adjustment technique is applied, through the Daltonization process, on original image, which is shown in Fig 5(c) and Fig 5(d) shows how it is seen by the CVD person.



**Fig 5(e)** **Fig 5(f)**

Then the color contrast enhancement shown in Fig 5(e) has been done and perception of a deuteranopic viewer can understood by Fig 5(f).



**Fig 5(g)** **Fig 5(h)**

After enhancing, the contrasted image is used for LAB color correction for the deuteranopia patients. The LAB color corrected image is shown in fig 5(g) and in the next step, the LAB color corrected image as seen by CVD viewer is shown in fig 5(h).

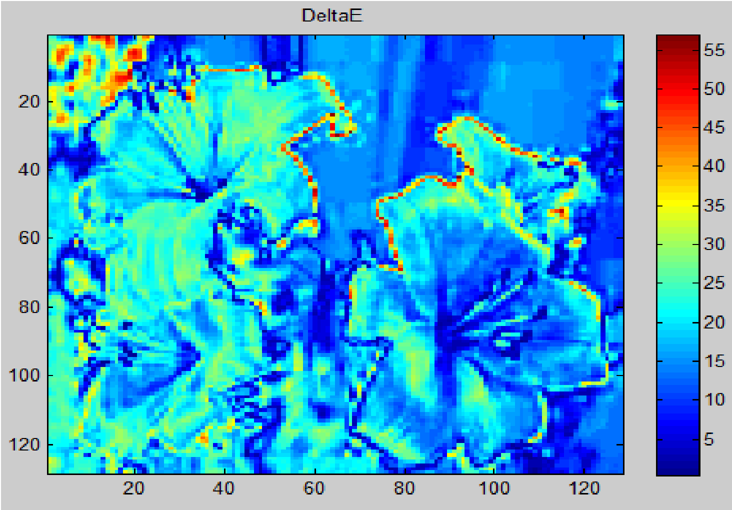


**Fig 5(i)**

A function Delta E is evaluated so as to know the difference between two images. In this case, we have considered the original image and the color contrasted image and we have evaluated Delta E in the image form as shown in fig 5(i). In this case, we have considered the original image and the color contrast image to obtain the Delta E image. This will provide us with the image difference between the two images taken into account. We can visualize the extent to which the original image has changed.

One can compare the three algorithms on the basis of efficient and clear perception of the CVD viewer. RGB color contrasting proves to be yielding better results as compared to Daltonization and LAB color Correction.

## VI. CONCLUSION

The proposed paper proposesa novel Image Modification algorithm for people with CVD. This paper is expected to show how the contrasting technique changes the image drastically for both color blind and non-color blind viewers; it also compares this technique with daltonization and color correction methods. With the help of these algorithms, the CVD viewer will be able to perceive the information that was lost due to his colourblindness. This paper explores the effectiveness of different methods to improve their perception.

We have considered Images of the original, adjusted and simulated formats, as well as plots of Delta E for each algorithm. The effectiveness of color blindness correction algorithms might be best served by applying them to an Ishihara color blindness test, but we have chosen to explore its effects on an image. Hence, we have made the unconventional choice of testing these algorithms on the image. This analysis shows that the contrasting technique changes the image drastically for both color blind and non-color blind viewers. Any adjustment in an image, from the perspective of a non-color blind individual, is a change from the original artistic vision. However, the changes for color blind individuals are both good and bad. The clarity obtained after image modification is crucial and available only after applying the RGB Color Contrasting algorithm. LMS Daltonization affects the image only marginally for both viewers; the adjusted images require close inspection to notice differences. Finally, the color correction algorithm is even more benign as it barely affects the test image whatsoever. This project gives us the opportunity to see the world through the eyes of someone suffering from colorblindness and explores the effectiveness of different attempts to improve their world.

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