# Automatic Testing of Color Blindness

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## Abstract

*Color Blindness can be challenging as well as cumbersome for a person when he is doing different works like driving a vehicle, purchasing clothes, testing strips for hard water, pH in laboratory, cooking etc. About 8% of men (mainly) are suffering from color blindness. The objective of this work is to investigate the problem in perspective of image processing and propose a model that not only detects color blindness but also provide details of the band in which he is colorblind. This is a fully automated system that works in an interactive mode with the patient and no external intervention is required. We have tested our system on some colorblind person and obtained encouraging results.*

## 1. Introduction

Color blindness (color vision deficiency) is a condition in which certain colors cannot be distinguished, and is most common due to an inherited condition. Red/Green color blindness is by far the most common form, about 99%, and causes problems in distinguishing reds and greens. Another color deficiency Blue/Yellow also exists, but is rare and there is no commonly available test for it.

Inherited color blindness is most common, affects both eyes, and does not worsen over time. This type is found in about 8% of males and 0.4% of females. These color problems are linked to the X chromosome and are almost always passed from a mother to her son.

Color blindness may be partial (affecting only some colors), or complete (affecting all colors). Complete color blindness is very rare. Those who are completely color blind often have other serious eye problems as well.

### 1.1 Some major problems of color blindness

- Weather forecasts
- Bi-color and tri-color LEDs
- Traffic lights, and worst of all, Caution lights
- Color observation by others
- Purchasing clothing
- Cooking and foods

### 1.2 Signs and Symptoms

The symptoms of color blindness are dependent on several factors, such as whether the problem is congenital, acquired, partial, or complete.

- Difficulty distinguishing reds and greens (most common)
- Difficulty distinguishing blues and greens (less common)
- The symptoms of more serious inherited color vision problems and some types acquired problems may include:
- Objects appear as various shades of gray (this occurs with complete color blindness and is very rare)
- Reduced vision
- Nystagmus

## 1.3 Treatment

There is no treatment or cure for color blindness. Those with mild color deficiencies learn to associate colors with certain objects and are usually able to identify color as everyone else. However, they are unable to appreciate color in the same way as those with normal color vision.

## 2. Types of Color Blindness

There are various types of color blindness. They are mainly categorized in two categories:

**2.1 Anomalous Trichromacy** - A mild shift in the sensitivity of pigments of the cones. It is of three kinds.

**2.1.1 Protanomaly** (one out of 100 males): Shades of red appear weaker in depth and brightness. Protanomaly is referred to as "red-weakness", an apt description of this form of color deficiency. Any redness seen in a color by a normal observer is seen more weakly by the protanomalous viewer, both in terms of its "coloring power" (saturation, or depth of color) and its brightness.

**2.1.2 Deuteranomaly** (five out of 100 of males): Shades of green appear weaker .Let the deuteranomalous person adjust your television and he would add more green and subtract red. He is considered "green weak". Similar to the protanomalous person, he is poor at discriminating small differences in hues in the red, orange, yellow, green region of the spectrum.

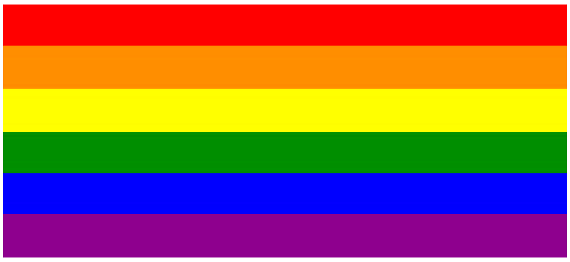
**2.1.3 Tritanomaly** - very rare case where shades of blue appear weaker.

**2.2 Dichromacy** - Great deficiency or missing completely one of the cones. It is of three kinds and it is more common compared to Anomalous Trichromacy. A person with normal color vision and with Dichromacy type of color blindness is shown in Fig.1(a-d).

**2.2.1 Protanopia** (one out of 100 males): Shades of red are greatly reduced, if present at all, in depth and brightness For the protanope, the brightness of red, orange, and yellow is much reduced compared to normal. For example see Fig.1(b).

**2.2.2 Deuteranopia** (one out of 100 males): Shades of green are greatly reduced, if present at all, in depth and brightness.The deuteranope suffers the same hue discrimination problems as the protanope, but without the abnormal dimming. For example see Fig.1(c).

**2.2.3 Tritanopia** - very rare case where shades of blue are greatly reduced, if present at all, in depth and brightness. For example see Fig.1(d).



(a)

(b)

(c)

(d)

**Fig. 1: The colors of the rainbow as viewed by a person with a) normal vision b) Protanopia c) Deuteranopia d) Tritanopia color blindness[10].**

## 3. What Wavelength Goes With Color?

Our eyes are sensitive to light which lies in a very small region of the electromagnetic spectrum labeled "visible light". This "visible light" corresponds to a wavelength range of 400 - 700 nanometers (nm) and a color range of violet through red. The human eye is not capable of "seeing" radiation with wavelengths outside the visible spectrum. The visible colors from shortest to longest wavelength are: violet, blue, green, yellow, orange, and red. Ultraviolet radiation has a shorter wavelength than the visible violet light. Infrared radiation has a longer wavelength than visible red light. The white light is a mixture of the colors of the visible spectrum. Black is a total absence of light.

Earth's most important energy source is the Sun. Sunlight consists of the entire electromagnetic spectrum. The detailed distribution of such spectrum is shown in Fig.2.

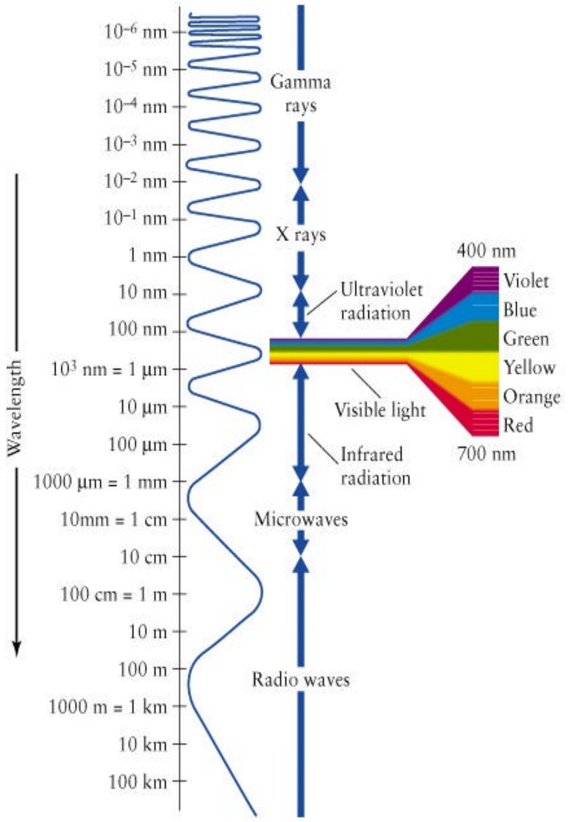



**Fig. 2: Wavelength of different color [11].**

## 4. Existing Color Blindness Test

**Ishihara Test:** The most famous colorblindness test was created by Dr. Shinobu Ishihara of University of Tokyo. If we visit an ophthalmologist we will most likely be given some variations of this test.

**Waggoner Test:** A variant of this test specially designed for pre-school children using shapes instead of numbers has been created and is sold by Dr. Terrace L. Waggoner of the Staff Naval Hospital Pensacola. His site also contains a wealth of general information about color vision deficiencies.

**Yee Test:** Arson's friend and collaborator Nick Yee even takes this test a step further on his wave site by including a graphic that reveals one thing to the color blind and to those with normal vision. This test does not constitute medical advice.

**Clauset Test:** This is an unique and very interesting variant to most conventional colorblind tests has been developed by Aaron Clauset of Haveford College. Unlike most tests, which requires good color vision, only colorblind people can pass this tests.

### 4.1 Limitations of the Existing Models

There are several color blindness test model available in the market. All are good in their places. The most common test done for color blindness people is Ishihara test. If we visit an ophthalmologist we will most likely be given some variation of this test. Here a man is subjected to some pictures of numbers consisting of doted pixels of various colors. If he can not identify it then it proves that he has color blindness in some color.

This test model tells only if a person is color blind or not. On the other hand this test is not designed for all categories of man. This test does not tell anything about the band of colors where he/she is color blindness.

The next test model is Waggoner model. This test model is specially designed for pre-school children using shapes instead of numbers.

In this test model some shapes of different colors comes to the pre-school children and they identify the shapes. If children do not identify shapes, then this proves that the children are colorblind. This test does not tell anything about the band of colors where he/she is color blindness.

The next test model is Clauset test model. Unlike most tests, which require good color vision, only the colorblind people can pass on this test.

The next test model is Yee test model. Arson's friend and collaborator Nick Yee even takes this test a step further on his website by including a graphic that reveals one thing to the color blind and to those with normal vision. This test does not constitute medical advice.

The other entire existing model tests for some categories of people. There is no such common test model, which can test for color blindness for all people.

## 5. Proposed system

The implementation of this proposed system is based on the idea that a color blind person can't differentiate between similar colors in which he is color blind. For this we have considered digital eight (8). As it consists of 7 lines and depending on absent of one or more lines it is converted into different digits. For example if the middle line is absent it will be zero (0) instead of eight (8). We have carefully designed the lines of this number and also backgrounds of this lines. The various buttons are also designed keeping in mind the possible numbers/shapes will be seen by a color blind person. We have taken utmost care to consider all types of possibility in respect to colorblindness. It is converted to a full fledge program for easy installation and execution in windows platform.

The program works as follows:

**Step 1:** A screen will appear to the person that instructs how to operate the system. And in second step he has to fill up some personal documents.

**Step 2:** First image comes to the person. There are two figures, one is foreground figure and another is background figure. The person has to identify the foreground figure (see Fig.3).

**Step 3:** If he can identify '8' from the previous image, one identical image with different foreground and background color will appears to him. Again if he identify '8' as previous, another identical image come for the another type of color blindness. If again he can identify the number '8', a report is generated that shows that he is not color blind.

**Step 4:** Suppose he identifies the foreground figure as '0' in Step 2, then an image appears to him to tell what to do in the next step.

**Step 5:** After reading the message, which appears to him, he presses the 'OK' button. Then the 'No' button is to be clicked repeatedly up to when he can identify the number '8' from the foreground image. Then when he can identify the number '8' properly, the 'Yes' button is to be clicked (see Fig.4).

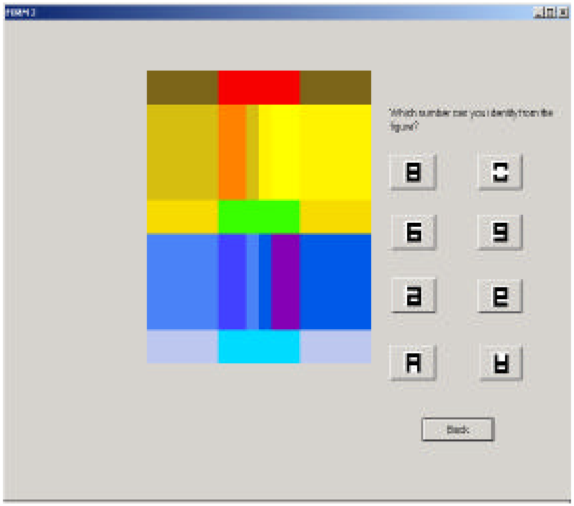


**Fig. 3: First screen shot**

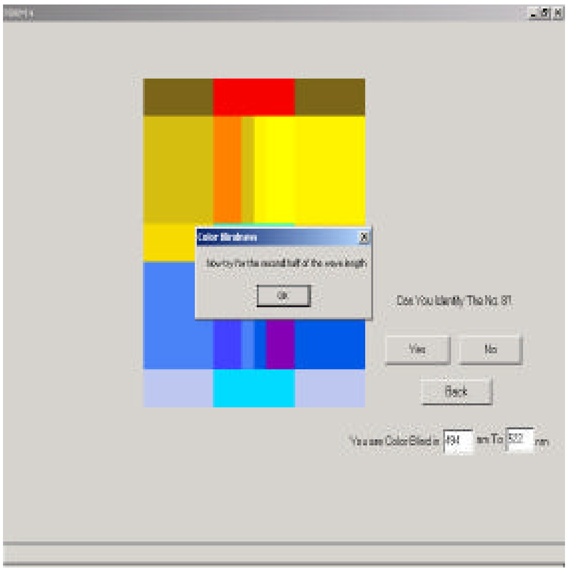



**Fig. 4: Intermediate screen shot**

**Step 6:** After reading the message that appears to him, he presses the 'OK' button. Now again the same process is to be done for the second half of the wavelength. When he can identify the number '8' the 'Yes' button is to be pressed as follows (see Fig.5).

**Step 7:** Finally the test report appears that shows the final range of color blindness (see Fig.6).

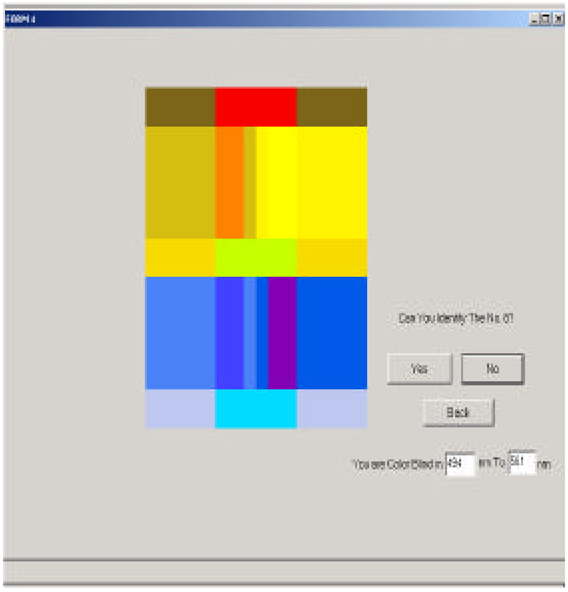



**Fig. 5: Intermediate screen shot**

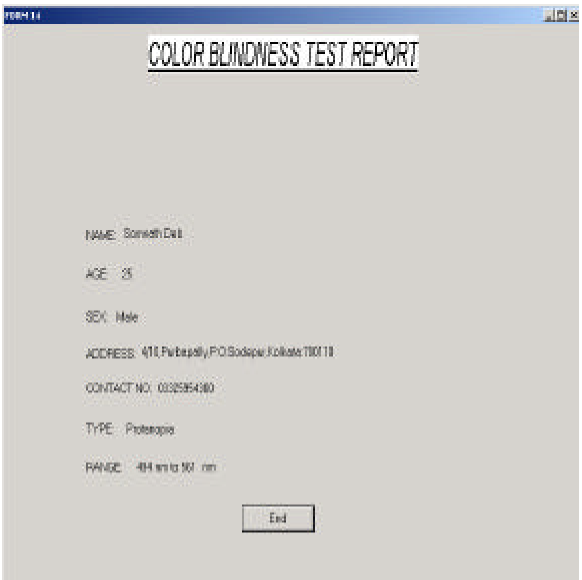



**Fig. 6: Final report of colorblindness**

## 6. Experimental Results and Conclusions

This program was tested on about 500 people and out of them we have tested on 20 people who have color vision problem to some extent. We have got a satisfactory result using our program. Our program tells two things, one is the man is color blind or not and if he is color blind then at what range of wavelength he is color blind and also what type of color blindness he has. We have also consulted doctors to validate the result obtained by our program. We have not only tested the result but also the band in which he is colorblind.

There are so many tests on color blindness that can tell weather a person is color blind or not but we could not find any system that can reveal the band of region where the person is colorblind. This project is built for identification the band of region where a colorblind people cannot identify a particular portion of color. This is an automatic system where every man can test himself whether he is colorblind or not and if he is colorblind than he can know in which band of color he is colorblind. We have tested on 500 people and have got encouraging results.

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