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PH INDICATOR PAPER COLOR MEASUREMENT USING WIRELESS TRISTIMULUS COLORIMETER

Biological Science

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ABSTRACT

This paper reports wireless color measurement using TCS-230. Colored papers are illuminated with white light & corresponding light intensity from reflecting surface is detected using photodetector. The spectral characteristics of photodetector are normalized. The reflectance for the colored surface is measured as a ratio of reflected intensity to emitted intensity, TCS-230 is a 'color light to frequency converter'. The output frequency is directly proportional to light intensity. The light to frequency converter reads an 8*8 array of photodiodes. Sixteen photodiodes are clear with no filter, 16 have red filters, 16 have green filters & 16 have blue filters. All 16 photodiodes of same color are connected in parallel. The chromaticity co-ordinates of pH colors papers are measured using the wireless colorimeter and compared with CIE standard co-ordinate values.

KEYWORDS

Tristimulus, Chromaticity Co-ordinates and TCS230 color sensor

Introduction:

Colorimetry is a physical science that deals with objective and quantitative ways of describing color. Since the impression of color is something subjective – what one person perceive as "light blue" may look "medium blue" to another – it is not quite clear how to describe and identify different colors. Colorimetry tries to connect the notion of a standard color sample with the physical concept of light as a form of energy. [1].

It is thought that the retina of the human eye has three kinds of color sensors or cones with peak sensitivities for red, green and blue light. This tristimulus theory is attractive since it allows us to think of color as a positively weighted sum of the primary colors red, green and blue. It turns out that large number of colors can be reproduced by mixing red, green and blue color lights with proper proportions. [2].

It has been known since the inception of color science that object colors are determined not only by the spectral composition of the light reflected from them but also by the spectral composition and brightness of the light reflected from the objects. [3].

Color in consumer products has become a distinctive feature of our modern society. From the cloths we wear, the cars we drive, and the houses we live in, to the shows we watch, books we read, and catalogues we shop from, color plays a central role. But it is not enough for an object to be colorful. The color must be "right" and in many cases it must "match". However, accurate reproduction of color is not an easy task and part of the reason for this is, accurate color measurement is quite difficult. Accurately measuring an object color is far more difficult than accurately measuring its weight or size.

There are many reasons for this uncertainty. First, many different standards and methods of measuring color are currently in use. Secondly, compatibility between instruments from different manufacturers is poor. Thirdly, many artifacts and confounding factors complicate color measurement. Lastly, instrument repeatability is sometimes poor. To make color measurement accurate, suitable calibrations of the instrumentation are required. [4].

Theoretical background:

Before a system to measure and specify color could be developed, it was necessary to understand the nature of the color sensing mechanism in the human eye. While some progress in this direction was made in the late 18th century, the prevalent anthropocentric views contributed to confusion between color vision and the nature of light. The wider acceptance of the wave theory of light paved the way for a better understanding of both light and color. Both Palmer and Young hypothesized that the human eye has three receptors, and the difference in their responses contributes to sensation of color. However Grassmann and Maxwell were the first to clearly state that color can be mathematically specified in terms of three independent variables. Maxwell demonstrated that any additive color mixture could be "matched" by proper amount of three primary stimuli, a fact now referred to as trichromatic generalization or trichromacy. Around the same time, Helmholtz explained the distinction between additive and subtractive color mixing and explained trichromacy in terms of spectral sensitivity curves of the three "color sensing fibers" in the eye. [5].

The three CIE standard weights can be calculated by using following equations:

$$X = \sum_{380}^{780} R(\lambda)E(\lambda)\bar{x}d\lambda \qquad Y = \sum_{380}^{780} R(\lambda)E(\lambda)\bar{y}d\lambda \qquad Z = \sum_{380}^{780} R(\lambda)E(\lambda)\bar{z}d\lambda \qquad \text{(I)}$$

Where R (λ) is surface reflectance and E (λ) is light source distribution. The weights X, Y and Z define a color in the CIE space x + y + z = 1, the result in a 2D space known as the CIE chromaticity diagram. The coordinates in this space are usually called x & y and they are derived from XYZ using following equations:

$$x = \frac{X}{X+Y+Z} \qquad y = \frac{Y}{X+Y+Z} \qquad z = \frac{Z}{X+Y+Z} \qquad \text{(II)}$$

$$x+y+z=1 \quad i.e. z=1-x-y$$

Methodology:

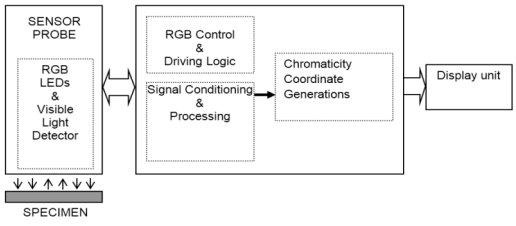

Figure: Block diagram of colorimeter

Experimental Work:-

The pH indicator paper is the sample , for the experimental work. The indigenously developed wireless colorimeter is used to measure the chromaticity co-ordinates of pH indicator paper by reflection method. TCS-230 color sensor is mounted on a specially designed PCB along with LEDs. The sample is illuminated with LED & the reflectance, which is the output of TCS-230 in the form of frequency is send to the PC via Bluetooth. The color shade of pH paper & RGB values are displayed on the screen. The process is repeated for total 12 shades with different pH values. Corresponding tristimulus values are obtained using a C++ program. Chromaticity co-ordinates are calculated using standard equation. The result is compared with CIE standard data.

Table 1: pH values of indicator papers and their chromaticity coordinates:

pH	Chromaticity Coordinates			
	Standard data		Measured data	
	X	y	x_o	yo
1.0	0.28	0.21	0.28	0.20
3.0	0.27	0.27	0.26	0.26

4.0	0.23	0.13	0.22	0.14
5.0	0.27	0.32	0.26	0.30
6.0	0.29	0.34	0.29	0.34
7.0	0.26	0.34	0.27	0.34
8.0	0.28	0.37	0.28	0.37
9.0	0.38	0.40	0.38	0.40
10.0	0.37	0.39	0.37	0.38
11.0	0.29	0.21	0.29	0.21
12.0	0.40	0.49	0.41	0.51
14.0	0.33	0.25	0.33	0.26

Result and Discussion:

The chromaticity co-ordinates of pH indicator papers are determined using tristimulus wireless colorimeter. The measured data is compared with CIE standard values and found in good agreement.

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