Color Segmentation and Recognition Using Fuzzy Logic Human based Perception Approach for Color Vision Deficiency

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***Abstract*—Generally, there is no treatment to cure color vision deficiencies and the only method to assist them is with a vision aid or assistive devices. There are several existing assistive devices and able to detect a few basic colors. However, due to large amount of color-coded data it will cause a complex programming and high computational cost. Therefore, this work will focus on developing multi-colors recognition and segmentation within color shades and range, which is similar to human perception by the implementation of Fuzzy Logic Human Based Perception (FLHBP) approach. Fuzzy logic approach enables perception and reasoning abilities similar to human intuition to be used in computer system. Fuzzy sets membership functions are defined in separated color plane, which is Hue (H), Saturation (S) and Value (V). Fuzzy rules in this model are defined based on human observation that is defined by classifying the color produced by combining the fuzzy sets of the Hue, Saturation and Value membership function. The FLHBP provides color segmentation within the color class and multi-color recognition for 125 colors. This system provides faster solution and accurate output due to the nature of fuzzy color identification using natural language rules of perception. This approach improves the color accuracy of 99.5% with computational time less than 0.5 seconds.**

***Index Terms*—Color Deficiency; HSV; Color Segmentation; Color Recognition; Fuzzy Logic; Fuzzy Inference System (FIS).**

I. Introduction

Color Vision Deficiency (CVD) or color blindness is a lack of ability to recognize and differentiate certain colors under normal lighting condition. Most cases of color blindness is found in males where the percentage reached 7-10%, while for women the number is less than 1% [1]. The deficiency occurs naturally and is usually due to genetic factors. The cause of this deficiency is due to the fault in one or more sets the photoreceptors during the development of eyes. The retinal cones are use function as perceiving color in light and transmit the information to the person‘s eye optic nerve [2].

Color blindness can divided in two categories, first is total color blindness, which can see only in monochrome and second is partial color blindness which has the difficulty discriminate color between red and green or between blue and yellow. The disability of the CVD to recognize color is potential to cause problems to their daily life and challenges on interacting with the environments because so much information are encoded visually. They also can easily become lost in surroundings that cannot be quickly scanned in which color perception is important for safety. In this case, impossible for person with CVD to employ in certain occupations such as firefighter, system networking and electrical engineering that involve many color for electronic wiring, resistor and capacitors [3-4].

This project focuses on assisting color vision deficiency people, which can be used to differentiate various colors in daily life. Fuzzy Logic Human Based Perception (FLHBP) approach on color segmentation and multi-colors recognition will be developed using Fuzzy Inference System (FIS).

II. Literature Review

The retina of the human eye contains about 7 million cone cells and more than 100 million rod cells that enable normal vision. There are two different types of photoreceptors in our eyeballs that allow us to see everything. They are called rods and cones [5]. The rod receptors allow night vision at low light level, brightness perception, have the ability to distinguish basic shape and form and very sensitive to low light’s level but not to color. While cones are sensitive to colors and majority of cone cells are located in the center of the retina. Each type of cones cell has a different sensitivity to the light spectrum. These sensitivities result from absorption of different wavelengths of light reflecting from color pigments. The disability of the patient to recognize color is potential to cause problems to the patient in daily life or in more specific area. Color blind person will likely experience trouble both in everyday life, and within the scope of a more specialized environment. Defective color vision could be a risk factor or a serious handicap. In fact, the number of occupations relying on color is growing as more and more tasks are increasing in complexity, influenced by emerging technologies and stricter operational regulations or work safety standards.

There are many ways to encode a picture by using different color spaces. Each pixel consists of three values that are red, green and blue value, which commonly specified using three integers between 0 and 255, representing RGB (Red, Green and Blue) intensities, in that order. To give a color specification, a user selects a spectral color and the amounts of white or black, which is to be added to obtain different shades, tints, and tones.

Color vision assist system [6] and visual auxiliary system [7] ware developed in order to compensate color for color vision deficient. The captured image in RGB color space is converted to HSV color space, which enables the defective color range to be avoided easily. The image is passed to the image-processing unit and transforms the colors that are invisible for the color vision deficient. The hue value is adjusted to transform the colors that cannot be identified by the red-green color vision deficient into the colors that they can. The second system is the color compensation vision system mainly for people with CVD. It uses a camera as live feed to capture the real-time image of surroundings which will be processed later and converted into different color, by manipulation the Hue of Red and converted to blue shades [8].

III. Project Methodology

Original color image contains digitized information in raw 8 bits; Red, Green and Blue (RGB). These colors are converted to Hue, Saturation and Value (HSV), which is similar to human‘s natural color identification in the pre-processing module. The separate plan of the HSV color image will be the input to the Fuzzy Inference System (FIS) of the color segmentation and recognition system. The output is divided into two sections. First is color segmentation, which is basically to know the image color group. The color image will be classified in the basic color group of the color band, which are Red, Yellow, Green, Orange, Blue, Purple and Pink. Second is color recognition that will reveal the exact color names. With the application of Fuzzy Logic, it can exactly determine the color within it shades and range. The overall process of the system is shown in Fig. 1.

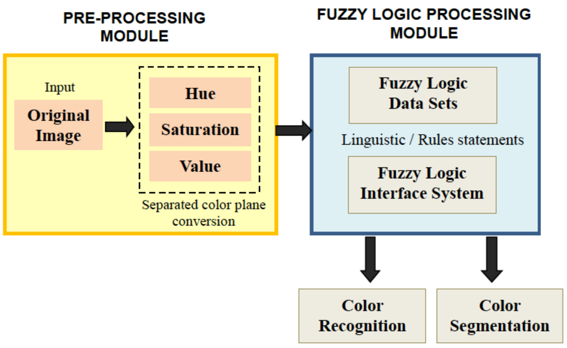

Fig. 1. Block diagram of the processes of the system

A. Pre-Processing Module

The first module of the proposed architecture works as the preparation of the input image before the input image can be processed and the original RGB components are converted to the HSV color space. This is desirable for the following steps, where the HSV components (Hue, Saturation and Value) are treated separately. After the conversion process from RGB to HSV, the value of Hue is represented in degrees, which is varies from 0º to 360º, which represent the location of the color wavelength in the Hue (H) color wheel. Saturation (S) and Value (V) represented in percentage, which varies from 0% to 100%. For programming and computer processing compatibility the value need to be normalized in 256 bit, which are defined in 0-255 format.

B. Fuzzy Logic Human Based Perception Approach For Color Segmentation Process

The design elements of the basic Fuzzy Logic Human Based Perception Approach algorithm are the design of membership functions for the fuzzy variables. For each fuzzy variable, the universe of discourse has to be determined. The universe of discourse represents the extent of validity of the fuzzy inference rule on each variable domain. The colors components are defined as red, orange, yellow, green, cyan, blue, purple, magenta and pink are defined by dividing value according to the visual spectrum wavelength. The Hue component values will be representing as the universe of discourse of the fuzzy logic data sets. Next the shape of the membership functions has to be fixed. In this project triangular function with were used.

Lastly, the number of membership functions or the number of mapping categories and their locations on the universe of discourse are defined. The linguistic variable will be the hue (H) and 10 fuzzy sets will be defined over Red, Dark Orange, Light Orange, Yellow, Dark Green, Light Green, Cyan, Blue, Purple and Pink. Fig. 2 shows the development of the fuzzy logic triangular membership function that to be used in color segmentation. In color segmentation process, the information of Hue color is the only important data on determining the color class or category of a given color image.

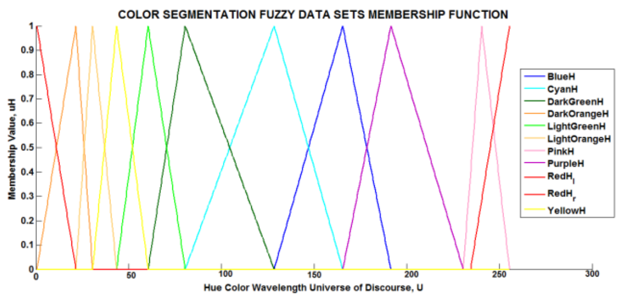

Fig. 2. Color Segmentation Fuzzy Logic Membership Function.

The segmentation of a color image means isolating certain areas of a certain color from the rest of the image. In this method, the separation or segmentation color areas in an image are represented using shades of grey. Color classes for this segmentation are divided into 7 groups, which are Red

Segment, Yellow, Green, Orange, Blue, Purple and Pink segments.

C. Fuzzy Logic Human Based Perception Approach For Color Recognition Modeling

The design of the project was done using Fuzzy Logic Toolbox inside MATLAB. Input Membership Function representing 3 separated HSV color planes from the result of pre-processing module as shown in Fig. 3. Mamdani type inference is defined by the design of Rules Statement that based on human perception to calculate in obtaining the output membership functions. After the aggregation process, there is a fuzzy set for each output variable that need defuzzification.

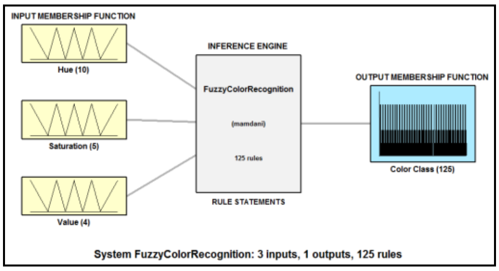

Fig. 3. Fuzzy Inference System (FIS) toolbox in MATLAB.

In HSV color space each color is defined by three antecedent variables and one consequent variable, which is a color class ID. All membership functions with 10 fuzzy sets for Hue, 5 fuzzy sets for Saturation and 4 fuzzy sets for Value. The fuzzy sets of the antecedent fuzzy variable Hue are defined based on 10 basic hues distributed over the 0 – 255 spectrum. As described in Fig 4, the hues are Red, Dark Orange, Light Orange, Yellow, Light Green, Dark Green, Cyan, Blue, Purple and Pink. The point of maximum of each membership function is determined based on the visual color spectrum and normalized to (0-255) interval.

Saturation is defined using the five fuzzy sets Gray, Almost Gray, Medium, Almost Clear, Clear, as shown in Fig. 6. Value is defined using the four fuzzy sets Dark, Medium Dark, Medium Bright and Bright as shown in Figure 7.

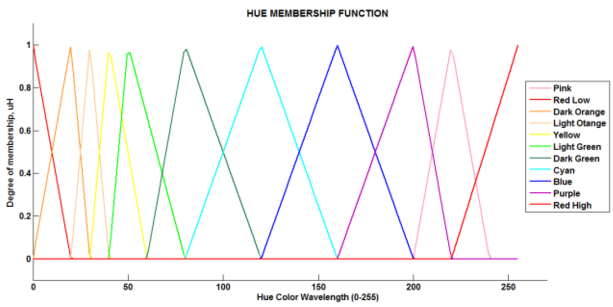

Fig. 4. The Hue (H) Membership Function with Correspond Color.

For simplicity the same triangular membership functions for each of the fuzzy subsets of all the fuzzy variables were choose. For the output Color ID memberships function classifies any given HSV triple to a known predefined color. In this project 125 colors are defined from the triple of each HSV membership value. Fig. 3 shows the Output Color ID of this Color Recognition Fuzzy Logic Human Based Perception Approach.

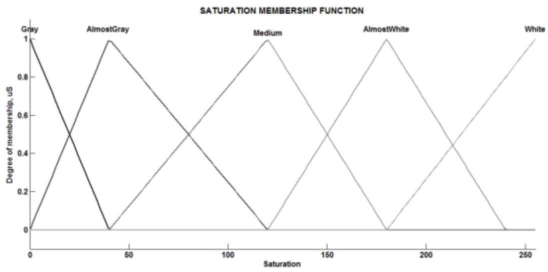

Fig. 5. The Saturation (S)Membership Function with Correspond Color.

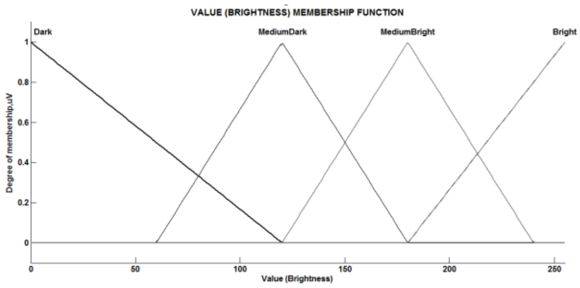

Fig. 6. The Saturation (V) Membership Function with Correspond Color.

The color produced by this Hue, Saturation and Value triple would be classified by most human observers as *Dark Brown*. This corresponds to the weight of the firing rules, which are developed based on natural language human perception. The reasoning procedure is based on a Mamdani model, which generally loses less information, can be very useful in fuzzy expert systems.

Since the domain of the consequent variable is a set of discrete values, continuous defuzzification method cannot be used. One possible defuzzification method in this case is to simply select the consequent part of the rule that has the maximal strength. However, since the same consequent part can be common to more than one fuzzy rule, considering only the fuzzy rule with the maximal strength can lead to a false conclusion since another consequent part may be supported by several rules, which are, together, stronger. The defuzzification is performed in three stages. Stage 1, all the fuzzy rules are grouped by their consequent parts. Stage 2, each group of fuzzy rules is assigned with a value that is the sum of the strengths of its contained rules. Lastly, stage 3, the group that has the maximal sum of strengths is selected, and the consequent part of its fuzzy rules is assigned to the consequent fuzzy variable.

IV. Result and Analysis

A. Color Segmentation Result

The segmentations were divided into 7 colors, which are Red, Yellow, Green, Orange, Blue, Purple and Pink segments. The image of each pixel is classified and assigned with the color that corresponds to the classification. Color segmentation process is shown in Figure 7, the colors are classified within in color range, which follows the boundary value that has bee set. The output will be in gray scale image, so that it easy to observe the high shad and low shade of each color region. This means that fuzzy can determine the color shades and range of it color region.

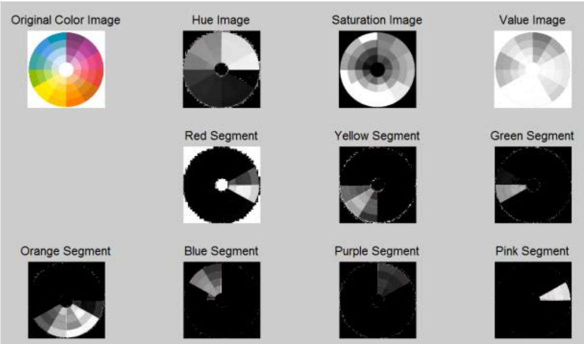

Fig. 7. Color wheel color image segmentation result

B. *Color Recognition Result*

For the recognition process, the text indicating the color name will appear to the desired region chosen by user. This will give an individual color name rather than segment it within it color class as shown in Fig. 8. The result shows a color wheel image with different color shades. It shows that the fuzzy logic design is able to differentiate all of the colors range and shades within 0.455 second.

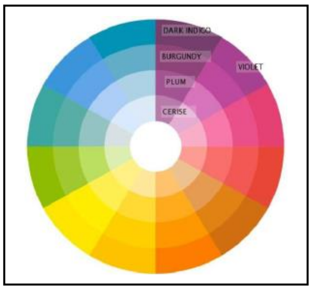

Fig. 8. Color wheel recognition result for shades of purple

The advantage of this approach is less computational complexity. Since the total number of rules in the model is constant, the classification of each pixel is performed in less complexity. The system has an option where user able to change the desired input to select. As for the experiment, 5 input are tested. 20 inputs also have been tested but it will cramp the image with text and will overlapping the text. Suggestion if to use maximum 5-10 inputs, if more than that can apply the segmentation by color class and use recognition to determine the exact color name with it exact shades and range. The software development of the color segmentation and recognition were fully tested with various color images ranging from all type of color from generated computer image and capture image. This is a new experience for the color deficiencies people in term of giving exposure of the existing of color in real life.

V. Conclusion

The difficulties in everyday life encounter by color deficiencies people have been studied in this project. Color recognition and segmentation using color image processing technique by using the advantages of Artificial Intelligent advantages is successfully develop and tested. Various lighting condition of the color image have been conducted to test the functionality and accuracy of the Fuzzy Logic Human Based Perception (FLHBP) approach for Color Segmentation and Recognition applications.

The results show that the device can recognize various colors within shades and range. Even the capture imaged affected by the lighting condition, it shows correct color shades. For color segmentation, able to segment the color images according to the Hue fuzzy logic data sets according to the color group assigned. Saturation and Value information are not important for segmentation, so it is not required to filter out or segmented the color the shades and range. All of the shades or shadow or tint or range of the color were keep in the image so that the range of Hue will process on determining the color group of given image. For color recognition, the developed application is able to recognize up to 125 colors. The processes require Hue, Saturation and Value information, which are added the advantage on becoming this project successful to recognize multi-colors.

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