# A Color Detection Method for Introductory Robotics

2003 Florida Conference on Recent Advances in Robotics
University of Florida

**Vinh Trinh**
Machine Intelligence Lab
Department of Electrical & Computer Engineering
University of Florida
Gainesville, Florida 32611
Email: vsn3e8@yahoo.com

**Eric M. Schwartz**
Machine Intelligence Lab
Department of Electrical & Computer Engineering
University of Florida
Gainesville, Florida 32611
E-mail: ems@mil.ufl.edu

**Antonio. A. Arroyo**
Machine Intelligence Lab
Department of Electrical & Computer Engineering
University of Florida
Gainesville, Florida 32611
E-mail: aroyo@mil.ufl.edu

**Michael C. Nechyba**
Machine Intelligence Lab
Department of Electrical & Computer Engineering
University of Florida
Gainesville, Florida 32611
Email: nechyba@mil.ufl.edu

**ABSTRACT:** *Color detection systems are rarely used in introductory robotics courses due to the lack of reliable inexpensive color detection methods. This paper examines how to develop an accurate color detection scheme that costs little to build and is easy to implement.*

**Color Detection:**

A blue surface when exposed to green light shines very brightly, however in the presence of red light appears to be black. An orange surface, on the other hand, displays reflection characteristics that are opposite that of blue. The idea is to take advantage of this property and create a system where a CDS cell can be used to differentiate between colors.

**Materials:**

- Microcontroller with A/D Channels
- Bright LEDs
- Resistors
- CDS Cells

**Test Bed:**

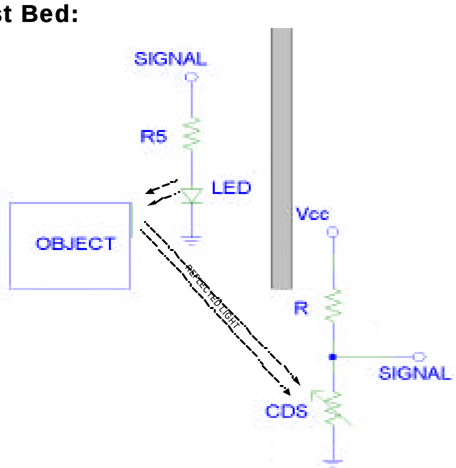


*Figure 1*

The circuit is a simple voltage divider [Figure 1]. An output port of a microcontroller is used to turn on and off the LED. The measured signal is taken between the CDS Cell and the resistor. A CDS Cell is a passive element where the resistance across the component's leads is directly proportional to the intensity of light shown upon the surface. A large voltage range is desirable in order to increase the resolution of our sensor. Assuming the CDS Cell has linearly varying resistance for our region of operation, we can evaluate for an R that will allow a maximum voltage range.

$$V_{range}(CDS_{min}, CDS_{max}, R) := \frac{CDS_{max}}{CDS_{max}+R} - \frac{CDS_{min}}{CDS_{min}+R} \qquad \text{I}$$

$$\frac{d}{dR}V_{range}(CDS_{min}, CDS_{max}, R) \rightarrow \frac{-CDS_{max}}{(CDS_{max}+R)^2} + \frac{CDS_{min}}{(CDS_{min}+R)^2} \qquad \text{II}$$

$$0 = \frac{d}{dR}V_{range}(CDS_{min}, CDS_{max}, R) \text{ solve}, R \rightarrow \begin{bmatrix} (CDS_{min} \cdot CDS_{max})^{\frac{1}{2}} \\ -(CDS_{min} \cdot CDS_{max})^{\frac{1}{2}} \end{bmatrix} \qquad \text{III}$$

CDSmin = The minimum resistance of the CDS Cell.
CDSmax = The maximum resistance of the CDS Cell.
R = The resistor which should be chosen
Vrange = The max and minimum signal

An array of differently colored LEDS is used for data collection. The array I built [Figure 2] consists of 4 collimated Red, Blue, Green and White LED's. The columns are used to guard the CDS Cell from direct exposure to the LED light.

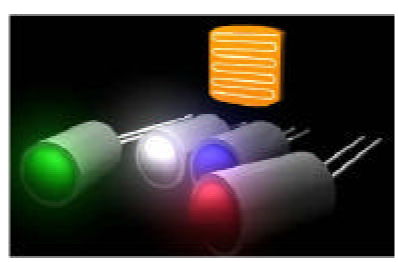

*Figure 2*

**Data Collection & Evaluation:**

Obtain a unique vector of data for each color we wish to distinguish using the method in figure 3.

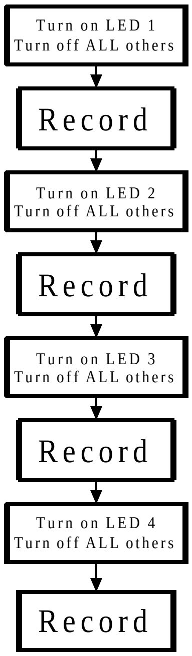


*Figure 3*

Let us assume we are using an 8-bit A/D and record measurements ranging from 0-255. To distinguish between Yellow, Red, Blue, Green, Brown, and Orange, we will derive a table similar to that of figure 4.

| Color to Detect | LED 1 (Green) Reading | LED 2 (White) Reading | LED 3 (Blue) Reading | LED 4 (Red) Reading |
|---|---|---|---|---|
| Yellow | 70 | 178 | 121 | 191 |
| Red | 3 | 80 | 83 | 160 |
| Blue | 12 | 90 | 120 | 60 |
| Green | 80 | 150 | 131 | 100 |
| Brown | 5 | 60 | 80 | 75 |
| Orange | 8 | 135 | 100 | 186 |

*Figure 4*

Finally, we can distinguish unknown colored surfaces by calculating the Euclidean Distance [IV] against each of our known vectors. The vector producing the shortest Euclidean Distance will have the greatest likelihood of being the unknown color.

$$D_{Euclidean} = \sqrt{\sum_{n=1}^{m} \left(X_n - Y_n\right)^2} \qquad \text{IV}$$

D = Euclidean Distance
X = Unknown Vector
Y = Known Vector
M = Number of test points per vector

**Example:**

Unknown Color Reading 1 = 65
Unknown Color Reading 2 = 130
Unknown Color Reading 3 = 150
Unknown Color Reading 4 = 90

$$D_{yellow} := \sqrt{(65-70)^2 + (130-178)^2 + (150-121)^2 + (90-191)^2}$$

$$D_{yellow} = 115.633$$

$$D_{red} := \sqrt{(65-3)^2 + (130-80)^2 + (150-83)^2 + (90-160)^2}$$

$$D_{red} = 125.431$$

$$D_{blue} := \sqrt{(65-12)^2 + (130-90)^2 + (150-120)^2 + (90-60)^2}$$

$$D_{blue} = 78.797$$

$$D_{green} := \sqrt{(65-80)^2 + (130-150)^2 + (150-131)^2 + (90-100)^2}$$

$$D_{green} = 32.955$$

$$D_{brown} := \sqrt{(65-5)^2 + (130-60)^2 + (150-80)^2 + (90-75)^2}$$

$$D_{brown} = 116.726$$

$$D_{orange} := \sqrt{(65-8)^2 + (130-135)^2 + (150-100)^2 + (90-186)^2}$$

$$D_{orange} = 122.434$$

Here, green is the most likely color with a Euclidean distance of *32*.

**Conclusion:**

This method has been implemented successfully on a robot I designed and built for EEL 5666, Intelligent Machines Design Laboratory, offered by the University of Florida graduate electrical engineering program. The name of my color sensing robot is EM. EM is able to move around gather M&M candies and sort them according to their color using this simple method of color detection.