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Portable Color Recognizer for Color and Vision Deficiency

Ain Farhana Mohd Raduan[1], Nabilah Ibrahim[1]*, Suhaila Sari[1]

[1]Faculty of Electrical and Electronic Engineering,
Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor.

*Corresponding Author Designation

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Abstract: Color blindness is a condition in which a person is unable to recognize similar contrasting colors. Nowadays, color blind people struggle to recognize the colors of everyday life. This involves activities such as choosing the color of clothes and food, playing sports, gardening, driving a car, and things around them. In addition, blind people also experience the same thing as being unable to see the surrounding environment and even being unable to see and recognize colors. Thus, the purpose of this project is to develop a color recognizer for color blind people as well as blind people to help them overcome their challenges in daily life. The device uses a TCS3472 color sensor to detect colors, an Arduino Uno to recognize colors, a serial MP3 player speaker to assist color blind people and blind people to hear the names of colors, and a servo motor is to point the colors braille script and provide feedback to the blind people. The device is intended to be user-friendly, portable, and inexpensive. Moreover, the device also works in standalone mode without the need for a PC once it is programmed. Hence, it is found that the proposed device has 75% - 100% accuracy when tested in different locations. In summary, this proposed device has the potential to help those who are color blind and totally blind by assisting them in solving their challenges in recognizing colors in daily life.

Keywords: Color Recognizer, Audio Speaker, Braille Script Color Name

1. Introduction

People who are diagnosed with color blind are unable to distinguish between particular colors. Color blindness has a variety of harmful effects on the development of a person in real life. There are two types of color blindness such as partial color blindness, in which one is unable to identify some colors, and full-color blindness, in which only white, grey, and black can be seen. However, colors work well for most people, but about 8% of males and less than 1% of females in the world are suffering from color blindness [1]. Even though blindness is defined as a lack of vision, it can also refer to vision loss that cannot be cured with glasses [2].

**Corresponding author: nabilah@uthm.edu.my*

Besides, color is meaningless for people who are born blind because they have never seen or understood color. On the other hand, color is important in helping some people who later become blind or experience partial blindness recognize something. Color blindness people sometimes feel difficult to recognize colors in their daily lives. For example, to distinguish colors in pedestrian crosswalk lights, clothing, paint, food, and others. Several methods have been developed to help with color blindness such as Braille with color-coding [3] and devices that can provide audio output from color sensor data [4]. Instead, braille is a type of communication in which people use their fingers to feel high bumps on a surface and understand what they want to translate [5]. To distinguish colors, color-blind people can make marks on their fabrics, such as staples or pins. They can remove the mark by using a color recognizer device.

The purpose of this project is to design a portable device that able to detect colors and inform the user of that color through the audio output from speakers. In addition, the servo motor is used for the pointer braille code. When the servo motor is triggered, its arm moves from the surface to provide feedback to blind people. Therefore, they can recognize each character converted to the braille script [6].

2. Materials and Methods

This section described the materials and methods used to develop the process for the portable color recognizer for color and vision deficiency persons. The flow chart of the system is shown in the first subsection and followed by the hardware implementation.

2.1 Overview of the system

The steps of development of the color recognizer are shown in Figure 1. Firstly, the device is set up using the Arduino Uno and TCS34725 color sensors before it starting to detect the color of the object. The calibration of RGB colors is also be done as the preparation of the colors to be detected. While the TCS4725 color sensor reads any color of the object, it will receive the RGB value and analyze it. If the colors match, it will recognize and play the audio of the color name, and a servo motor will rotate its pointer to point the braille code of the color name.

2.2 Hardware Implementation

The device's electronic components include an Arduino Uno, a TCS3472 color sensor, a YX5300 Serial MP3 Music Player Module, a servo motor, and a power source. The microcontroller board used in this device is known as the Arduino Uno [7]. It contains fourteen I/O pins, six of which are analog input pins. It has a USB port that can be used to power it. The TCS3472 color sensor can detect the intensity of RGB colors and generates digital output. In addition, The TCS3472 color sensor contains an integrated IR-blocking filter for accurate color measurement. It has a high sensitivity and wide dynamic range making it an ideal sensor for varying color intensity [8].

A servo motor is used to rotate its pointer to point the braille script of the color names. Besides, the YX5300 Serial MP3 Music Player Module is used to play the color names. Thus, it has a high- quality MP3 audio chip that supports MP3 and WAV file formats [9]. Besides that, a micro-SD card saves database of the sound of all colors used for the device. An MP3 player speaker is used to deliver the output audio of color from the device.

Figure 2 shows the schematic circuit design for the portable color recognizer. The components used are Arduino Uno, TCS3472 color sensor, YX5300 Serial MP3 Music Player Module, servo motor, battery, push button switch and serial MP3 speaker.

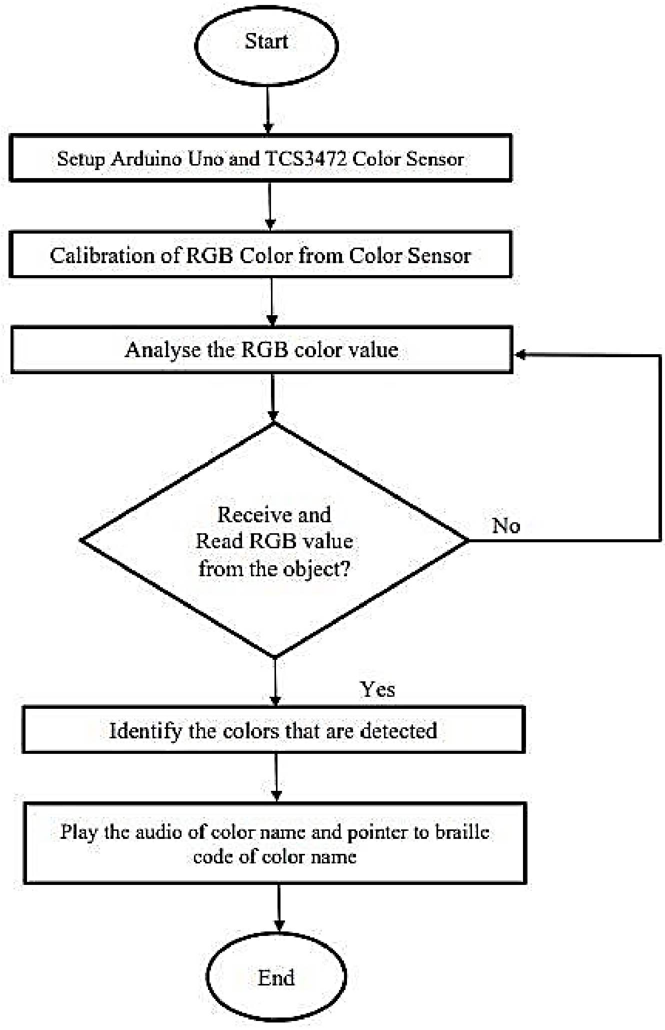

Figure 1: Steps of development of color recognizer

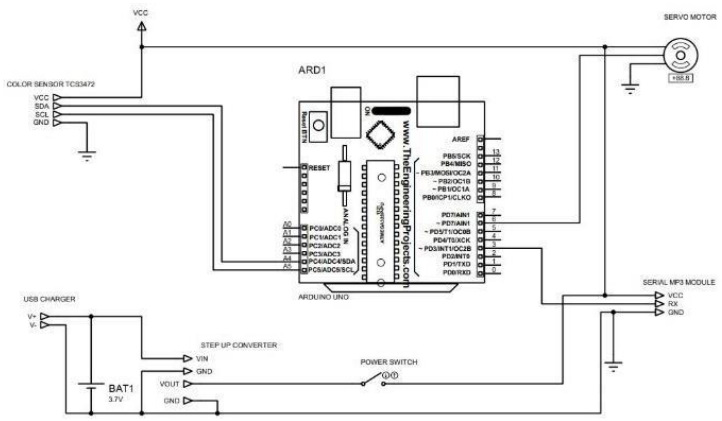

Figure 2: Schematic circuit design

2.3 Comparison on existing devices

Table 1 shows a comparison of existing devices on the market. A lot of research have been carried out on color recognition for the visually impaired with some advantages and disadvantages of the device.

Table 1: Comparison Advantage and Disadvantage on existing devices

Title Device	Advantage	Disadvantage
Color Recognition System forVisually Impaired Persons [10]	- It is a self-contained and low-cost assistive system. - This color recognition system is also good at responding, user-friendly,and easy to use.	Has less feature to detect and recognize a variety of indoor and outdoor objects.
Color Recognition WearableDevice Using Machine Learning For Visually Impaired Person [11]	- This color recognition wearable device using machine learning is capableof transforming colors tosound, vibration, and feeling emotions allowing color blind and blind people to differentiate between colors.	Camera detection cannot detectthe objects because it is affectedby the light surrounding.
The Talking Color Identifying Device for The Visually Impaired [4]	- This device can pronounce the color name in four different languages such asEnglish, Chinese, Thai and Vietnamese. - It also consists of 27 common colors, easy to use, and is inexpensive.	The device is expensive and difficult uses for visually impaired people.
A Wearable Device for Blind People to Restore ColorPerception [12]	- Haptics is used to help blind people interpret color and enhance theirquality of life. - A Proof-of-Concept device is developed inside this wearable device.	Less power to function in long-term used.

Based on the research observation made, the devices on the market were created for people who only have color blindness problems and they are also expensive. Therefore, an innovation is made in this device where a color braille script has been added for people who are totally blind. In addition, a color voice has been added to be used by those with low vision and some colors other than primary colors is also added for detection purposes. However, this portable device can be helpful and easy to use for totally blind and low vision people to detect the colors around them and also, they can get these devices at affordable prices.

3. Results and Discussion

3.1 Hardware Design for the portable color recognizer

Figure 3 shows the final design of the project device. This device includes a color sensor used to detect the color, a servo motor used for braille script pointer of color name, and a speaker used for the sound of the color name. Furthermore, these devices can make it easier for people who are colorblind or blind to use.

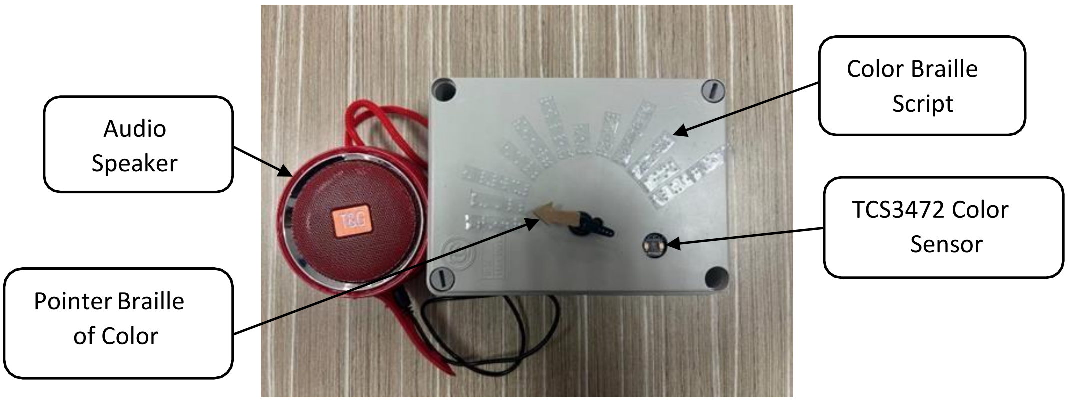

Figure 3: Proposed prototype of the portable color recognizer

3.2 Testing on Light Intensity

The experiment was conducted in several conditions. The device is tested to determine its ability to identify and recognize color under various light intensity conditions. This is due to the photodiode's sensitivity to light, as it also requires light from four LEDs on the sensor to read the RGB value. The test is conducted under three conditions which are indoor, outdoor, and dark room light intensity. Table 2 shows the results of light intensity testing.

Table 2: Results of light intensity testing

Color	Indoor	Outdoor	Dark Room
White	Success	Failed	Success
Black	Success	Failed	Success
Purple	Success	Success	Success
Blue	Success	Success	Success
Green	Success	Success	Success
Yellow	Success	Success	Success
Red	Success	Success	Success
Grey	Success	Success	Success
Orange	Success	Success	Success
Brown	Success	Success	Success
Pink	Success	Success	Success
Blue-green	Success	Failed	Success
Results (%)	**100%**	**75%**	**100%**

For light intensity γ in each condition, the following equation (1) is presents:

$$\gamma = \frac{n}{12} x100\% \qquad \text{Eqn. (1)}$$

Here, n is defined as number of successful testing. 12 represents the total number of testing.

According to the testing results shown in Table 2, the color sensor can detect all colors in indoor and dark room conditions and both conditions have 100% device accuracy. This is because the color sensor is not affected by any disturbance light intensity when the device is used indoor and dark room, allowing the sensor value to correctly read RGB information from an object.

While in outdoor condition, the device's accuracy is 75%. This is due to some colors such as white, black, and blue-green unable to be detected due to the extra light from the sun on the sensor and photodiode. Thus, it cannot detect the accurate RGB values.

3.3 Testing on Real Objects

The device was also be tested to identify input colors from various shapes, textures, and sizes of objects. This is to show the device's ability to read input from a real object. These tests also important for the real application of this device to help color blind people to overcome their challenges in daily activities and tasks. Table 3 shows the testing color results on real objects. The color sensor can identify all the correct colors of the six tested objects. This shows that the color sensor can detect color on color paper and objects with color. Thus, it is convenient to be used in any condition or object that intend to be recognized. Table 3 shows the results of real object experiment.

Table 3: Results of real object experiment

Object	Color	Result
	White	Success
	Red	Success
	Green	Success
	Blue	Success

	Brown	Success
	Black	Success

3.4 Testing of the Proposed Prototype on the Blind Person

The device was also be tested by low-vision people and fully blind people. Both subjects are the student of Sekolah Kebangsaan Sungai Wangi, Ayer Tawar Perak. Figures 4 and 5 show the test progression. The volunteers wore the device, and it was tested on random objects of various colors compatible with the device. Table 4 shows the results of low-vision and fully blind people experiment.

Figure 4: Subject I is a low-vision person

Figure 5: Subject II is a fully blind person

Table 4: Results of low-vision and fully blind people experiment

	Color	**Without Device**	**With Device (Audio & Braille)**	**Results**
Subject I		Orange	Yellow	Succeed
		Brown	Red	Succeed
		Red	Blue	Succeed
		Red	Orange	Succeed
		Yellow	Green	Succeed
		Blue	Purple	Succeed
Subject II		Red	Brown	Succeed
		Pink	Grey	Succeed
		Pale pink	White	Succeed
		Dark red	Black	Succeed
		Light grey	Pink	Succeed
		Dark grey	Blue-green	Succeed

Based on Table 4, Figure 4 and Figure 5 show two visually impaired people who are low-vision and fully blind who recognize each color in a different way. This shows that each subject has color blindness in different situations where subject 1 uses audio to help recognize colors while subject 2 uses braille color names to recognize colors by touching the dots for each color. Both subjects, however, are able to recognize the colors that were tested on them.

4. Conclusion

In conclusion, a color recognizing system that is used in an electronic circuit technique has been successfully developed and tested, thus achieving the first objective of designing a device that will help color blind and totally blind people in recognizing colors that they are unable to see. The experiment that has already been conducted proves and supports the idea of assisting these types of visually impaired people to recognize color. This device also helps and works with people who are color blind or totally blind in handling simple activity or task in their daily lives. Furthermore, various tests were carried out to assess the functionality and accuracy of the developed color contrast application system. This device can detect up to 12 different colors. This project also successfully by applying the RGB color model as a methodology for determining color contrasts and storing them in the device database. In this project, the braille script for color names is used to help people who are totally blind recognize colors by touching the color braille script. This research paper is a small contribution to the challenge of integrating people with visual impairments into society through the provision of an independent help system.

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