Indian Journal of Electronics and Communication Engineering (INDJECE)
Volume 2, Issue 2 (May- August 2025), PP: 32-37.
https://www.doi.org/10.59256/indjece.20250202005
https://fdrpjournals.org/indjece
ISSN NO: 3048-6408

Food Spoilage Detection Powered By IoT & Ml

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To Cite this Article: *Sinchana B[1], Balaji B S[2], Dileep Kumar K M[3], Kusuma R K[4], Nithesh M[5], "Food Spoilage Detection Powered By IoT & Ml", Indian Journal of Electronics and Communication Engineering, Volume 02, Issue 02, May-August 2025, PP: 32-37.*

Abstract :*Food spoilage is among the major issues against public health and environmental sustainability and leads to a loss in addition to the more significant waste of resources. Therefore, a novel food spoilage detection and monitoring system has been proposed with the integration of IoT technology and ML to enhance food safety and reduce waste. The smart system will be using a network of sensors to monitor continuous environment variables like temperature, humidity, and gas emissions within the storage facilities. Data streams from these sensors can be further analyzed through advanced algorithms with ML like Random Forest Classifier to detect spoilage patterns and predict the shelf life remaining for the perishable items. It integrates a user-friendly interface that enables customers to receive real-time alerts and actionable insights, which can be used by stakeholders to intervene accordingly in time. Therefore, with the integration of IoT and ML, this solution ensures freshness in food products and promotes sustainability through a decrease in food and resource waste. Through several scenarios, the results presented prove that this system can be effectively implemented, thereby making a system like ours more alluring and feasible for larger deployments in the food supply chain.*

Keywords: *Random Forest Classifier; Machine learning; Food spoilage; DHT11;MQ6 Sensor.*

I.INTRODUCTION

The rise of modern technology has led to an increasing demand for intelligent application development, highlighting the need for society to identify spoiled food effectively. Various surveys have been established to determine the quality of food items, with some focusing on tracking moisture and humidity levels in food products using diverse sensors [1]. Food should not remain stationary but should be transferred to different locations, necessitating the use of sensors embedded in the food to monitor its condition continuously during transportation. One advancement involves the real-time tracking of food components to notify users of their status, thus preventing food spoilage, through the utilization of Bluetooth Low Energy (BLE) and the Internet of Things (IOT). By incorporating modern tools like GPS and GSM into the system, users can receive frequent updates regarding their food items and potentially reduce the 30-40% of global food waste caused by food decay each year. To combat this waste, innovative methods must be devised to prevent it, such as employing various sensors to constantly assess food materials for signs of spoilage and notifying users through diverse devices, ultimately reducing food wastage on a global scale through effective food preservation practices. Nutrition is essential for life on Earth, providing us with the energy to function and the health to live fulfilling lives. Ensuring individuals consume a healthy diet is crucial not only for their well-being but also for the economic prosperity of a country. Eating spoiled food can lead to illness and indirectly impact a nation's economy. Therefore, the development of a device utilizing a range of biosensors is necessary to identify fresh food accurately.

The aim of this project is to establish a system capable of recognizing the stages of spoilage and informing individuals about the freshness status. This tool can assist people in understanding the shelf life of items and preserving them for future use. By utilizing GSM technology, the device can send an SMS or place a call to retrieve the necessary details.

The system should be able to determine the freshness of food. The components utilized in the design of the system include the Arduino UNO R3, GSM module, DHT11 sensor, MQ6 gas sensor, LED, buzzer, and power supply unit. The necessary software components are the Arduino IDE compiler and online tools. The main objective of the system is to identify components within solid meals. It consists of two main modules: a GSM unit that alerts the appropriate individual or authority regarding the food's condition by sending a notification to a designated number, and a food spoilage detection system that utilizes an Arduino to identify spoiled food.

II. MATERIAL AND METHODS

Food wastage has been a topic of concern in recent years, and studies are being conducted to identify innovative ways to reduce it. It has been described as a major concern in the long-term sustainability of food production, demand, and food supply chains. Since meals are the essential source of diet for all living beings, the quality and security of meals have always been in high demand. The Internet of Things (IoT) links anything, everywhere, and at any time and by incorporating the IoT into the

Food Supply Chain (FSC) management, it is possible to improve food shelf life by measuring and monitoring the state of the food and exchanging data to and from customers. Currently, the whole use of IoT technologies in FSC is only in its early stages, with a long way to go. To avoid food wastage, food sanitation and safety are of paramount importance. The consistency of meals should be regulated. As a result, wastage can be reduced by installing quality control systems in grocery stores. It will further help in controlling diseases. These types of quality control systems keep an eye on the environmental conditions that may maintain the food quality. Previously, atmospheric effects were monitored by procedures such as refrigeration, vacuum storage, and so on. Food pollution can occur during the manufacturing process, although it is most often caused by inefficient food handling activities due to unsuitable environmental conditions during food transportation and storage.

Food spoilage occurs when a food product becomes unfit for use by the customer. The factors of such a process are a result of a variety of external factors, including the type of food item, how it is packaged and processed. Every year, one-third of the world's melded are lost which is provided for human consumption due to meal wastage. In Figure 4.1, it could be visualized that once the germs start attacking fresh apples, gas emission takes place and after few hours, the apple is spoiled completely.

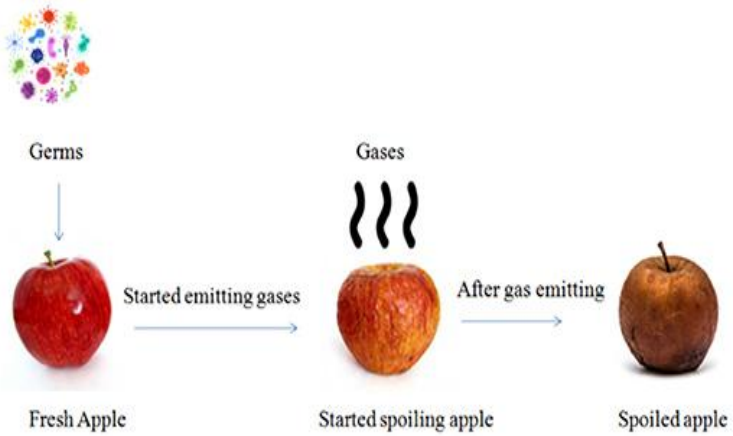


Figure 1. Food spoilage process.

Bacteria, virus, protozoa, and fungi are factors of food spoilage. These factors can create harmful results for consumers, but we can apply prevention techniques to them to save the life and quality of food. Usually, bacteria can not cause food poisoning and most of the microorganisms that cause food borne illness are odorless and tasteless, otherwise owing to mycotoxins and microbial wastes. Therefore, eating spoiled food is never recommended. Two pathogenic bacteria Clostridium perfringens and Bacillus cereus can spoil the food.

Food spoilage can be caused by a variety of human, chemical, and biological causes, including plants, enzymes found in plant food tissues, insects, parasites, and microbes. The most common and serious cause of food spoilage is microbial degradation. Food will invariably be polluted by such forms and amounts of microorganisms when microbes are commonly spread in nature. Figure 4.2 shows the factors that can destroy fruits and veggies. In terms of heat, humidity, moisture, temperature, and oxygen content they have a threshold value. If the threshold value crosses then food spoiling starts. If we maintain a threshold value then we can vary the life of fruits and vegetables.

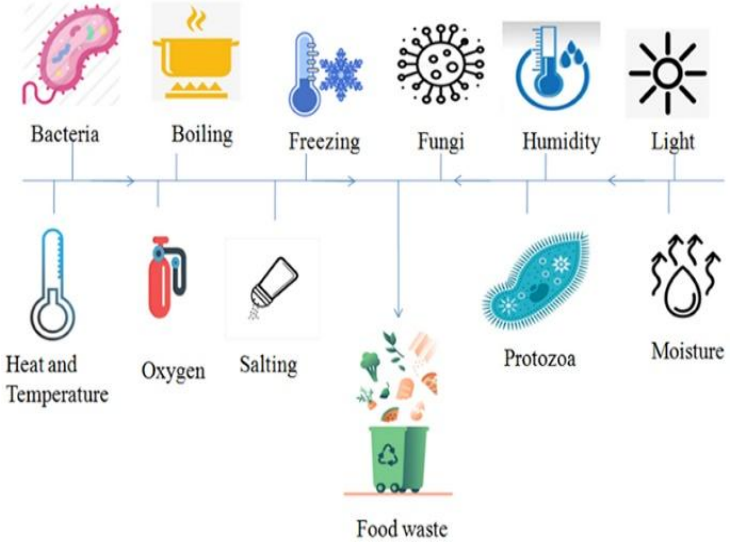


Figure 2. Factors of food spoilage

Techniques for Food Preservation

Food preservation's main goal is to save food from spoiling so it can be eaten. Gardeners also grow too much food at once, much more than can be consumed until it spoils. Food preservation also allows you to enjoy a wide range of foods all year long. The four techniques for food preservation are shown in Figure 3.

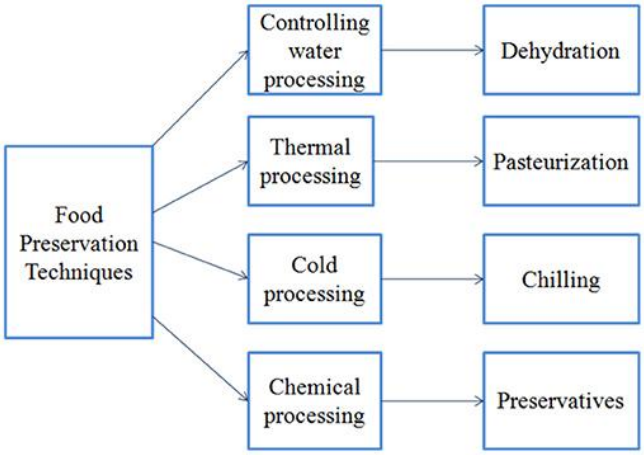


Figure 3. Food preservation techniques.

Architecture

The proposed solution includes new device architecture with few configuration modifications as per the requirement. The new device architecture includes a humidifier to maintain the humidity of the device and a cooling module that maintains the temperature for the food items. The prototype of the device is represented in Figure 4. Various electronic instruments have been used for monitoring. Furthermore, the registered values are used for monitoring purposes. The information gathered by various sensors can be correlated to the target values. The speed control kicks in and interprets the provided procedure to keep it running in the correct direction if the sensor readings do not match the key parameters. This theory can be used to create a method that can protect raw foods. This architecture consists of the following components:

• **Controller:** Arduino is used as a microcontroller.
• **Gas detection sensor:** A gas detector is a device that measures the number of gases in a given environment, and is often used as part of a protection system. Operators in the field where the leak is happening will be alerted by a gas detector.
• **Humidifier:** A humidifier is a system that raises humidity (moisture) in a single room or a whole house. It is essentially an electrical appliance. Point-of-use humidifiers are widely used in the home to humidify a single room, and humidifiers are used in medical ventilators for greater patient convenience.
• **Heat sensor:** The key function of a heat sensor is to detect the heat that is present inside it. When the temperature around the heat sensor rises above its fixed point, it detects the heat and alerts us, allowing us to protect the devices from injury.
• **Humidity sensor:** A humidity sensor is a sensor that senses humidity and converts the information into an electrical current. Humidity sensors are available in a range of shapes and sizes, as well as with different features (40). The Humidity sensor first senses any humidity or moisture in the fruits or vegetables and it sends some value to the microcontroller if any moisture content is detected then an alert message sends to our mobile phone if the moisture content is not detected then again taking values from the microcontroller.
• **Light sensor:** Light sensors are electronic devices that monitor the intensity of natural or artificial light. Light energy is converted into an electrical signal by these devices. Light sensors are used in a variety of manufacturing application areas.

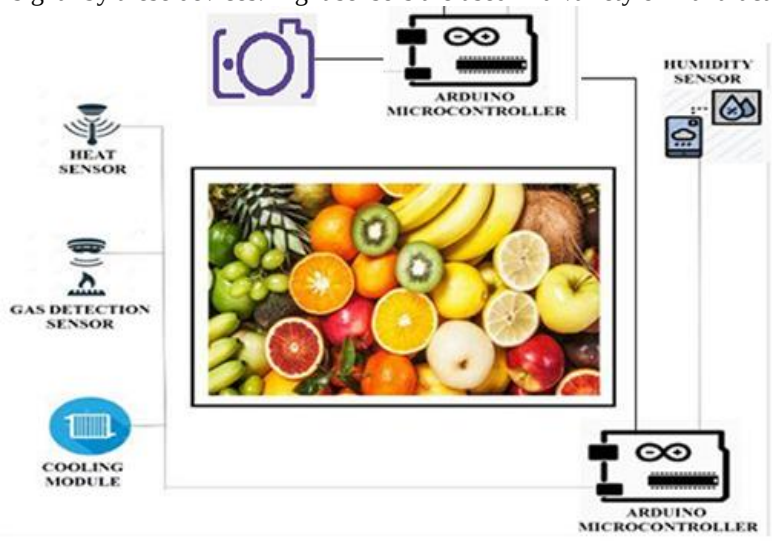
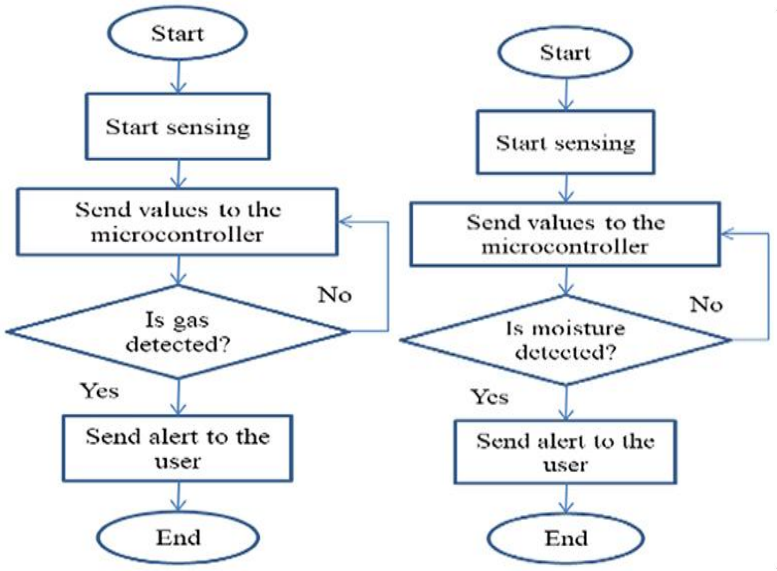


Figure 4. The architecture of Monitoring and analysis of food spoilage using Machine Learning.



1: Turn on the device
2: Capture the image of fruit or vegetable
3: Turn on the Cooling module
4: Turn on Humidifier
5: Store the optimal values of parameter according to captured object
6: Read the values of sensor for monitoring process of fruits or vegetables
7: **if** Gas content is detected **then**
8: go to step 20
9: **else**
10: go to step 21
11: **end if**
12: **if** Moisture content is detected AND moisture > maximum optimal humidity of object AND Humidifier is off **then**
13: Turn on the humidifier
14: **else if** heat content is detected AND temperature > maximum optimal storage temperature of object AND cooling module is off **then**
15: Turn on the cooling module
16: **else if** life of object > average shelf life of object **then**
17: go to step 20
18: **else**
19: go to step 21
20: **end if**
21: Send alert to the user
22: Capture an image of fruit or vegetable
23: go to step 7

Figure 5. Food spoilage detection using (1) Humidity sensor, (2) Gas sensor and (3) Algorithm.

We have different types of sensors that play a major role in the detection and monitoring of food spoilage. It includes the camera sensor, humidity sensor, gas sensor, and heat sensor. The camera sensor captures the image of fruit or vegetable. The humidity sensor senses the humidity of the environment. If it is below the threshold value then the humidifier increases the humidity up to the threshold value. The temperature sensor monitors the temperature for the predefined threshold value which is controlled by Arduino. Arduino is directly connected to the Raspberry pi, which acts as a mini computer having own processing unit and memory. Whenever temperature reaches above the value of the threshold, the cooling module gets turned on. The gas sensor detects early spoilage via detecting a little amount of gas emission of the food items. It sends the value to the Arduino, after receiving the values, Arduino pushes the values to the cloud. The web application notifies the user via a buzzer or voice-activated commands or through the display messages.

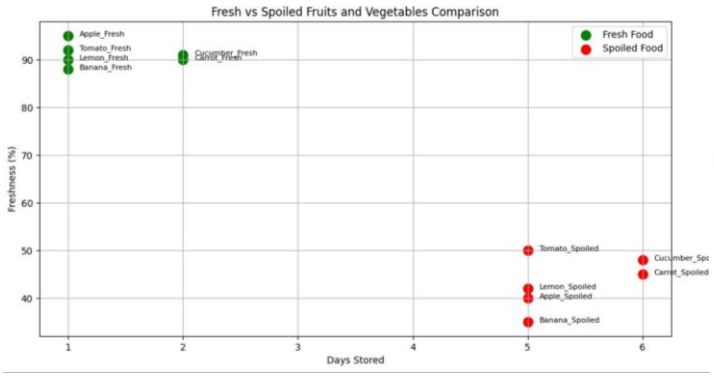
The food life cycle has different stages which include the following stages: Fresh Food; Food spoilage just started; Spoilage Food. For prediction, we have trained 50 types of fruits and vegetables over different three classes. We proposed a Random forest classifier for object detection and prediction model. This is trained over three different classes.

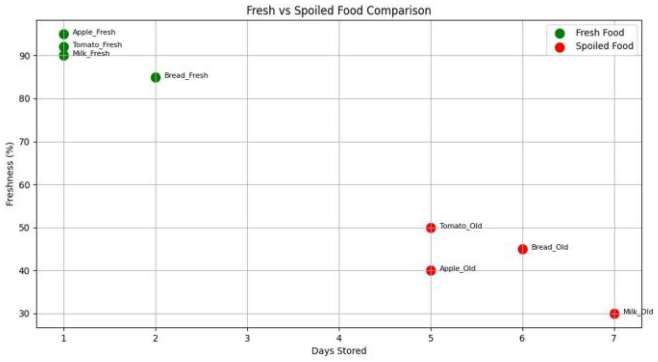
III. RESULT

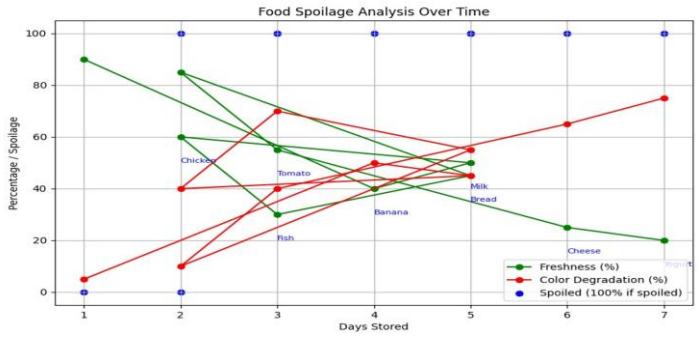
Figure 6. Food Spoilage detected in the IOT Module

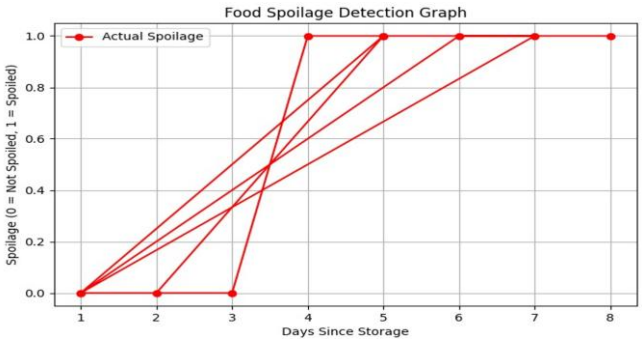
The average shelf life of any fruit or vegetable is a time period in which fruits or vegetables are healthy for eating. After this period of time, it is harmful for health to consume this fruit or vegetable as spoilage may have taken place previously before the average shelf life. Every fruits or vegetables have a different minimum optimal storage temperature below which they started spoiling. So, careful minimum optimal storage temperature must be maintained.

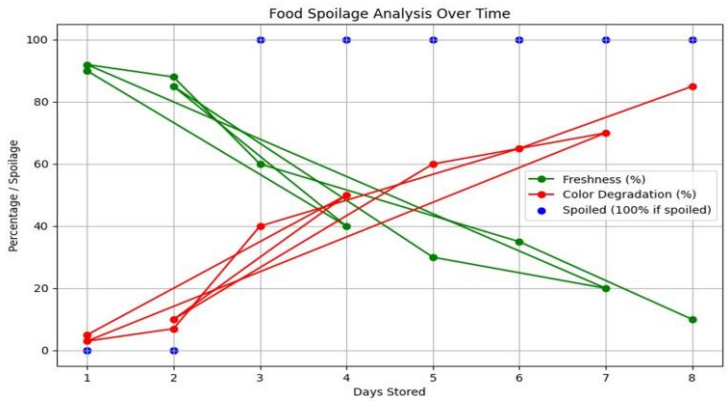
The performance graph for our model is plotted for both the training and validation data. We show the training data loss vs. validation data loss graph, as well as the training data accuracy and validation data accuracy of the Rainforest classifier model for fruits and vegetables, for object detection. validation data loss, as well as training data accuracy and validation data accuracy, are shown on the graph shown in Figures 7.











In the graph, Food Spoilage analysis over Time – Green dots represents freshness (%), Red dots represents Color Degradation (%), Blue dots represents Spoiled (100% if Spoiled) Chicken, Tomato, Fish, Banana, Milk, Bread with in a span of 5 to 7 days.

IV.DISCUSSION

The food spoilage detection system is developed that can identify the different phases of spoiling and notify people of the freshness status. This application can help individuals preserve products for later use and understand their shelf life. To obtain the required information, the device can send using Blynk app in Andriod phone through WiFi module connected to ESP 32 microcontroller.

The freshness of the food should be detectable by the system. Among the parts used in the system's design are the Arduino UNO R3, GSM module, MQ6 gas sensor, DHT11 sensor, LED, buzzer, and power supply unit. The Arduino IDE compiler and online tools are required software components. Finding the components of solid meals is the system's primary goal.We show the training data loss vs. validation data loss graph, as well as the training data accuracy and validation data accuracy of the Rainforest classifier model for fruits and vegetables, for object detection. validation data loss, as well as training data accuracy and validation data accuracy, are shown on the graph.

So, our model has a 95% accuracy rate, which is excellent enough to recognize the kind of vegetable and fruit from a picture. It provides extremely precise results for the photos that are fed into the model.

V.CONCLUSION

The sensors equipped will sense the food material and send the data to the Arduino board connected to display the sensed data through the LCD screen connected to Arduino, and also alert the person through led about the quality of food, whether it is spoiled or not. If the food is spoiled a red led will glow and if the food is not spoiled a green led will glow.

After detecting whether the food material is spoiled or not, it will send an email alert about the condition of the food. The high amount of food spoilage will alert as “food is spoiled”, while a low amount will alert as “food is not spoiled”. The consumer will be let to know about the food quality through the system.

The proposed smart device can be improved by applying image processing and machine learning algorithms to detect early spoilage. The device can be incorporated into food transportation containers which would allow tracking and detecting the spoilage if any during transportation. The device could also be tested for different variety of foods as well.

It will detect the early gases emitted by the food material, like methane, ammonia, etc., before the indication of food spoilage. The system guides the user to consume quality food and also helps to maintain good health.

This study presents a novel technique for Monitoring and analysis of food spoilage using a sensor bases system. The device proposed in this study is able to preserve food for more days. Additionally, food items can be prevented from getting spoiled by increasing their lifespan. It monitors the quality of food items and keeps notifying the user with voice-activated commands or via display, and it also generates alerts to the user with the predicted remaining time of the food spoilage. The proposed device shows an accuracy of 95%.

The proposed smart device can be improved by applying image processing and machine learning algorithms to detect early spoilage. The device can be incorporated into food transportation containers which would allow tracking and detecting the spoilage if any during transportation. The device could also be tested for different variety of foods as well.

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