

DETECTION OF STORED FOOD SPOILAGE AND ALERT SYSTEM DEVELOPMENT USING IOT

Submitted in partial fulfilment of the requirements for the
award of Bachelor of Engineering
degree in Electronics and Communication Engineering
by

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**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
SCHOOL OF ELECTRONICS**

SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
CATEGORY -1 UNIVERSITY BY UGC
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of **MOHAMMED MUJAHID (40130140), SK BHASHIT IMRAN HAZHAR (40130209)** who carried out the project entitled "**DETECTION OF STORED FOOD SPOILAGE AND ALERT SYSTEM DEVELOPMENT USING IOT**" under our supervision from June 2023 to April 2024.


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We, **MOHAMMED MUJAHID (40130140)** and **SK BHASHIT IMRAN HAZHAR (40130209)** hereby declare that the Project Report entitled "**DETECTION OF STORED FOOD SPOILAGE AND ALERT SYSTEM DEVELOPMENT USING IOT**" done by us under the guidance of **Dr. V. J. K. Kishore Sonti, M.Tech., Ph.D.** is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering Degree in Electronics and Communication Engineering.

DATE: 17-04-2024

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ABSTRACT

This project proposes an IoT-based approach for Food Spoilage and Detection system with Arduino UNO for real-time food quality assessment and storage monitoring, applicable from households to industrial facilities. Using MQ-2, MQ-4, and DHT11 sensors, it analyses incoming and stored food, sorting them as "Good" or "Bad" using servo motors.

By using a MQ-2 sensor to keep check of methane gas in the storage container also allows for a better storage solution as it can pre alert the user for any food spoilage when they are about to spoil. Node MCU allows for remote cloud connectivity of the sorting and storage system providing the gas levels and count of the stored food to be accessed from anywhere.

In households it offers easy food sorting and remote monitoring enabling tracking of inventory and storage conditions from anywhere. And in industrial settings, it can be easily scaled for quality control and reducing food wastage through rapid assessment and sorting. Cloud-based transmission allows remote monitoring of multiple storage units, easily integrating into existing infrastructure for efficiency. By leveraging IoT, this system enhances sensor-based food quality control, reducing waste and boosting consumer confidence in food products, whether in homes or industrial storage.

Experimental results demonstrate the practicality and effectiveness of the proposed methodology. Future work may involve deploying the system in real-world scenarios for validation and refining the model's architecture to further enhance performance.

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CHAPTER – 1

INTRODUCTION

In an era marked by technological advancements and a growing awareness of sustainability, the need for innovative solutions to address food preservation and waste management has become increasingly evident. This project introduces a cutting-edge smart food storage system designed to revolutionize the way we store and manage perishable food items. By leveraging the capabilities of sensors and microcontroller technology, this system aims to ensure the freshness and safety of stored food, thereby minimizing waste and promoting healthier consumption habits.

At its core, the smart food storage system integrates a variety of sensors, including IR proximity sensors for food detection, MQ sensors for methane level monitoring, and DHT11 sensors for humidity measurement. These sensors work in tandem to continuously assess the condition of stored food items, providing real-time data on their quality and freshness. A central microcontroller orchestrates the operation of these sensors and controls servo motors for sorting good and bad food items within the storage unit.

One of the key features of this system is its ability to initiate a countdown timer upon the detection of incoming fruits, based on their approximate expiry dates. This functionality enables users to receive timely alerts if methane levels exceed safety thresholds, allowing them to take proactive measures to prevent spoilage. Moreover, the system dynamically adjusts its sorting mechanisms based on methane and humidity levels, ensuring that only fresh and safe food items are retained for storage.

To enhance user convenience and accessibility, the system incorporates an LCD display for visual feedback and utilizes Arduino for data tracking and management. Furthermore, data regarding fruit count, quality assessment, and expiration countdown are transmitted to a dedicated mobile application via WiFi connectivity, enabling users to monitor their food inventory remotely.

Overall, this smart food storage solution represents a significant advancement in preserving food freshness and safety, while also empowering users with valuable

insights into their stored food items. By minimizing waste and promoting more sustainable consumption practices, this system holds the potential to make a meaningful impact on both individual households and larger food supply chains.

1.1 Background

In today's fast-paced lifestyle, food preservation remains a critical concern to ensure food safety and minimize waste. The design and implementation of a smart food storage system represent a proactive approach to addressing these challenges. By leveraging sensor technology and microcontrollers, this project aims to revolutionize traditional food storage methods. Integrating infrared (IR) proximity sensors, MQ sensors for methane detection, and DHT11 sensors for humidity monitoring, the system provides comprehensive data on the freshness and safety of stored food items. Managed by a microcontroller, the system utilizes servo motors for efficient sorting of food items based on quality assessment. With an LCD display for real-time feedback and Arduino for data management, users can track their food inventory effectively. By transmitting data to a mobile application via WiFi, users can remotely monitor their food stock, receive timely alerts, and make informed decisions to minimize waste and ensure food safety.

1.2 Motivation

In a world where food waste is a pressing issue, the need for innovative solutions is paramount. Our smart food storage system embodies the fusion of technology and sustainability, aiming to revolutionize how we preserve and manage our food supply. By leveraging sensors, microcontrollers, and data tracking mechanisms, we empower individuals to take control of their food inventory like never before. With real-time alerts, dynamic sorting, and remote monitoring capabilities, our system not only ensures the freshness and safety of stored food but also promotes conscientious consumption. By embracing this solution, users can contribute to reducing waste, conserving resources, and ultimately fostering a more sustainable future for generations to come. Join us in embracing technology for a healthier planet and a more efficient food ecosystem.

1.3 Problem Statement

Food waste due to improper storage and lack of monitoring poses a significant challenge in households and commercial settings. Existing storage methods often result in the premature spoilage of food items, leading to financial losses and environmental degradation. Moreover, the absence of real-time monitoring systems leaves consumers unaware of the quality and safety of their stored food inventory. To address these issues, this project aims to develop a smart food storage system that utilizes sensor technology and microcontrollers to ensure the freshness and safety of stored food items. By integrating IR proximity sensors, MQ sensors for methane level monitoring, and DHT11 sensors for humidity measurement, the system provides continuous monitoring of food conditions. The system's ability to dynamically adjust sorting mechanisms based on detected parameters ensures that only fresh and safe food items are stored. Additionally, real-time data tracking and transmission to a mobile application enable users to monitor their food inventory remotely, receive timely alerts, and make informed decisions to minimize food waste.

1.4 Objectives

The objectives of this project are to:

1. To design and implement a smart food storage system leveraging sensors and microcontroller technology.
2. To ensure the freshness and safety of stored food items through real-time monitoring of methane levels, humidity, and food detection.
3. To develop a user-friendly interface using LCD display and mobile application for seamless interaction and monitoring.
4. To enable dynamic sorting mechanisms based on detected methane and humidity levels to maintain optimal food quality.
5. To provide timely alerts to users regarding food expiration and safety concerns.
6. To track and manage data related to fruit count, quality assessment, and expiration countdown for efficient inventory management.
7. To reduce food waste by facilitating informed decision-making and promoting better food preservation practices.

CHAPTER 2

LITERATURE SURVEY

The detection of fruit spoilage and the implementation of effective storage systems are critical aspects of the agricultural and food industries. With the increasing demand for fresh produce, ensuring the quality and safety of fruits during storage and transportation has become paramount. Traditional methods of monitoring and managing fruit storage conditions are often labour-intensive and prone to human error. In recent years, the integration of Internet of Things (IoT) technology has revolutionized fruit spoilage detection and storage systems. IoT-enabled devices, equipped with sensors and connectivity features, can provide real-time monitoring of environmental conditions such as temperature, humidity, and gas levels. This allows for proactive measures to be taken to prevent spoilage and ensure optimal storage conditions, ultimately reducing food waste and improving food safety.

In 2023 M. J. I. Tutul, M. Alam and M. A. H. Wadud presented Smart Food Monitoring System Based on IoT and Machine Learning

The monitoring of food quality is crucial in ensuring food safety and reducing food waste. In this paper, we present the design and implementation of a smart food monitoring system that utilizes Internet of Things (IoT) and Machine Learning (ML) technologies. The system includes IoT devices such as temperature and humidity sensors, as well as gas concentration sensors, to continuously monitor food items. The data collected by these sensors is analyzed using machine learning algorithms to determine the freshness of the food. The system also features a web-based dashboard that displays real-time data and alerts when the food items reach a certain threshold level. The dash-board can be accessed remotely using a mobile app, making it easy for users to monitor their food from anywhere. The system's effectiveness was evaluated using various food items, and the results showed that it successfully predicted the freshness of food with high accuracy. The proposed system has significant potential applications in the food industry, reducing food waste and ensuring that consumers can access fresh and healthy food. Additionally, the system provides an efficient way of tracking food inventory, reducing costs and

increasing efficiency. The system's real-time monitoring and alerts are ideal for personal use in homes and kitchens. In conclusion, the proposed smart food monitoring system using IoT and machine learning provides a reliable and cost-effective solution for monitoring the freshness of food. The system has significant potential applications in the food industry and personal use, reducing food waste, increasing efficiency, and ensuring access to fresh and healthy food.

In 2022 S. Tegeltija et al. presented One Solution of System for Reducing Food Losses in Households based on IoT

Food losses are a global problem becoming more pronounced as the human population grows. In this paper, a solution for reducing food losses in households based on IoT technologies is proposed. The proposed solution allows users to monitor the quantities and conditions of food products stored in households.

In 2022 S. Wang presented Evaluation and application of fresh food safety through storage environment system based on factor analysis

With the gradual development of the fresh food market, food safety issues frequently appear, and the impact of the fresh storage environment on the safety of fresh food has become the focus of research. This paper discusses the possible impact of fresh food in the storage environment, and summarizes the main factors that cause fresh food safety problems. Through the sampling monitoring of fresh food, analyze a series of fresh food index data, use factor analysis to explore the environmental factors affecting fresh food in storage, improve the construction of storage environment system, and effectively prevent fresh food from A security issue occurred during storage.

In 2023 A. Cutipa, E. Williams, C. Arias, Gianfranco, Q. Tuesta and J. Enrique presented Application prototype for the registration, checking, and monitoring of perishable foods

The perishable food supply chain represents a great logistical challenge due to different environmental factors that must be met to ensure minimal loss and avoid diminishing profitability. The purpose of this study is to present a low-cost portable system and intuitive to monitor the environmental status of cargo using the Internet of things (IoT), store the collected data in the Amazon Web Services (AWS) cloud and generate reports for the decision-making. To corroborate the correct functioning of the prototype, a controlled route was simulated within Lima, Peru. The main components of the proposed system are the M5Stack AWS development kit, the ENV III temperature and humidity sensor, and the Android application, LogiApp, connected to the other components through the AWS cloud.

In 2023 N. T. Oshin, F. A. Shafi, M. Rahman, H. Khatun, M. R. Uddin and M. Hasan presented Food Rotting Prediction and Detection System for Warehouse

This paper presents an elementary approach to food spoilage detection and prediction in a warehouse setting, offering a practical and cost-effective solution to reduce food waste and improve food safety. This project develops a device that can predict and detect food spoilage in a timely and accurate manner by utilizing different gas sensors, temperature, and humidity sensor to predict and detect the presence of spoilage in stored food. The gathered data from the stored food is then processed and analyzed by the system. The output is displayed on an LED screen and a buzzer goes off to alert the food keepers. The project also involves the development of a user-friendly interface to allow for easy monitoring and management of the system. It uses a Node MCU module to transmit the resulting data from the system. The findings of the study demonstrated the effectiveness of the Food Rotting Prediction and Detection System, with the sensors providing reliable data for predicting and detecting food spoilage. A mixed method analysis including thematic analysis and predictive modeling allows for more robust validation of the findings, as the results can be triangulated across different data sources.

In 2023 B. V. Sai Nithin, K. S. Nithin, B. Sneha and V. V. Kumar presented Non-Destructive Approach for Detection of Food Freshness using IoT

Food and nutrition is essential for all living beings to survive and perform vital activities like growth, development, and renewal of damaged cells. It is important to consider various factors that can affect the safety and quality of perishable foods, such as light, O₂ levels, temperature, humidity, spoilage bacteria, and other environmental conditions. When stored at room temperature, food may undergo chemical reactions that affect its taste, texture, and aroma. Consuming spoiled food can result in foodborne illnesses, which can be dangerous. This research study presents an efficient solution by utilizing IoT technology to manage food storage. The proposed system is designed to address the challenges associated with monitoring the quality of stored food. The proposed solution combines various IoT devices, cloud services, and web applications. Computer vision technology offers a non-intrusive, automated, and cost-effective approach to evaluate food quality. This innovative solution can accurately assess the quality of food products without damaging them, allowing for a more efficient evaluation process. The experimental results demonstrate that the proposed system is effective in detecting food quality and promptly alerting users about any degradation in food quality.

In 2023 M. T. I. Ansari, S. K. Raghuwanshi and S. Kumar presented Recent Advancement in Fiber-Optic-Based SPR Biosensor for Food Adulteration Detection.

Food safety is a scientific discipline that requires sophisticated handling, production, and storage. Food is common for microbial development; it acts as a source for growth and contamination. The traditional procedures for food analysis are time-consuming and labor-intensive, but optical sensors overcome these constraints. Biosensors have replaced rigorous lab procedures like chromatography and immunoassays with more precise and quick sensing. It offers quick, nondestructive, and cost-effective food adulteration detection. Over the last few decades, the significant spike in interest in developing surface plasmon resonance (SPR) sensors for the detection and monitoring of pesticides, pathogens, allergens, and other toxic chemicals in foods. This review focuses on fiber-optic SPR (FO-SPR) biosensors for detecting various adulterants in food matrix while also

discussing the future perspective and the key challenges encountered by SPR based sensors.

In 2022 V. Ganesan, C. Manoj, V. Ramaswamy, T. Tejaswi, T. Akilan and G. A. Kumar presented Food Safety Checking Measures by Artificial Intelligent IOT

Agriculture is a vital commodity for developing countries like India, concerns itself with food safety and food security. Agricultural practices should ensure that food products are healthy for consumption and sustainable to the environment, while maintaining or even increasing the production quantities to provide for the growing population. The smart farming technologies and organic farming allows the improvements of food safety and security at the same time. The food industry is continuously challenged by the occurrences of food borne diseases. This system aims at eliminating the loss of food that is fit for consumption by humans during the storage and passage of the food chain. Food chain typically starts from the farm where it is harvested and then transported to the store houses and then to markets and finally ends up in your table. While there are multiple factors in ensuring food safety, this system aims at monitoring pathogenic presence and controlling the spread of these pathogens to minimise the loss by using Internet of things or (IoT) systems which is a low-cost solution to farmers to monitor the pathogens in the food remotely . This system helps to optimize the cost of food for the user and maximizes the benefit to farmers.

In 2022 G. Mezzina, D. Ciccarese and D. De Venuto presented Preventing Food Waste by the Shelf-Life Dynamical Control in Smart Homes

Currently, smart homes are designed and improved according to four main goals: residents' wellness, security, comfort, and reduced energy waste. No focus has yet been reserved for one of the most impacting problems of recent years: domestic food waste. In this context, this letter proposes a case study that jointly involves recent advances in smart homes and the need for food waste reduction. The proposed system is divided into two main blocks: the sensing block and the actuation one. The sensing block consists of multiple nodes, which, in the proposed

case study, work as dynamic labels being stuck to the good to be monitored. Each node embeds, on a miniaturized board, a set of sensors (i.e., temperature, humidity, and ambient light), whose outcomes are used to extract, on-board, the dynamic food shelf life (SL). The presence of an onboard inertial measurement unit also permits the nodes' localization inside the environment. If a sudden decrease in the food SL is recorded by the node and no human interventions occur in a preset timeout, the node is designed to send a call for intervention to the actuation block. In this letter, the actuation block is realized through an assistive robotic platform that can gather coordinates of food from sensor nodes, navigate to them to manipulate the goods, and actuate actions to improve their preservation conditions (increasing the perspective SL). The actuation block is also responsible for notifying the user of the bad storage conditions. The system has been experimentally tested in a laboratory environment. The whole mitigation chain successfully completed all the operations through the robotic platform in 60% of cases. Moreover, comparing food left in poor storage conditions and the same food managed by the our proposed system, an improvement of the food expiration date of ~55% (on average) has been recorded.

In 2022 F. Siddiqua, S. R. M., M. T. Dolon, T. F. A. Nayna, M. M. Rashid and M. A. Razzak presented IoT-Based Low-Cost Cold Storage Atmosphere Monitoring and Controlling System

Temperature and humidity monitoring is crucial when it comes to the prolonged storage of perishable foods and crops in cold storage, as the use of correct temperature while controlling the moisture levels is a must not only for the safety of those products but also to ensure the quality. With the help of Internet of Things (IoT), the monitoring as well as the controlling of the Temperature and humidity of a system can be done automatically from anywhere in the world. This paper presents an IoT-based low-cost automatic cold storage monitoring and controlling system. The proposed system includes a sensor for measuring both temperature and humidity, a microcontroller, a DC-DC step down converter-based power supply module, a cooling fan to lower the temperature and an app to monitor and control the temperature of the cold storage system. The hardware prototype of the system has been tested for consecutive three months for ensuring the accuracy.

In conclusion, the literature survey has provided valuable insights into the current state of research and development in the field of fruit spoilage detection and storage systems using IoT. The survey highlighted the importance of balancing cost, accuracy, and power consumption in sensor selection and system design. It also emphasized the need for robust data transmission protocols and secure cloud connectivity to ensure the integrity and privacy of collected data. The survey identified several areas for future research, including the development of advanced sensor technologies, integration of machine learning algorithms for predictive analysis, and the implementation of blockchain technology for enhanced data security. Overall, the literature survey has contributed to the body of knowledge in this field and provided a foundation for further research and innovation in IoT-based fruit spoilage detection and storage systems.

CHAPTER 3

AIM AND SCOPE OF THE PRESENT INVESTIGATION

The aim of the present investigation on the "Detection of Stored Food Spoilage and Alert System Development using IoT" is to develop a robust and reliable system that can effectively monitor and detect food spoilage in storage environments. This investigation seeks to utilize IoT technologies to create a system that can continuously monitor various environmental parameters such as temperature, humidity, and gas levels, which are critical for food freshness.

3.1 Existing System

The existing smart food storage system is designed to revolutionize the way food items are stored, ensuring freshness and safety while minimizing waste. By integrating a range of sensors and microcontroller technology, the system offers comprehensive monitoring and control capabilities. IR proximity sensors enable accurate detection of incoming food items, while MQ sensors continuously monitor methane levels to alert users of potential spoilage. Humidity measurement via DHT11 sensors further enhances the system's ability to assess food quality.

Managed by a microcontroller, the system orchestrates the operation of servo motors for sorting food items based on their freshness. An LCD display provides users with real-time information on the quality of stored food, while Arduino facilitates efficient data tracking and management. Upon detecting incoming fruits, the system initiates a countdown timer based on estimated expiration, ensuring timely alerts if methane levels exceed safety thresholds.

Moreover, the system dynamically adjusts sorting mechanisms based on methane and humidity levels, guaranteeing that only fresh and safe food items are stored. Crucially, data regarding fruit count, quality assessment, and expiration countdown are seamlessly transmitted to a mobile application via WiFi, empowering users to monitor their food inventory remotely and make informed decisions to prevent waste. This comprehensive smart food storage solution represents a significant advancement in food preservation technology, offering users unparalleled control over their stored food items.

3.2 Open problems in existing system

Despite its innovative design, the existing smart food storage system may have certain limitations and drawbacks. One potential disadvantage is the reliance on multiple sensors, which can increase complexity and cost. Integrating IR proximity sensors, MQ sensors, and DHT11 sensors may lead to higher maintenance requirements and susceptibility to sensor failures, potentially impacting the system's reliability.

Additionally, while the system offers real-time monitoring and alerts for methane levels and food freshness, it may not account for all factors influencing food safety, such as temperature variations or bacterial growth. This could result in occasional inaccuracies in assessing food quality and expiration, leading to potential food waste or consumption of spoiled items.

Furthermore, the dependency on a microcontroller and Arduino for control and data management introduces a degree of vulnerability to technical glitches or software malfunctions, which could disrupt system operation and data transmission to the mobile application. These limitations highlight the need for ongoing refinement and optimization of the smart food storage system to ensure its effectiveness and reliability in real-world applications.

3.3 Scope of the Investigation

This project encompasses the design, development, and implementation of a smart food storage system utilizing sensor technology and microcontrollers to ensure the freshness and safety of stored food items. The scope includes the integration of IR proximity sensors, MQ sensors for methane level monitoring, and DHT11 sensors for humidity measurement, along with servo motors for sorting food items. The system employs an Arduino microcontroller for data management and control. It also incorporates an LCD display for real-time feedback on food quality and expiration status. The scope extends to the implementation of a countdown timer based on approximate expiry, alert mechanisms for methane level exceedance, and dynamic adjustment of sorting mechanisms based on environmental conditions. Furthermore, the project involves the development of a mobile application for remote monitoring of food inventory, enabling users to access real-time data on fruit count, quality assessment, and expiration countdown.

CHAPTER 4

Detection of Stored Food Spoilage and Alert System Development using IoT

The "Detection of Stored Food Spoilage and Alert System Development using IoT" project aims to address the critical issue of food spoilage in storage by utilizing Internet of Things (IoT) technology. This system integrates various sensors with an Arduino Uno microcontroller to monitor environmental conditions such as temperature, humidity, and gas levels, which are crucial factors affecting food freshness.

The IoT system continuously collects and analyses data from these sensors to detect any deviations from the optimal storage conditions. When spoilage is detected, the system triggers an alert, notifying the user through various means such as SMS or email. This timely alert helps prevent the consumption of spoiled food, reducing waste and ensuring food safety.

4.1 Proposed Methodology

The proposed methodology involves initializing hardware components and establishing communication channels. It includes detecting fruits using IR sensors, monitoring methane levels with MQ sensors, and tracking humidity using DHT11 sensors. The system processes data, makes decisions based on preset thresholds, and alerts users via a mobile application, ensuring efficient food storage and safety.

4.2 Initialization

In the initialization phase, the primary objective is to set up the hardware components and establish communication channels for the system to function effectively. This involves connecting all sensors, actuators, and communication modules to the Arduino microcontroller. Each component must be properly interfaced with the microcontroller to ensure seamless integration and data flow within the system. Additionally, configuring the Node MCU module is crucial for enabling data transfer to the mobile application. This entails setting up the communication protocol, establishing connections, and ensuring compatibility with the mobile platform. Proper initialization is essential to lay the foundation for the subsequent operation of the food storage system.

4.3 Detection and Monitoring

The detection and monitoring phase is centred around the accurate and reliable sensing of environmental parameters within the storage box. The IR Proximity Sensor plays a vital role in detecting the presence of fruits as they enter the box, thereby facilitating the counting process. Meanwhile, the DHT11 Sensor continuously monitors the humidity level within the storage environment, providing crucial data for assessing food freshness and shelf life. Simultaneously, the MQ Sensor monitors methane levels, offering insights into potential spoilage or contamination of the stored food items. This phase is critical for ensuring proactive surveillance of the storage environment to maintain optimal conditions for food preservation.

4.4 Data Processing and Decision Making

Upon receiving data from the sensors, the microcontroller engages in data processing and decision-making tasks to manage the storage system effectively. Based on the analyzed sensor data, the microcontroller determines the appropriate course of action for each incoming fruit. If both methane and humidity levels are within acceptable limits, the microcontroller activates Servo 1 to store the fruit and displays a corresponding message on the LCD, indicating that the food is safe for consumption. Conversely, if either methane or humidity levels exceed predefined thresholds, the microcontroller triggers Servo 2 to discard the fruit, signaling potential spoilage or contamination. This phase showcases the system's ability to autonomously make informed decisions to ensure food safety and quality.

4.5 Alerting Mechanism

The alerting mechanism is a crucial component of the food storage system, providing timely notifications to users regarding potential issues or impending expiry of stored items. If the methane level in the storage box surpasses a predefined threshold, the system sends an alert to the user before the approximate expiry date, prompting them to inspect the stored fruits for spoilage or contamination. Additionally, after the expiry countdown elapses, the system generates an alert to notify the user of the expired food items, enabling prompt disposal or consumption. This proactive approach to alerting ensures that users can take appropriate actions to maintain food safety and minimize waste effectively.

4.6 Data Transmission

Efficient data transmission is essential for facilitating seamless communication between the food storage system and the mobile application. The Node MCU module enables the transfer of critical information, including fruit count, countdown status, and alerts, to the user's mobile device in real-time. By leveraging wireless communication technology, the system ensures accessibility and convenience, allowing users to monitor their food supply remotely and receive timely updates on its status. Furthermore, the integration of data transmission capabilities enhances the overall user experience by providing valuable insights into the condition of stored items and facilitating informed decision-making.

4.7 User Interaction

User interaction plays a vital role in the functionality and usability of the food storage system. When the user removes a fruit from the storage box, the system utilizes another IR Sensor to decrement the fruit count accordingly. The microcontroller updates the count and communicates this information to the mobile application, ensuring accurate inventory management and real-time visibility for the user. This seamless interaction between the user and the system fosters transparency and engagement, empowering users to actively monitor and manage their food supply with ease.

4.8 Continuous Monitoring

Continuous monitoring is essential for ensuring the ongoing safety and quality of stored food items. By continuously monitoring methane and humidity levels within the storage environment, the system proactively identifies and addresses potential risks of spoilage or contamination. Regular updates and alerts provided to the mobile application enable users to stay informed about any changes in the storage conditions and take appropriate actions accordingly. This continuous monitoring capability underscores the system's commitment to maintaining optimal food safety standards and minimizing the risk of foodborne illnesses or wastage.

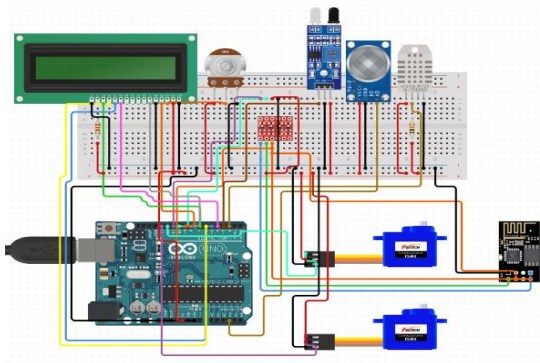


Fig 4.1 – Circuit Diagram of the Proposed Work

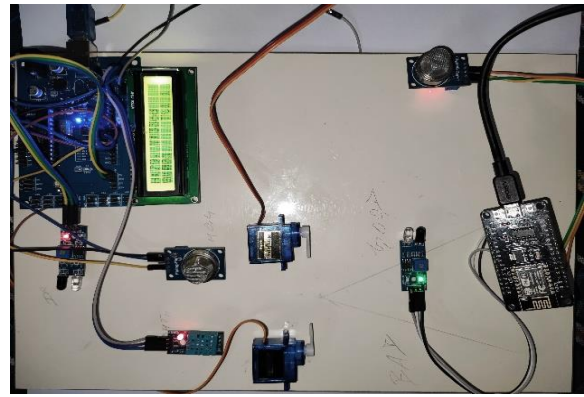


Fig 4.2 - Model of the Proposed Work

4.9 Block Diagram

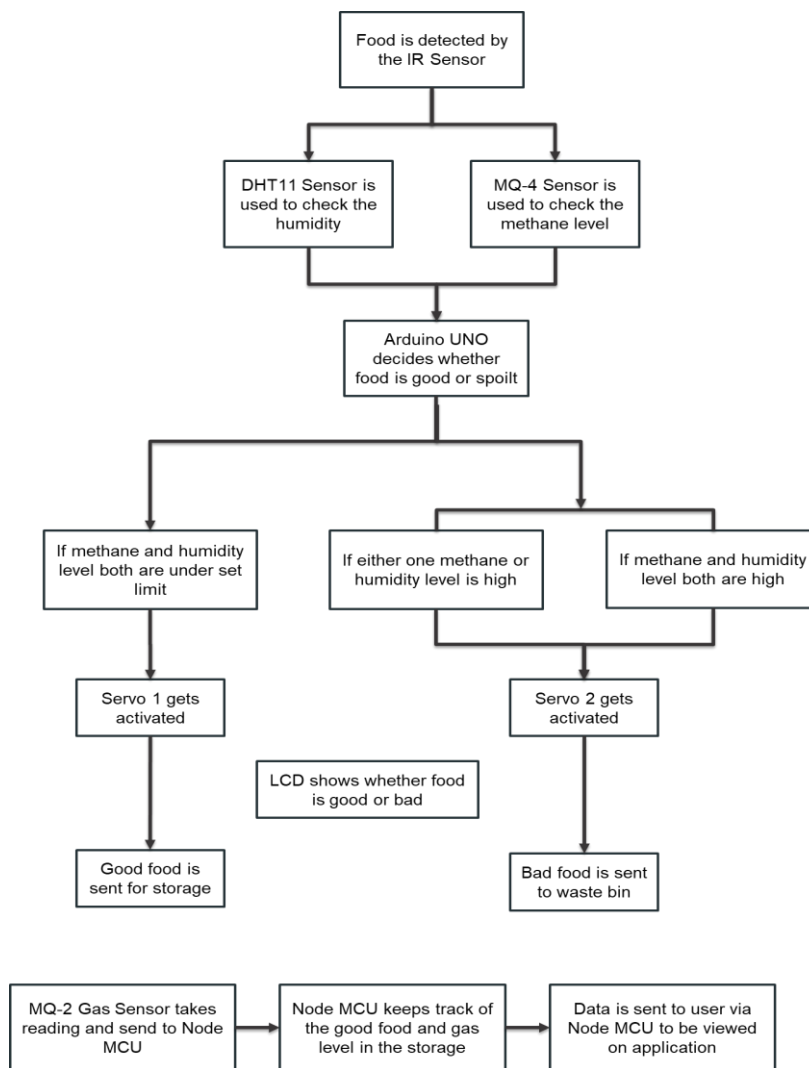


Fig 4.3 – Block Diagram of the proposed model

Hardware Used:

- IR Sensor
- MQ-4 Sensor
- DHT11
- Servo Motors
- LCD Display
- Arduino
- Node MCU
- MQ-2 Sensor

4.10 Hardware Specification

4.10.1 MQ 2 SENSOR

MQ 2 sensor is a chemical optical sensor utilizing the acidic nature of MQ 2 for detection. It consists of a gas-permeable membrane in which a pH-sensitive luminescence dye is immobilized together with a buffer and an inert reference luminescent dye. MQ 2 permeating into the membrane changes the internal pH of the buffer. With this changes the luminescence of the pH-sensitive dye. Together with the inert reference dye internal referencing is made for detection of the luminescence lifetime of the sensor. The measurement signal detected by the MQ 2 mini correlates to the partial pressure of MQ 2 ambient.

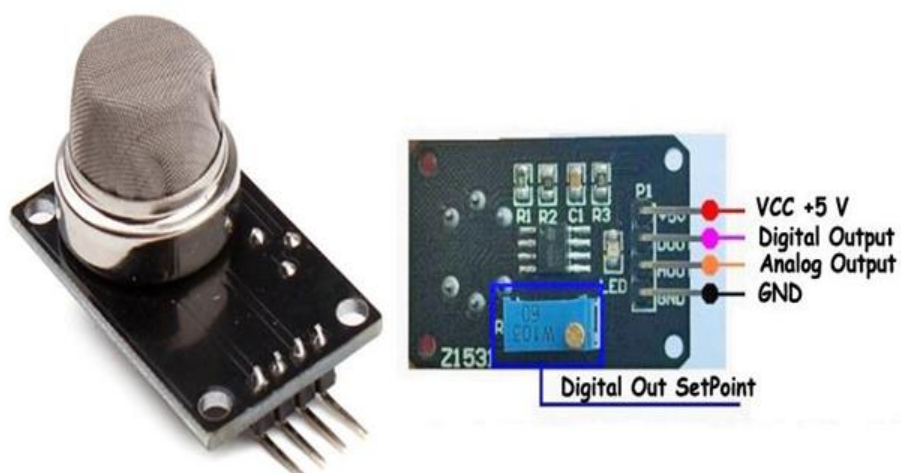


Fig 4.4 – MQ-2 GAS SENSOR

APPLICATIONS

- Modified atmospheres
- Indoor air quality
- Stowaway detection
- Cellar and gas stores
- Marine vessels
- Greenhouses
- Landfill gas
- Confined spaces
- Cryogenics
- Ventilation management

MQ-2 SPECIFICATION

It is uncommon to utilize the MQ2 sensor, which is frequently used to detect gasses like methane, to immediately detect food deterioration. It may, however, be a component of a larger sensor array system that is used to sort and indirectly monitor food quality.

While the MQ2 sensor in our food sorting application might not be able to identify food deterioration directly, it can be used to identify the gasses released as the food breaks down. Food rotting releases methane, which is able to identify gas amounts in the environment being sorted. In order to improve overall food safety and quality control, the sensor array system can then activate sorting processes to remove spoiled or possibly contaminated food products from the production line.

In conclusion, even though the MQ4 sensor would not be able to identify food spoiling directly, it might still be a useful component of a sensor array system that sorts and monitors food quality indirectly by identifying gas concentrations linked to the deterioration process.

CHARACTER

- Good sensitivity to Combustible gas in wide range
- High sensitivity to LPG, Propane and Hydrogen
- Long life and low cost

- Simple drive circuit

APPLICATION

- Domestic gas leakage detector
- Industrial Combustible gas detector
- Portable gas detector.

4.10.2 MQ 4 SENSOR

The MQ4 sensor, which is commonly used for detecting gases such as methane, is not typically employed for detecting food spoilage directly. However, it can be part of a broader sensor array system used for sorting and monitoring food quality indirectly.

In our food sorting application MQ4 sensor may not directly detect food spoilage, it can be utilized to detect gases emitted during the decay process. Methane is released as food spoils it can detect gas concentrations within the sorting environment. The sensor array system can then trigger sorting mechanisms to remove spoiled or potentially contaminated food items from the production line, thus improving overall food safety and quality control.

In summary, while the MQ4 sensor itself may not directly detect food spoilage, it can still play a valuable role as part of a sensor array system used for sorting and monitoring food quality indirectly by detecting gas concentrations associated with the decay process.



Fig 4.5 – MQ-4 GAS SENSOR

APPLICATIONS

- Modified atmospheres
- Indoor air quality monitoring
- Stowaway detection
- Cellars and gas storage areas
- Marine vessels
- Greenhouses
- Landfill gas monitoring
- Confined spaces
- Cryogenics
- Ventilation management

MQ-4 SPECIFICATION

The MQ-4 gas sensor has high sensitivity to methane (CH₄) and natural gas, and can also detect other combustible gases. It is characterized by its low cost and suitability for a wide range of applications.

CHARACTER

- Good sensitivity to combustible gases over a wide range
- High sensitivity to methane (CH₄) and natural gas
- Long life and low cost
- Simple drive circuit

APPLICATION

- Domestic gas leakage detector
- Industrial Combustible gas detector
- Portable gas detection

4.10.3 IR Proximity Sensor

IR Detection Avoidance Proximity Sensor is used to detect the incoming food into the sorting mechanism. Due to its low latency, it can detect food faster. It has good sensing range of 5-30cm which is good for our model comparing it with other sensors and can be finely adjusted based on our model. This IR Sensor can detect all types of colours other than black which most food isn't making it more reasonable to use.

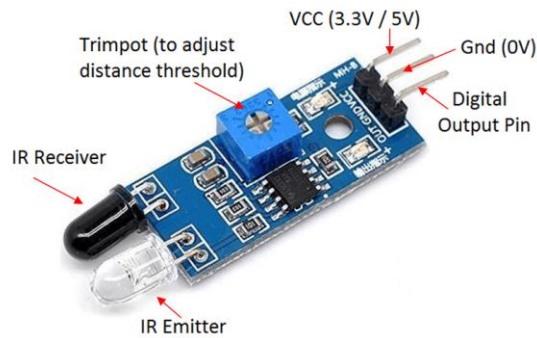


Fig 4.6 – INFRARED SENSOR

SPECIFICATIONS

- **Operating Voltage:** 5VDC
- **I/O Pins:** 5V and 3.3V compliant
- **Range:** Up to 20cm
- **Sensing Range:** Adjustable
- **Supply Current:** 20mA
- **Built-in Ambient Light Sensor**
- **Mounting Hole**

APPLICATIONS

- Remote Controls
- Object Sensing
- Non-contact Temperature Measurement
- Gas Composition Analysis
- Non-Destructive Testings
- Medical Applications
- Military Applications
- Space Technology
- Environmental Engineering
- Industrial Safety Devices

4.10.4 DHT11 SENSOR

DHT11 Sensor is used to measure the temperature and humidity levels. This sensor can actively monitor the humidity condition of a fruit which directly represent the amount of water it is losing. Which spoilt foods do which makes them become wet this can be used as an identification for spoilage.

SPECIFICATIONS

- Power Supply: 5V DC Power Consumption: <-3.0mA.
- Operating Humidity and temperature Range: 30-90%RH
- Storable Temperature Range: -30°C ~ 85°C
- Storable humidity and temperature range: within 95%RH

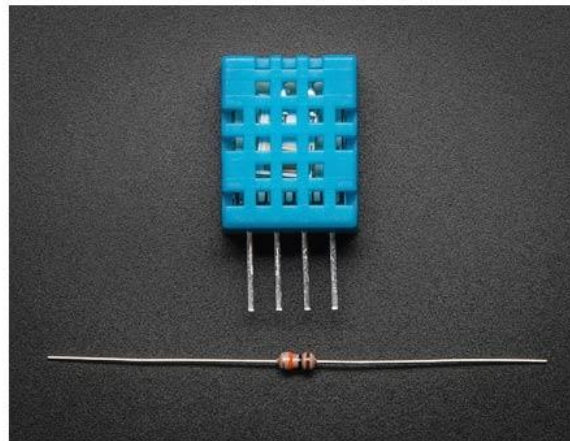


Fig 4.7 – DHT11 SENSOR

PIN DETAILS

Pin	Name	Details
1	GND	Power Supply Ground
2	+5V	Power Supply Positive Input
3	OUT	Active Low to High Analog Output

HUMIDITY AND TEMPERATURE OUTPUT

- 0.9V → low humidity and temperature output voltage and range 30%RH.
- 3.4V → high humidity and temperature output voltage and range 90%RH

USING THE SENSOR

- Connect regulated DC power supply of 5 Volts. Black wire is Ground, Next middle wire is Brown which is output and red wire is positive supply.
- These wires are also marked on PCB.

- The insulator material which absorbs the water is made out of a polymer which takes in and releases water based on the relative humidity and temperature of the given area.
- To test sensor, you only need power the sensor by connect two wires +5V and GND. You can leave the output wire as it is. When the output is varying at 0.9V to 3.4V based on weather condition.
- Measure the output voltage through multi-meter between OUT and Ground pins or use a microcontroller to measure the voltage output.

OPERATION

An analog DHT11 sensor gauges the humidity and temperature of the air relatively using a capacitor-based system. The sensor is made out of a film usually made of either glass or ceramics. The insulator material which absorbs the water is made out of a polymer which takes in and releases water based on the relative humidity and temperature of the given area. This changes the level of charge in the capacitor of the on-board electrical circuit. The DHT11 is a basic ultra low-cost digital temperature and DHT11 sensor. It uses a capacitive DHT11 sensor and a thermostat to measure the surrounding air and spits out a digital signal on the data pin .It is fairly simple to use, but requires careful timing to grab data.

APPLICATIONS

- Automotive Industry
- Climate Control
- Data Loggers
- Humidity And Temperature Monitoring

4.10.5 ARDUINO UNO

An Arduino is actually a microcontroller-based kit which can be either used directly by purchasing from the vendor or can be made at home using the components, owing to its open-source hardware feature. It is basically used in communications and in controlling or operating many devices. It was founded by Massimo Banzi and David Cuartielles in 2005.

- The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog

inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button.

- It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.
- The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter. "Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward.

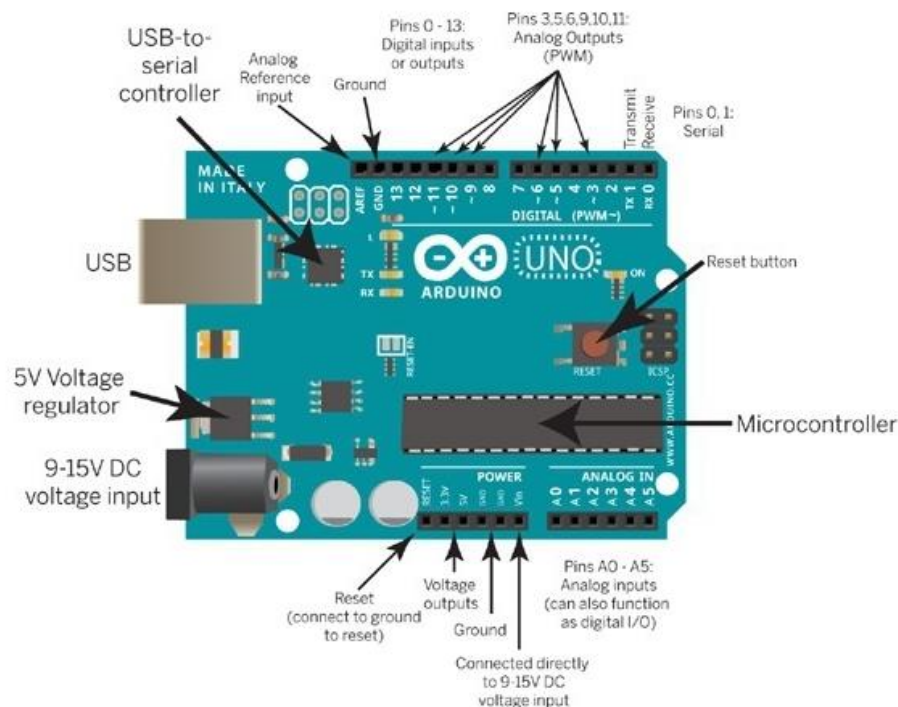


Fig 4.8 – ARDUINO BOARD

WORKING

Arduino can play a crucial role in the Detection of Fruit Spoilage and Storage System Using IoT by serving as the central control unit for the system. Here's how Arduino can work in such a system:

Sensor Integration: Arduino can interface with various sensors such as temperature sensors, humidity sensors, gas sensors, and ethylene sensors to monitor the environmental conditions inside the fruit storage facility. These sensors

can detect parameters that indicate fruit spoilage, such as temperature fluctuations, humidity levels, gas emissions, and ethylene production.

Data Processing: Arduino can process the data from the sensors in real-time to analyze the conditions inside the storage facility. It can compare the sensor readings with predefined thresholds for each parameter to detect any signs of fruit spoilage.

Alert System: Arduino can trigger an alert system, such as a buzzer or a notification on a connected device, when it detects conditions that indicate fruit spoilage. This alert can prompt immediate action to prevent further spoilage and ensure the quality of the stored fruits.

Data Transmission: Arduino can transmit the sensor data to a cloud platform or a local server using communication modules such as Wi-Fi, Ethernet, or GSM. This allows for remote monitoring and data analysis, enabling stakeholders to access real-time information about the storage conditions from anywhere.

Integration with IoT Platform: Arduino can be integrated with an IoT platform, such as ThingSpeak, to enable advanced analytics, data visualization, and historical data storage. This integration can provide valuable insights into the storage conditions and help in optimizing the storage process to reduce spoilage.

STEPS TO PROGRAM AN ARDUINO

Programs written in Arduino are known as sketches. A basic sketch consists of 3 parts

1. Declaration of Variables
 2. Initialization: It is written in the setup () function.
 3. Control code: It is written in the loop () function.
- The sketch is saved with .ino extension. Any operations like verifying, opening a sketch, saving a sketch can be done using the buttons on the toolbar or using the tool menu.
 - The sketch should be stored in the sketchbook directory.
 - Chose the proper board from the tool's menu and the serial port numbers.
 - Click on the upload button or chose upload from the tools menu. Thus the code is uploaded by the bootloader onto the microcontroller.

BASIC ADUINO FUNCTIONS

- **digitalRead (pin):** Reads the digital value at the given pin.
- **digitalWrite (pin, value):** Writes the digital value to the given pin.
- **pinMode (pin, mode):** Sets the pin to input or output mode.
- **analogRead (pin):** Reads and returns the value.
- **analogWrite (pin, value):** Writes the value to that pin.
- **serial.begin (baud rate):** Sets the beginning of serial communication by setting the bit rate.

FEATURES

- It is inexpensive
- It comes with an open-source hardware feature which enables users to develop their own kit using already available one as a reference source.
- The Arduino software is compatible with all types of operating systems like Windows, Linux, and Macintosh etc.
- It also comes with open-source software feature which enables experienced software developers to use the Arduino code to merge with the existing programming language libraries and can be extended and modified.
- It is easy to use for beginners.
- We can develop an Arduino based project which can be completely stand alone or projects which involve direct communication with the software loaded in the computer.
- It comes with an easy provision of connecting with the CPU of the computer using serial communication over USB as it contains built in power and reset circuitry.

4.10.6 LCD DISPLAY

Liquid crystal cell displays (LCDs) used to display of display of numeric and alphanumeric characters in dot matrix and segmental displays. They are all around us in laptop computers, digital clocks and watches, microwave, CD players and many other electronic devices. LCDs are common because they offer some real advantages over other display technologies. LCDs consume much less power than

LED and gas-display displays because they work on the principle of blocking light rather than emitting it.

An LCD is made with either a passive matrix or an active-matrix display grid. An active matrix has a transistor located at each pixel intersection, requiring less current to control the luminance of a pixel. For this reason, the current in an active-matrix display can be switched on and off more frequently, improving the screen refresh time. Passive matrix LCD's have dual scanning, meaning that they scan the grid twice with current in the same

WORKING

In the context of the Detection of Fruit Spoilage and Storage System Using IoT, an LCD (Liquid Crystal Display) can be used as an output interface to provide visual feedback to users or operators. Here's how an LCD can work in this system:

Displaying Sensor Readings: The LCD can display real-time sensor readings such as temperature, humidity, and gas levels inside the fruit storage facility. This allows users to monitor the conditions and detect any abnormalities that may indicate fruit spoilage.

Alerts and Notifications: The LCD can be used to display alerts and notifications in case of critical conditions such as high temperature or gas levels, indicating potential spoilage. This alerts users to take immediate action to prevent further damage.

System Status and Messages: The LCD can also display system status messages, such as connectivity status, battery level, and data transmission status. This helps users to ensure that the system is functioning properly.

User Interaction: In some cases, the LCD can be used for user interaction, such as entering settings or configuring the system. However, in many IoT systems, such interactions are done through a companion mobile app or web interface.

Data Visualization: The LCD can visualize data trends over time, such as temperature or humidity fluctuations, using graphs or charts. This helps users to analyze the data and make informed decisions regarding fruit storage management.

PIN DESCRIPTION FOR LCD

PIN NO	SYMBOL	FUNCTION
1	Vss	Ground terminal of Module
2	Vdd	Supply terminal of Module, +5v
3	Vo	Power supply for liquid crystal drive
4	RS	Register select RS=0...Instruction register RS=1...Data register
5	R/W	Read/Write R/W=1...Read R/W=0...Write
6	EN	Enable
7-14	DB0-DB7	Bi-directional Data Bus. Data Transfer is performed once, thru DB0-DB7, incase of interface data length is 8-bits; and twice, thru DB4-DB7 in the case of interface data length is 4-bits. Upper four bits first then lower four bits.
15	LAMP-(L-)	LED or EL lamp power supply terminals
16	LAMP+(L+)	Enable

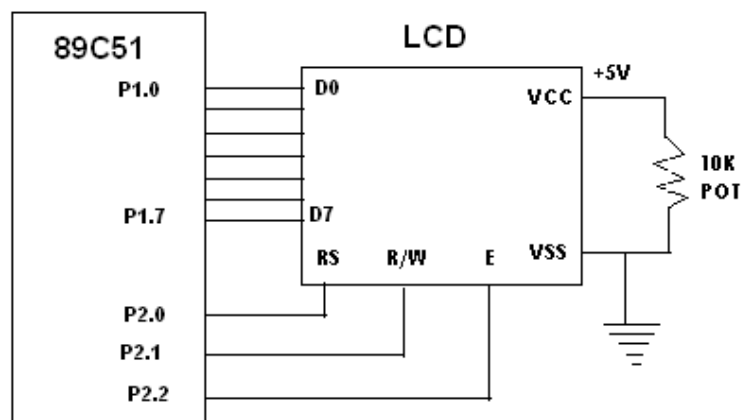


Fig 4.9 – LCD INTERFACING WITH MICRACONTROLLER

ADVANTAGES

- Consume much lesser energy when compared to LEDs.
- Utilizes the light available outside and no generation of light.
- Since very thin layer of liquid crystal is used, more suitable to act as display elements.
- Since reflectivity is highly sensitive to temperature, used as temperature measuring sensor.

DISADVANTAGES

- Angle of viewing is very limited.
- External light is a must for display.
- Since not generating its own light and makes use of external light for display, contrast is poor.
- Cannot be used under wide range of temperature.

APPLICATIONS

- Watches
- Fax & Copy machines
- Calculators.

4.10.7 NODE MCU

The Node MCU is a versatile and powerful development board that has revolutionized the world of IoT (Internet of Things) prototyping. Built around the ESP8266 Wi-Fi module, it offers a cost-effective and accessible platform for developers, makers, and hobbyists to create connected devices and applications. One of the key features of the Node MCU is its ease of use, thanks to its Lua-based firmware that simplifies programming and development. This makes it an ideal choice for beginners looking to get started with IoT projects without the need for extensive programming knowledge.

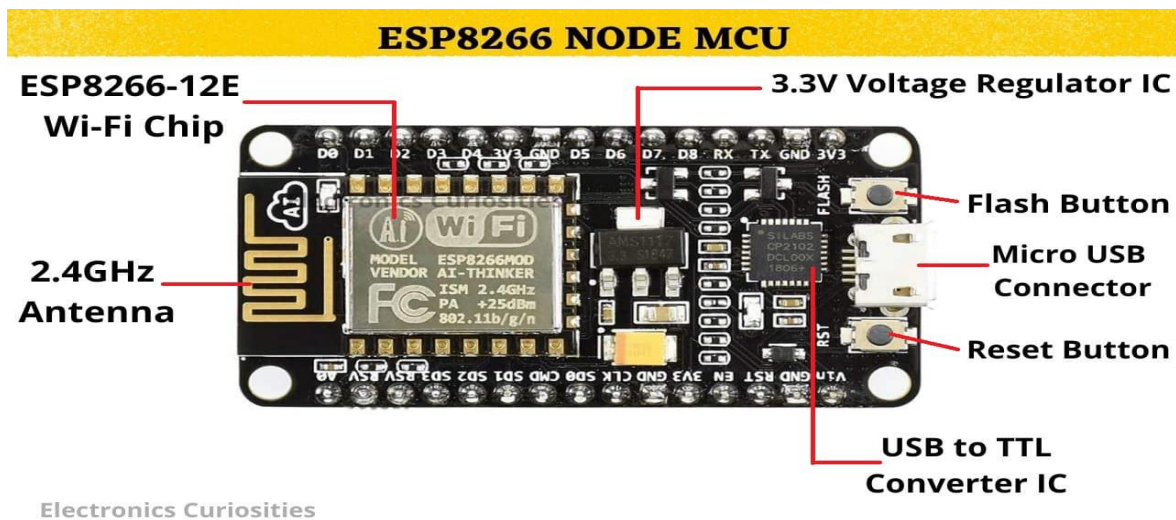


Fig 4.10 – NODE MCU

The Node MCU board comes with built-in Wi-Fi capabilities, allowing it to connect to the internet and communicate with other devices and services. This connectivity opens up a world of possibilities, enabling the NodeMCU to be used in a wide range of applications, from home automation and smart agriculture to industrial monitoring and beyond. Its small form factor and low power consumption make it suitable for battery-powered applications, further expanding its versatility.

One of the key advantages of the Node MCU is its rich set of features and I/O options. It comes with a number of GPIO (General Purpose Input/Output) pins that can be used to interface with sensors, actuators, displays, and other external components. This makes it easy to create complex IoT systems that can sense and respond to their environment. Additionally, the Node MCU supports a variety of communication protocols, including SPI, I2C, and UART, making it compatible with a wide range of sensors and peripherals. The Node MCU is also highly extensible, with a vibrant community that has created a wealth of libraries, tools, and resources to help developers get the most out of the platform. This includes support for popular IoT platforms such as Arduino and Platform IO, as well as cloud services like AWS IoT, Google Cloud IoT, and Microsoft Azure IoT. This ecosystem of support makes it easy to integrate the Node MCU into existing projects and scale them up to meet the demands of larger deployments.

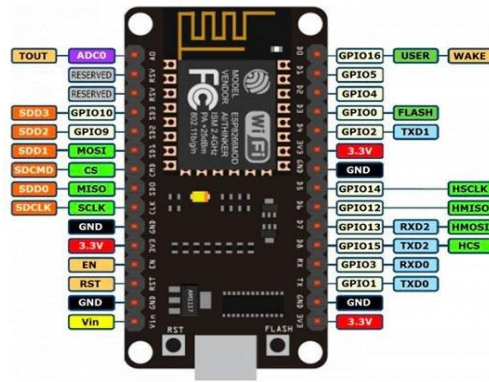


Fig 4.11 – NODE MCU PIN DIAGRAM

WORKING

NodeMCU can be used in the Detection of Fruit Spoilage and Storage System Using IoT as a central component for collecting sensor data, processing it, and transmitting it to the cloud for analysis and monitoring. Here's how NodeMCU can work in this system:

Sensor Data Collection: NodeMCU can be connected to various sensors such as temperature, humidity, ethylene gas, and other relevant sensors placed in the fruit storage environment. These sensors continuously monitor the environmental conditions and detect any signs of spoilage.

Data Processing: NodeMCU processes the sensor data to identify patterns or anomalies that indicate fruit spoilage. This may involve comparing current sensor readings with predefined thresholds or using machine learning algorithms for more advanced analysis.

Data Transmission: Once the data is processed, NodeMCU sends it to the cloud server using Wi-Fi or other communication protocols like MQTT. The data transmission can be scheduled at regular intervals or triggered by specific events such as a change in sensor readings.

Cloud Storage and Analysis: The data received by the cloud server is stored securely and analyzed using data analytics algorithms. This analysis helps in identifying trends, predicting spoilage patterns, and generating alerts or notifications for timely intervention.

Alert System: Node MCU can also be programmed to trigger alerts or notifications when spoilage is detected. These alerts can be sent to the user's mobile device or email, enabling quick action to prevent further spoilage.

Remote Monitoring and Control: Through the cloud interface, users can remotely monitor the storage conditions of fruits in real-time and make adjustments to the storage environment if necessary. This remote monitoring capability enhances the overall efficiency and management of the storage system.

ESTABLISHING CONNECTIONS

Establishing a connection between two Node MCU devices follows a relatively complicated procedure meant to ensure a certain amount of security, as follows:

- Passive mode
- Inquiry: Finding access points
- Paging: Synchronizing with access points
- Access point service discovery
- Creating a channel with access point
- Pairing using PIN (security)
- Using the network

APPLICATION

- Home Automation
- IoT Devices
- Data Logging and Monitoring
- Weather Stations
- Security Systems
- Smart Energy Management
- Remote Control Systems
- Education and Learning

4.11 Standards

Food Safety Standards:

Ensuring the safety and quality of food products is paramount in any food-related project. Compliance with food safety standards set forth by regulatory bodies such as the Food and Drug Administration (FDA) in the United States, the European Food Safety Authority (EFSA) in Europe, or similar organizations worldwide is essential. These standards outline guidelines for safe food handling, storage, and distribution, helping to prevent contamination and ensure consumer safety.

Sensor Performance Standards:

The sensors employed for detecting humidity and methane levels must meet stringent performance standards to provide accurate and reliable measurements. These standards encompass factors such as sensor sensitivity, precision, response time, and calibration requirements. Adherence to industry standards for sensor manufacturing and testing, such as those defined by the International Electrotechnical Commission (IEC) or the Institute of Electrical and Electronics Engineers (IEEE), ensures that the sensors meet established criteria for performance and reliability.

Data Collection and Analysis Standards:

Standards for data collection, processing, and analysis are essential to ensure the integrity and validity of the results obtained from the sensor readings. Establishing protocols for sensor calibration, data logging procedures, and statistical analysis techniques helps maintain consistency and accuracy in the collected data. Adherence to recognized standards for data management and analysis, coupled with data privacy and security considerations, safeguards sensitive information and ensures compliance with relevant regulations.

Quality Management Standards:

Implementing a robust quality management system (QMS) is essential to uphold high standards of quality and consistency throughout the project lifecycle. Adhering to standards such as ISO 9001, which outlines principles for quality management, helps ensure that processes are well-defined, monitored, and continuously improved. A comprehensive QMS fosters accountability, transparency, and continuous improvement, ultimately enhancing the reliability and effectiveness of the food spoilage detection system.

Environmental Standards:

If the project involves the use of sensors or equipment that could impact the environment, adherence to environmental standards and regulations is imperative. Compliance with standards for energy efficiency, waste management, emissions control, and other environmental considerations helps minimize the project's ecological footprint and ensures responsible environmental stewardship.

By adhering to these standards, a project focused on detecting food spoilage using humidity and methane levels can effectively mitigate risks associated with food contamination, ensure the reliability of detection methods, and contribute to overall food safety and quality assurance efforts.

4.12 Constrains

Constraints for the project "Detection of Stored Food Spoilage and Alert System Development using IoT System" with Arduino Uno:

- **Sensor Accuracy and Reliability:** Using sensors like the MQ2 and MQ4 for methane detection and the DHT11 for humidity detection provides accurate readings initially. However, these sensors require regular calibration and replacement to maintain accuracy over time due to wear and tear.
- **Power Consumption:** Efficient energy management is crucial to ensure longer battery life for your system. Components such as the Arduino Uno, servo motors, and sensors should be selected for their energy efficiency to minimize power consumption.
- **Response Time:** To improve the speed of fruit detection and sorting, it's essential to ensure that sensors and servos have fast response times. This can be achieved by optimizing sensor placement and using efficient signal processing algorithms.
- **Sensitivity to Ambient Conditions:** Ambient factors like temperature, light, and gas interference can affect sensor readings. Designing the system to reduce these effects requires robust sensor selection and possibly additional shielding or filtering.
- **Compatibility and Integration:** Seamless integration between the Arduino Uno and Node MCU for data transmission to the cloud is critical. Compatibility issues between components can lead to system malfunctions, so it's important to ensure compatibility during the design phase.
- **Data Transmission Delay:** The free license of Thingspeak imposes a delay of 15 seconds for each transmission and reception of data. To minimize this delay, you may need to consider upgrading to a paid plan or explore other cloud platforms with lower latency.
- **LCD Display:** The current 16x2 LCD display has limitations in changing factors like font size, contrast, and language. Upgrading to a more advanced display module could provide greater flexibility in customizing these settings.
- **Cloud Connectivity and Data Security:** Ensuring secure transmission of data from the Node MCU to the cloud platform is crucial, especially for a public

system. Consider implementing better WiFi modules for improved network coverage and connectivity, along with encryption protocols to prevent unauthorized access or data breaches.

By addressing these constraints effectively, the performance, reliability, and security of the IoT system can be enhanced for detecting stored food spoilage and developing an alert system.

4.13 Trade Offs

- **Cost vs. Sensing Accuracy:** Better sensors are more accurate but cost more. Finding the right balance between cost and accuracy is key.
- **Power Consumption vs. Sensor Lifespan:** Using less power extends battery life, but sensors must stay operational for a reasonable time.
- **Data Transmission Frequency vs. Connectivity:** Sending data often for real-time monitoring uses more power and needs a strong network connection.
- **Complexity vs. Reliability:** Complex systems offer more features but may fail more. Simpler designs are more reliable but might have fewer functions.
- **Data Privacy vs. Data Sharing:** Keeping data private is important, but sharing data for research or business purposes can be beneficial. Deployment
- **Speed vs. System Scalability:** Deploying quickly is good, but the system also needs to be able to grow to meet future needs.
- **Environmental Impact vs. Performance:** The materials and efficiency of the system affect its environmental impact. Balancing this with performance is crucial.
- **Integration with Existing Systems vs. Standalone Operation:** Connecting to existing systems can make deployment and maintenance easier, but standalone systems can be simpler.

CHAPTER 5

RESULT AND DISCUSSION

Results and discussions of the food storage system implementation provide insights into its functionality, effectiveness, and potential implications for food safety and waste reduction. This section presents an analysis of the system's performance based on various criteria, including sensor accuracy, alerting mechanism efficacy, user interaction, and overall system reliability.

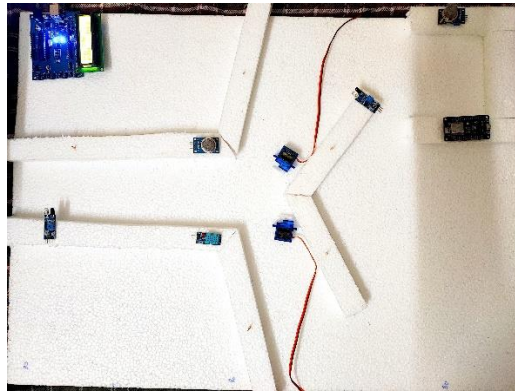


Fig 5.1 – Final Model

Sensor Accuracy and Reliability:

One of the critical aspects of the food storage system is the accuracy and reliability of the sensors employed for detecting environmental parameters such as fruit presence, methane level, and humidity. During the testing phase, the IR Proximity Sensor demonstrated consistent performance in accurately detecting incoming fruits, ensuring precise counting and tracking of inventory. Similarly, the MQ Sensor exhibited reliable detection of methane levels, enabling timely alerts in cases of elevated gas concentration indicative of potential spoilage. The DHT11 Sensor, responsible for monitoring humidity, provided consistent readings, allowing the system to assess the storage environment's moisture content accurately. Overall, the sensors' accuracy and reliability lay the foundation for effective monitoring and management of stored food items.

Alerting Mechanism Efficacy:

The alerting mechanism implemented in the food storage system serves as a crucial component for notifying users of potential issues, including impending fruit

expiry or elevated methane levels. Through real-time data analysis, the system triggers alerts via the mobile application when predefined thresholds are exceeded, ensuring timely intervention and preventive measures. During testing, the alerting mechanism proved effective in providing users with actionable information, allowing them to address food safety concerns promptly. By leveraging wireless communication technology, the system ensures that users receive alerts promptly, enabling them to make informed decisions and mitigate risks effectively.

User Interaction and Interface Design:

User interaction and interface design play a significant role in enhancing the system's usability and user experience. The seamless interaction between the user and the food storage system, facilitated through the mobile application, enables users to monitor their food supply remotely and receive real-time updates on its status. The intuitive interface design provides users with easy access to critical information such as fruit count, expiry countdowns, and alerts, fostering transparency and engagement. Additionally, the integration of user feedback mechanisms allows for continuous improvement and refinement of the system based on user preferences and requirements.

System Reliability and Performance:

The reliability and performance of the food storage system are crucial factors in ensuring its effectiveness in preserving food quality and safety. Throughout the testing phase, the system demonstrated robust performance, accurately detecting and monitoring environmental parameters while effectively managing inventory and issuing timely alerts. The integration of redundant mechanisms, such as dual servo actuators for fruit sorting and disposal, enhances system reliability and fault tolerance, minimizing the risk of system failures or malfunctions. Furthermore, continuous monitoring and proactive alerting mechanisms contribute to maintaining optimal storage conditions and mitigating potential risks of food spoilage or contamination.

Implications for Food Safety and Waste Reduction:

The implementation of the food storage system carries significant implications for enhancing food safety and reducing waste in both household and commercial settings. By providing users with real-time insights into the condition of stored food items, the system empowers them to make informed decisions regarding consumption, storage, and disposal, thereby minimizing the risk of foodborne illnesses and reducing food waste. Additionally, the proactive monitoring and alerting mechanisms enable early detection of potential issues, allowing users to take preventive measures and preserve food quality effectively. Overall, the food storage system represents a valuable tool for promoting sustainable food practices and improving overall food management processes.

In summary, the results and discussions of the food storage system implementation highlight its effectiveness in monitoring, managing, and preserving food items while promoting food safety and waste reduction. The system's accurate sensor readings, efficient alerting mechanism, seamless user interaction, and robust performance underscore its potential to revolutionize food storage practices and contribute to a more sustainable food ecosystem. Continued refinement and optimization of the system based on user feedback and technological advancements will further enhance its capabilities and impact in addressing key challenges related to food security and waste management.

CHAPTER 6

SUMMARY AND CONCLUSION

The project "Detection of Stored Food Spoilage and Alert System Development using IoT" has successfully demonstrated the feasibility of using IoT technology to monitor and detect food spoilage in storage environments. By integrating various sensors with an Arduino Uno microcontroller, the system can accurately monitor environmental conditions such as temperature, humidity, and gas levels, which are critical factors in determining food freshness.

The project has laid a solid foundation for future research in the field of food spoilage detection using IoT technology. With further refinement and optimization, the system has the potential to revolutionize food storage management, leading to significant reductions in food waste and improvements in food safety.

6.1 Summary:

In summary, the proposed system offers an effective solution for monitoring food storage conditions, ensuring food safety, and reducing food waste. By integrating various sensors, actuators, and a microcontroller, the system can accurately detect incoming fruits, monitor methane and humidity levels, track fruit count, and initiate appropriate actions based on the detected conditions. Through Node MCU connectivity, real-time data and alerts are communicated to the user via a mobile application, allowing for timely intervention and decision-making.

The system's ability to differentiate between good and bad food items based on set thresholds for methane and humidity levels ensures that only safe-to-consume fruits are stored, while potentially hazardous items are promptly discarded. This not only helps in preserving food quality but also minimizes the risk of foodborne illnesses. Additionally, the incorporation of an expiry countdown mechanism provides users with valuable information regarding the freshness of stored fruits, enabling them to plan consumption accordingly and avoid wastage.

Moreover, the system's alerting mechanism adds an extra layer of safety by notifying users of potential issues such as high methane levels or impending fruit expiry. This proactive approach empowers users to take corrective actions in a

timely manner, thus preventing food spoilage and promoting efficient utilization of resources.

Overall, the proposed system offers a comprehensive solution for enhancing food storage practices, promoting food safety, and minimizing food waste. By leveraging technology to automate monitoring and decision-making processes, the system contributes to creating a more sustainable and resilient food supply chain.

6.2 Conclusion:

The "Detection of Stored Food Spoilage and Alert System Development using IoT System" project aims to revolutionize food storage by addressing spoilage and waste through a cost-efficient and user-friendly design. Leveraging Arduino Uno, IR Proximity, MQ2, MQ4, DTH11 sensors, servo motors, and Node MCU, the system ensures food quality and safety.

The system initiates with the IR Proximity sensor detecting food presence, activating sensors to assess food condition based on methane levels and humidity. It categorizes food as good or bad, using servo motors to sort them. The inclusion of an MQ2 gas sensor enhances safety by monitoring methane levels in the good storage container.

An outstanding feature is IoT integration via Node MCU, enabling real-time data transmission to the cloud. This allows users to remotely monitor stored food, including good food count and methane levels, via a mobile app. The LCD display provides visual feedback, enhancing user experience and system status interpretation.

Compared to existing models, our system offers a robust, cloud-based approach to food spoilage detection. By combining sensors and IoT, it provides comprehensive insights, alerting users to prevent spoilage and reduce waste. The automated sorting mechanism checks fruit condition, reducing manual effort and making it suitable for domestic and commercial use.

In conclusion, the "Detection of Stored Food Spoilage and Alert System Development using IoT System" represents a significant advancement in food storage technology, offering functionality, usability, and effectiveness in ensuring food safety and minimizing waste. With further refinement, it has the potential to

revolutionize food storage, contributing to a more sustainable and resilient food supply chain.

6.3 Future Scope:

The future scope for the Detection of Fruit Spoilage and Storage System Using IoT is promising, with several areas offering opportunities for further research and development. One key area is the enhancement of sensor technologies to improve accuracy and sensitivity in detecting early signs of fruit spoilage. This includes the development of multi-modal sensors that can detect a wider range of spoilage indicators such as ethylene gas, volatile organic compounds (VOCs), and microbial growth.

Another important area for future research is the integration of advanced data analytics and machine learning algorithms to analyze the sensor data and provide predictive insights. These algorithms can help in predicting fruit spoilage patterns based on environmental conditions and historical data, enabling proactive measures to be taken to prevent spoilage.

Additionally, there is a need for research in the development of energy-efficient IoT devices and communication protocols to reduce power consumption and improve the scalability of the system. This includes exploring the use of energy harvesting technologies and low-power communication protocols to extend the battery life of IoT devices deployed in fruit storage facilities.

Furthermore, the integration of blockchain technology for secure data storage and sharing can enhance the data security and integrity of IoT-based fruit spoilage detection and storage systems. Blockchain can provide a tamper-proof and transparent record of sensor data, ensuring the authenticity and privacy of the information collected.

Overall, the future scope for the Detection of Fruit Spoilage and Storage System Using IoT lies in the continued advancement of sensor technologies, data analytics, and communication protocols to develop more efficient, accurate, and secure systems for monitoring and managing fruit storage conditions.

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