Application of Arduino Control Mainboard with Color Light Sensor TCS3200 in Color Recognition of Edge Banding In Laser Edge Banding Machine

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Abstract. In the laser edge banding system, automatic color reading and adjustment of input color matching that of edge banding is an important factor in achieving high automation level. This paper describes a working prototype designed for color-based automatic sorting of objects. TCS3200 sensor was used to detect the color of the product; and Arduino board was used to control the overall process in which matching sealing edge was introduced. Color input was based on analysis of reading of TCS3200 sensor. Results illustrated matching of color in a series of products coded E1, E2, E3, E4, E5, E6, E7, and E8. According to the results, we concluded that laser edge sealing reduces unstable factors, reduces labor and stabilizes product quality.

1. Introduction
The process of laser edge sealing in general 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 adhesive layer. The high-performance laser edge sealing equipment is equipped with a scanning storage device, which stores the information of technological parameters of the edge sealing strip by scanning. When replacing the edge sealing strip, manual adjusting parameters are not needed [1-2]. In furniture manufacturing, surface color of each surface sealed product requires its matching color of the sealing edge. This color reading and matching once relied solely on human eyes; yet with laser based edge sealing machine, the task was automated by computer input of color code from a list according to color of products. This color code input is prone to human reading mistake. Automatic color reading and adjustment of input color matching that of edge banding is therefore an important factor in achieving high automation level. We attempted to provide a solution to this potential issue by the project “Application of Arduino control mainboard with Color light sensor TCS3200 in color recognition of edge banding in laser edge banding machine”.

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Color recognition is becoming more and more widely used in modern production, including but not limited to material, industrial automation, remote sensing technology, image processing, product quality inspection, and several fuzzy detection technologies that require color detection. In many practical applications, it is often not necessary to accurately determine the spectral composition of colors, just to distinguish different colors. The frequency signals collected by sensors can be processed by single chip microcomputer, which can effectively distinguish different colors. It can be used in printing, dyeing, painting, automobile and other industries. It can also be installed on automatic production lines to detect the color of products, implement quality management, and provide color control for the central control system of production lines [3].

Sensor Color TCS3200 is a programmable color light to frequency converter developed by TAOS (Texas Advanced Optoelectronic Solutions), TCS3200 is a programmable IC which is the way it works to convert light into colour frequency with output signal box-shaped. The main constituent of this colour is the sensor and photodiode current to frequency converter. TCS3200 colour sensor light is equipped with a filter and a light base colour RGB. Each colour can be composed from the basic colours. On the central of the colour compilation unit integrated the colour red, green and blue, or better known as the RGB (Red, Green, and Blue). The colour spectrum is contained within a perfect light (white). The RGB colour model is a model based on the concept of adding strong colour radiance primer i.e. Red, Green and Blue. In a space that is absolutely no protected from light, then the room is dark. No signal light waves are absorbed by the eye or RGB (0, 0, and 0). When adding the red light in the room, then the room will change colour to red for instance RGB (255, 0, 0), all objects in the room only can be seen in red [4-5].

Arduino is a single-board microcontroller designed to make the use of electronics in multi academic projects more accessible. First invented in late 2005, its hardware basically consists of simple open source hardware. Sixteen versions of the Arduino hardware (boards) have been commercially produced to date, of which the Arduino Uno was used in this project. This board uses a surface-mounted Atmega328, bringing the total memory to 32 kB [6-8].

Through our work, an inexpensive color reading system was proposed for matching of edge banding color and sealing edge. This can be applied in automation of color reading and changing of sealing edge color in industrial process.

2. Material and methods

2.1. Edge banding color

Edge bandings were exposed to color sensor, at which light from surface was absorbed and analysed and subsequently sent to Arduino 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, we established a range of available color surface based on colors currently used in industry and assigned codes E1, E2, E3, E4, E5, E6, E7, and E8 as can be seen in Fig.1.
2.2. Colour Sensor of TCS3200

TCS3200 colour sensor is the way it works to change the colour into the frequency. Made from a mixture of silicone and current to frequency converter on one circuit integration. This gave rise to a wave of censorship output box with 50% duty cycle with a proportional frequency. Pin configuration TCS3200 can be seen in (Fig.2)

![Fig.2. Pin TCS 3200](image)

A full-scale frequency can be set with one of the three initial values through two control input pin. On TCS3200, the sensor light to frequency converter read 8 x 8 array of photodiodes, 16 blue filter photodiodes, 16 green filter photodiodes, and the last is red filter photodiode. All colors are linked together in parallel with photodiode, alternately designed to counter interference. Example of the colour sensor can be seen in (Fig.3)

![Fig.3. Sensor TCS3200](image)

PIN S2 and S3 is used to select the photodiode that want enabled. The combination of inputs for each colour. Take a look at the (Table 1)

| S2 | S3   | Filter type   |
|----|------|---------------|
| L  | L    | Red           |
| L  | H    | Blue          |
| H  | L    | No filter (clear) |
| H  | H    | Green         |
PIN S0 and S1 which are used for scaling the output frequency. The frequency can be scaled to three different preset values of 100 %, 20 % or 2%. This frequency-scaling function allows the output of the sensor to be optimized for various frequency counters or microcontrollers. Take a look at the Table 2.

**Tab.2. Output Frequency Scaling of PIN S0 and S1**

| S0 | S1 | Output Frequency Scaling |
|----|----|--------------------------|
| L  | L  | Power down               |
| L  | H  | 2%                       |
| H  | L  | 20%                      |
| H  | H  | 100%                     |

Terminal function TCS3200 can be seen in (Table 3)

**Tab.3. Terminal function of Sensor TCS3200**

| Name        | No | I/O | Description             |
|-------------|----|-----|-------------------------|
| GND         | 4  | I/O | Power supply Ground     |
| OE          | 3  | I   | Active Low              |
| OUT         | 6  | O   | Output Frequency        |
| S0, S1      | 1,2| I   | Output Frequency at scale |
| S2, S3      | 7,8| I   | Type photodiode         |
| VDD         | 5  |     | Power Supply            |

2.3. Arduino UNO

Arduino UNO is a microcontroller board based on ATmega328. Arduino has a 14 pin input/output, 6 pin which can be used as PWM outputs, 6 analogue input, a 16 MHz crystal oscillator, a USB connection, power jack, head of the ICSP, and the reset button. Arduino UNO is able to download support microcontroller; can be connected to the computer using the USB cable and can be supplied with an AC adapter to the DC or battery to get started (Fig.4)

Board Arduino UNO has the following features:

- Pin out 1.0: SDA and SCL pins plus closer to AREF pin and two new pin the other is placed close to pin RESET, IOREF which allows shield-shield to adjust the voltage supplied from the board. For the future, the shield will be made compatible/match the board which uses an AVR that operates with a voltage of 5V Arduino Due and with operating voltages 3.3V. The second is a pin is not connected, which provided for the purpose in the future.
- Reset Circuit.
- Atmega16U2 replaces Atmega8U2
As for the Arduino UNO specification summary can be seen in (Table 4)

**Fig.4. Board Arduino Uno**

**Tab.4. Parameters of Arduino Uno**

| Parameter                        | Value                                          |
|----------------------------------|------------------------------------------------|
| Microcontroller                  | ATmega328b                                     |
| Operating voltage                | 5V – DC                                        |
| The timing speed                 | 16 MHz                                         |
| Dòng tiêu thụ                     | 30mA                                           |
| Input voltage (recommended)      | 7-12V – DC                                     |
| Input voltage (limit)            | 6-20V – DC                                     |
| Digital pin I/O                  | 14 (six of them is PWM pin)                    |
| Analog input pin                 | 6                                              |
| DC current I/O pin               | 30 mA                                          |
| DC current for pin (5V)          | 500 mA                                         |
| DC current for pin (3.3V)        | 50 mA                                          |
| Flash Memory                     | 32 KB (ATmega328) with 0.5KB to use for the bootloader |
| SRAM                             | 2 KB (Atmega328)                               |
| EEPROM                           | 1 KB (Atmega328)                               |
2.4. LCD Display
A liquid-crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. We are using 16x2 LCD display which has 2 horizontal line comprising a space of 16 displaying character (Fig.5)

![Fig.5. LCD Display](image)

2.5. Research Methodology
The TCS230 senses color light with the help of an 8 x 8 array of photodiodes. Then using a Current-to-Frequency converter the readings from the photodiodes are converted into a square wave with a frequency directly proportional to the light intensity. Finally, using the Arduino Board we can read the square wave output and get the results for the color (Fig.6)

![Fig.6. Scheme of light intensity transformation into rectangular signal](image)

Arduino is an open-source computer hardware and software company, project and user community. It also designs and manufactures µc based kits for building digital devices and interactive objects that can sense and control objects with many devices.

2.5.1. Design of Hardware. A functional unit of colorimeter detection of scar color was built using several commercially available electronic components: colour sensor TSC230, programming board Arduino Uno with microprocessor ATMega328 and alphanumeric LCD display 16x2. For the initial test run wiring breadboard with Arduino kit connection cables were applied.

Arduino Uno, an open source platform, accounts for the data acquisition hardware in our toolbox. Different types of connection ports, including digital input/output, PWM output, UART TTL (5V) serial communication, and analog input, make the Arduino Uno board a powerful and cost-effective hardware for data collection purposes. The Arduino Uno board has an Atmel ATmega328 microcontroller which can be programmed in C/C++ language through an integrated development environment (IDE). Regulated 5 V and 3.3 V outputs can be obtained from the Arduino board to provide the supply voltage for particular sensors. The Arduino Uno supports 6 analog input pins which read data in the range of 0–5 V with the resolution of 10 bits [9-10].
2.5.2. Design of Software. The controlling software of colorimeter was written in JAVA language in Arduino IDE environment and it uses functionalities of the ElecFreaks library, especially functionalities for signal frequency measurement and LCD display control. The programme algorithm is presented in the first step, the LiquidCrystal LCD functionality and the #define clause were used to define communication pins of the LCD display and the sensor. Afterwards the sensor was initialized and the frequency scale was set to 20 % (enables measurement with higher sensitivity). Subsequently the sensor was calibrated to level [255, 255, and 255] which in RGB space corresponds to absolute white. In this way, the upper limit of the RGB space was created. To calibrate the sensor, a mat white plate or cardboard is sufficient. Calibration must be done during the first start or restart [11].

3. Results and discussion

3.1. Breadboard schematics
(Fig.7) shows Wiring the TCS3200 sensor to your Arduino is pretty straightforward. Simply follow the next schematic diagram

![Breadboard schematics for Arduino UNO and sensor TCS3200](image)

**Fig.7.** Breadboard schematics for Arduino UNO and sensor TCS3200

After plugging-in of the sensor (Fig.8) the power supply and communication with the programming board was tested. A bypassing capacitor (reduction of high frequency current flow) and a LCD display for simple viewing of the data measured were connected to the feeder circuits. There is a potentiometer (10 kΩ) connected to the LCD display to set up the required contrast. The circuit is activated on by a push-button switch.
3.2. The results of frequency code product

The frequency values picked of 8 product on your code, as show in (Table 5). The experiment is conducted using an Arduino UNO and Sensor Color TCS3200. The results show that the collected frequency values can be seen in (Fig. 9a, b)

| Measurement | E1 | E2 | E3 | E4 | E5 | E6 | E7 | E8 |
|-------------|----|----|----|----|----|----|----|----|
| R<sub>fre</sub> | 28 | 28 | 19 | 10 | 9  | 18 | 22 | 13 |
| G<sub>fre</sub> | 21 | 32 | 26 | 12 | 10 | 15 | 18 | 25 |
| B<sub>fre</sub> | 29 | 28 | 18 | 11 | 9  | 18 | 22 | 13 |
Distinguish between different colors: In this section you’ll insert the frequency values picked previously on your code, so that your sensor can distinguish between different colors. We’ll detect E1, E2, E3, E4, E5, E6, E7 and E8 colors can be seen in (Fig. 10a, b).

![Fig.10. Shows detected code- color: (a) detected E8- red, (b) detected E6- light green.](image)

### 4. Conclusion
1) Our study successfully used Arduino control mainboard and Sensor Color TCS3200 in reading color and sealing edge in laser based edge sealing machine.
2) Sealing edge surface was precisely recognized by Arduino analysis of signal from color sensor TCS3200, with high working speed and stability.
3) Our data can be further used in prototyping and manufacturing of automatic color recognition systems in next generations of laser based edge sealing machine in which color.

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