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Automated Colour Sorting System Using Arduino and TCS3200 Sensor

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Abstract. This project focuses on the design and implementation of an automated color sorting machine utilizing Arduino microcontroller and servo motors. The system integrates several key components, including a TCS3200 color sensor for color detection and multiple servo motors for precise movement of objects. Designed using AutoCAD software, the project encompasses the creation of 3D printed and CNC machined parts, facilitating the construction of the mechanical structure. The electronic circuit involves connecting the color sensor and servo motors to the Arduino, which processes the color data and controls the motors to sort objects into designated bins based on their colors. The programming is executed using Arduino IDE, which is based on C++. The system's functionality is enhanced through careful calibration and optimization, ensuring high accuracy and efficiency. The machine is designed for applications in various industries, such as agriculture, food, and recycling, where color-based sorting is essential. This chapter delves into the detailed design process, electronic circuit connection, component integration, and operational workflow of the color sorting machine, demonstrating its potential for real-time and automated sorting tasks.

Keywords: Sensor colour, Sensor TCS3200, Arduino UNO R3.

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1. Introduction

In the rapidly evolving manufacturing sector, enhancing production efficiency is a key driver of success. As industries strive to increase manufacturing speed, reduce labor costs, and minimize downtime, automation becomes an essential solution. Sorting products at various stages of production is a crucial task that traditionally relies on manual labor, which is both time-consuming and labor-intensive. However, with advancements in technology, automated sorting systems have emerged as a viable alternative [1].

Colour sensors play a pivotal role in these automated systems. These sensors detect colours by analyzing the reflected light from objects, making them invaluable in various applications such as sorting objects by colour, quality control systems, and enhancing printer colour performance. The TCS3200 colour sensor, in particular, provides accurate colour detection, contributing significantly to the automation of sorting processes [2].

This project focuses on designing and implementing an Arduino-based colour sorting machine using the TCS3200 sensor. The system is designed to detect and sort objects based on their colour, utilizing the Arduino microcontroller to process data from the sensor and control servo motors for object manipulation. By leveraging 3D printing and CNC machining for creating machine parts, the project aims to offer a cost-effective and efficient solution for automated colour sorting [3][4].

The project is divided into two main parts: the electronic circuit and the software. The electronic circuit involves connecting the TCS3200 colour sensor and servo motors to the Arduino, while the software component involves programming the Arduino to process colour data and control the motors. The overall goal is to create a reliable and accurate colour-sorting machine that can be used in various industries, including agriculture, food processing, recycling, and more [5][6].

This introduction sets the stage for the detailed exploration of the project's design and implementation, highlighting the importance of automation in manufacturing and the role of colour sensors in achieving efficient sorting solutions [7][8].

2. Related Work

2.1 Introduction

In this related work explores the theoretical foundations of colour sensing and differentiation reviews the components used in colour detection systems, and summarizes relevant projects. Understanding the principles of colour sensing is crucial for developing efficient and accurate colour sorting machines. The interaction between an object's surface, light, and an observer determines the perceived colour, which is quantified using various colour spaces like the RGB model. This review focuses on the application of RGB colour sensors in sorting systems, emphasizing their practicality and versatility in manufacturing processes [9][10].

2.2 Theory of Colour Sensing

Colour sensing relies on measuring light intensity across different wavelengths. One approach involves using a spectrometer to split light into its component wavelengths, but this method is complex [11]. A simpler and more common method uses sensors to measure light intensity in three primary colour bands: red, green, and blue (RGB). This method allows for accurate colour detection by analyzing the proportions of these primary colours. For instance, pure magenta light can be identified by a 1:0:1 ratio of red to green to blue light in the RGB colour space [12][13].

2.3 Components of Colour Sensing Systems

2.3.1 TCS3200 Colour Sensor

The TCS3200 colour sensor module is widely used for colour detection. It contains an array of photodiodes, each sensitive to red, green, blue, or white light. These photodiodes are arranged in an

8x8 grid, allowing the sensor to measure light intensity for each primary colour. The sensor outputs a frequency proportional to the light intensity, which can be read by a microcontroller. This module is programmable, enabling customization for various applications. Figures 1 to 4 illustrate the TCS3200 sensor and its microscopic RGB matrix array [14][15].

Fig .1. Color Sensor

Fig .2. Microscopic view of TCS3200 chip

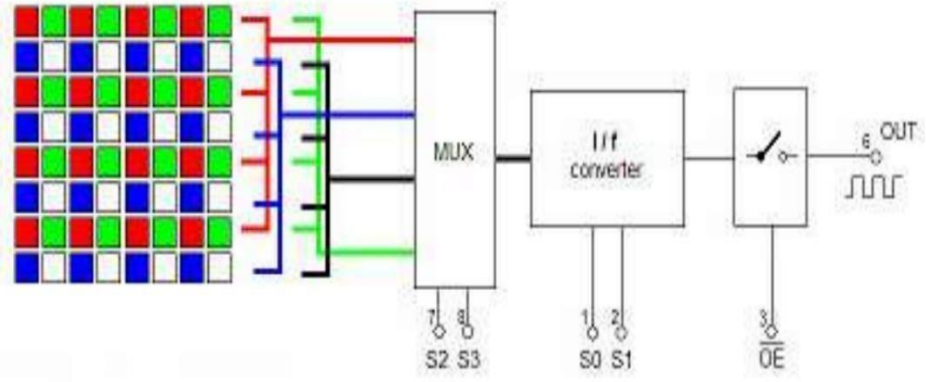

Fig .3. Microscopic view of RBG Matrix Array

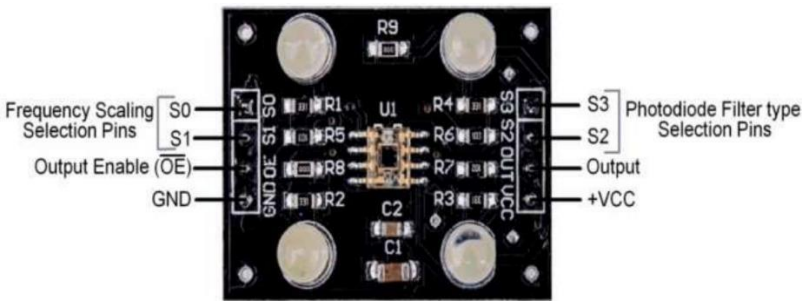

Fig .4. Color Sensor TCS3200 Pin Description

2.3.2 Arduino Microcontroller

Arduino microcontrollers are popular in prototyping and educational projects due to their simplicity and versatility. They can read inputs from sensors and control outputs like motors and LEDs. The Arduino Uno, can be powered via USB or an external power supply. It features multiple input and output pins for connecting various components, making it suitable for controlling the TCS3200 colour sensor. Figures 5 show the Arduino Uno board and its components [16].

Fig .5. Arduino UNO Board

2.4 Relevant Projects

2.4.1 Application in Manufacturing

We noticed that the related work emphasized the importance of sensors in manufacturing, where they transform physical stimuli into electrical signals for analysis. Colour sensors, particularly those using the RGB model, are essential for sorting and quality control applications. They can detect multiple colours, making them versatile for various manufacturing processes [17].

2.4.2 Colour-Based Sorting System

Also, we in the literature review describe a system for sorting objects based on colour using an Arduino controller and a colour sensor. The system detects the colour of objects on a conveyor belt and sorts them into different bins. The colour sensor provides RGB values, allowing the system to distinguish between 16.7 million colour shades with 8-bit accuracy [18].

2.4.3 Line Following and Colour Detection Robot

The robot is designed to navigate autonomously by following a black line on a white platform, achieved through an array of photoresistors for precise line detection. Additionally, it utilizes an IR sensor to detect obstacles in its path, ensuring safe traversal. Furthermore, an RGB color sensor enhances its functionality by enabling the robot to identify and distinguish between various colors accurately. This integrated sensor array empowers the robot to navigate dynamically and respond intelligently to its environment, showcasing the versatility and effectiveness of sensor technologies in robotic applications [19].

2.4.4 Real-Time Colour Inspection and Selection

The system is designed for real-time inspection and selection of objects based on color using advanced image processing techniques. It captures images in real time and processes them to detect specific colors, enabling precise sorting of objects according to predefined criteria. This application showcases the potential of image processing in developing sophisticated sorting systems that enhance efficiency and accuracy in various industries. By leveraging real-time image analysis, the system exemplifies how technology can automate and streamline complex tasks, demonstrating its transformative impact on industrial processes and logistics [20].

2.4.5 Colour Recognition for the Visually Challenged

The prototype utilizes an Arduino microcontroller in conjunction with an RGB color sensor to detect colors accurately. This technology plays a crucial role in assistive devices aimed at aiding visually challenged individuals. By converting color information into audible speech, the system empowers users to independently identify and differentiate colors in their surroundings. This application of color sensors demonstrates their pivotal role in enhancing accessibility and autonomy for visually impaired individuals [21].

3. Methodology

The methodology for designing and implementing a color sorting machine involves using AutoCAD software to create detailed 3D printable parts for the machine structure, integrating electronic components such as the Arduino microcontroller for processing, the TCS3200 color sensor for color detection, and servo motors for precise object movement, and programming the system using Arduino IDE to develop algorithms that accurately interpret color data and control the servo motors to sort objects into designated bins based on their detected colors, with iterative testing and calibration to ensure high accuracy and efficiency in various operational conditions.

4. Result and Discussion

The colour detection machine, integrated with servo motors and a TCS3200 colour sensor, effectively identifies and sorts objects based on their colour. During testing, the system accurately detected colours such as red, yellow, and blue, illuminating corresponding LEDs and moving servo motors to designated positions with precision. This functionality demonstrates the successful implementation of colour sensing and servo motor control in automating the sorting process.

The performance of the colour detection machine hinges on several critical factors. Firstly, the accuracy and reliability heavily rely on the calibration of the TCS3200 colour sensor. Calibration ensures that the sensor can distinguish between different shades and intensities of colours accurately, thereby minimizing errors in sorting operations. Additionally, the precision of servo motor control plays a crucial role in the system's functionality, as it determines the exact positioning of objects based on colour detection.

While the system demonstrated commendable performance in controlled environments, challenges such as variations in ambient lighting and object textures can impact colour detection accuracy. These factors necessitate further improvements in sensor calibration techniques and possibly integrating ambient light sensors to dynamically adjust sensor parameters. Moreover, enhancing the resolution and sensitivity of the colour sensor could broaden the range of detectable colours and improve overall sorting efficiency.

Furthermore, the system's robustness against environmental conditions such as temperature and humidity should be considered for applications requiring continuous operation in diverse settings. Addressing these environmental factors could enhance the system's reliability and longevity.

5. Conclusion

The Automated Colour Sorting System Using Arduino and TCS3200 Sensor has proven to be a highly effective solution for automated colour detection and sorting tasks. By leveraging the TCS3200 sensor's precise colour recognition capabilities and Arduino's flexibility, this system offers efficient sorting processes with minimal error rates. Its potential applications span across various industries, from manufacturing to recycling, promising increased efficiency and reduced operational costs. As technology advances, further enhancements in sensor accuracy and system integration could pave the way for even more sophisticated automated sorting solutions. Also, we can see the future work for this project includes exploring machine learning integration for enhanced color classification accuracy, developing automated calibration routines for sensor and servo motor alignment, and investigating IoT integration for remote monitoring and data analytics capabilities.

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مجلة كلية العراق الجامعة للهندسة والعلوم التطبيقية

نظام فرز الألوان الآلي باستخدام مستشعر Arduino و TCS3200

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الملخص: يركز هذا المشروع على تصميم وتنفيذ آلة فرز الألوان الآلية باستخدام متحكم Arduino ومحركات مؤازرة. يدمج النظام العديد من المكونات الرئيسية، بما في ذلك مستشعر الألوان TCS3200 لاكتشاف الألوان ومحركات مؤازرة متعددة للحركة الدقيقة للأشياء. تتضمن الدائرة الإلكترونية توصيل مستشعر الألوان والمحركات المؤازرة بـ Arduino، الذي يعالج بيانات الألوان ويتحكم في المحركات لفرز الكائنات في صناديق مخصصة بناءً على ألوانها. يتم تنفيذ البرمجة باستخدام Arduino UNO R3 المبني على لغة C++. ويتم تعزيز وظائف النظام من خلال المعايرة والتحسين الدقيقين، مما يضمن الدقة والكفاءة العالية. تم تصميم الآلة لتطبيقات في مختلف الصناعات، مثل الزراعة والأغذية وإعادة التدوير، حيث يكون الفرز على أساس اللون أمرًا ضروريًا. يتعمق هذا الفصل في عملية التصميم التفصيلية، واتصال الدوائر الإلكترونية، وتكامل المكونات، وسير العمل التشغيلي لآلة فرز الألوان، مما يوضح إمكاناتها لمهام الفرز الآلي في الوقت الفعلي.

الكلمات الرئيسية : مستشعر اللون، مستشعر TCS3200، Arduino UNO R3.