Artificial Teeth Shades' Evaluation Using Color Sensor Module

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Abstract

Aim: This study is conducted to evaluate the use of TCS230 color recognition sensor to analyze the color shade of artificial teeth.

Method: A standard acrylic teeth shade guide was used in this study, and each shade is digitally analyzed by the color sensor through multiple readings according to RGB system for color analysis. The average Red, Green, and Blue readings were analyzed and the data were plotted statistically.

Results and conclusion: The results showed a significant variation for each color value among all the shades. Each shade showed a significant proportional difference among the others. The red color values appeared to have the most fluctuating trend. It is recommended to use this technique for teeth shade guide examination and selection than relying only on visual evaluation.

Key words: Artificial teeth shades; Color recognition sensors; RGB color analysis

Introduction

Finding the best match for the natural dentition is always a concern to both the dentist and the patient [1]. It was suggested by several studies that the artificial teeth shades or the degree of whiteness is an important esthetic factor that should be considered carefully for the patients [2,3]. It is challenging to find a good restorative match for the natural teeth with limited range of shades because the accurate tooth color is highly influenced by age, type, and location [4-6]. In order to optimize shade matching efficiency, digital assistance could provide reliable results [7]. There are some available digital tools that predict teeth shade types [8]. However, this study aims to evaluate the use of a custom-made color recognition sensor to examine the artificial teeth shade degree and then developing a calibration chart for future applications. This approach would be much less costly from today's available products.

Materials and Methods

Acrylic teeth shade guide (Huge 16 shades, China) was used in this study as reference guide. Only shades from (A1 to A4), (B1 to B4), and (C1 to C4) were used in the analysis step. Color recognition sensor (TCS230, China) was used with the Arduino Uno microcontroller as a setup for the system. The sensor consist of four LED lights at the corners of the PCP, and an RGP color sensor located at the center.

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The system was programmed to provide the Red, Green, and Blue color level readings and the program code [9] was modified to take the readings every 3 seconds. The reading levels for each color were set from 0 to 1023 according to the program code. The color sensor was boxed by a black piece of polymer with dimensions of (2.5mm x 3mm x 2.5mm) to accommodate the size of the sensor and the light distribution of the LEDs. The artificial teeth were detached from the shade guide and each one was placed inside the box with the labial surface facing the sensor and 5 different readings were taken. The average readings were calculated and the data were plotted by Microsoft Excel for visual analysis. The RGB data were also statistically analyzed by the IBM SPSS (Version 20) with the ANOVA test for significant difference.

Results

Table (1) shows the collected data based on the RGB values including the baseline readings which is an empty black background reading as shown in Figure (4) No. (1) data which has superior RGB values compared to the rest of the data.

The ANOVA Tukey HSD test for multiple comparison showed that there is a statistically significant difference (P-value < 0.05) among all color groups, which is reasonable since the wavelength of each color is distinctly different from the others.

According to table (2), and Figure (4), the red color shows intermediate mean value but with the highest standard variation among the color groups, while the mean value for the green color was the highest, and the blue color was the lowest.

Discussion

Due to the modern advances in digital technologies and to find a more reliable substitution to ordinary techniques used in specific steps in prosthodontic work, this study was developed to evaluate the reliability of using TCS230 color recognition sensor to determine the shade of the artificial teeth that matches the patient case. A regular shade guide for acrylic teeth was tested in this study by the setup that consists of the color sensor and a digital microcontroller. This setup presents the output in the computer via Arduino IDE software [10]. The output was basically the absorbance of red, green, and blue colors by the sensor.

The study results presents the statistical variation among the three colors in terms of absorbance values. In Figure (4), a similar pattern was found in the green and blue values for each shade. However, the red color values appear to be the most unstable among the other groups. This fact gives a key for differentiating artificial teeth shades based on the red color in proportion with the green and blue colors.

Besides being affordable, this technique can be used more conveniently and accurately to select the appropriate shade for the patient just by modifying the setup in terms of program code and some hardware addition to determine the natural teeth shade and select the appropriate shade for the artificial teeth practically. Thus, eliminating the false visual reading as a result of bad illumination.

Conclusion

In order to evaluate artificial teeth shades digitally, a color sensor module was programmed and used to analyze each shade into three basic values for the colors red, blue, and green. The statistical analysis showed that individual color variation among the shades was significant as the red color values were the most fluctuating. However, the blue color values were the least significant variable among the sample shades. This technique provides reliable and accurate description of the artificial teeth shade examination and can be programmed further to be utilized in the practical setting for shade detection in a much affordable manner.

References

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Table (1): Average RGB readings for the samples

	Red	**Green**	**Blue**
Baseline	440	476	327
A1	346	374	273
A2	386	402	287
A3	372	409	291
A4	370	410	294
B1	371	371	273
B2	361	395	283
B3	289	403	289
B4	364	402	291
C1	370	404	285
C2	284	398	284
C3	373	411	295
C4	284	424	302

Table (2): Descriptive statistics for the RGB data

	N	**Mean**	**Std. Deviation**	**Std. Error**	**Minimum**	**Maximum**
Red	12	347.50	38.425	11.092	284	386
Green	12	400.25	14.943	4.314	371	424
Blue	12	287.25	8.497	2.453	273	302

Table (3): Tukey HSD multiple comparison ANOVA test results

RGB Groups	**N**	**Subset for alpha = 0.05**		
		1	**2**	**3**
Blue	12	287.25		
Red	12		347.50	
Green	12			400.25
Sig.		<0.001	<0.001	<0.001

Figure (1): Acrylic teeth shade guide (Huge 16 shade)

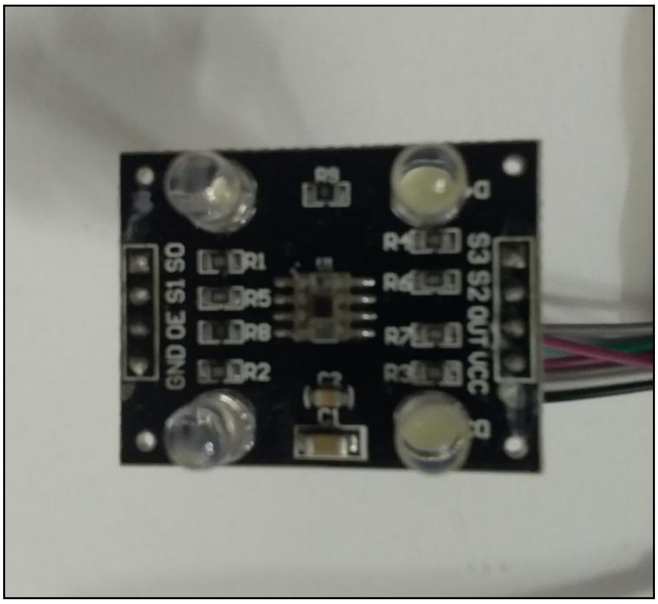

Figure (2): TCS230 Color Recognition Sensor

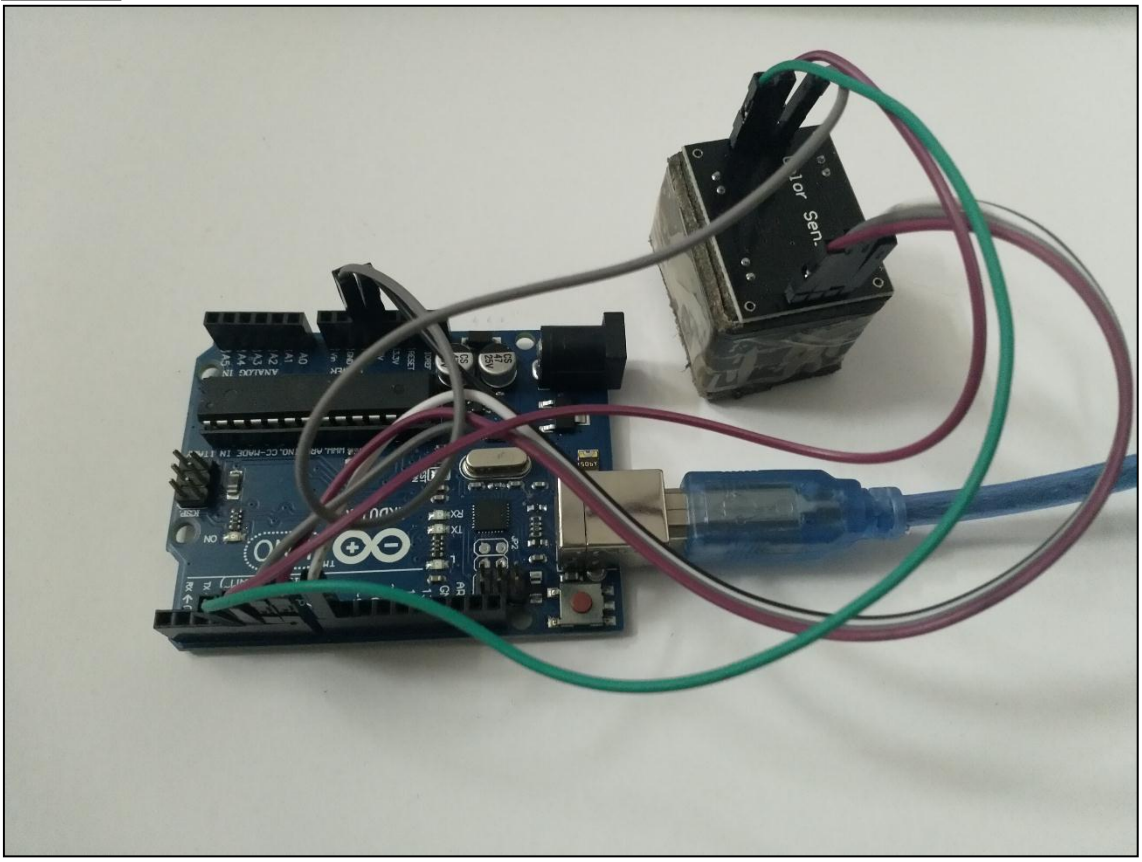

Figure (3): Color Sensor-Microcontroller setup

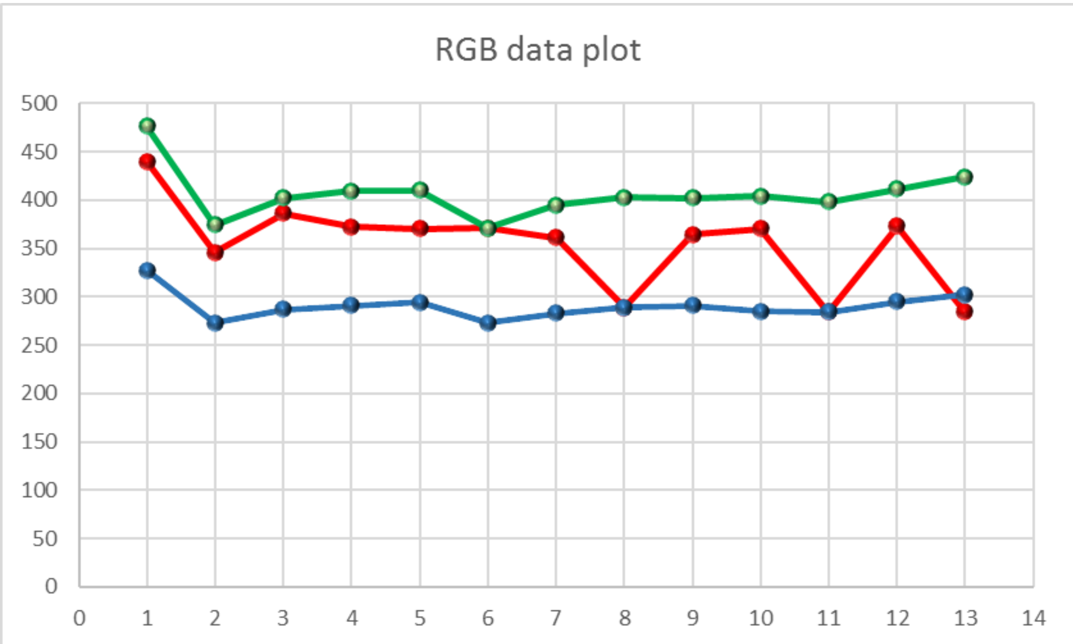

Figure (4): RGB data plot *(X axis = shade type, Y axis = color level)*