# Traffic Signal Color Detection Using the Pixy2 Camera

## Purpose

The purpose of this experiment is to optimize Pixy2 camera parameters with the Raspberry Pi 3B+ to accurately detect and report the color of red and yellow traffic lights. This project aims to find an efficient, low cost solution to problems faced by drivers with color blindness.

## Introduction

Traffic lights are used at many intersections worldwide on a daily basis. The standard color scheme of red, yellow and green is the premise of the reliability of the traffic signal. The vast majority of the population has no trouble distinguishing between these colors. However, those suffering from color blindness or color deficiency are at a disadvantage. With the most common types of color blindness, red and yellow traffic lights may be indistinguishable. (see Fig. 1).

People with color blindness often find alternative means of interpreting information. For example, in the common three light, vertical configuration, the position of the red, yellow and green bulbs is standard. Drivers can distinguish the light color based on the position of the light in the stack. However, in the case of single-bulb flashing lights (see Fig. 2), the standard positioning of the lights cannot be used for reference. Many colorblind people find it difficult to determine if a single flashing light at an intersection is red or yellow, forcing them to rely on other drivers and surrounding traffic to ascertain the correct response to the light, ie proceed through the intersection or stop. This can be extremely hazardous and result in an accident if the signal is misinterpreted. This is a problem that should be addressed, not only to increase the safety for the colorblind drivers, but also for those around them.

The Pixy2 camera offers an efficient, and low cost option for color detection. The Pixy2 is a small visual sensor that can be interfaced with microprocessors such the Raspberry Pi. The Pixy2 has both image and color sensing and tracking capabilities. The Pixy2 camera coupled with a Raspberry Pi can be utilized as an alternative, reliable and more cost efficient option for accurately displaying yellow and red traffic light signals for color blind drivers. (see Table 1).

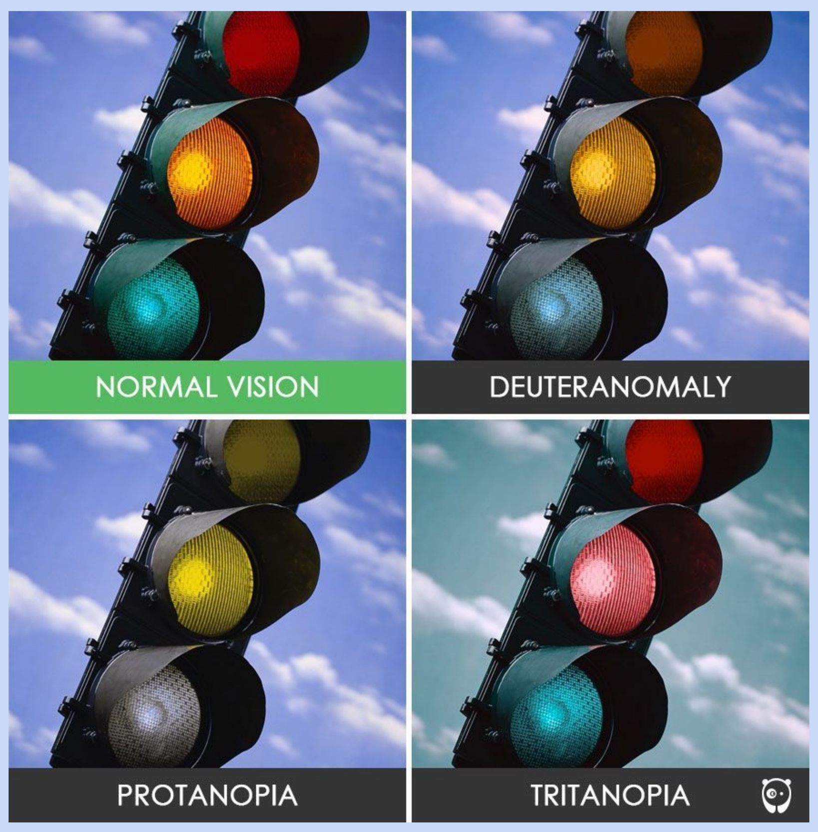


Fig. 1: This image shows how different types of color blindness affect the way traffic light colors are viewed. Note that red and yellow are nearly indistinct in Deuteranomaly and Protanopia, the most common forms of color blindness.

## Results

| Conditions | Test | Number of Trials | True Positives | False Positives | No-Lock | Distance Avg(Blocks) | Comments |
|---|---|---|---|---|---|---|---|
| Home Parameters | D2FT1 | 13 | 11 | 0 | 2 | 0.077 | Interference from other bright lights |
| Home Parameters | D2FT2 | 15 | 14 | 0 | 1 | 0.25 | |
| Home Parameters | D2FT3 | 7 | 7 | 0 | 0 | 0.21 | Interference |
| Home Parameters | D2FT4 | 4 | 3 | 1 | 0 | | Detecting everything as Red |

Table 2: Results for field tests utilizing the Home Parameter camera settings.
Key: True Positives: Camera detected correct light color. False Positives: Camera detected incorrect light color. No-Lock: Camera did not detect traffic light.

| Conditions | Test | Number of Trials | True Positives | False Positives | No-Lock | Distance Avg(Blocks) | Comments |
|---|---|---|---|---|---|---|---|
| Custom Parameters (CP) | D2FT5 | 7 | 7 | 0 | 0 | 0.14 | mostly at or just before stop line |
| CP LED 20, T 2 | D2FT6 | 10 | 7 | 1 | 1 | 0.43 | Interfering signals, tracking errors |
| CP LED 20, T 5 | D2FT7 | 10 | 10 | 0 | 0 | 0.85 | Accuracy < 1 block |
| CP LED 20, T 7.5 | D2FT8 | 10 | 10 | 0 | 0 | 1.75 | Accuracy > 1 block |
| CP LED 20, T 10 | D2FT9 | 10 | 10 | 0 | 0 | 2.15 | Accuracy >2 blocks |
| CP LED 0, T 10 | D2FT10 | 10 | 10 | 0 | 0 | 2.4 | Longest distance |

Table 3: Results for field tests utilizing the Custom Parameter camera settings with retrained color tunings and adjusted LED brightness and Signature Teach Threshold levels. LED brightness reported in thousands of lumens and signature teach threshold reported in thousands.

Fig. 2: Single flashing traffic light. Due to the lack of other sequential lights, drivers are unable to use position for reference to determine the color of the light.

| Device | Cost |
|---|---|
| Raspberry Pi 3 + Pixy2 camera + monitor | $134.78 |
| EnChroma Glasses without corrective lenses | $300 - $429.00 |
| EnChroma Glasses with corrective lenses | $450 - $600.00 |
| ChromaGen Contacts | $750 - $1200.00 |

Table 1: Cost comparison of devices for managing color deficiency

## Procedure

The Raspberry Pi was initialized with Python 3.7.4. The Pixy2 camera was connected (see Fig. 3). After that, in a naturally lit room, the camera was taught to recognize red and yellow lights on a home made, simulated traffic light. Once trained, testing and adjustment of the parameters was continued until the lowest amount of false negatives and false positives were achieved.

Next, the Pixy2 camera was field tested using the home parameters by driving around in the evening after many of the traffic lights were switched to flashing red/flashing yellow. This was tested at approximately 60 intersections. The color recognition was based upon teaching on the simulated traffic light.

Next, an actual traffic light was obtained. The camera was re-taught to recognize red and yellow on the traffic light in the driveway at home (see Fig. 4). The camera was then field tested as above. The range of detection was not good, with the camera reporting the color only when close to or at the stop line of the intersection.

The red/yellow recognition was re-calibrated from inside the car, aiming at a traffic light at an intersection. The color recognition testing was repeated with the new custom parameters at various LED brightness and threshold levels. The accuracy of light color recognition as well as distance (in blocks) were recorded.

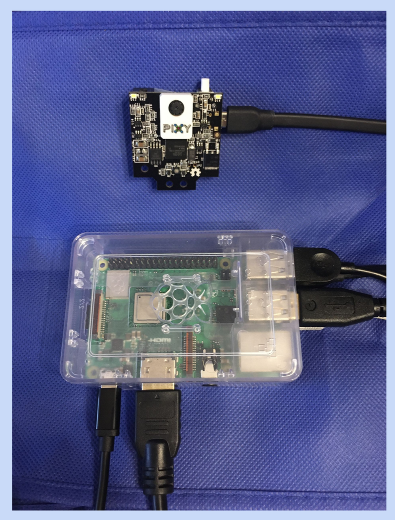

Fig. 3: Camera and microprocessor setup


Fig. 4: Red and Yellow lights identified by Pixyw Camera

## Conclusion

In conclusion, the goal of this project was achieved. The optimal operation parameters of the Pixy 2 camera via Raspberry Pi 3 B+ for the purpose of detecting and distinguishing red and yellow traffic lights was found to be at LED brightness of 0-20,000 lumens with a signature teach threshold of 7,500.
This device is reliable and more cost effective than the other available corrective devices for color blindness.

Photo credit: Anita Tekchandani, Nicholas Shepich
https://www.forhealthylifestyle.com/color-blindness-world-10-pics/
https://www.allstardrivereducation.com/michigan-traffic-rules-lights-not-working/