COLOR TRANSFORMATION FOR PROTANOPIA COLOR VISION DEFICIENCY USING INTEGRATION OF IMAGE PROCESSING AND ARTIFICIAL NEURAL NETWORK

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Dedicated to my beloved family, lecturers and friends,
who make all things seem possible

For their encouragement, support and motivation
through my education journey

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ABSTRACT

Color blindness deficiency is inability to distinguish colors with each other. Nowadays, the individual who are not being able to recognize color may be crucial in some day life situation because many common activities depend on signals with color-coded such as road sign, traffic light, electric wire, resistor and many more. There are many forms of color blindness such Monochromacy (total color blindness), Dichromacy (Red/ Green/Blue blindness) and Trichromacy and etc. Most types of defective color blindness can be classified into two categories which are green color defective and red color defective. The objective of this project is to improve the ability of color discrimination for Protanopia which a type of dichromacy where the patients does not naturally develop red color or Long wavelength cones in their eyes. This project proposed a method using image processing to improve the ability of color discrimination for Protanopia as well as adjusting images such that a person suffering from Protanopia is able perceive image detail and color dynamics. This method is first developed by simulating an image through the eyes of a person suffering from protanopia by converting RGB space to LMS (long, medium, short) color space based on cone response and then modifies the response of the deficient cones. The linear multiplication matrix is derived by referring to CIE color matching functions. ANN is then set up by using the input/output from matrix conversion. For this research, the ANN is introduced to reduce simulation time in image processing. The transformation technique used is RGB Color Contrasting where this step is to enhance contrast between red and green which in general, make green pixels appear to be bluer. Based on the result, the objectives are successfully achieved. ANN gives the minimum computational time than conventional matrix conversion which is 36% increment. The changes of the image drastically for both color blind and non-color blind viewers. The result shows that the reds become redder and greens become greener from the image before being adjusted.

ABSTRAK

Buta warna ialah ketidakmampuan individu untuk membezakan warna antara satu sama lain. Pada masa kini, individu yang menghidapi penyakit buta warna mungkin mengalami masalah dalam beberapa kehidupan seharian kerana banyak aktiviti bergantung kepada isyarat yang menggunakan kod warna seperti tanda jalan, lampu isyarat, wayar elektrik, perintang dan pelbagai lagi. Terdapat banyak jenis warna buta seperti Monochromacy (buta warna), Dichromacy (merah / hijau / buta biru) dan Trichromacy dan lain-lain. Kebanyakan jenis buta warna boleh diklasifikasikan kepada dua kategori iaitu kerosakan warna hijau dan kerosakan warna merah. Objektif projek ini adalah untuk meningkatkan keupayaan diskriminasi warna untuk Protanopia (dichromacy) yang mana pesakit secara semula jadi tidak dapat melihat warna merah atau gelombang kon panjang di mata mereka. Projek ini mencadangkan satu kaedah menggunakan pemprosesan imej untuk meningkatkan keupayaan diskriminasi warna untuk Protanopia serta menyesuaikan imej dengan orang yang mengalami Protanopia supaya dapat melihat dengan lebih detail imej dan warna. Kaedah ini dimulakan dengan simulasi imej melalui mata seseorang yang mengalami protanopia dengan menukar ruang RGB ke ruang LMS (panjang, sederhana, pendek) warna. Pendaraban secara matriks secara linear diperolehi dengan merujuk kepada fungsi CIE yang hampir sama warna. ANN kemudiannya ditubuhkan dengan menggunakan input dan output daripada penukaran matrik. Untuk kajian ini, ANN diperkenalkan untuk mengurangkan masa simulasi dalam pemprosesan imej. Teknik transformasi yang digunakan adalah RGB warna yang berbeza di mana langkah ini adalah untuk meningkatkan kontras antara merah dan hijau yang secara umum, membuat piksel hijau kelihatan lebih biru. Perubahan imej secara drastik untuk kedua-dua buta warna dan bukan warna-penonton buta. Hasil kajian menunjukkan objektif berjaya dicapai. Kaedah ANN menunjukan masa simulasi adalah minimum berbanding kaedah penukaran matrik iaitu sebanyak 36% peningkatan. Transformasi image juga berjaya dari merah menjadi lebih merah dan warna hijau menjadi lebih hijau daripada imej sebelum diselaraskan.

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LIST OF ABBREVIATIONS

CVD	-	Color Vision Deficiency
ANN	-	Artificial Neural Network
AI	-	Artificial Intelligence
HSL	-	Hue, Light, Saturation
HSV	-	Hue, Saturation, Value
MATLAB	-	Mathematical Laboratory
RGB	-	Red Green Blue
CIE	-	International Commission on Illumination
CRT	-	Cathod Ray Tube
NTSC	-	Nasional Television System Commitee
SMPTE	-	Society of Motion Picture and Television Engineers
LMS	-	Long, Medium, Short

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Color is very important and plays significant role in our daily life. There are situations in daily activities that are depend on signals that are color-coded such as road sign, traffic light, electric wire, resistor and many more. Recently, many graphics, images, instructions and web pages on internet have been design to deliver information. So, with that kind of 'color' sources the people who are not being able to see the actual color may have crucial to get those information [1].

The defective visual color perception is a common occurrence which is about 8% -12% of men and 0.5% of the female population in the various forms of color vision disorder. Generally, 1 of 12 men and 1 of 200 women are color blindness this is based on global statistics from World Health Organization (WHO). Although there is no known medical method to correct this damage to human vision, it is considered that people who have such disorders suffer from a severe dysfunction [1].

In the retina of the eye, the response of three cones of photoreceptors derives the human color vision. Normal color vision is called trichromatic. It is originated by the absorption of photons in three classes of cones, whose peak sensitivities lie in

three regions of the spectrum namely, the long-wavelength (L), middle-wavelength (M) and short-wavelength (S). Any alteration of one of three classes of cone pigments will affects Color Vision Deficiency (CVD). There are three kinds of CVD which are monochromacy, dichromacy and anomalous trichromacy. In dichromacy it can be broken down into three forms which are protanopia, deuteranopia and tritanopia. This type is the most common category of color vision deficiency and it is called as red-green color vision deficiency[3]. However, it cannot be concluded that these groups of people cannot see red or green. They just have difficulty in differentiating between these two colors exactly, especially when their brightness is altered or come in a combination of colors. In general, the problem with dichromacy is the reddish and greenish colors look yellow hue.

Some people may not even know they are affected by this CVD and yet, there are several researches still dealing with the problem caused by CVD. It started to aid the color blind with traffic signals which blue hues are merged to the green traffic light, while orange hues are added to the red light to further distinguish the three colors from each other [4]. However, with modern image processing technology, it may be possible to design an aid to enhance the color blind's perception of color in everyday situations [5].

Color transformation means transforming the color space of an image into another color space that can be distinguished by the color vision deficient, depending on the types of color vision deficiency they have. Color transformation is generally a primary stage in the image processing application. [6], [7], and **[**8] have done this image simulation by using mathematical transformation which is simple matrix conversion. The color transformation of an image can be adjusted manually by matrix conversion but that requires advance image manipulation technique with consume optimum time.

Artificial Neural Network (ANN) technique using Levenberg-Marquardt training method is proven as an acceptable method for color optimization and

consumes less time simulation. The input taken from the conventional matrix conversion is being fed into ANN to be trained. ANN is computational model that consist of interconnected group of artificial neurons. It is used to create complex relationship between input and output to find pattern in data. In ANN, the concept of MultiLayer perceptron is used to solve the nonlinear problems by which in this problem is to get the same image simulation but less in simulation time. The concept is estimate a desired system and predicts the output of system based on input/output matrix conversion variable. This concept is inspired by the human brain. Thus, it can learn by itself in the image given [9].

This project propose a method using image processing to improve the ability of color discrimination for Protanope as well as adjusting images such that a person suffering from Protanopia is able perceive image detail and color dynamics. The first step of development is by simulating an image through the eyes of a person suffering from Protanope by converting RGB space to LMS (long, medium, short) color space based on cone response and then modifies the response of the deficient cones. The linear multiplication matrix is derived by referring to CIE color matching functions. ANN is then set up by using the input/output from matrix conversion. The transformation technique used is RGB Color Contrasting where this step is to enhance contrast between red and green which in general, make green pixels appear to be bluer. For this research, the ANN is introduced to reduce computational time in image processing.

1.2 Problem Statement

As mentioned in introduction, roughly one of twenty people has some kinds of CVD. Many pictures, documents, and web pages on Internet have been designed without any consideration about the problem. Furthermore, most commonly activities also depend on the signal with color coded. CVD have difficulties to run their life routine. The major problem is the people with CVD will face confusion in colors when they see any coloring image. The idea is to provide some change in any image seen by Dichromacy CVD so that imperceptible color difference can be distinguish by them. By meaning, when this approach is applied to the image through some kind of electronic devices, the confusion in colors will be solved.

In order to provide some ‘information’ in image so that the CVD can distinguish the colors, image processing is used. Color transformation is generally a primary stage in the image processing application. This is the process which is called classifier of converting the “normal” RGB color space into its color defect versions. As mentioned in introduction, many researchers have done this image simulation by using mathematical transformation which is simple matrix conversion. The color transformation of an image can be adjusted manually by matrix conversion but that requires advance image manipulation technique with consume optimum time. Artificial Neural Network (ANN) technique is proven as an acceptable method for color optimization and consumes less time simulation [10].

1.3 Objectives Of The Project

i. To identify the eight benchmark colors that can be used to transform any images with any colors to be simulated for Protanope vision using Neural Network.

ii. To design neural network supporting tool with consume optimum time for image simulation from Original image seen by normal person to the simulated image seen by Protanope.

iii. To design a technique used in RGB Color Contrasting for contrast enhancement between red and green color in order to eliminate confusion between them for Protanope Color Vision Deficiency.

1.4 Scope Of Work

The scopes of this project are as below:

I. Study on two main software which are software graphics Microsoft Paint and MATLAB. Microsoft Paint is used to design the image color model with RGB values. The other software is MATLAB which is functioned for image processing and constructing the Artificial Neural Network.

II. Focused on RGB Color Space and LMS color space for overall simulation.

III. Eight colors in prism shape and four different sizes of the image color model.

IV. The process of training ANN MultiLayer Perceptrons is used for function approximation in ANN bringing in the Levenberg-Marquadt learning algorithm.

1.5 Significance of Project

This research shows an important role in assisting people with color vision deficiencies to have better refinement and perception of the colors and eventually, each image on the websites. In real life, they would see the images of different colors as just an image consisting of only one color with different lightness. This color transformation algorithm transforms the colors of the original image to colors that are visible and distinguishable to them. Relatively little research has been done into the effects of color blindness in everyday life. The Color Blind Awareness organization has intentions to increase awareness of the necessities of color blind people in everyday life. Some areas of industry, transport services and the armed forces are probably the only areas where it is accepted that color blindness could possibly cause problems and it is acknowledged that there are certain types of job which the color blind are not suited to. Industry is also forced by legislation to take account for color blind people in the workplace but only for safety reasons.

1.6 Thesis Organization

This thesis is organized into 5 chapters:

Chapter 1 is introduction. This chapter explains the introduction of the project, objective, scope of work, and organization of thesis. The information and scope of the project is discussed briefly in this chapter.

Chapter 2 focuses on literature review of Color Vision Deficiency and theories regarding project. Furthermore, this chapter covers previous related work in the area of color image processing and neural network. Analyses are made on previous works.

Chapter 3, explain the methodology and its development overview. Detail discussions on step by step procedure are demonstrated in this chapter. Chapter 4 discusses the results and discussion of this project. Some of the results are also presented in displayed figures and tables.

Chapter 5 is the last chapter. This chapter concludes the overall discussion for this project. Recommendations or suggestions for future research will also being explained in this chapter.

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