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DEVELOPMENT OF AUTOMATIC COLOR RECOGNITION SYSTEM FOR PANEL SURFACE IN LASER SEALING PROCESS

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SUMMARY

Automatic color recognition is an important factor to achieve high levels of automation for laser edge banding system in furniture manufacturing. In this article, a color recognition system was designed and evaluated based on the Arduino UNO mainboard and TCS3200 sensor. The TCS3200 sensor was used to detect the color of the product, and the Arduino mainboard was used to read the output frequency and analyze the color result. Eight-panel surfaces with different colors were used to validate the accuracy of the designed system. The results showed that the design system had the ability to accurately identify colors with high stability. Therefore, this result might be applied for developing automatic color recognition systems in the next generations of laser-based edge sealing machine.

Keywords: Arduino UNO, color recognition, TCS3200 sensor, laser edge technology

Phát triển hệ thống nhận diện màu sắc tự động cho bề mặt ván gỗ công nghiệp trong máy dán cạnh bằng công nghệ laser

Nhận dạng bề mặt của ván gỗ công nghiệp tự động thông qua màu sắc là một yếu tố quan trọng để đạt được mức độ tự động hóa cao cho hệ thống máy dán cạnh bằng công nghệ laser trong sản xuất ván đồ nội thất. Trong bài viết này, hệ thống nhận dạng màu sắc được thiết kế, đánh giá dựa trên bản mạch Arduino UNO và cảm biến nhận diện màu sắc TCS3200. Cảm biến TCS3200 được sử dụng để phát hiện, nhận diện màu sắc của các bề mặt sản phẩm và bản mạch chủ Arduino được sử dụng để đọc tần số đầu ra và nhận kết quả màu sắc. Tám bề mặt tấm ván với các màu sắc khác nhau được sử dụng để xác nhận độ chính xác của hệ thống được thiết kế. Kết quả cho thấy hệ thống thiết kế tự động nhận diện bề mặt tấm ván thông qua màu sắc là chính xác với độ ổn định cao. Do đó, kết quả này có thể được áp dụng để phát triển hệ thống nhận dạng màu sắc bề mặt ván gỗ công nghiệp tự động trong các thế hệ tiếp theo của máy dán cạnh dùng công nghệ laser.

Từ khóa: Arduino UNO, nhận dạng màu sắc, cảm biến TCS3200; máy dán cạnh Laser

I. INTRODUCTION

Color recognition is becoming more and more widely used in modern production, including, industrial automation, remote sensing technology, image processing, product quality inspection, and several fuzzy detection technologies that require color detection [1 - 5]. Edge sealing is an important step in furniture manufacturing. It offers the protection against moisture and steam for the kitchen worktop, provides stabilization of cut edges and can seal narrow surfaces of wood artificial board [6 - 9]. Currently, the process of laser edge sealing, is similar to that of traditional edge sealing, but that of laser edge sealing is less complex thanks to the integration of edge sealing tape and the adhesive layer.

In addition to the stability and quality of the weld, the surface color of each surface sealed product requires its matching color of the sealing edge. With laser-based edge sealing machine, the task was automated by computer input of color code from a list according to color of products. However, this color code input is prone to human reading mistake. Therefore, automatic color reading and adjustment of input color matching that of edge banding is, an important factor in achieving a high automation level.

Currently, there are many color sensors in the market with different prices depending on the quality and field of use. Among them, TCS3200 sensor is a programmable color light to frequency converter developed by Texas Advanced Optoelectronic Solutions, which is used in many fields due to its high accuracy and reasonable cost [10, 11]. In this study, we used the TCS3200 sensor and Arduino UNO mainboard to design the color recognition system of panel surface for an automatic laser sealing process. Through our work, a high economic efficiency color reading system was proposed for sealing edge machine. This can be applied in automation of color reading and changing of sealing edge color in furniture manufacturing industries.

II. MATERIAL AND METHODS

2.1. TCS3200 color sensor

The TCS3200 color sensor is a complete color detector, including a TAOSTCS3200 RGB (Red, Green, Blue) sensor chip and four white LEDs. It can detect and measure a nearly limitless range of visible colors. The applications of TCS3200 include test strip reading, sorting by color, ambient light sensing, and calibration, and color matching, etc [10,12,13]. The circuit diagram of TCS3200 color sensor as shown in Fig. 1.

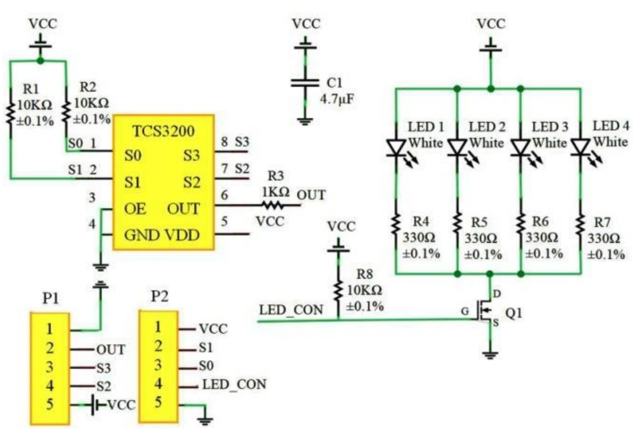

Fig. 1. The circuit diagram with a chip structure of the TCS3200 sensor

2.2. Arduino UNO board

The Arduino expansion was emerged in Italy to build up low-cost hardware for communicating design. Recently, Arduino UNO an outstanding option for many In-Out-through application designs[14 - 18]. It is widely used for an open-source single-board microcontroller development platform due to the flexible applications, easy-to-use hardware, and software components.

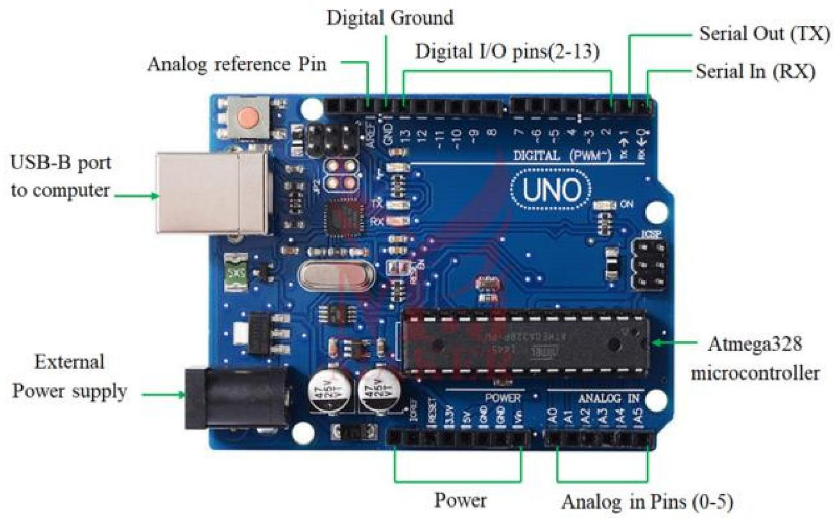

Fig. 2. General structure of Arduino UNO Board

Arduino UNO is a microcontroller board designed based on the microchip ATmega328 (Fig. 2). It includes 14 digital Input/Output pins such as the Pulse Width Modulation outputs, analog inputs, Universal Serial Bus connection, and others. In addition, the Arduino-compatible custom sensor expansion boards can be developed to directly plug into the standardized pin-headers of the Arduino UNO board, allowing the Arduino UNO to connect to several sensors [19 - 21].

2.3. Research methodology

Design principle

The color edge banding constitutes the values of the three primary colors of blue, green and red. When a color filter is used, it only allows a specific primary color to pass through, and other primary colors are not allowed to pass. The sensor converts it to a specific frequency, which is then fed into the frequency converter. This output frequency determines the perceived color and uses the Arduino UNO processor to read the output frequency and receive the color result. The scheme of light intensity transformation into a signal shown in Fig. 3.

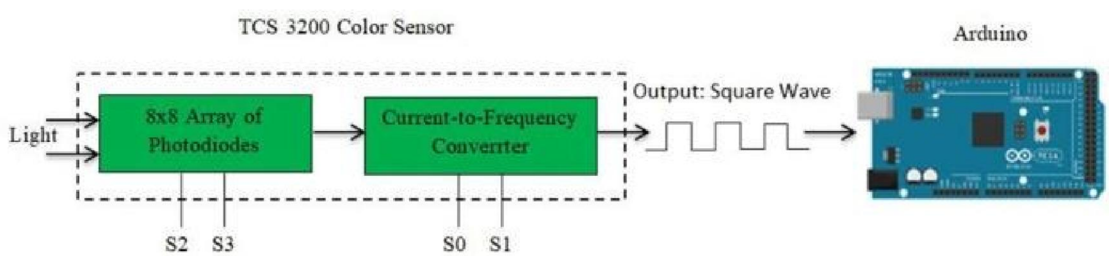

Fig. 3. Scheme of light intensity transformation into a square signal

III. RESULTS AND DISCUSSION

3.1. Surface panel color

Panel surfaces were exposed to the color sensor, at which light from the surface was absorbed and analyzed and subsequently sent to Arduino UNO for further analysis, color coding and screen display. Analytical results also triggered input of sealing edges with matching color in the manufacturing process. In preparation steps, this study established a range of available color surface based on colors currently used in the industry. Specifically, seven surfaces were assigned the codes P1, P2, P3, P4, P5, P6, P7, and P8 are blue, green, yellow, black, gray, brown, oak and gray oak, respectively, as shown in Fig. 4.

Fig. 4. Assigned codes of panel surfaces color

3.2. Design of model

The main function of the Arduino UNO controller is to control other modules to achieve color detection and display. Among them, the main controller is the ATMega328 microcontroller board. To speed up the Arduino UNO board, a 9V DC input was used to enable the ability to drive high-power external devices such as servos and a universal serial bus (USB) port. After plugging in the sensor, the power supply and communication with the programming board was tested. A bypassing capacitor (reduction of high-frequency current flow) and an LCD display for simple viewing of the data measured were connected to the feeder circuits. There is a potentiometer (10 $kk\Omega$) connected to the LCD display to set up the required contrast. The circuit is activated on by a push-button switch (Fig. 5).

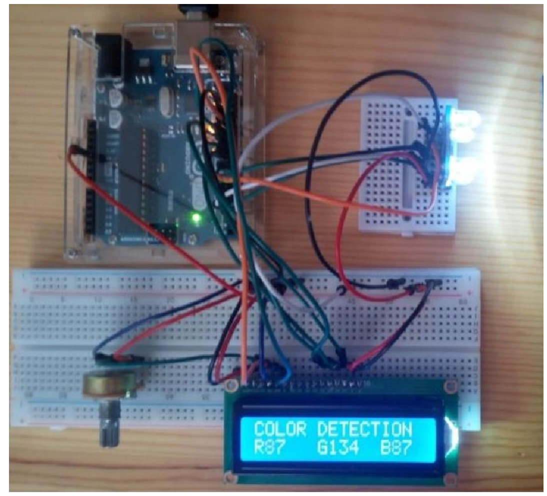

Fig. 5. Initial wirings of the sensor to the programming board

The development platform selected for this application was previously developed [14]. The controlling software of colorimeter was written in JAVA language in the Arduino IDE environment. The functionalities of the elec Freaks library, especially functionalities for signal frequency measurement and LCD control were used.

3.3. Frequency RGB value

The color detecting device was used to recognize the color of the panel surface. To stabilize the brightness of the illumination lamp and the A/D conversion accuracy, the DC power supply was adjusted stability with accuracy within ± 0.1%. In addition, the color sensor TCS3200 was adjusted to an optimal detection distance of 1 cm. The results of the measurements for 8 panel surfaces in this study are shown in Fig. 6 for each color component R, G, B.

The results show that the highest R values when there are more red components in the color of the measured object such as P3, P5, P6, P7, and P8 samples. Similarly, if there are many green components, G in the output result is the largest value such as P2 sample. If there are many blue components, B is the highest value such as P1 and P4 samples.

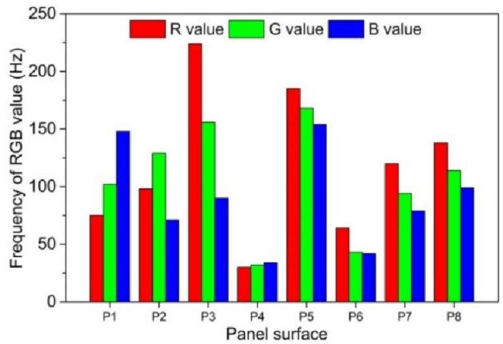

Fig. 6. The frequency of RGB value for on color panel surfaces

3.4. Validation results

In order to validate the accuracy of the automated color recognition system, the tests were carried out on two different types of paint surfaces such as solid paint color (P1, P2) and texture paint color (P7, P8). On each sample, 20 random points on the paint surfaces were measured with the automated color recognition system. The frequency of the RGB value of P1 and P2 are presented graphically in Fig. 7a and Fig. 7b, respectively.

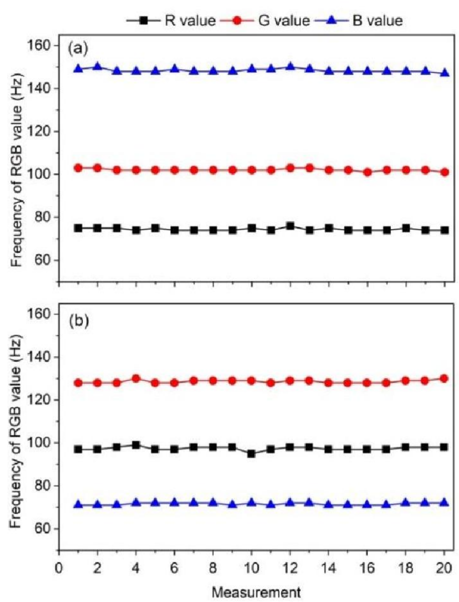

Fig. 7. Frequency of RGB values at different points of P1 (a) and P2 (b) samples

The results show that the SD values of R, G, B of P1 and P2 samples are less than 1, indicating that the color parameters measured at different locations on the surface of the sample are not significantly different. This demonstrates that the sensor has high sensitivity and accurately identifies colors on the solid paint color surfaces.

The frequency of RGB values at different points of P7 and P8 samples are plotted in Fig. 8a and Fig. 8b, respectively. The results show that the SD values of R, G, B of P7 and P8 samples are greater than 1. This result can be explained by the fact that the color of texture paint surfaces is dark and uneven color distribution according to the characteristics of each type of wood grain.

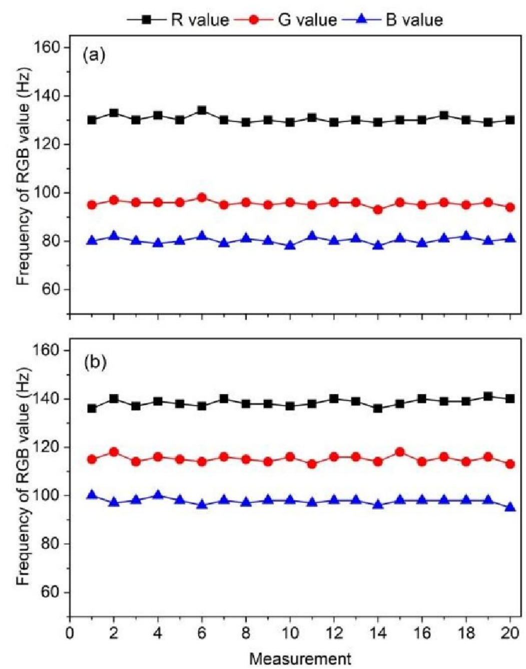

Fig. 8. Frequency of RGB values at different points of P7 (a) and P8 (b) samples

The validation results again confirm the accuracy and stable work of the color recognition system with the TCS3200 sensor. However, the proposed color recognition system in this study has some limitations to be mentioned. First, a small number of panel surfaces were used to validate the system in experiments; this reduced the accuracy of the system. Thus, further validation with more panel surfaces, especially the texture paint color surfaces, need to be conducted. Additionally, this color recognition system was not linked to actual laser edge sealing equipment which may cause significant differences among the outcomes, thus results have limited reliability. Thus, a field study is needed in the future to validate the results of the present study.

IV. CONCLUSIONS

This article introduces the system of color recognition for the panel surface based on Arduino UNO board and TCS3200 sensor. The results indicated that the panel surface was precisely recognized by Arduino UNO analysis of the signal from color sensor TCS3200, with high working speed and stability. Although the system development is still in an early phase, it might be used in prototyping and manufacturing of automatic color recognition systems in the next generations of laser-based edge sealing machine.

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