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Design and Development of an Arduino-Based Food Spoilage Detection System Using MQ-135 Gas Sensor

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Abstract- Food spoilage is a big concern affecting health, safety, and economy worldwide. This paper presents the design and implementation of a food spoilage detection system using an Arduino Uno microcontroller and MQ-135 gas sensor. The system detects gases such as ammonia, carbon dioxide, and volatile organic compounds (VOCs) released during food decomposition. Gas sensors provide a non-destructive and efficient way to monitor food quality by detecting chemical changes in the surrounding environment [1]. The MQ-135 sensor is mainly used due to its sensitivity to harmful gases associated with spoilage [2]. When the gas concentration exceeds a predefined threshold, the system alerts the user through an LED indicator in Arduino Board. The proposed system is cost-effective, portable, and easy to implement. It can be used in households, food storage facilities, and small-scale industries to ensure food safety and reduce wastage.

Keywords- Food Safety, Arduino Uno, MQ-135, Gas Sensor, Spoilage Detection, VOCs, Embedded Systems

I. LITERATURE REVIEW

1.1 Need for Food Spoilage Detection System

Food spoilage leads to significant economic losses and health risks. Traditional detection methods rely on human senses such as smell and appearance, which are unreliable and subjective to people [3].

Modern research shows that spoiled food releases gases like ammonia, methane, and hydrogen sulfide, which can be detected using gas sensors [4]. These gases act as indicators of microbial activity and decomposition.

Gas sensors are considered highly effective for food quality monitoring because they can detect volatile organic compounds (VOCs) emitted during spoilage [1]. This makes them suitable for real-time monitoring systems.

1.2 Existing Solutions

Manual inspection techniques have always been employed in order to determine if food is spoiled. This technique, although cheap and easy to implement, is not very accurate and fails in most cases in detecting food spoilage in its early stages [3].

The other method that has always been used is refrigeration. Refrigeration acts as a preserver since it reduces the speed of the growth of microbes. This means that refrigeration will delay food spoilage but will never give an exact report as to whether food is still fresh [7].

Due to the development of technology, some IoT-based detection devices are being used today to monitor environmental variables including temperature, humidity, and gas concentrations [10]. The e-nose technology employs multiple sensors to detect any food spoilage accurately [5]. However, it is worth noting that the advanced IoT systems are not very cheap and therefore do not suit everyone. To overcome these issues, simpler systems using Arduino and MQ-series gas sensors have been introduced. These systems are cost-effective and capable of detecting gases like ammonia and carbon dioxide, which are released during food spoilage [6].

1.3 Limitations of Existing Systems

Even with different methods available, there are still some important limitations:

1. **High Cost of Advanced Systems:**
Systems like electronic nose and AI-based monitoring require multiple sensors and complex processing, making them expensive and less accessible [5].
2. **Lack of Real-Time Detection in Traditional Methods:**
Manual inspection and basic preservation methods do not provide continuous monitoring, which can lead to delayed detection of spoiled food [3].

3. Dependency on Human Judgment:
Traditional methods rely on human senses, which are subjective and may lead to inaccurate results.

4. Limited Accessibility for Small Users:
Many smart systems are designed for industrial use and are not affordable or practical for household applications.

II. INTRODUCTION

Food spoilage occurs due to microbial activity, leading to the release of gases such as ammonia and carbon dioxide. These gases change the chemical composition of air surrounding the food, which can be detected using sensors [7].

Recent studies show that MQ-135 sensors are effective in detecting ammonia and VOCs released during food decomposition [2]. These sensors provide analog output that can be processed using microcontrollers like Arduino.

2.1 Objective

The primary aim of this project is to develop a low-cost and efficient system that uses the MQ-135 gas sensor and Arduino Uno board to detect spoilage in food. Another key aim of this project is to develop an alerting system that uses LEDs as indicators. These will inform the user when the gas concentration exceeds the threshold.

The other aim of this project is to develop an effective yet portable system which does not require elaborate infrastructure. The system should be developed with the aim of making it easily usable in households and small scale food storage systems.

2.2 Motivation

The reason for undertaking this research project is due to the growing concern for food safety and reduction of wastage. There are cases where food spoilage is not identified on time resulting in health risks and wastage of food.

The conventional ways require human interaction, which is not 100% reliable. Therefore, there is a need for an automated monitoring system that can continuously analyze the quality of food. The automation of the process is enabled through gas sensors and microcontrollers [5].

III. METHODOLOGY

3.1 About Model

Arduino Uno
The Arduino Uno is a major component of the system, serving as the controller. It consists of the ATmega328P microcontroller, which reads the data from the gas sensor and processes it accordingly. Based on the reading from the gas sensor, it triggers an output device (LED).

Gas Sensor
An MQ-135 gas sensor is employed for detecting the presence of dangerous gases in the air, such as ammonia, carbon dioxide, and other VOCs emitted by spoiled foods [2]. The gas sensor outputs an analog signal whose strength depends on the concentration of the detected gas in the environment.

LED Indicator
The LED indicator is an output device that blinks when the concentration of gas exceeds a certain limit, suggesting that the food may be spoiled. Conversely, the LED will remain off in case the concentration of gas is normal.

Breadboard
The breadboard is an important part of the project since it facilitates assembly of the circuit components without any soldering required.

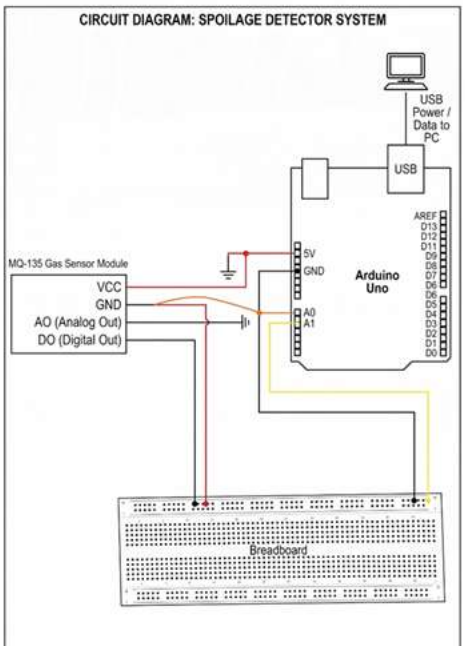
Jumper Wires
They are utilized to join various components such as the LED indicator and gas sensor with the Arduino board.

3.2 Circuit and Arduino Code

The circuit is designed by connecting the MQ-135 gas sensor and LED to the Arduino Uno. The gas sensor is connected to the analog input pin so that it can send continuous readings to the microcontroller. The LED is connected to a digital pin, which is controlled based on the sensor output.

Connections:

MQ-135 → Analog Pin A0
LED → Digital Pin 13



The Arduino program continuously reads the analog values from the gas sensor and compares them with a predefined threshold value. If the sensor reading exceeds the threshold, it indicates a higher concentration of gases, suggesting possible food spoilage. In response, the LED starts blinking as a warning signal. Otherwise, the system indicates that the food is fresh.

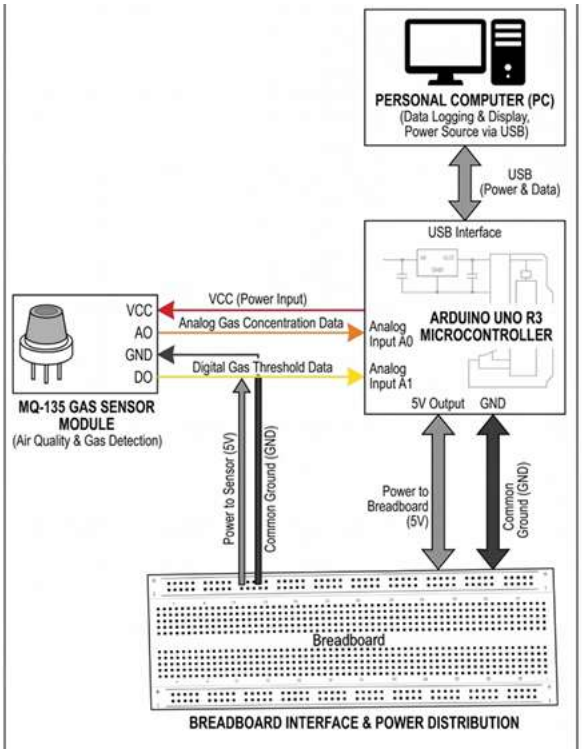
Arduino Code

```
int gasSensor = A0;
int threshold = 120;
int ledPin = 13;
void setup() {
  Serial.begin(9600);
  pinMode(ledPin, OUTPUT);
}
void loop() {
  int value = analogRead(gasSensor);
  Serial.print("Gas Value: ");
  Serial.println(value);
  if (value > threshold) {
    Serial.println("⚠ Food Might Be Spoiled!");
    digitalWrite(ledPin, HIGH);
    delay(200);
    digitalWrite(ledPin, LOW);
    delay(200);
  }
  else {
    Serial.println("Food is Fresh");
    digitalWrite(ledPin, LOW);
    delay(1000);
  }
}
```

3.3 Block Diagram of Proposed System

The proposed system follows a simple flow where the gas sensor acts as the input device, the Arduino Uno processes the data, and the LED provides the output indication.

Gas Sensor → Arduino Uno → LED Indicator



Working Steps

1. The system is powered on and initialized.
2. The MQ-135 gas sensor continuously monitors the surrounding air for harmful gases.
3. The sensor sends analog values to the Arduino Uno.
4. The Arduino compares the sensor value with a predefined threshold.
5. If the value exceeds the threshold, it indicates possible food spoilage and the LED starts blinking.
6. If the value is below the threshold, the LED remains off, indicating that the food is fresh.

7. This process repeats continuously for real-time monitoring.

3.4 Experimental Results

Different situations were experimented with using both fresh and spoiled food in order to test the functionality of the system. If fresh food was brought close to the sensor, the values of gases were quite low and constant, meaning everything was fine. However, introducing spoiled food caused an increase in the gas concentration, leading to higher analog values.

As soon as the analog value reached the predetermined threshold, the Arduino set the LED to start blinking. These observations confirm that the MQ-135 sensor is capable of detecting gases released during food decomposition, even before strong visible or smell-based signs appear [8].

IV. RESULT

1.1 System Component Integration

The system was successfully implemented using the following components:

- Arduino Uno (ATmega328P microcontroller)
- MQ-135 Gas Sensor
- LED Indicator
- Breadboard and Jumper Wires

All components were properly connected and worked together to achieve real-time spoilage detection.

1.2 Sensor Calibration

The system operates based on a predefined threshold value that determines whether the food is fresh or spoiled. The threshold was set experimentally based on observed gas readings.

Parameter	Value
Threshold Value	120
Sensor Output	Analog
Alert System	LED Blink

1.3 Performance

The system showed reliable performance during testing. It was able to detect changes in gas concentration effectively and respond accordingly.

- Provides real-time monitoring of food condition
- Responds quickly to changes in gas levels
- Simple and cost-effective design
- Suitable for small-scale and household use

Discussion

This system indicates the effectiveness of using gas detectors like MQ-135 in the detection of food spoilage. The process involved in using this system is faster than the traditional method, and there is little reliance on sensory organs of the human body.

The MQ-135 detector works on the basis of detecting the change in concentrations of gases like ammonia and volatile organic compounds (VOCs) emitted in the food spoilage process. The gases serve as early signs of food spoilage, allowing the system to identify unsafe conditions even before visible signs appear [1].

With the Arduino Uno used, there is easy processing and fast reaction. In case the level of gas exceeds the threshold limit, the LED warning alerts the user instantly. The system is therefore realistic and easy to apply in real situations.

On the other hand, the effectiveness of the system relies heavily on calibration of the sensors and other factors like humidity and temperature. Gases in the environment might affect the readings of the sensors, resulting in small inaccuracies.

Future improvements can enhance the system further, such as:

- Adding a buzzer for audible alerts
- Integrating IoT for remote monitoring
- Developing a mobile application for notifications

V. CONCLUSION

The design of the system offers a convenient and economical solution to the problem of food spoilage using the MQ-135 gas sensor and Arduino Uno. The system is capable of detecting toxic gases produced from food spoilage and displaying a signal via LED lights.

Through automation of the process, food spoilage can be detected more efficiently while minimizing the use of human judgment, making the system an excellent choice for residential and low-cost commercial purposes.

The findings of the study clearly demonstrate the immense potential of gas sensing systems in the development of smart food monitoring systems, especially when combined with IoT and automation technologies [9].

Overall, the proposed system is reliable, easy to implement, and serves as a practical step toward improving food safety and reducing waste.

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