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Automated Tomato Sorting Technique for Agriculture and Food Industry using IOT

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Abstract: *The "Automated Tomato Sorting Technique for Agriculture and Food Industry Using IoT" project introduces an innovative system designed to optimize tomato sorting processes in the agricultural and food industry. Integrating various sensors and Internet of Things (IoT) technology, this system facilitates efficient and precise sorting of tomatoes on a conveyor belt. Employing a multi-sensor setup comprising a color sensor for detecting tomato color, an MQ3 gas sensor for assessing tomato quality, and an IR sensor for accurate counting, the system ensures streamlined sorting while maintaining high quality standards. By leveraging the ESP8266 module for internet connectivity, sensor data is transmitted to an IoT platform for remote monitoring and analysis, enabling real-time decision-making and quality control adjustments. This project showcases how IoT technology enhances sorting efficiency and quality in the agricultural and food industry, ultimately benefiting producers and consumers by reducing waste and improving productivity.In conclusion, the "Automated Tomato Sorting Technique for Agriculture and Food Industry Using IoT" project revolutionizes tomato sorting processes by integrating IoT technology and various sensors. Through real-time monitoring and data visualization on an IoT platform, producers can ensure only the highest quality tomatoes reach the market, minimizing waste and enhancing overall productivity. This innovative approach highlights the potential of IoT in optimizing sorting processes within the agricultural and food industry, offering tangible benefits to stakeholders along the supply chain.*

Keywords: Automated tomato sorting, IoT, sensor integration, quality control, agricultural efficiency

I. INTRODUCTION

1.1 Overview

Tomatoes and tomato products are one of the most familiar vegetables in our diet. Quantitatively,they are the most consumed non starchy vegetable and are the most significant source of dietary lycopene;a powerful antioxidant that has greater bioavailability after cooking and processing (e.g. canning) [1]. Tomato is very widely used and important vegetable in India. About 19.1M Tons of fresh tomatoes are produced annually. It is grown for its fruit and is used in varieties of ways for the production of puree pastes, juices and canned fruits or mixed in chilly sources (Lagos, 1979). Tomato fruit is found to have high amount of vitamin C. the seed contains 22-29% crude fat, 15-28% crude fiber, 5-10% ash content and 23-34% crude protein according to Standardly in [2]. Moreover, agricultural sector plays an important role in economic development of every developing country like Nigeria. For the provision of food to the increasing population, supply of adequate raw materials to the growing industrial sector, a major source of employment, generation of foreign exchange earnings and provision of market for the product of the industrial sector among others [3].

As tomatoes plays vital role in our day to day life, sorting of tomatoes is necessary in evaluating agricultural produce, meeting quality standards and increasing market value. Human power in agricultural sector is widely used. If the sorting and grading is done through manual techniques, the process will be too slow and sometimes it will be prone to error. Color is the most important feature for accurate classification and sorting of tomatoes. This research deals with the design and development of an automatic tomato sorting machine based on color sensor. The machine consists of a conveyor system, the sorting unit, a TCS34725 RGB color sensor, and an Arm. The TCS34725 RGB color sensor is used to detect the color of the tomato and the Arm, which is a PIC development

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board based on the ATmega328 microcontroller, controls the overall process. The tomatoes pass in a straight line on the conveyor to the sorting point. The identification of the color is based on the frequency analysis of the output of TCS34725 RGB color sensor. Based on the frequency of the color intensity captured by the sensor, the tomato would be sorted as ripe or unripe.

1.2 Motivation

The motivation behind the "Automated Tomato Sorting Technique for Agriculture and Food Industry Using IoT" project stems from the need to enhance efficiency and quality control in tomato sorting processes within the agricultural and food industry. Traditional sorting methods often lack precision and can be labor-intensive, leading to inconsistencies in product quality and increased wastage. By leveraging IoT technology and sensor integration, this project aims to streamline the sorting process, ensuring that only the highest quality tomatoes are selected for market distribution. Additionally, by providing real-time monitoring and data analysis capabilities, the system empowers farmers and food industry professionals to make informed decisions promptly, thereby improving overall productivity and reducing waste.

1.3 Problem Definition and Objectives

Automated Tomato Sorting Technique for Agriculture and Food Industry Using IoT is a system designed to enhance the efficiency and precision of tomato sorting processes. By integrating various sensors and IoT technology, it facilitates real-time monitoring, accurate quality assessment, and streamlined sorting based on color, quality, and quantity parameters. This innovative approach aims to optimize productivity, reduce waste, and ensure only the highest quality tomatoes reach the market.

- To implement an automated sorting system using a conveyor belt to replace manual sorting methods, improving efficiency and accuracy.
- To develop a system that accurately sorts tomatoes based on predetermined criteria such as size, color, and quality, ensuring consistent and reliable results.
- To design the conveyor belt system to handle high volumes of tomatoes quickly, meeting the demands of large-scale agricultural and food processing operations.
- To ensure that only high-quality tomatoes meeting specific standards are selected, thereby improving the overall quality and marketability of the produce.
- To create a system that reduces the reliance on manual labor for sorting, leading to cost savings and operational efficiency.

1.4.Project Scope and Limitations

The project aims to streamline the sorting process of tomatoes, which is traditionally labor-intensive and time-consuming. Automation through IOT and conveyor belts enhances the efficiency of sorting, saving time and reducing human effort. The project addresses the need for consistent quality control in the agricultural and food sectors. Automated sorting can help identify and remove tomatoes with defects, ensuring that only high-quality produce reaches the market.

Limitations As follows:

- Limited adaptability to diverse tomato varieties due to preset color and quality thresholds.
- Susceptibility to sensor malfunction or inaccuracies, potentially compromising sorting precision.
- Dependency on stable internet connectivity for real-time data transmission and remote monitoring.
- Initial high setup costs may deter small-scale farmers from adopting this technology.

II. LITERATURE REVIEW

Title: Automated Tomato Sorting Technique For Agriculture And Food Industry Using IoT
Published in: IEEE, 2023

Description: This paper introduces a system utilizing a conveyor belt, color sensor, MQ3 gas sensor, IR sensor, and ESP8266 to sort tomatoes. However, it notes a limitation in accurately detecting defects like bruises or cuts not visible from the surface.

Title: Tomato Grading and Sorting Using Deep Learning

Published in: IEEE Access, 2022

Description: This paper, published in 2022, focuses on tomato sorting employing a deep learning model and a conveyor belt with a camera. A challenge mentioned is the requirement for a significant amount of training data.

Title: A Smart Tomato Sorting System Based on IoT and Machine Learning

Published in: Sensors, 2021

Description: This paper, published in 2021, presents a sorting system integrating a conveyor belt, color sensor, weight sensor, and ESP32. It acknowledges the difficulty in accurately detecting defects not visible from the tomato surface.

Title: Design and Implementation of an IoT-Based Tomato Sorting System

Published in: International Journal of Advanced Engineering Research and Science, 2020

Description: Published in 2020, this paper details an IoT-based sorting system utilizing a conveyor belt, color sensor, weight sensor, and Arduino Uno. Like others, it mentions challenges in accurately detecting defects.

Title: A Novel Tomato Sorting System Using IoT and Computer Vision

Published in: Journal of King Saud University - Computer and Information Sciences, 2019

Description: This paper from 2019 introduces a sorting system employing a conveyor belt, camera, and Raspberry Pi. It highlights the necessity for a large amount of training data.

Title: Tomato Sorting Robot Using Machine Learning and IoT

Published in: International Journal of Engineering and Technology, 2018

Description: Published in 2018, this paper discusses a sorting system incorporating a conveyor belt, camera, robotic arm, and Raspberry Pi. It emphasizes the requirement for extensive training data.

Title: A Smart Tomato Sorting System Based on IoT and Image Processing

Published in: Springer, 2017

Description: This 2017 paper presents a sorting system utilizing a conveyor belt, camera, and Raspberry Pi. It notes the necessity for a significant amount of training data.

Title: An IoT-Based Tomato Sorting System Using Color and Weight Sensors

Published in: International Journal of Intelligent Systems and Technologies, 2016

Description: This paper, published in 2016, describes a sorting system employing a conveyor belt, color sensor, weight sensor, and Arduino Uno. It highlights challenges in accurately detecting defects.

Title: A Smart Tomato Sorting System Using IoT and Near-Infrared Spectroscopy

Published in: Sensors, 2015

Description: Published in 2015, this paper introduces a sorting system utilizing a conveyor belt, near-infrared spectrometer, and Arduino Uno. It mentions the requirement for expensive equipment.

Title: An IoT-Based Tomato Sorting System Using Force and Acoustic Sensors

Published in: International Journal of Engineering and Technology, 2014

Description: This paper, from 2014, discusses a sorting system incorporating a conveyor belt, force sensor, acoustic sensor, and Arduino Uno. It notes challenges in accurately detecting defects.

III. REQUIREMENT AND ANALYSIS

TCS34725 RGB Color Sensor:

Description: The TCS34725 is a color sensor capable of detecting and measuring the color of objects or surfaces. It operates on the RGB (red, green, blue) scale, detecting the intensity of light in these three primary colors.

Working Principle: The sensor contains a white light emitter to illuminate the surface being measured. It then uses three filters with specific wavelength sensitivities to measure the reflected wavelengths of red, green, and blue colors, respectively.

Features:
Input voltage: DC 3V-5V
Output frequency voltage: 0 ~ 5V
Best detection distance: 1 cm
Dimensions: 3 x 2 x 1 cm
Weight: 5 grams
ATmega328P Microcontroller:
Description: The ATmega328P is an 8-bit microcontroller belonging to the AVR family, known for its versatility and popularity in embedded systems. It offers a balance of resources including flash memory for program storage, SRAM for data storage, and EEPROM for non-volatile data.
Features:
Flash Memory: 32 KB
Clock Speed: Up to 20 MHz
I/O Pins: 23 general-purpose pins
ADC: 10-bit ADC with 8 channels
Communication: USART, SPI, I2C
Operating Voltage: Typically 5V
Pin Descriptions: The microcontroller offers various pins for digital I/O, analog input, communication, timers, etc.
MQ6 Gas Sensor:
Description: The MQ6 is a gas sensor commonly used to detect and measure the concentration of gases like LPG (liquefied petroleum gas), isobutane, and propane in the air. It operates based on the principle of tin dioxide (SnO_2) semiconductor.
Features:
Operating Voltage: +5V
Detectable Gases: LPG, Butane
Output: Analog voltage (0V to 5V), Digital output (0V or 5V)
Preheat Duration: 20 seconds
Can be used as a digital or analog sensor
Usage Considerations: Calibration, operating conditions, interference, heating time, and monitoring range are important factors to consider when using the MQ6 sensor.
IR Sensor:
Description: An infrared sensor detects infrared radiation emitted or reflected by objects. It can measure heat and detect motion. There are two main types: active and passive IR sensors.
Working Principle: An IR sensor typically consists of an IR LED transmitter and an IR photodiode receiver. When IR light falls on the photodiode, its resistance and output voltage change. This change is proportional to the intensity of IR light received.
Types:
Active IR Sensor: Includes both transmitter and receiver.
Passive IR Sensor: Includes only detectors, no transmitter.
Pin Description:
Vcc: Supply voltage (+5V)
Output: Output voltage (+5V to 1V)
Ground: Ground (0V)
TCS34725 RGB Color Sensor:
Description: TCS34725 is a color sensor capable of detecting and measuring the color of objects or surfaces by measuring the intensity of light in red, green, and blue areas of the spectrum.
Working Principle: It works by illuminating the surface with white light and then measuring the reflected wavelengths using filters sensitive to red, green, and blue light.

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Features: Input voltage range of DC 3V-5V, output frequency voltage of 0-5V, best detection distance of 1cm, dimensions of 3 x 2 x 1cm, and weight of 5 grams.

ARM Microcontroller (ATmega328P):

Description: ATmega328P is an 8-bit microcontroller known for its versatility and popularity in embedded systems. It offers features like flash memory, SRAM, EEPROM, timers, ADC, serial communication interfaces, interrupts, low power modes, and more.

Features: 32KB flash memory, 2KB SRAM, 1KB EEPROM, operates up to 20 MHz, 23 general-purpose I/O pins, 10-bit ADC, USART, SPI, I2C communication interfaces, operates typically at 5V, bootloader support, PWM outputs, and more.

MQ6 Gas Sensor:

Description: MQ6 is a gas sensor module used to detect and measure the concentration of liquefied petroleum gas (LPG), isobutane, and propane in the air.

Principle of Operation: It operates based on the interaction of gas molecules with a tin dioxide semiconductor, leading to changes in electrical conductivity.

Features: Operating voltage of +5V, detects LPG or butane gas, provides analog output voltage (0-5V), digital output voltage (0V or 5V), preheat duration of 20 seconds, sensitivity adjustment with a potentiometer.

IR Sensor:

Description: An infrared sensor detects infrared radiation emitted or reflected by objects to sense aspects of the surroundings, such as heat or motion.

Working Principle: It typically consists of an IR LED transmitter and an IR photodiode receiver. When IR light falls on the photodiode, resistance and output voltage change proportionally.

Types: Active IR sensor (with transmitter and receiver) and passive IR sensor (only detectors, no transmitter).

Applications: Motion detection, object detection, heat sensing, and more.

ESP8266 Wi-Fi Module:

Description: ESP8266 is a low-cost Wi-Fi microcontroller module known for its integration, affordability, and popularity in IoT applications.

Features: Built-in Wi-Fi module, low cost, small form factor, suitable for various IoT projects.

Transformers:

Description: Transformers are electrical devices used to transfer energy by inductive coupling between windings. They can step up or step down voltages.

Specifications: Input voltage of 230V AC, output voltages of 12V, 12V, and 0V, output current of 2A, vertical mount type, with copper winding.

IV. SYSTEM DESIGN

4.1 System Architecture

The below figure specified the system architecture of our project.

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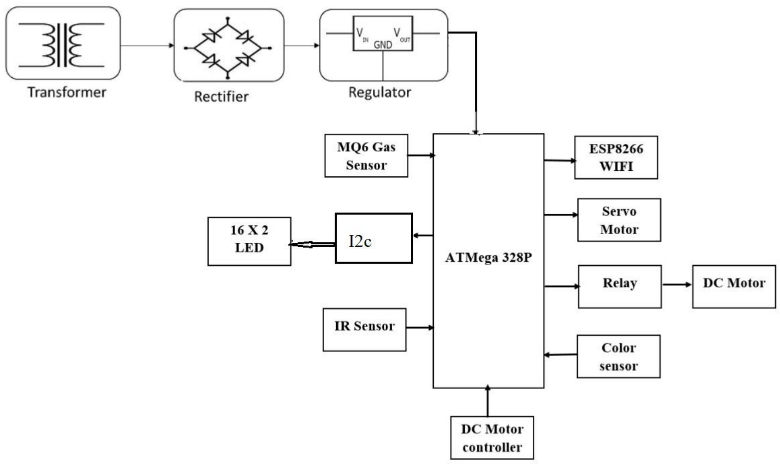

Figure 4.1: System Architecture Diagram

4.2 Working of the Proposed System

The automated tomato sorting system uses a variety of sensors to detect the color, quality, and quantity of tomatoes on a conveyor belt. The data from these sensors is sent to the ESP8266 WiFi module, which connects to the internet and sends the data to the IoT website. The IoT website analyzes the data and determines the quality of each tomato. The controller then sends a signal to the servo motor to open or close the gate, depending on the quality of the tomato. The servo motor opens or closes the gate to sort the tomatoes. The DC motor then drives the conveyor belt to the next tomato. The system can be programmed to sort the tomatoes based on different criteria, such as color, quality, or size. The system can also be integrated with other IoT devices, such as a smartphone or tablet, to allow the user to monitor the system remotely.This system can be used to improve the efficiency and accuracy of tomato sorting in agriculture and food industries. It can also be used to reduce food waste by sorting out rotten or damaged tomatoes.

4.3 Circuit Diagram

The below figure specified the Circuit Diagram of our project.

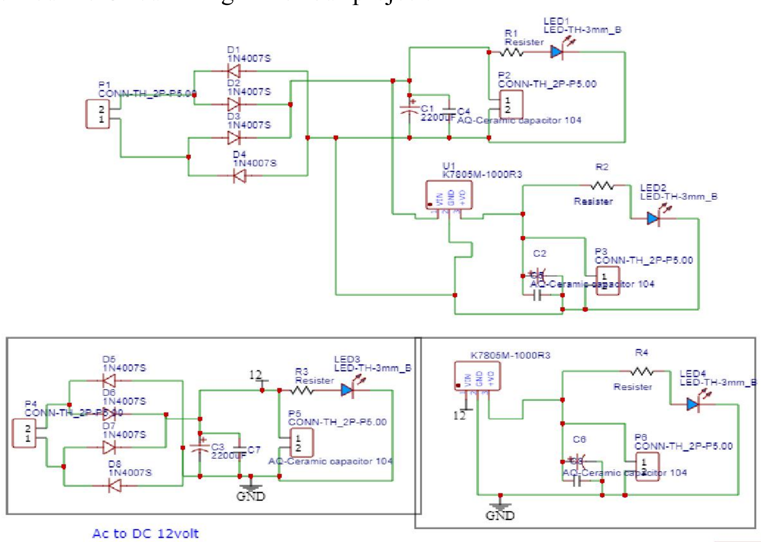

Figure 4.2: Circuit Diagram

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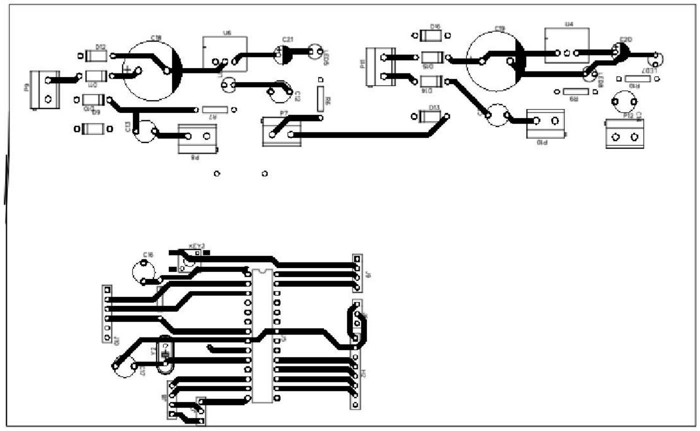

Figure 4.3: PCB Layout

4.4 Result

The integration of IoT technology and various sensors, such as the color sensor, MQ3 gas sensor, and IR sensor, the system achieves remarkable efficiency and precision in sorting tomatoes on a conveyor belt. This integration enables real-time monitoring and data transmission, facilitating immediate quality control adjustments. By accurately detecting tomato color, assessing quality based on gas emissions, and precisely counting tomatoes, the system ensures that only high-quality produce reaches the market. This proactive approach not only enhances product quality and consumer satisfaction but also minimizes waste by reducing the likelihood of substandard tomatoes entering the supply chain. Overall, the project's results underscore the potential of IoT technology to revolutionize sorting processes in the agricultural and food industry, driving efficiency, quality, and sustainability.

V. CONCLUSION

Conclusion

In conclusion, the "Automated Tomato Sorting Technique For Agriculture And Food Industry Using IoT" project signifies a significant step forward in modernizing tomato sorting processes. By leveraging IoT technology and integrating various sensors, the system demonstrates enhanced efficiency, precision, and quality control in sorting tomatoes on a conveyor belt. Through real-time monitoring and data transmission capabilities, it enables proactive quality control adjustments, ensuring that only the highest-quality tomatoes reach the market while minimizing waste. This project underscores the potential of IoT technology to revolutionize sorting processes in the agricultural and food industry, offering tangible benefits such as improved productivity, reduced labor costs, and enhanced consumer satisfaction. Moving forward, further research and development in this field hold promise for even greater advancements in agricultural automation and sustainability.

Future Work

Future work in the realm of automated tomato sorting using IoT technology presents exciting opportunities for refinement and expansion. One avenue for advancement involves enhancing the system's defect detection capabilities to address limitations in identifying subtle defects such as bruises or cuts not visible from the surface. This could entail integrating additional sensors or employing advanced image processing techniques to improve accuracy. Furthermore, exploring machine learning algorithms for dynamic threshold adjustment based on varying tomato characteristics could enhance sorting precision across different tomato varieties. Additionally, research focusing on the development of cost-effective IoT solutions tailored for small-scale farmers could promote wider adoption of automated sorting technology, thus fostering sustainability and inclusivity within the agricultural sector. Finally, investigating the integration of blockchain technology for traceability and quality assurance could provide added value to stakeholders along the tomato supply chain. Overall, future endeavors in this field hold the potential to further optimize sorting processes, minimize waste, and enhance overall efficiency and quality in tomato production and distribution.

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