Sensors & Sensing Lab 5: Color Sensor

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1 Introduction

Color sensors are widely used in applications ranging from industrial automation to consumer electronics. They work by measuring the intensity of reflected light when an object is illuminated with different wavelengths (colors). By analyzing the reflected light, the sensor can determine the color of the object. This lab explores the design, calibration, and testing of a custom color sensor using an RGB LED, a photoresistor, and an Arduino microcontroller.

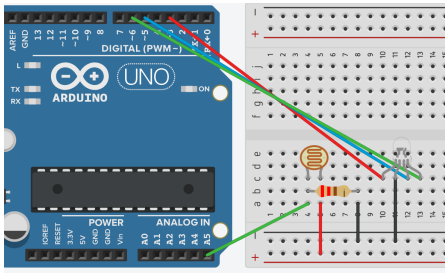
2 Components

2.1 Components Used

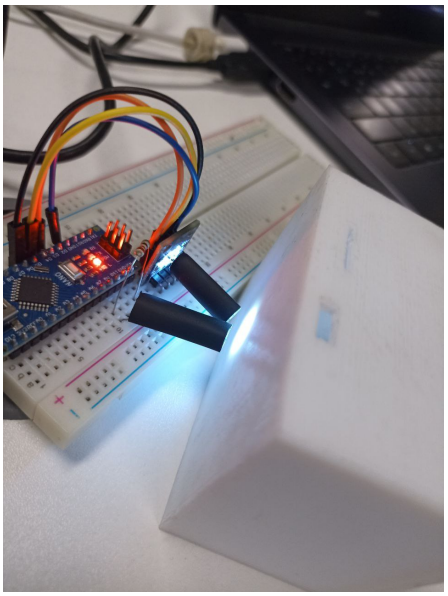
The following components were used in this experiment:

- **RGB LED**: Provides red, green, and blue illumination.
- **Photoresistor**: Detects the intensity of reflected light.
- **Arduino Uno**: Acts as the microcontroller for controlling the RGB LED and reading the photoresistor values.
- **Resistors, Breadboard, Jumper Wires**: For circuit assembly.
- **Calibration Materials**: White reference object for calibration.
- **Testing Materials**: Colored samples for testing.

2.2 Experimental Setup



(a) Circuit schematic



(b) Physical setup

Figure 1: Experimental configuration

To minimize interference from ambient light, the photoresistor and RGB LED were enclosed in an electrical shrink tube. This ensured that only the reflected light from the illuminated object was detected.

3 Code Implementation

Listing 1: Color sensing code snippet

```
// Connection pins
const int red = 3;
const int green = 5;
const int blue = 6;
const int photores = A7;
const int del = 100; // Delay between readings
const int val = 250; // Intensity of emitted light
const float green_factor = 1.3f;
const float blue_factor = 1.5f;

void setup() {
  Serial.begin(9600);
  pinMode(photores, INPUT);
  pinMode(red, OUTPUT);
  pinMode(green, OUTPUT);
  pinMode(blue, OUTPUT);
}
void loop() {
  analogWrite(red, val);
  delay(del);
  int redVal = analogRead(photores);
  analogWrite(red, 0);

  analogWrite(green, val);
  delay(del);
  int greenVal = green_factor * analogRead(photores);
  analogWrite(green, 0);

  analogWrite(blue, val);
  delay(del);
  int blueVal = blue_factor * analogRead(photores);
  analogWrite(blue, 0);

  analogWrite(red, val);
  analogWrite(green, val);
  analogWrite(blue, val);
  delay(del);
  int whiteVal = analogRead(photores);
  analogWrite(red, 0);
  analogWrite(green, 0);
  analogWrite(blue, 0);
  // Output fromatted for plotting
  Serial.println(String("R:") + redVal + ",G:" + greenVal +
      ",B:" + blueVal + ",W:" + whiteVal);
}
```

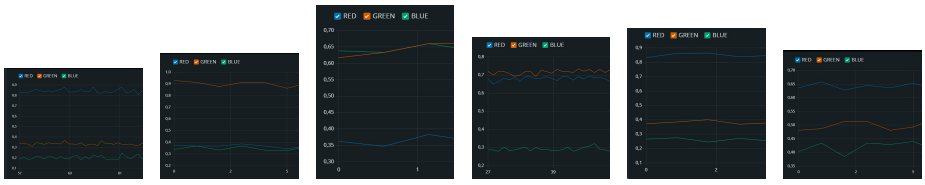
The code sequentially illuminates the object with red, green, and blue light, then measures the intensity of the reflected light using the photoresistor. Finally, it emits white light (all three colors simultaneously) to provide a reference value for normalization. This approach allows the sensor to detect colors on both matte and reflective surfaces but does not differentiate between light and dark shades of the same color.

4 Calibration Procedure

To calibrate the sensor, we illuminated a white reference object and measured the reflected light intensity for each color channel. Ideally, the readings for red, green, and blue should be equal for a white surface. However, due to variations in LED brightness and sensor sensitivity, the readings differed. To compensate, we applied scaling factors (experimentally determined) to the green and blue channels.

5 Testing and Results

The sensor was tested with several colored objects, including red, green, blue, and yellow. The results are shown below:



(a) Red readings (b) Green readings (c) Blue readings (d) Yellow readings (e) Orange readings (f) Purple readings

Figure 2: Color test results

The sensor was able to distinguish between the primary colors (red, green, blue) and the secondary color (yellow, orange, purple).

6 Conclusion

This lab demonstrated the design, calibration, and testing of a simple color sensor using an RGB LED, a photoresistor, and an Arduino microcontroller. The sensor effectively detected primary and secondary colors by analyzing the intensity of reflected light under different illumination conditions.

Andrey Yanov, github: `https://github.com/Anryan2/Sensors_and_sensing_lab`