IJARSCT
ISSN: 2581-9429
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Volume 5, Issue 4, June 2025
Impact Factor: 7.67

Fruit Sorting Using Image Processing

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Abstract: *This project explores the development of an automated tomato sorting system that leverages Raspberry Pi, image processing algorithms, and sensor-based controls. The system captures images of tomatoes in real time as they travel on a conveyor belt. By analyzing the color and surface features, it categorizes them into green (unripe), red-healthy (ripe), and red-diseased groups. Based on this classification, a servo motor guides each tomato to its respective bin. The system reduces human intervention, enhances accuracy, and supports scalability. It demonstrates the potential of smart farming by integrating IoT-ready components and automation in post-harvest processing.*

Keywords: Image Processing, Tomato Sorting, Ripeness Detection, Size Measurement, Machine Learning

I. INTRODUCTION

In the modern agricultural landscape, efficient and accurate post-harvest processes are crucial for ensuring the quality and market readiness of produce. Among various fruits, tomatoes require special attention due to their delicate texture and perishable nature. Traditionally, tomato sorting has been carried out manually, which involves identifying ripeness and health based on visual inspection. However, this method is often prone to human error, fatigue, and inconsistency, leading to reduced productivity and increased wastage. To overcome these limitations, technological solutions like image processing and embedded systems are being employed to automate such labor-intensive tasks with greater accuracy and efficiency. [1]

This project proposes an automated fruit sorting system that specifically targets the sorting of tomatoes based on their ripeness and physical condition. Using Raspberry Pi 4B+ as the central processing unit, a camera module captures real-time images of tomatoes as they move on a conveyor belt. These images are processed using OpenCV and Python algorithms to detect the tomato's color and identify any visible signs of disease or damage. The system classifies the tomatoes into three categories: green (unripe), red and healthy (ripe), and red but diseased (spoiled or damaged). This automated categorization helps streamline post-harvest handling, enhances quality control, and reduces the reliance on human labor for repetitive visual tasks. [2]

The hardware setup includes an infrared (IR) sensor that detects the presence of tomatoes and triggers the system to momentarily stop the conveyor belt, allowing a stable image to be captured. A servo motor is then used to guide each tomato to the correct bin based on the analysis result. The conveyor is driven by a low-speed DC motor, maintaining a consistent speed to ensure clear image capture. All components are coordinated through the Raspberry Pi, which uses GPIO interfacing to communicate with the motors and sensors. This integration of image processing with mechanical automation allows for a compact and cost-effective solution that can be implemented in small farms, local sorting units, or even in educational labs for demonstration. [4]

II. LITERATURE SURVEY

In recent years, the integration of image processing with agriculture has been extensively explored to enhance the efficiency and quality of post-harvest operations. Numerous studies have investigated the use of machine vision systems to sort fruits and vegetables based on their color, size, shape, and surface defects. Researchers have

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demonstrated that color detection is one of the most reliable indicators of ripeness in fruits like tomatoes. For example, studies conducted on tomato grading using color histograms and RGB thresholding techniques have shown high levels of accuracy in distinguishing between green and red tomatoes. Moreover, research on diseased fruit detection has successfully applied texture and pattern recognition using techniques such as edge detection and contrast enhancement to identify abnormalities like bruises, mold, or skin infections. [4].

The use of low-cost embedded platforms such as Raspberry Pi has become increasingly popular in academic and industrial prototypes. Literature highlights that Raspberry Pi offers sufficient processing power for real-time image analysis when combined with optimized OpenCV algorithms. Projects based on this platform have achieved promising results in applications such as automatic plant disease detection, crop monitoring, and fruit sorting. These systems generally include a camera module for data acquisition, followed by software routines to analyze images and make classification decisions. The advantage of using Raspberry Pi lies in its compact size, affordability, GPIO interfacing capabilities, and compatibility with Python—making it an ideal choice for automation in agriculture. [5].

Further advancements in smart farming have emphasized the role of IoT and AI in developing scalable and intelligent systems. Some studies have integrated wireless data transmission, remote monitoring, and data logging to support large-scale agricultural automation. Literature also points to the benefit of using servo motors and IR sensors for precise object handling and accurate sorting on conveyor-based systems. The integration of sensors with vision algorithms ensures that each fruit is analyzed under controlled conditions, improving the reliability of the system. Overall, previous research confirms the technical feasibility and practical value of using image processing in automated fruit sorting, which this project builds upon and adapts specifically for tomatoes using a real-time, sensor-driven approach. [6].

III. BLOCK DIAGRAM

This block diagram shows the hardware setup for an automated tomato sorting system using a Raspberry Pi 4B+. The Raspberry Pi acts as the central controller, receiving input from three infrared (IR) sensors labeled IR1, IR2, and IR3, which are likely used to detect the presence and position of tomatoes. Based on sensor input and image processing results, the Raspberry Pi controls three servo motors (Servo Motor 1, 2, and 3) to direct tomatoes into appropriate categories or sections. A DC motor, controlled through a relay module, handles the movement of the conveyor belt or rotating mechanism to keep the tomatoes moving through the system. A power supply provides the necessary energy to all components. This setup enables automated, sensor-based sorting of tomatoes based on size, ripeness, or quality, is shown in Figure 1.

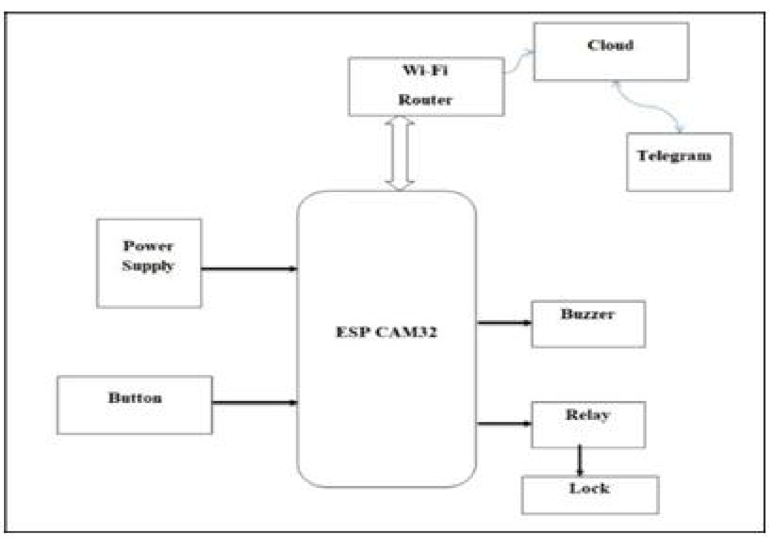

Fig 1. Block Diagram

IV.COMPONENTS

A. RASPBERRY PI 4B+

Serves as the main controller of the entire system. Executes image processing algorithms to analyze tomato color and detect disease. Connects to the camera for real-time image capturing. Controls other hardware like the conveyor motor and servo motor. Interacts with sensors such as the IR sensor for detecting tomato presence. Uses its GPIO (General Purpose Input/Output) pins to manage connected devices. Compatible with Python, allowing the development of custom logic. Can connect to the internet for remote monitoring or data storage. Offers ports for USB-based peripherals (keyboard, mouse, storage devices, etc.).

B. CAMERA MODULE

Captures high-resolution images of tomatoes on the conveyor belt. Provides the visual input required for processing and analysis. Helps differentiate between green, red, healthy, and diseased tomatoes. Works well with OpenCV, the image processing library used. Easily connects to the Raspberry Pi via the CSI interface. Can handle varying lighting conditions with proper illumination. Enables real-time decision-making for accurate sorting.

C. DC MOTOR (10 RPM)

Drives the conveyor belt to move tomatoes through the system. Rotates at a low and stable speed to ensure clear image capture. Works continuously without frequent interruptions. Can be controlled through motor drivers and programmed for adjustable speeds. Operates efficiently under varying loads and fruit sizes.

D. IR Sensor

Detects the presence of tomatoes on the conveyor. Sends a signal to pause the conveyor momentarily for image capture. Ensures the camera gets a focused and stable image for processing. Works effectively even under different lighting conditions. Increases system precision by ensuring each tomato is correctly positioned. Easy to connect and calibrate with Raspberry Pi.

E. Servo Motor

Responsible for physically sorting the tomatoes into the correct bins. Moves accurately to specific angles based on sorting decisions. Lightweight and efficient, suitable for handling fruits like tomatoes. Controlled by PWM signals from Raspberry Pi. Operates silently and reliably during continuous use. Allows quick changes in sorting logic if needed.

F. Conveyor Belt

Transports tomatoes from one stage of the system to another. Provides consistent speed and direction for image capturing and sorting. Constructed from durable material to handle regular use. Tensioned properly to prevent slipping or misalignment. Can be resized and maintained easily depending on needs. Ensures smooth integration with the motor and sensor system.

V. CIRCUIT DIAGRAM

a This circuit diagram shows an integrated system consisting of a power supply unit, a relay control section, a Raspberry Pi 4B+, and an Arduino Uno that coordinates with servos and IR sensors. The power supply section converts 12V AC into regulated 12V and 5V DC using a bridge rectifier (comprising four 1N4007 diodes), followed by filtering capacitors and voltage regulators (7812 and 7805). These regulated outputs power various components in the circuit. The relay circuit is activated through a BC547 transistor and diode protection (1N4007), which controls the 5V relay that is connected to external devices. The relay gets its signal from the Arduino, acting as a switching mechanism.

In the control section, the Raspberry Pi is interfaced with the Arduino Uno to manage peripheral operations. GPIO pins from the Raspberry Pi send control signals to the Arduino through the "Relay1" connection. The Arduino Uno, in turn, operates four servos and receives inputs from four IR sensors connected to its digital pins. The servos are connected to headers labeled H1 and H2, and IR sensors are connected to headers H3 and H4, with each module supplied with 5V

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and GND. This system design suggests it is used for an automated sorting or detection mechanism potentially in an agricultural or industrial application where sensors detect conditions and servos actuate sorting mechanisms based on the arduino's logic.

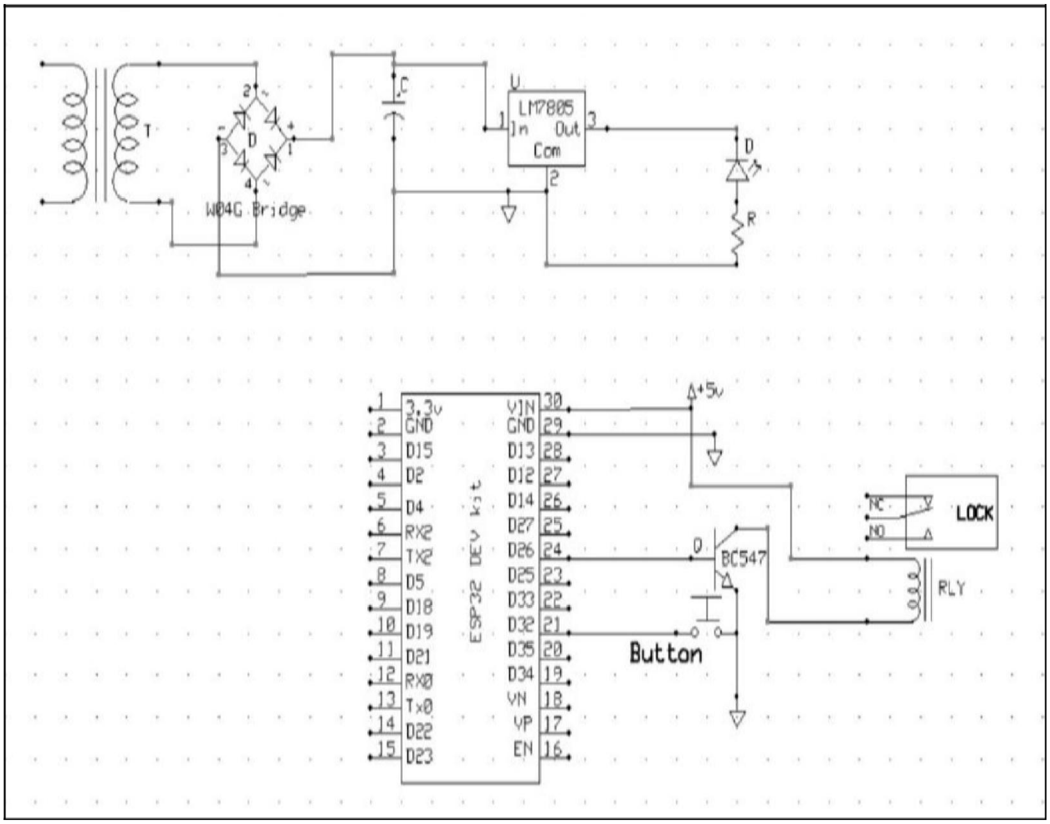

Fig 2. Circuit diagram of proposed work

VI. WORKING OF PROPOSED WORK

The working of the proposed tomato sorting system is based on a sequence of automated operations controlled by a Raspberry Pi 4B+ and driven by image processing logic. As tomatoes move along a conveyor belt powered by a 10 RPM DC motor, an infrared (IR) sensor detects each incoming fruit. This sensor momentarily halts the conveyor to stabilize the tomato's position. A high-resolution camera, integrated with the Raspberry Pi, captures an image of the tomato, which is then processed using OpenCV and Python. The system analyzes the color and texture of the fruit to classify it as green (unripe), red and healthy (ripe), or red and diseased. Depending on this analysis, the Raspberry Pi sends a signal to a servo motor, which shifts to the designated angle and pushes the tomato into the correct bin. This continuous loop enables real-time, accurate, and contactless sorting, significantly improving efficiency, reducing manual effort, and enhancing quality control in post-harvest processing.

VII. RESULTS

The developed system successfully automated the sorting of tomatoes based on ripeness and health using real-time image processing and sensor-based control. During testing, the system was able to consistently differentiate between green, ripe-healthy, and diseased tomatoes with a high degree of accuracy. The camera efficiently captured images while the conveyor belt moved at a controlled speed, and the IR sensor accurately detected fruit presence for image capture timing. The Raspberry Pi processed the data quickly, and the servo motor effectively redirected tomatoes to their correct bins without damage. The results demonstrated the project's potential for reducing manual labor,

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improving sorting precision, and minimizing fruit wastage. The system operated reliably under standard lighting conditions and proved suitable for small to medium-scale agricultural use, laying a strong foundation for further improvements and scalability.

Fig 3. Actual image of proposed work

VIII. CONCLUSION

In conclusion, the tomato sorting system developed using image processing and Raspberry Pi technology demonstrates an effective and intelligent approach to automating a traditionally manual and error-prone agricultural task. By combining real-time image capture, color and defect detection, and motor-driven mechanical sorting, the system successfully classifies tomatoes based on ripeness and health. It eliminates the inconsistencies associated with human judgment, accelerates the sorting process, and significantly reduces labor dependency. The use of components like the IR sensor, servo motor, and DC motor ensures seamless coordination between detection and physical sorting, while Python and OpenCV enable accurate decision-making. This solution not only improves operational efficiency and product quality but also lays the groundwork for scalable and modular implementations across various crops. With future integration of IoT features, remote monitoring, and data analytics, the system holds great potential to support smart farming and precision agriculture practices, contributing to a more sustainable and technologically empowered agricultural sector.

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