Smart Agri Bot for Multi-Crop Harvesting

Dr.D.R.P. Rajarathnam[1], R. Krishva[2], R. Dhivakaran[3], S. Parthiban[4]
[1] UG - Professor, Department of Mechatronics Engineering, Paavai Engineering College, Namakkal, Tamilnadu, India.
[2, 3, 4] UG Student, Department of Mechatronics Engineering, Paavai Engineering College, Namakkal, Tamilnadu, India.
Emails: drprajamala@gmail.com[1], krishvaravi@gmail.com[2], dhivakaranux@gmail.com[3], sundarparthi55@gmail.com[4]

Abstract

The integration of automation and robots into modern agriculture is crucial for improving output and efficiency. A recent development in this field is the creation of a color-sensing robot specifically designed for agricultural purposes. This robot utilizes advanced color detection technology to accurately identify objects and exert control over them based on their color characteristics. The primary goal of this research is to find solutions for labor-intensive agricultural tasks, particularly fruit and vegetable harvesting. By combining robotics and computer vision technology, this robot aims to streamline these processes. Automation plays a significant role in reducing human effort in routine and frequently performed tasks. In the case of agriculture, color-sensing robots have been employed to pluck fruits and vegetables. The robot's mobile application is controlled through a Bluetooth Module, sending instructions to the microcontroller, and then to the motor. The robot's architecture is also programmed with Arduino, an open-source programming language that is a simplified version of other languages. These robots have the potential to reduce damage, increase productivity, and prove cost- effective, while also freeing up labor resources. In addition to object recognition, the robot's navigational capabilities have been enhanced with the integration of an ultrasonic sensor. This sensor emits high-frequency sound waves and analyzes the echoes to accurately estimate distances to nearby objects. This information is crucial for the robot to identify obstacles in its path, ensuring safe and effective navigation

Keywords: Automation, Robots, Modern agriculture, Color-sensing robot, Agricultural purposes, Color detection technology, Labor-intensive tasks, Ultrasonic sensor, High- frequency sound waves, Obstacle detection, Effective navigation

1. Introduction

A significant aspect of agricultural automation is the development of intelligent robots that can selectively harvest crops based on their ripeness. This study introduces the Color Sensor-Based Pick and Place Robot, [1] specifically designed for agricultural applications. Traditional harvesting methods often involve manual work, which can be time-consuming, physically demanding, and prone to human error. Indiscriminate harvesting can also result in the collection of under ripe or overripe vegetables, leading to decreased product quality and financial losses. [2] To overcome these challenges, the suggested robot utilizes advanced color detecting technology. The robot's design incorporates a highly adjustable robotic arm and gripper system, specifically designed to handle a variety of crops with care. Its multi-degree- of-freedom arm allows for precise placement, while its adjustable gripper can accommodate fruits and vegetables of different shapes and sizes. Through cutting-edge sensing

and manipulation technologies, the robot is able to perform pick-and-place operations with remarkable precision and efficiency. [3] This study represents a significant advancement in the field of agricultural automation. By harnessing the power of color detecting technology, this robot has the potential to revolutionize the harvesting process, resulting in higher yields, improved product quality, and reduced labor costs. Additionally, its potential applications extend beyond typical farms and into specialized horticulture environments. In the following sections of this article, the design of the Color Sensor-Based Pick and Place Robot, its sensing capabilities, navigation system, and user interface will be discussed in detail. Furthermore, experimental findings and performance assessments will be presented to demonstrate the effectiveness and efficiency of this groundbreaking agricultural automation system. [4]

2. Literature Survey

Takuya Otani et al. conducted a study on multiple crop production and environmental recovery techniques, focusing on regreening the environment and establishing a diverse ecosystem. They proposed a method where various plants are grown densely, and their management relies on manual labor due to the limitations of conventional agricultural machinery and robots in complex vegetation. To enhance work efficiency and promote regreening through scaling up Synecoculture, the researchers developed a robot capable of sowing, pruning, and harvesting in dense and diverse vegetation growing under solar panels. The robot featured a four-wheel mechanism designed to navigate uneven terrain and a two orthogonal axes mechanism for precise tool positioning during management tasks. In a field experiment, the robot successfully navigated shelving slopes, overcame obstacles like small steps and weeds, and effectively performed harvesting and weeding tasks under human supervision. This was achieved by utilizing a tool maneuver mechanism that relied on camera image recognition to assess and respond to field conditions. [5]

3. Existing System

In the packaging area, an IR sensor is utilized to

detect material arrival; the conveyer stops when material arrives at the packing area, and a color sensor is used to sort materials depending on their color. Following the identification of the material's hue, the same colored object is placed in the required bins, which are maintained at the packing junction. The robotic arm is used to choose and place the material in this case. Robotic area block diagram shown in Figure 1. [6]
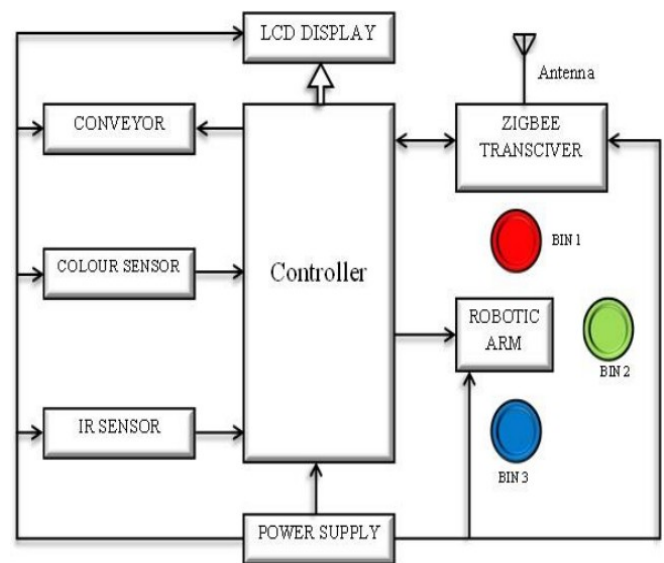

Figure1 Robotic Area Block Diagram

4. Proposed Method

The proposed system is designed to enhance the efficiency and accuracy of fruit and vegetable harvesting. It comprises a colour sensor, a robotic arm, and a controller. The colour sensor plays a crucial role in identifying fruits and vegetables based on their colour. This enables the system to accurately differentiate between different types of produce. The information gathered from the colour sensor is processed by the controller, which then dictates the movement of the robotic arm. The robotic arm is responsible for the actual picking and placing of the fruits and vegetables. It is designed to effectively retrieve the produce from a conveyor belt or other surface. By automating this process, the system eliminates the need for manual labor and significantly improves efficiency. To ensure seamless operation, the Arduino Uno serves

as the central control unit of the system. It processes sensor data, controls the movement of the robotic arm and the colour sensor, and facilitates communication with external devices through the Bluetooth module. Additionally, the system incorporates obstacle detection technology using an Ultrasonic sensor. This sensor enables the robot to detect and avoid obstacles in its path, ensuring safe and uninterrupted operation. By combining colour sensing and obstacle detection, the system further enhances its efficiency, accuracy, and safety in performing object handling tasks. In summary, the proposed system utilizes a colour sensor, a robotic arm, and a controller to automate fruit and vegetable harvesting. By accurately identifying and handling the produce, it significantly improves efficiency while ensuring safety through obstacle detection technology. [7]

5. Software Description

5.1 Arduino Ide

The Arduino Integrated Development Environment (IDE) is a piece of software that allows you to programme and upload code to Arduino microcontrollers. It has an easy-to-use interface for creating, compiling, and uploading code to Arduino boards. Here are some of the Arduino IDE's important features and aspects: [8]

- **Cross-Platform and Open Source:** The Arduino IDE is open-source software, which means that its source code is freely available to the public. It's also available for Windows, mac OS, and Linux, allowing it to be used by a wide spectrum of people

- **Easy to Use Interface:** The IDE offers an easy-to-use interface that is suited for both novice and professional programmers. A text editor, toolbar, menus, and a status bar are all included with the controlling device after being connected. This permits data to be sent between the two devices.

- **Commands from the Controlling Device:** The controlling device can communicate with the Bluetooth module by sending commands or data. These orders are often in the form of strings or bytes and can convey robot instructions.

- **Receiving Arduino Uno Commands:** When the Arduino Uno is linked to the Bluetooth module, it constantly checks for new data. When data is received, it is processed by the Arduino Uno to identify the appropriate action.

- **Command Interpretation and Execution:** The Arduino Uno evaluates the received commands and performs the appropriate operations. It may, for example, receive directions to pick an object or travel in a certain direction.

- **Sending Feedback and Status Updates:** Using the Bluetooth module, the Arduino Uno can also transmit feedback and status updates back to the controlling device. This gives you real-time information on the robot's movements and status.

- **Real-Time Interaction:** Because the Bluetooth connection is wireless, real-time interaction between the controlling device and the robot is possible. This allows the user to remotely watch and control the robot's actions.

- **Error Handling and Safety Measures:** The Arduino Uno may include error-handling algorithms to respond to unexpected or erroneous Bluetooth requests. This might involve doing safety inspections to avoid crashes or other catastrophes.

- **End of Operation:** When the operation is finished or the user ends the job, the Arduino Uno can disconnect the Bluetooth connection and prepare for the next operation.

- **Power Control:** The Bluetooth module and Arduino Uno collaborate to intelligently regulate power consumption, delivering maximum performance while conserving energy. [9]

5.2 Color Sensor

The colour sensor in the Colour Sensor-Based Pick and Place Robot is an important component that detects and distinguishes different colors. Here's a more in-depth explanation of how the colour

sensor works:

Figure 2 Color Sensor

The colour sensor in the Colour Sensor-Based Pick and Place Robot is an important component that detects and distinguishes different colors. Here's a more in-depth explanation of how the colour sensor works and image shown in Figure 2. [10]

- **Luminescence of the Object:** The colour sensor illuminates the item with light from its built-in LEDs. LEDs produce light in the red, green, and blue colour spectrums. Light Refraction: When light hits an item, it bounces back to the colour sensor. Different colors absorb and reflect light at different wavelengths.
- **Detection of Light:** An array of photodiodes in the colour sensor detects the intensity of reflected light in the red, green, and blue channels.
- **Electrical Signal Conversion:** The intensity of the reflected light is converted into electrical impulses by the photodiodes. The stronger the light, the stronger the electrical signal.
- **ADC (Analog-to-Digital Conversion):** The colour sensor's inbuilt Analog-to-Digital Converter converts the analogue signals from the photodiodes to digital values.
- **Data Transfer to the Arduino Uno:** The digital colour data (red, green, and blue values) from the colour sensor is transmitted to the Arduino Uno via digital or analogue pins. Colour Identification: The colour data is received by the Arduino Uno and processed to

identify the precise colour of the item. This is commonly accomplished by comparing the red, green, and blue value ratios.
- **Classification of Colors:** The Arduino Uno decides what action to take based on the decided colour. For example, based on present criteria, it may decide to pick the object or transfer it to a certain position. [11]

5.3 Ultrasonic Sensor

Figure 3 Ultrasonic Sensor

To the Ultrasonic Sensor for obstacle detection and directional navigation combines a complex mix of sensors and control system it was shown in Figure 3.

- **Object Recognition:** The robot begins by scanning its environment for things using the colour sensor. It emits light and uses RGB and light intensity measurements to analyses the reflected colour spectrum. The system recognizes and categorizes things in its area of vision using predetermined colour profiles. This data is used to generate a list of probable items.
- **Detection of Obstacles:** The ultrasonic sensor simultaneously emits high-frequency sound waves and monitors the time it takes for the echoes to return. This data is used to compute distances to neighboring objects. If an obstacle is identified within a certain range, the system records its presence as well as its position. This information is critical for safe navigation.

- **Planning Your Route:** The object recognition and obstacle detection data are processed by the system's control algorithm. It estimates the best path for the robot to take to reach the specified item while taking obstacle locations into consideration.
- **Avoiding Obstacles:** When an obstruction along the planned path is discovered, the system recalculates the course to prevent collisions. This might include taking a different path or altering the robot's orientation.
- **Object Retrieval and Positioning:** When the robot reaches the desired object, it picks it up using its manipulator. The manipulator's grip is made to fit a wide range of item shapes and sizes. Based on established coordinates, the robot subsequently goes to the right direction.
- **Adjustment and verification:** To guarantee precision, the robot validates its location before depositing the object using both the colour sensor and the ultrasonic sensor. Minor changes are done as needed to position the item appropriately.
- **Putting the Object Down:** Once validated, the object is gently placed in the specified area by the robot.
- **Constant Operation:** The robot keeps going, going through the motions of item identification, obstacle detection, path planning, and manipulation until all of the tasks are performed.

Result

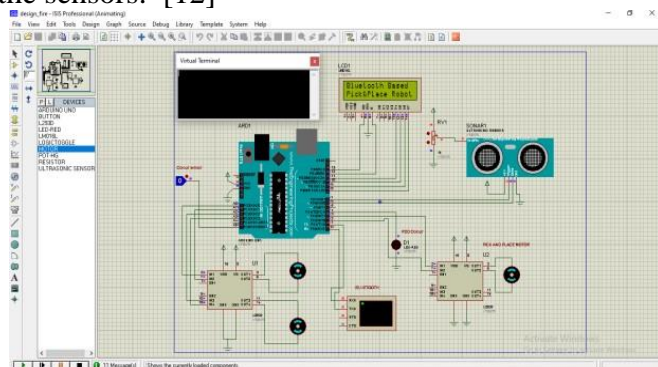Figures 4 a, b, c, d, and e show the final results of the sensors. [12]
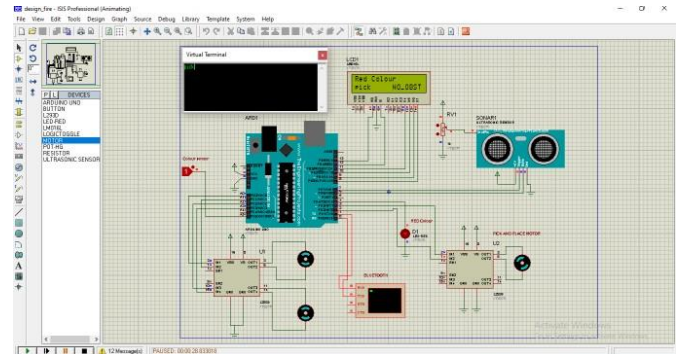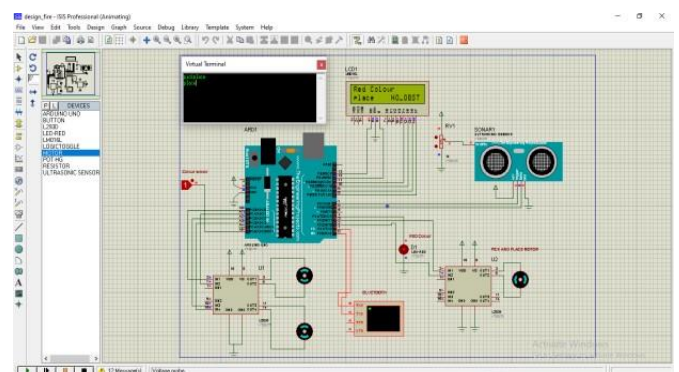

Figure 4 (a)

Figure 4 (b)
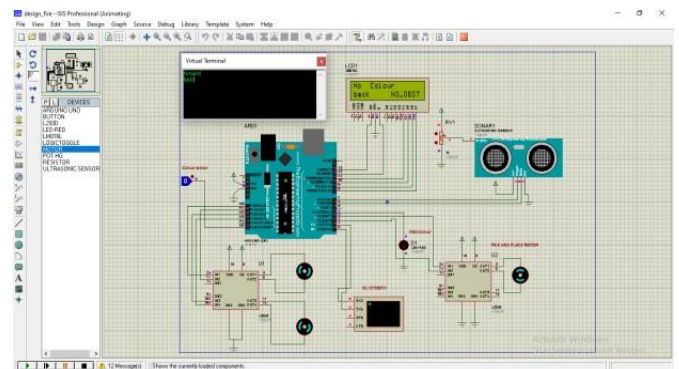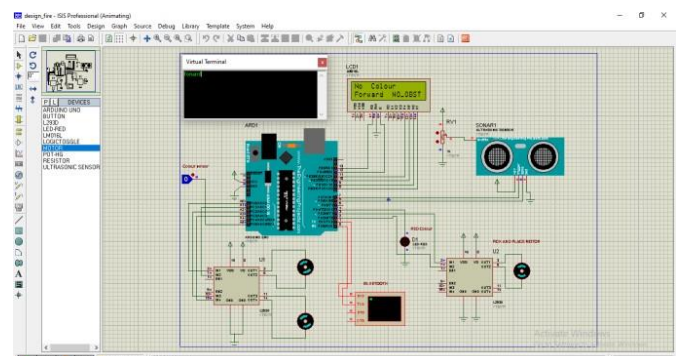

Figure 4 (c)

Figure 4 (d)

Figure 4 (e)

Conclusion

The revolutionary Colour Sensor-Based Pick and Place Robot project demonstrates the remarkable capabilities of current automation technologies. By utilizing color identification to efficiently handle objects, this project opens up endless possibilities in various sectors, from industrial automation to research and development. With continued advancements and adaptations, this technology has the potential to significantly transform and enhance operations across numerous industries, ultimately boosting productivity and operational efficiency in the long run. This ground breaking study revolves around the state-of-the-art Colour Sensor- Based Pick and Place Robot, which is further enhanced with an Ultrasonic Sensor for obstacle detection and directional navigation. This significant development represents a major stride in the creation of intelligent automation systems capable of accurately and safely handling items even in complex scenarios. The suggested technology holds great promise for applications requiring flexible and cost-effective robotic pick and place operations. The Colour Sensor- Based Pick and Place Robot project serves as a crucial advancement in the field of automation technology. This specialized robot showcases its remarkable ability to handle items with utmost precision by incorporating essential components such as a color sensor, Bluetooth module, power supply, Arduino Uno, LCD, and L293D motor driver.

References

[1]. Li, Y. Lu, and Y. Gao, "Design and Implementation of Intelligent Pick-and-Place Robot System Based on IoT Technology," in IEEE Access, vol. 8, pp. 210470- 210482, 2020.

[2]. S. Ramakrishna, S. S. Karthik, and S. S. Sreejith, "An IoT Based Automated Pick and Place Robotic Arm," in International Journal of Innovative Technology and Exploring Engineering (IJITEE), vol. 8, issue 6, pp. 1465-1469, 2019.

[3]. H. Hussain, R. A. Ahmad, and M. F. Arshad, "Development of IoT-Based Pick and Place Robotic Arm System for Industrial Automation," in Journal of Robotics, vol. 2020, pp. 1-9, 2020.

[4]. S. Matharu and A. Bansal, "IoT Based Automated Pick and Place Robotic Arm with Object Detection," in International Journal of Advanced Research in Computer Science, vol. 11, issue 3, pp. 29-35, 2020.

[5]. Basu, R. Biswas, and M. K. Naskar, "An IoT-Based Pick and Place Robotic Arm for Industrial Automation," in Proceedings of the 4th International Conference on Computational Intelligence in Data Mining (ICCIDM), pp. 89-97, 2020.

[6]. Priyambada Mishra, Riki Patel, Trushit Upadhyaya, Arpan Desai "Review of Development Of Robotic Arm Using Arduino UNO", International Journal on Recent Researches in Science, Engineering and Technology, ISSN: 2348-3105 Volume 5, Issue 5, May 2017.

[7]. Puran Singh, Anil Kumar, Mahesh Vashishth "Design of Robotic Arm with Gripper and End effector for spot welding", Universal Journal of Mechanical Engineering 1(3); 92-97, 2013, DOI: 10.13189/ujme,2013.010303.

[8]. Areepen Sengsalonga, Nuryono Satya Widodo "Object Moving Robot Arm based on Color", Signal and Image Processing Letters, Vol.1. No.3, November 2019, pp. 13-19 ISSN 2714-6677.

[9]. V. K. Banga, Jasjit Kaur, R. Kumar, Y. Singh "Modeling and Simulation of Robotic Arm Movement using Soft Computing", International Journal of Mechanical And Mechatronics Engineering, Vol:5, No:3,2011.

[10]. Kemal Oltun Evliyaoğlu1, Meltem Elitaş "Design and Development of a Self-Adaptive, Reconfigurable and Low Cost Robotic Arm" Department of Mechatronics Engineering, Sabanci

University. University St. No: 27, 34956 Tuzla/İstanbul Turkey1

[11]. Anughna N, Ranjitha V, Tanuja G "Design and Implementation of Wireless Robotic Arm Model using Flex and Gyro Sensor", International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277- 3878, Volume-8 Issue-5, January 2020.

[12]. Kurt E. Clothier and Ying Shang "A Geometric Approach for Robotic Arm Kinematics with Hardware Design, Electrical Design, and Implementation" Hindawi Publishing Corporation Journal of Robotics Volume 2010, Article ID 984823, 10 pages doi:10.1155/2010/984823