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ABSTRACT
In the traditional setting, the only way to identify color-blindness is if an individual has a severe color deficiency which make it easy to identify due to individuals have difficulty in identifying colours. However, this is not the case for those suffering from mild color-blindness, as the only way to ensure that a person is truly color-blind with a mild case is to have a check up with an eye care professional. The proponents developed an Android mobile application that provides an Ishihara test, a standardized eye test which allows users to take a color-blind test to determine if an individual is color-blind. Existing adaptation tools, the color-blind uses an eyeglass or contact lenses modified for color vision deficiency to help distinguish colors. These types of products. Due to limited resources of supply in the Philippines, specialized type of eyeglasses is not readily available and there are people that cannot afford or are reluctant to purchase this type of device. The researchers developed an Android mobile application that aids with color-blind people using color segmentation and the Color Thresholding Algorithm.

Keywords: Color Segmentation, Anomalous Trichromacy, Color Vision Deficiency, Ishihara Test, Color Thresholding

I. INTRODUCTION

Color deficiency or color blindness is the inability to recognize colors normally in a person. It frequently happens when someone has trouble telling one color from another. There is no cure for color blindness [1]. A person can acquire this deficit at any time throughout their life, including at birth. Red and green can be difficult to differentiate from one another due to the most prevalent type of color blindness. It is difficult to discern between blue and yellow while using another type. A relatively rare disorder, total color blindness prevents a person from seeing any color at all. If a person's color blindness is hereditary, their color vision would not improve.An individual has a condition or injury that affects their vision or brain, this may potentially manifest later in life [2].

People who are color-blind have trouble distinguishing colors on their own, especially if their color blindness is severe. People who are color-blind encounter several challenges in daily life that ordinarily sighted people are simply unaware of. Even when they interact with ordinary tasks, problems can still occur. People who are color-blind may also run into difficulties if they are unable to recognize a change in someone's attitude from the color of their face or fail to see their child's sunburn. Exam results, employment options, and access to school can all be impacted by color blindness [3]. Many color-blind people are ignorant of their condition, and many of those who are affected struggle with it on a daily basis. Many others also have no idea what color-blindness is. Color-filtering technology is the only method color-blind persons can independently discern between different hues.

The results of the Ishihara test can also be used to help users choose the optimum filter to employ when identifying the colors of objects and provide critical information concerning color blindness. In addition, the test will be a crucial component in making the program more user-friendly.

The majority of people in today's generation use mobile phones as a tool. People who are color-blind will gain from designing apps leveraging the infrastructure currently found in smartphones[4].The best method to create a more helpful, entertaining, and educational application to aid color-blind persons will be to use the currently available application as both an inspiration and a reference. Through the use of glasses and contact lenses with CVD-adjusted lenses, there are tools and technology that can aid color-blind people in distinguishing colors. However, taking into account that some locations do not have an easy access to this kind of product and that other people cannot afford or are hesitant to purchase this kind of equipment Visual aids, apps, and other forms of technology are an alternate adaption strategy for people who are colorblind.

The division or segmentation of an image into parts with similar or nearly similar characteristics, such as color, texture, gradient, and spatial attributes like location, is known as color segmentation. Fundamentally, when a color segmentation technique assigns a distinct region or label to each pixel, it is said to be "complete" when all of the segmented region's pixels meet the specified criteria, but the segmented region pixels from disconnected portions [5].There are many different kinds of segmentation algorithms based on techniques including region detection and extraction, edge detection, thresholding, physics-based schemes, and data clustering. The simplest way to separate images in digital image processing is through thresholding, which can produce binary images from a grayscale image. The majority of thresholding processesinvolves defining limits based on the intensities or grey values of image pixels. Based on the color values in real-world photos, thresholding is to be carried out. The grey level thresholding algorithm is used as the foundation for the color thresholding technique, with a few minor modifications. Red, green, and blue (RGB) color information for the object has been extracted from the backdrop and other objects using multilevel thresholding. The study of color information has made use of a variety of natural imagery. The outcomes demonstrated that the picture segmentation technique was able to distinguish the object from the background by applying the chosen threshold values[6].

.There are existing programs that have similar characteristics but none of them include a color blindness test that can distinguish between users with normal vision and those who are color blind. There are only two color-blind features offered by almost all applications: a simulation and a filter. The color-blind test can also be used by those who are color-blind as an assessment, and if the application can offer information on the common issues faced by color-blind people and guidance to parents and caregivers on how to support the color-blind children under their care, including information on how to access color-blindness tests[6].

A different approach to offering a different adaptation tool for color blindness is to create an android-based mobile application. In comparison to color-blind spectacles, there is a smartphone app that can be downloaded and installed that offers color-blind help. Since Android is the most widely used operating system in the world (40.47%), color-blind users can access android-based mobile applications more easily [7].

The main method for helping persons who are color blind perceive or differentiate between colors is to use a visual assistance kit. With a few changes, modern technology finds ways to help those with vision impairment. The color filters are the features that will employ an algorithm in order to identify colors utilizing a mobile application. The color filter, which will be utilized for image color segmentation, employs the color thresholding algorithm. Using a color thresholding algorithm, images from any other color space can be divided into grayscale images. Images can be segmented using thresholding. Thresholding and a combination of color spaces can be used to remove a specific color from the image, outline it, and highlight it in a red, green, and blue (RGB) constructed image. Thresholding is most typically used to isolate important portions of an image, such as those with high contrast or few colors, while ignoring those that have little bearing on how a color is classified[7].

The proponents developed an Android Based Mobile Application for Color Detection Assistance for Color-Blind People Through Color Segmentation using Color Thresholding Algorithm was designed for people who have color vision deficiency as well as individuals with normal eyesight. This study is mainly emphasized on designing and developing an android application that aids with Color-blindness.The developed system includes an Ishihara test, which is a readily available color-blind test feature that will assist in determining whether the user is color-blind. After completing the Ishihara test, it will process the result and display it to the user, after which the user will be able to use the specific color filter based on the Ishihara test.

The study also provides the user with a filter mode of the application to separate an object or part of an object by color. There are three filters in the application. These are the RED-GREEN filters, which mainly focus on the types of color-blindness like Protan (Red color-blindness) and Deutan (Green color-blindness), the BLUE-YELLOW filters, which mainly focus on the types of color-blindness like Tritan (Blue color-blindness), and the Custom Color Filter. The Custom Color Filter allows the user to select any basic color to filter other than the colors red, green, and blue by combining R, G,B and H,S,V values using sliders. It also includes a feature that helps the user to identify if they are color-blind using a color-blind test. The result of the test will show if the user is color-blind or not, and also show the score in the test, which shows the type of color-blindness the user has, and also recommends which filter (RED or GREEN) the user will use based on the type of color-blindness given by the test result.

The research study developed an assistive application tool to provide color-blind people with functions including the Ishihara test, color detection using color segmentation, and informative features that could help the users in their daily tasks. Because the project is android-based the user will use the smartphone’s camera using the application and look through it to identify the color of objects and environment.

II. RELATED LITERATUREANDSTUDIES

Color Vision Deficiency

Color vision deficiency (CVD) is a visual condition that makes it difficult to discern between colors, according to [8]. There are two types of color vision impairment: congenital and acquired. There are three types of anomalous trichromacy, dichromacy, and monochromacy in congenital color vision loss. Deuteranomalous was the most prevalent congenital CVD; it is an X-linked recessive mode of inheritance and primarily affects males. A direct effect of a disease or any medication taken to treat it can be acquired CVD. Changes in color perception brought on by acquired CVD may be a result of ocular disease, medication side effects, or severe systemic illnesses like diabetes.CVD may be brought on by diabetic retinopathy, various forms of maculopathy, crystalline lens alterations brought on by aging, glaucoma, diabetes, optic nerve illnesses, and traumatic brain injuries. Although the type of defect for acquired CVD may be difficult to categorize, tritanopia predominates, and both the type and severity of the defect change over the course of the disease. According to certain theories, an increase in CVD prevalence has occurred in most societies as a result of human progress toward industrial civilization. A lack of color information processing anywhere along the relevant visual pathway, from the photoreceptors to the cortex, can be seen in an acquired CVD. It is occasionally possible to identify a visual impairment early on by testing color vision.

Dichromatic

Anopia, or the inability to see red (prot-), green (deuter-), or blue (trit-), occurs when one opsin (a protein that is released by the action of light and is a component of the optical pigment rhodopsin) is totally missing. These people have dichromatic vision, which means they must match each color they see with a blend of only two primary hues [9].
Dichromacy only occurs when one of the cone pigments is lacking, and it can be classified as Protanopia (characterized by the utter absence of red cone) , Deuteranopia (full absence of green cone), or Tritanopia (total loss of all three cone pigments) (complete absence of blue cone) [10].

Anomalous Trichromacy

Anomalous trichromatism reduced sensitivity to one of the three cone pigments, which includes protanomaly, deuteranomaly, and tritanomaly, in which the spectral sensitivity of the red, green, and blue cone receptors is altered [11]. The condition as a non-null mutation in any of the opsins that can cause a modest shift in one of the three types of cones' maximal sensitivity. As a result, there will be fewer color combinations available, and hence a reduction in the apparent color range.

Color -Blind Test

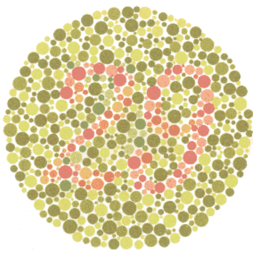


Figure 6.Ishihara Test Plate

The procedure of administering a color-blind test is still done manually, requiring those interested in taking one to go directly to the clinic. As a result, those who took color-blind tests had to be prepared to wait a long time. Along with these issues, people are less aware of the value of early color-blindness testing due to a lack of community comprehension and knowledge about the condition. Therefore, a media that can do color blindness tests quickly and readily is required, as well as information regarding color blindness that can help the community gain understanding.One of the best medium for facilitating easy information access is the implementation to Android mobile application. Through their research, the advocates believed that developing an Android-based color-blindness test application would make it simpler for people to perform color-blindness tests whenever and wherever they like, as well as serve as a medium for information regarding color-blindness [12]
The most popular test for color blindness is the Ishihara test. Each of his exams consists of a collection of colored dots plates, each of which displays a path or a number. Since then, this test has been the most frequently used to diagnose color vision deficiencies. Most optometrists and ophthalmologists still use it today, and one of the best ways to administer it is through an electronic media. Nearly similar sensitivity and specificity to the Ishihara test, computer-based color deficiency test software can be presented on screen to

screen for color vision deficiencies. This has the advantage of lowering costs by requiring fewer resources over time and taking less time to analyze the results. The findings of this study will enable the researchers to gain understanding of how the Ishihara test will perform when the application is deployed [13]. Computer-based color deficiency test software can be used to screen for color vision deficiency with sensitivity and specificity that are nearly identical to the Ishihara test, with the added benefit of lowering costs by lowering the resources needed over time and speeding up the time it takes to analyze the results[12].

Color Segmentation

Color segmentation method is the basis for the use of object detection algorithms. Compared to other color models, the HSV color space model allows for greater segmentation of the color image. By altering the values for H (Hue), S (Saturation), and V (Variation), an interactive GUI application created in Python is used to extract only the foreground from an image (Value). A segmented color image will be produced from an input RGB image[14]. The user unquestionably needs a running camera app, and it ought to function well on low realistic or low API forms. For their perception of the street signs, the writers rely on a color division technique. They observed how a few street signs' RGB (red, green, and blue) sections behaved from sunrise till dusk. These findings must show that street signs can be constantly divided by a clear inspection of the RGB components taken in pairs. It should be much easier to distinguish the tones and statuses of different traffic signs from this division.

Color Space

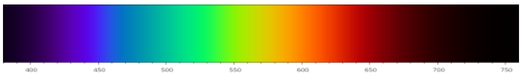


Figure 1. Linear and Non-Linear RGB space

RGB that has two types: Linear and Non-Linear RGB space. The linear RGB values are a physical representation of the chromatic light radiated from an object, but the perceptual response of the human eye depends on the non-linear RGB space [15].

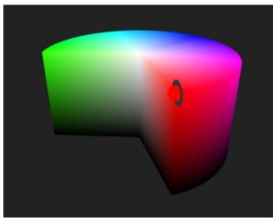


Figure 2.HSV Colorspace

Red, green, and blue (RGB) alone, however, are insufficient to view all colors; color filtering also considers color brightness and intensity. RGB is not the most insightful approach to describe colors.
Instead, individuals frequently utilize hue, saturation, and brightness when describing colors. The well-known characteristics of the HSV color model, such as the symmetrical and purely lightness-controlled transition from black to a hue to white [15]

Color Vision

What the People See Different Colors in Additive Mixing." The human eye has three types of color cone cells in its retina: S, M, and L cells, each of which has a different sensitivity to various wavelengths of the visible spectrum. The ability of the human brain to discern between roughly 10 million different colors was also mentioned. I. The combination of electromagnetic waves that correspond to green, red, and blue colors was also highlighted by the authors. As an illustration, when green and red are combined, no intermediary color is produced, hence the result is perceived as red [16].

Color Thresholding Algorithm

Most thresholding techniques involved establishing boundaries based on the grayscale values or pixel intensities of the image. According to the study's findings, the picture segmentation technique was able to separate the item from the background using the predetermined threshold values. Color thresholding technique is based on a minor modification and adaption of the grey level thresholding algorithm. Thresholding is done based on the color values in real photographs.Using multilevel thresholding, the object RGB color information was simultaneously retrieved from the background and other objects[17].

Furthermore, the system would be able to detect colors that may occur with slight changes in lighting conditions by using a redistribution method based on color criteria on the training data in the study. It providesreliable discrete adaptive color thresholding method for real-time object identification that can be employed on low-profile hardware and needs little training [18].

F1 Score

$$F_1 = 2 * \frac{precision * recall}{precision + recall}$$

Figure 5.F1 Score Formula

F-measure yields a single score that takes precision and recall issues into account simultaneously. IT practitioners makes a comment about the degree of accuracy with which the f1 scores were calculated; the study also discusses the distinction between recall and precision and how to compute both. Even though machine learning was not required for the investigation, great accuracy in color segmentation is still required in order to produce a reliable result for color filtering [19].

III. METHODOLOGY

A. Conceptual Framework

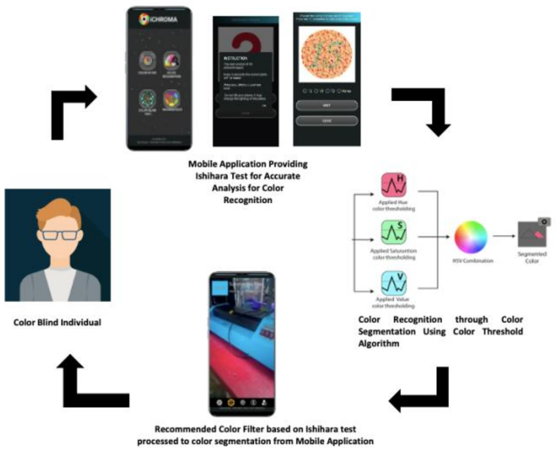


Fig.2.Conceptual Framework of the Study

Fig. 2 presents context diagram for the Android Based Mobile Application for Color Recognition Assistance for Color-Blind Individual Through Color Segmentation using Color Thresholding Algorithm which shows the connection of the user, the mobile application. In this diagram, the Users will supply the input, which is their test answers by doing the Ishihara Test. The Users will receive the data from the application, which is the test result and the real-time filter. The application will provide the color-blind test with an informational feature for the user to answer along with the other features of the application. The user will interact with the Test and the recommendation of filter through its result. The user will provide the Answer for the Ishihara test. The Test Answer will be calculated and after Calculating, the application will show the result to the user. The result will recommend a specific Filter for the user to use along with the information about the color-blindness type that the user has. When the User use the Camera Filters, the recommended filter will show to the user selection of filters. After selecting a filter, the application will apply the algorithm for the live camera input to be segmented, and the real-time camera filter output will be shown to the user. The diagram also shows the other feature of the application.

B. System Design

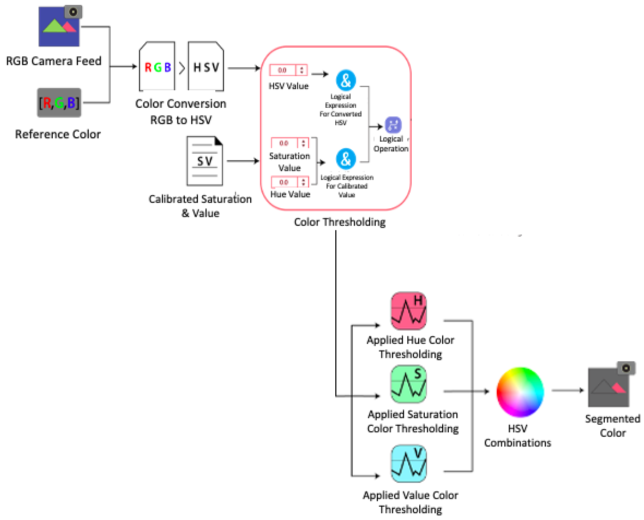


Fig. 3.System Design Using Color Threshold Algorithm

The figure shows the process of implementing color thresholding application in the study. The images or the captured live images are already in red, green, blue (RGB) color space, this is needed to be converted into HSV color space, and the reference color in red, green, blue (RGB) format is needed. After both of the reference and the red, green, blue (RGB) input is converted, HUE, SATURATION and VALUE is separately undergo on color thresholding with the calibrated saturation and value values. After the color thresholding the applied color thresholding value will be combine to a HSV value and will be segmented.

C. System Architecture

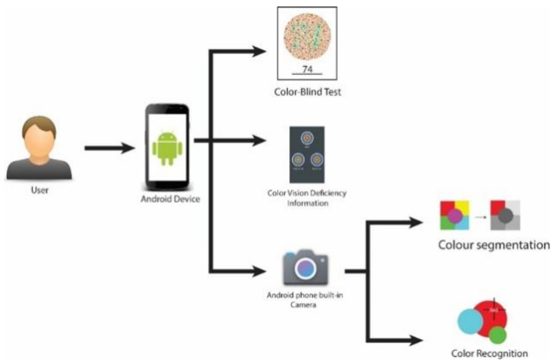


Fig.4.System Architecture

Fig. 4 shows the structure and the behavior of the application. It also shows the interaction between the application and the hardware. The architecture shows that the hardware which is the Android-based application uses the built-in camera of the smartphone for color segmentation and color recognition. It also shows that the color-blind test uses the screen of the smartphone so that the user can interact with the test. It also shows that there is no module or other hardware as it only needs an android smartphone to use.

IV. RESULTS

A. Datasets

The proponents used 360 images as datasets in color segmentation process of Color Thresholding Algorithm to the mobile application. Each images of color used as reference have 500 x 500 pixel in jpeg format 50% percent of the images which consist of 180 color based images were used to train the model for color segmentation. Another 50% of the images were used as validation for color recognition of the mobile application which consist of 180 images.

Table I. Dataset

Segmented Colors	Test Images	Validation	Total
Blue	30	30	60
Orange	30	30	60
Red	30	30	60
Green	30	30	60
Violet	30	30	60
Yellow	30	30	60
Total	180	180	360

Table II. F1 Score

Class	Precision	Recall	F1 Score
Blue	0.967	0.933	0.949696
Orange	0.867	0.833	0.849660
Red	0.933	0.933	0.933000
Green	0.933	0.933	0.933000
Violet	0.933	0.900	0.916203
Yellow	0.900	0.900	0.900000
Total	0.922	0.905	0.913593

Table 2 presents the F1 score result that shows the accuracy of the application segmentation of specific colors. The F1 score is calculated using the precision and recall of each colors. The table shows that the Blue color has the highest accuracy within the other colors. On the other hand, Orange obtained the lowest prediction rate due to the unsegmented colors and broken segmented color of the test and validation images.

Table III. Confusion Matrix

Color	TP	%	FP	%	FN	%
Blue	29	96.67%	1	3.33%	1	3.33%
Orange	26	86.67%	4	13.33%	4	13.33%
Red	28	93.33%	2	6.67%	2	6.67%
Green	28	93.33%	2	6.67%	2	6.67%
Violet	28	93.33%	2	6.67%	2	6.67%
Yellow	27	90%	3	6.67%	3	6.67%

Table 3 shows the computed data of the colors for color segmentation, the Blue color obtained the highest number in terms of accuracy for color recognition. Conversely, color Orange have the lowest number in terms of accuracy. Lowest result for False Negative color recognition falls to Blue.

Table 4 depicts a graphical representation of the summary of evaluation results. Experts evaluated the mobile Application with a weighted mean of 3.59 and with a verbal interpretation of “Very Good”. The Application was evaluated and tested based on its accuracy and effectivity during the segmentation of the color using color thresholding algorithm. Also, the application was tested based on its performance and consistency in color detection using the camera provided by the application.

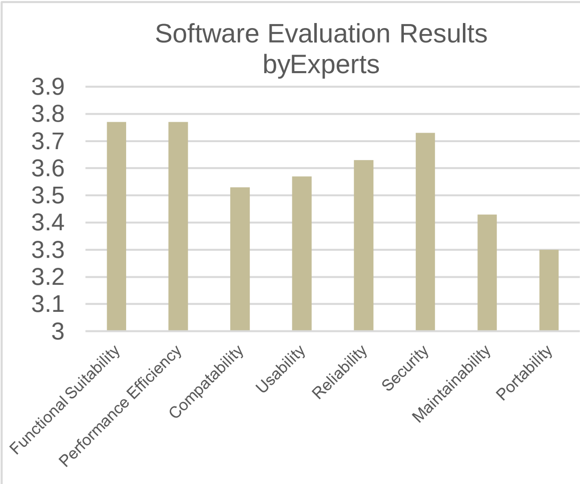
The experts recommend to include feature that can import photos from the user's device that can be used in color recognition and color filtering.Other features for the application like color-blind simulation that can be useful for color-blind people.

V. CONCLUSIONS

The study provided color-blind people with an alternative adaptation tool for distinguishing objects with major or minor hue differences, to provide a readily available color-blindness test to determine if the person is color-blind or not, to provide information in the form of infographics that help users understand color vision deficiency.The researchers develop a mobile application with color recognition using color segmentation through Color Thresholding Algorithm that shows the color name using the smartphone camera. The application is created not to replace the existing adaptation tool, color-blind glasses, but to provide color-blind people with an alternative when the said glasses are not available in their location or cannot be afforded.

B. System Performance Result

Table IV. Android Based Mobile Application for Color Recognition Assistance for Color-Blind Individual Through Color Segmentation using Color Thresholding Algorithm



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