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IoT based Food Spoilage Detection System

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ABSTRACT: This paper introduces an innovative Internet of Things (IoT) based food spoilage detection system designed to enhance food safety and preservation. The system integrates three distinct gas sensors—MQ4, MQ7, and MQ135—each playing a crucial role in monitoring and analyzing the environment to detect potential spoilage. The MQ4 sensor specializes in detecting methane (CH4) levels, a gas commonly associated with decomposing organic matter. By employing MQ4, the system can identify early signs of spoilage in food items, particularly those susceptible to microbial decay. The MQ7 sensor is dedicated to detecting carbon monoxide (CO), a gas emitted during the decay of organic materials. Its inclusion in the system allows for a comprehensive assessment of the storage environment, providing insights into the freshness and integrity of stored food items. The MQ135 sensor serves a multi-purpose role by detecting a range of gases, including ammonia (NH3), benzene (C6H6), and carbon dioxide (CO2). This sensor broadens the system's capability to identify various spoilage-related gases, offering a more nuanced understanding of the storage conditions. A central Arduino microcontroller processes the data gathered by these sensors in real-time, providing accurate and timely information about the food storage environment. The system employs a 16x2 LCD to display critical information, enabling users to monitor the condition of stored items at a glance. In the event of detected spoilage, a buzzer serves asan audible alarm, alerting users to take immediate action. The integration of a GSM modem facilitates communication with the ThingSpeak server, allowing for remote monitoring and management. This cloud connectivity enables users to receive real-time updates on the status of their stored food items, enhancing proactive decision-making.Furthermore, the system incorporates SMS notifications via the GSM modem. In instances of spoilage, the system automatically sends alert messages to predefined mobile numbers, ensuring that users are promptly informed and can take corrective measures. This comprehensive integration of MQ sensors, Arduino, LCD, buzzer, and GSM modem forms a robust IoT-based solution for effective food spoilage detection and alerting. The system not only leverages advanced sensor technologies but also empowers users with remote monitoring capabilities, ultimately contributing to improved food safety in a technologically driven society.

KEYWORDS: Gas Sensors, MQ4, MQ7, MQ135, Methane (CH4).

I. INTRODUCTION

In an era characterized by rapid urbanization, global trade, and increasing demand for perishable goods, ensuring the safety and longevity of food resources has become a paramount concern. The challenge of preserving food items, particularly those prone to spoilage, necessitates innovative solutions that blend technological advancements with practical functionality. In response to this imperative, the development of food spoilage detection systems has emerged as a crucial frontier in food safety and preservation.

Food spoilage, often caused by microbial activity, enzymatic reactions, or chemical processes, poses significant risks to consumer health and economic sustainability. Traditional methods of monitoring food storage conditions, reliant on manual inspection or rudimentary indicators, are prone to inaccuracies and inefficiencies. Consequently, there arises a pressing need for advanced systems capable of detecting and mitigating spoilage risks in real-time.

The advent of Internet of Things (IoT) technologies has revolutionized various industries, offering unprecedented capabilities in data collection, analysis, and remote communication. Leveraging the power of IoT, food spoilage detection systems have evolved to incorporate specialized sensors, microcontrollers, and connectivity solutions,

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enabling precise monitoring and proactive alerting in diverse storage environments.

This paper introduces an innovative IoT-based food spoilage detection system designed to address the complexities of modern food preservation. By integrating state-of-the-art gas sensors, including MQ4, MQ7, and MQ135, this system offers a comprehensive approach to monitoring spoilage-related gases in real-time. Each sensor is tailored to detect specific gases associated with food decomposition, providing users with actionable insights into the condition of stored items.

The core processing unit of the system, an Arduino microcontroller, interprets data from the sensors and facilitates seamless communication with peripheral devices. A user- friendly interface, comprising a 16x2 LCD display, ensures accessibility and immediacy in monitoring storage conditions. In the event of detected spoilage, an audible alarm alerts users, prompting timely intervention to mitigate risks and minimize food wastage.

Furthermore, the system harnesses the power of cloud connectivity through a GSM modem, enabling remote monitoring and management via the Thing Speak server. Real- time updates on storage conditions are transmitted to users' mobile devices through SMSnotifications, facilitating informed decision-making and proactive intervention.

By combining advanced sensor technologies with IoT capabilities, this system represents a significant advancement in food safety and preservation. Its ability to detect spoilage risks in real-time, coupled with remote monitoring and alerting functionalities, empowers users to safeguard food resources effectively in an increasingly complex and interconnected world. Through continued innovation and integration, food spoilage detection systems hold the promise of enhancing food security, reducing waste, and fostering a sustainable food supply chain.

The Internet of things (IoT) describes the network of physical object “things” that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet.

The definition of the Internet of things has evolved due to the convergence of multiple technologies, real-time analytics, machine learning, commodity sensors, and embedded systems. Traditional fields of embedded systems, wireless sensor networks, controlsystems, automation (including home and building automation), and others all contributeto enabling the Internet of things. In the consumer market, IoT technology is most synonymous with products pertaining to the concept of the "smart home", including devices and appliances (such as lighting fixtures, thermostats, home security systems and cameras, and other home appliances) that support one or more common ecosystems, and can be controlled via devices associated with that ecosystem, such as smartphones and smart speakers.

There are a number of serious concerns about dangers in the growth of IoT, especially in the areas of privacy and security, and consequently industry and governmental moves to address these concerns have begun including the development of international standards.

INTRODUCTION TO INTERNET OF THINGS:

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INTRODUCTION TO PROTEUS DESIGN SUITE:

The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards.
It was developed in Yorkshire, England by Labcenter Electronics Ltd and is available in English, French, Spanish and Chinese languages.

INTRODUCTION TO ARDUINOIDE:

The Arduino Integrated Development Environment (IDE) is a cross-platform application(for Windows, macOS, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards. The source code for the IDE is released under the GNU General Public License, version

2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU tool chain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board' Firm ware. By default, arduino is used as the uploading tool to flash the user code ontoofficial Arduino boards.

II. EXISTING SYSTEM

Traditional methods of food spoilage detection and monitoring predominantly rely on manual inspection and subjective judgment, which are often time-consuming, labor- intensive, and prone to errors. In many cases, spoilage is only detected after visible signs, such as foul odors or mold growth, become apparent, leading to potential health risks and economic losses. Moreover, conventional monitoring systems lack the ability to provide real-time insights into the storage environment, limiting the effectiveness of preventive measures.
While some automated systems for food spoilage detection exist, they often exhibit limitations in terms of sensor accuracy, coverage of spoilage indicators, and remote monitoring capabilities. These systems typically rely on single-sensor solutions or rudimentary sensor technologies, which may not adequately capture the complex dynamics of food degradation processes. Additionally, the lack of remote monitoring functionalities restricts the accessibility and timeliness of information, hindering proactive decision-making by users.
Furthermore, the integration of IoT technology into existing food spoilage detection systems remains relatively nascent, with few solutions leveraging the full potential of interconnected sensor networks and cloud-based communication. Limited integration with modern communication platforms, such as mobile networks and cloud servers, inhibits the scalability and versatility of these systems, restricting their adoption in diverse settings.
Thus, the current landscape of food spoilage detection systems is characterized by a reliance on manual methods, limited sensor capabilities, and inadequate real-time monitoring functionalities. There is a clear need for innovative solutions that harness the power of IoT technology to overcome these limitations, enabling more effective and proactive management of food safety and preservation.

III.PROPOSED METHADOLOGY

The proposed system aims to address the drawbacks of existing food spoilage detection methods by leveraging the capabilities of IoT technology, advanced sensor technologies, and real-time monitoring functionalities. Key features of the proposed system include:
Multi-Sensor Integration: The system integrates multiple gas sensors, such as MQ4, MQ7, and MQ135, to detect a wide range of spoilage-related gases, including methane, carbon monoxide, ammonia, benzene, and carbon dioxide. This multi-sensor approach provides a comprehensive assessment of the storage environment, enabling early detection of potential spoilage indicators.

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Real-Time Data Processing: A central Arduino microcontroller processes the data gathered by the sensors in real-time, allowing for accurate and timely monitoring of the food storage environment. This real-time processing ensures that users receive immediate updates on the condition of stored food items, facilitating proactive intervention to prevent spoilage.

Remote Monitoring and Management: The system incorporates GSM modem connectivity, enabling communication with cloud-based servers such as the ThingSpeak server. This cloud connectivity facilitates remote monitoring and management of the food storage environment from anywhere and at any time. Users can access real-time data and receive alerts on their mobile devices, empowering them to take prompt corrective measures in the event of detected spoilage.

User-Friendly Interface: Critical information about the storage environment, including gas levels and spoilage indicators, is displayed on a 16x2 LCD screen. This user-friendly Interface allows users to monitor the condition of stored food items at a glance, facilitating informed decision-making.

Automated Alerting System: In the event of detected spoilage, an audible alarm is triggered to alert users to take immediate action. Additionally, the system sends SMS notifications via the GSM modem to predefined mobile numbers, ensuring that users are promptly informed of spoilage events and can take necessary corrective measures.

Scalability and Versatility: The proposed system is designed to be scalable and versatile, allowing for easy integration with existing infrastructure and adaptation to diverse environments and settings. The modular design facilitates customization and expansion based on specific requirements and preferences.

Cost-Effective and Low-Maintenance: The system is designed to be cost-effective and low-maintenance, making it accessible to a wide range of users. Utilizing off-the-shelf components and open-source software frameworks helps minimize initial installation costs and ongoing maintenance expenses.

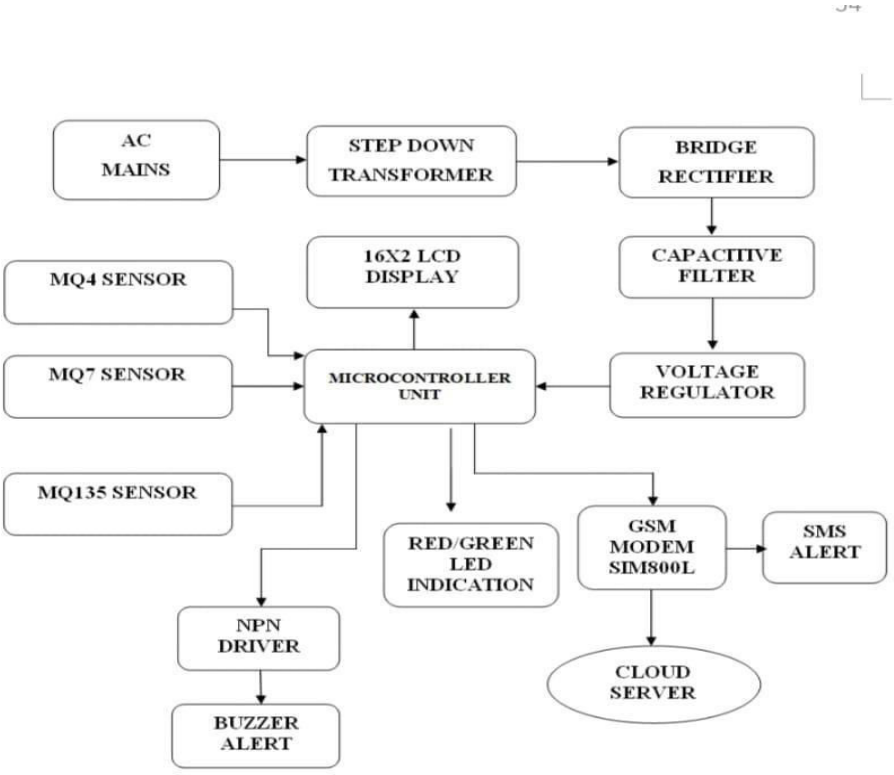

Fig.1 Block Diagram of IOT Based automatic stretcher with automatic sanitization

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IV. FUTURE SCOPE

- Enhanced Sensor Technology: Explore advancements in sensor technology to improve the accuracy and sensitivity of detecting food spoilage indicators such as temperature, humidity, gases (like ethylene), and pH levels. This could involve developing more compact, affordable, and versatile sensors suitable for different types of food products.
- Integration with AI and Machine Learning: Integrate artificial intelligence (AI) and machine learning algorithms to analyze data collected from sensors in real-time. This can enable predictive analytics and early warning systems for detecting potential spoilage events before they occur, allowing for proactive intervention.
- Blockchain for Supply Chain Transparency: Investigate the integration of blockchain technology to enhance transparency and traceability in the food supply chain. By recording and verifying each step of the food's journey from production to consumption, blockchaincan help prevent food fraud, reduce waste, and ensure food safety.
- Mobile and Cloud-Based Applications: Develop user-friendly mobile applications and cloud- based platforms that allow consumers, retailers, and food producers to access real-timeinformation about the freshness and quality of food products. These applications can provide alerts, recommendations, and personalized suggestions based on individual preferences and dietary requirements.

V.CONLUSION

In conclusion, the development and testing of the handheld food allergen detection device have demonstrated its potential to significantly improve food safety and allergen management practices. With high accuracy, rapid response times, and user- friendly features, the device offers a practical solution for on-the-spot allergen detection in various settings. While further optimization and refinement are needed to address limitations and enhance performance, the device represents a cost-effective and accessible tool for individuals, food service establishments, and food manufacturers to mitigate the risks associated with food allergies and ensure informed decision-making. By empowering users with timely allergen detection capabilities, the device contributes to the broader goal of promoting safer food environments and protecting the health and well-being of individuals with food allergies.

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