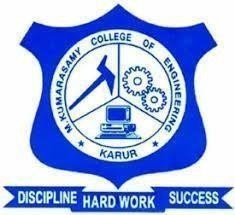
 

**A Minor Project Report on**

# SMART REFRIGERATOR MONITORING SYSTEM

**Submitted by**

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**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

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MAY 2025

M.KUMARASAMY COLLEGE OF ENGINEERING

(Autonomous Institution, Affiliated to Anna University, Chennai)

# BONAFIDE CERTIFICATE

Certified that this report titled **“SMART REFRIGERATOR MONITORING SYSTEM”** is the Bonafide work of **ATHIKESANAN S (927622BEE009), CHARMITHA P S (927622BEE015), KARNA S (927622BEE051)** who carried out the work during the academic year (2024-2025) under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other project report.

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Submitted for Minor Project IV (18EEP302L) viva-voce Examination held at M.Kumarasamy College of Engineering,Karur-639113 on ………………..

### DECLARATION

We affirm that the Minor Project report titled “**SMART REFRIGERATOR MONITORING SYSTEM”** being submitted in partial fulfillment for the award of **Bachelor of Engineering in Electrical and Electronics Engineering** is the original work carried out by us.

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|  |  |
| --- | --- |
| **Abstract (Key Words)** | **Mapping of POs and PSOs** |
| Arduino, Gas Sensor, Temperature Sensor, Display screen, Power supply | PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9. PO10, PO11, PO12, PSO1, PSO2, PSO3. |

### [ACKNOWLEDGEMENT](https://www.google.com/search?rlz=1C1CHBD_enIN820IN820&q=ACKNOWLEDGEMENT&spell=1&sa=X&ved=0ahUKEwj99az1_ZXhAhVN63MBHRVODE4QkeECCCkoAA&cshid=1553265789884876)

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# ABSTRACT

The Smart Refrigerator Monitoring System is an innovative approach developed to tackle the widespread issue of food spoilage and waste, primarily caused by inadequate storage conditions and the absence of real-time monitoring. Conventional refrigerators operate by maintaining a constant internal temperature but fail to provide any intelligent feedback on the actual condition or freshness of the stored fruits and vegetables. To overcome these limitations, this project integrates a combination of hardware sensors and machine learning technologies to enable continuous assessment of food quality. At the core of the system is a camera module that captures images of the stored produce. These images are analyzed using machine learning models to detect variations in color and texture, which are reliable indicators of ripening or spoilage. In parallel, a gas sensor such as the MQ-135 or MQ-3 is used to detect ethylene and other volatile organic compounds that are typically released as fruits and vegetables begin to decay. Monitoring these gases enables the system to identify early signs of spoilage that may not yet be visually apparent. A temperature sensor is also employed to ensure that the refrigerator maintains the optimal cooling environment necessary for food preservation. All sensors are interfaced with an Arduino microcontroller, which collects, processes, and analyzes the sensor data. When the system detects elevated gas levels, rising temperature or visual indicators of spoilage, it triggers an alert, which can be displayed on a screen or sent via a connected IoT device to the user. This enables timely intervention to remove or consume the affected items before they become unsafe. The integration of these technologies results in a cost-effective, scalable solution that not only reduces food wastage but also improves food safety at the household level. Furthermore, the system can be adapted for use in smart kitchen environments, restaurants, or commercial cold storage units. By combining computer vision, environmental sensing, and microcontroller-based automation, this project contributes to promoting healthier lifestyles, reducing environmental impact and supporting more sustainable food storage practices in both domestic and industrial settings.



**INTRODUCTION**

In recent years, the issue of food spoilage and wastage has emerged as a significant global concern. A substantial portion of fruits and vegetables stored in both domestic and commercial environments is discarded due to the lack of proper monitoring systems and timely intervention. Traditional refrigerators are designed primarily to maintain a consistent low temperature, which slows down the natural degradation process of food items. However, they do not possess any intelligent mechanism to evaluate the real-time condition or freshness of the stored food. Consequently, users often end up consuming spoiled items unknowingly, leading to potential health risks or discard food that could have been salvaged if spoilage had been detected earlier. This situation calls for an intelligent solution capable of real-time monitoring and prediction of food quality to prevent wastage and ensure consumer safety. To address this critical issue, the Smart Refrigerator Monitoring System was developed as a modern solution that incorporates automation, sensing technology, and machine learning to enhance the functionality of conventional refrigeration. The primary objective of this system is to monitor the freshness of fruits and vegetables stored inside a refrigerator in real-time. The system is equipped with a camera module that periodically captures images of the stored items. These images are analyzed using a machine learning model trained to recognize changes in visual features such as colour and texture key indicators of ripeness, freshness, or spoilage. By evaluating these characteristics, the model can classify whether an item is still fresh, ripening, or has already begun to decay. In addition to visual analysis, the system uses a gas sensor like the MQ-135 or MQ-3 to detect the presence and concentration of gases such as ethylene, which are naturally emitted by fruits during the ripening and decomposition process. Elevated levels of these gases are reliable indicators of over-ripeness or spoilage. A temperature sensor, such as the DHT11, is also included to continuously monitor the internal environment of the refrigerator, ensuring optimal conditions for preserving the freshness of stored food. All data collected from the camera, gas sensor, and temperature sensor is processed by an Arduino microcontroller, which serves as the core processing unit of the system. The Arduino not only collects the data but also interprets it based on predefined thresholds and the machine learning model's predictions. If the system detects any anomalies such as a significant colour change, increased gas concentration or temperature deviation it generates an alert for the user. This alert can be displayed on a screen or transmitted via a connected IoT system, enabling timely user intervention.



## CHAPTER 1 LITERATURE REVIEW

**Paper 1: Smart Refrigerator using Deep Learning for Freshness Detection**  
 This paper presents the development of a smart refrigerator system that integrates Internet of Things (IoT) and deep learning technologies for effective food freshness monitoring. The proposed system employs various environmental sensors to detect gases such as ethylene and ammonia, which are released during the decomposition of organic food items. Simultaneously, a camera module captures images of the stored fruits and vegetables at regular intervals. These images are analyzed using a convolutional neural network (CNN), a type of deep learning model that classifies the items based on visual characteristics such as colour, texture and surface condition. The CNN is trained to differentiate between fresh and spoiled items with a high degree of accuracy. Additionally, sensor and image data are transmitted to a cloud-based platform, enabling remote access, real-time alerts and long-term data analytics. The fusion of sensor-based gas detection and visual analysis provides a more comprehensive and intelligent method of spoilage detection. This paper supports the foundational concept of the smart refrigerator monitoring project, particularly highlighting the role of machine learning and IoT in enabling real-time, automated food quality assessment and remote monitoring.

**Paper 2: Fruit Freshness Classification Using Image Processing and Machine Learning** This research focuses on identifying the freshness level of fruits using computer vision and machine learning techniques. The authors used standard image processing tools like OpenCV to extract features such as colour, edge sharpness and surface texture. A Support Vector Machine (SVM) model was trained to classify the fruits into three categories: fresh, ripening and spoiled. The model demonstrated over 85% accuracy when tested on a dataset consisting of banana, tomato, orange and apple images. This paper highlights the practicality of visual-based monitoring systems in determining the state of perishable items. The methodology presented aligns with the project, where a camera module will capture fruit images and an external processor will perform freshness classification using a trained machine learning model. This enhances spoilage prediction beyond what gas and temperature sensors alone can provide.

**Paper 3: Ethylene Gas Detection in Fruits Using MQ-3 Sensor**

This paper explores the use of the MQ-3 gas sensor to detect ethylene gas emitted during the ripening and rotting of fruits. Ethylene is a natural plant hormone that accelerates the ripening process and is released in greater quantities as fruits deteriorate. The study measured gas concentrations from different fruits at various stages of decay and confirmed that ethylene levels correlate with spoilage. By using an Arduino microcontroller to collect and process sensor data, the researchers demonstrated a reliable method for monitoring fruit freshness. This work provides strong evidence that low-cost gas sensors can effectively contribute to freshness detection systems. For your smart refrigerator project, this supports the inclusion of gas sensors like MQ-3 or MQ-135 as a non-invasive and continuous method for spoilage detection, especially when combined with visual and temperature data.

**Paper 4: IoT-Based Smart Refrigerator with Spoilage Detection Using Temperature and Gas Sensors**

This paper presents a prototype of a smart refrigerator that uses Arduino, a DHT11 temperature sensor and an MQ-135 gas sensor to detect spoilage conditions. The system monitors environmental parameters inside the refrigerator and triggers alerts when sensor readings exceed safe thresholds. Data is displayed on an LCD and also sent to a cloud platform using an IoT module for remote access. The research emphasizes the importance of combining multiple sensors for improved reliability in freshness detection. The use of simple, cost-effective hardware makes this design feasible for real-world implementation. The relevance of this paper lies in its hardware architecture and its approach to combining gas and temperature sensing - both of which are crucial elements. It confirms that such systems can be implemented using microcontrollers like Arduino to automate food monitoring in domestic environments.

## CHAPTER 2

## PROPOSED METHOLOGY

* 1. **BLOCK DIAGRAM**

CAMERA MODULE

Arduino UNO

PC MODULE

BUZZER/

ALARM

GAS SENSOR

TEMPERATURE

SENSOR

LCD DISPLAY

**Diagram**

**Fig:2.1 Block Diagram**

**2.2 DISCRIPTION**



The Smart Refrigerator Monitoring System is an innovative project designed to monitor the freshness of fruits and vegetables stored in a refrigerator using a combination of sensors and intelligent image processing. This system integrates camera-based image analysis, gas detection and temperature monitoring to identify early signs of spoilage and ensure that food is stored under optimal conditions. Its primary objective is to reduce food wastage, enhance food safety and improve household food management through real-time data analysis and timely alerts. The core of the system lies in its ability to monitor the freshness of produce using a camera module that captures images at regular intervals. These images are processed using machine learning algorithms trained to detect changes in colour and texture, such as browning, fading, wrinkling - key indicators of ripening or spoilage. This visual analysis enables the system to assess the freshness level with high accuracy and efficiency.

In addition to the visual inspection, the system uses a gas sensor, such as the MQ-135 or MQ-3, to detect the presence of gases like ethylene and ammonia. These gases are commonly released by fruits and vegetables during ripening and decomposition. A rise in gas concentration provides an early indication that the stored items are nearing spoilage. A temperature sensor DHT11 or LM35 is also employed to monitor the internal climate of the refrigerator. Maintaining the temperature within the ideal range is crucial for prolonging the shelf life of food. Any deviations from the optimal temperature can accelerate spoilage.

The Arduino microcontroller functions as the central processing unit, collecting data from all the sensors and initiating image capture. Based on the sensor readings and visual analysis, the system compares values to predefined thresholds. If high gas levels, abnormal temperature or spoilage signs are detected, the system generates alerts. These alerts can be displayed on an LCD screen or sent through external modules such as Wi-Fi or GSM for remote notification. This intelligent monitoring not only helps in preventing the consumption of spoiled food but also contributes to environmental sustainability by minimizing unnecessary food waste. The system offers an affordable and scalable solution suitable for homes, restaurants and cold storage facilities.

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**2.3 PROJECT – TOTAL COST**

|  |  |  |  |
| --- | --- | --- | --- |
| **S.NO** | **COMPONENT DESCRIPTION** | **QUANTITY** | **COST** |
| 01 | ARDUINO | 1 | 500 |
| 02 | WEB CAMERA – USB MODULE | 1 | 1200 |
| 03 | GAS SENSOR | 1 | 300 |
| 04 | TEMPERATURE  SENSOR | 1 | 120 |
| 05 | BUZZER | 1 | 100 |
| 06 | LCD DISPLAY | 1 | 300 |
| 07 | OTHERS |  | 800 |
|  |  | TOTAL | 3320 |

### Table Project – Total Cost

### CHAPTER 3

### RESULT AND DISCUSSION

### The Smart Refrigerator Monitoring System was successfully implemented to monitor and assess the freshness of fruits and vegetables stored in a refrigerator. The system integrated multiple sensors, including a camera module, gas sensor (MQ-135) and temperature sensor with an Arduino Uno microcontroller to track freshness and spoilage in real-time. The results from the system demonstrated its effectiveness in detecting food spoilage and maintaining optimal storage conditions.

### The camera module played a critical role in monitoring changes in the texture and colour of food items. Images were captured periodically and machine learning algorithms processed them to detect signs of ripening or spoilage. For example, the system accurately identified signs of over-ripeness in fruits like bananas and tomatoes by observing colour fading and the formation of wrinkles. This visual analysis provided real-time, actionable insights into the food’s freshness.

### The gas sensor (MQ-135) detected the presence of ethylene, a gas released by fruits and vegetables during the ripening and spoilage processes. As food deteriorates, the concentration of ethylene increases, which the gas sensor successfully identified. The system generated an alert when gas levels exceeded a predefined threshold, indicating potential spoilage. The gas sensor proved effective in detecting changes in food freshness, contributing to timely intervention.

### The temperature sensor (DHT11) consistently monitored the refrigerator's internal environment, ensuring the temperature remained within the optimal range of 4–8°C for food preservation. If the temperature deviated from this range, the system immediately triggered an alert to prevent premature spoilage. This function was particularly useful in ensuring that environmental factors did not accelerate food degradation.

### 

### Fig.3.1 Temperature under normal condition

### Under normal conditions, the DHT11 sensor continuously monitors the refrigerator’s internal temperature, ensuring it remains within the optimal range of 4–8 °C to preserve food freshness. The sensor transmits real-time data to the Arduino microcontroller, allowing the system to maintain environmental stability without triggering alerts. This passive monitoring is essential for preventing unnoticed temperature shifts that could accelerate spoilage. By keeping the temperature within the ideal range, the system ensures that fruits and vegetables stay fresh longer. The data can also be logged for analysis, supporting efficient refrigerator management and contributing to reduced food waste

### 

### Fig.3.2 Temperature under higher condition.

### When the internal temperature of the refrigerator rises above the optimal 4–8 °C range, the DHT11 sensor immediately detects the deviation and alerts the system. This triggers a warning signal, notifying the user of a potential issue such as door misalignment, power failure or cooling malfunction. The timely alert helps prevent premature spoilage of fruits and vegetables by prompting corrective action. Continuous monitoring ensures that temperature fluctuations are addressed before they impact food quality. This feature is vital in maintaining freshness and extending shelf life, especially when combined with the system’s gas and image-based freshness detection capabilities.

### The Arduino Uno acted as the central processing unit, handling data input from all sensors and processing it to trigger real-time alerts via an LCD display. It also enabled the integration of external modules like Wi-Fi for remote monitoring, expanding the system’s capabilities. When any parameter exceeded the threshold values (gas levels, temperature or visual signs of spoilage), the system sent alerts, preventing the consumption of spoiled food.

# CHAPTER 4

# HARDWARE IMPLEMENTATION

**4.1 HARDWARE COMPONENTS DESCRIPTION**

**4.1.1 ARDUINO BOARD:**

The Arduino Uno is the central microcontroller board used in the Smart Refrigerator Monitoring System. It is based on the ATmega328P microchip and offers a versatile, easy-to-use platform for managing various sensors and components. The Arduino Uno is ideal for this project because of its ability to handle multiple inputs and outputs, making it perfect for integrating sensors like the MQ-135 gas sensor, DHT11 temperature sensor and the camera module. In this system, the Arduino Uno processes data from the sensors to monitor food freshness, detecting gases like ethylene and ammonia released during spoilage. It also tracks the refrigerator’s internal temperature, ensuring optimal storage conditions. The Arduino Uno triggers alerts when any irregularities, such as increased gas levels or abnormal temperature, are detected. It communicates with external modules to send notifications and displays the results on an LCD screen.



**Fig 4.1.1 ARDUINO BOARD UNO**

**4.1.2 TEMPERATURE SENSOR:**

The temperature sensor is essential for monitoring the internal environment of the refrigerator. It provides digital temperature readings with moderate accuracy (±2°C) and offers higher precision with an analog voltage output proportional to temperature. These sensors help detect temperature fluctuations that can accelerate food spoilage. Interfaced with the Arduino, the sensor continuously monitors temperature levels and helps trigger alerts when readings go beyond the safe storage range, ensuring better preservation of fruits and vegetables.



**Fig 4.1.2 Temperature Sensor**

**4.1.3 GAS SENSOR:**

The gas sensor is used to detect spoilage gases such as ethylene, ammonia, and alcohol vapours emitted by decaying fruits and vegetables. This project uses either the MQ-135 or MQ-3 sensor. The MQ-135 is suitable for detecting a wide range of gases, while the MQ-3 is particularly sensitive to alcohol and ethylene vapours. The analog sensors produce variable voltage outputs based on gas concentration. Connected to the Arduino, the sensor helps identify early signs of spoilage by monitoring changes in gas levels, enabling timely alerts to prevent food wastage and ensure freshness.



**Fig 4.1.3. Gas Sensor**

### 4.1.4 CAMERA MODULE- USB MODULE:

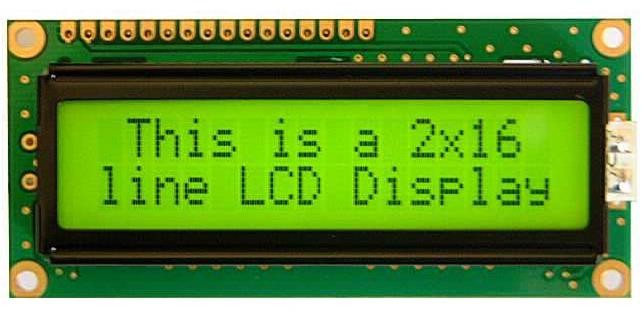
### The camera module is used to capture images of fruits and vegetables stored in the refrigerator to assess their colour and texture. These visual features are important indicators of freshness and spoilage. A USB camera can be used, depending on the processing platform. The captured images are analyzed using a machine learning algorithm to detect changes like browning and wrinkling. While the camera is not directly connected to the Arduino, it works alongside it using external processor for real-time image processing and classification.



**Fig 4.1.4.** **Camera Module – USB Camera**

### 4.1.5 LCD DISPLAY:

An LCD consists of two glass panels, with the liquid crystal material sand witched in between them. The inner surface of the glass plates are coated with transparent electrodes which define the character, symbols or patterns to be displayed polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle.



**Fig 4.1.5. LCD Display**

**4.2 HARDWARE KIT**



### 

**Fig 3.2 HARDWARE KIT**



### 4.3 WORKING PRINCIPLE

The Smart Refrigerator Monitoring System works on the principle of real-time sensing and intelligent analysis of environmental and visual parameters to determine the freshness of fruits and vegetables stored inside a refrigerator. The system integrates a temperature sensor, gas sensor, camera module and an Arduino microcontroller to monitor, process and report the condition of stored food items. The working of the system can be broken down into several key stages:

**1. Data Collection from Sensors**

The system begins with the continuous monitoring of the internal environment using sensors:

* **Temperature Sensor:** This sensor records the internal temperature of the refrigerator. It ensures that the cooling conditions are optimal for preserving fruits and vegetables. Any rise in temperature beyond a set threshold may indicate a malfunction or door left open, both of which can contribute to spoilage.
* **Gas Sensor:** This sensor detects the presence of gases such as ethylene, ammonia, and alcohol vapours. Ethylene gas is naturally released by ripening fruits, and higher concentrations of such gases indicate over ripeness or spoilage. The sensor outputs analog voltage that varies with gas concentration, which is read by the Arduino.
* **Camera Module**: At scheduled intervals, the camera captures images of the fruits and vegetables. These images are analyzed using a machine learning model running on an external processor like a Raspberry Pi or computer. The model detects visual signs of spoilage such as discoloration or texture changes (e.g., wrinkling or softening).

**2. Data Processing and Decision Making**

The **Arduino** collects data from the temperature and gas sensors and compares it to predefined threshold values. If any of the readings exceed safe limits, the Arduino identifies a potential spoilage condition. Simultaneously, the captured image is processed by a trained machine learning model. This model uses image classification techniques (such as CNN – Convolutional Neural Networks) to detect whether the fruit or vegetable is fresh, ripening or spoiled. The result is interpreted alongside sensor readings to determine the overall freshness status.

**3. Alert Generation**

The system detects the abnormal gas levels (indicating the presence of spoilage gases), temperature deviations from the safe range or Visual signs of decay (from image analysis). It triggers an alert. This can be displayed on an LCD screen, sent to a mobile application or logged for the user to review. This real-time notification allows users to take timely action-consume the food before it spoils or discard it to avoid health risks.

**4. System Advantages**

By combining visual and environmental data, the system provides more accurate freshness detection than traditional methods. It helps prevent foodborne illnesses, reduces food wastage, enhances the lifespan of stored items and encourages healthier storage practices.

**5. Automation and Scalability**

The system can be scaled or integrated with smart home platforms. More advanced versions may include automatic fan control, cloud data logging and AI-driven recommendations for food management.

**CHAPTER 5**

**CONCLUSION**

The Smart Refrigerator Monitoring System developed in this project demonstrates a practical and innovative solution for reducing food spoilage and improving the efficiency of food storage. By integrating multiple sensors including a temperature sensor, a gas sensor and a camera module. The system is capable of continuously monitoring the internal conditions of a refrigerator and assessing the freshness of stored fruits and vegetables. The use of Arduino as the central microcontroller ensures that data from all sensors is processed efficiently, while also allowing for scalability and integration with other IoT platforms. The gas sensor provides real-time detection of ethylene and other volatile organic compounds released during fruit and vegetable spoilage. This early warning system enables timely removal or consumption of degrading produce. The temperature sensor monitors the internal environment of the refrigerator, ensuring that it remains within safe storage limits. Temperature fluctuations are promptly detected, helping maintain the overall quality of stored food. The camera module adds a layer of intelligence by capturing images of the fruits and vegetables, which are then processed using machine learning algorithms (externally) to evaluate changes in colour and texture indicators of freshness.

This multi-sensor approach offers improved accuracy and reliability in freshness detection compared to systems that rely on a single parameter. Furthermore, the implementation of machine learning allows for continuous improvement in spoilage prediction through model training and refinement. The system can be expanded in the future to include cloud connectivity, user notifications via mobile apps and integration with smart home systems for better user interaction.

In conclusion, this project provides a low-cost, effective, and scalable method for real-time food monitoring inside refrigerators. It has strong potential for reducing food waste, improving food safety and offering convenience to users. The successful integration of hardware and software in this system lays the foundation for future innovations in smart kitchen technologies and sustainable food management practices.

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