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Detecting the Quality of Food using Internet of Things and Machine Learning

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Abstract:

Food spoiling causes a great deal of waste, financial losses, and health hazards. This research offers an innovative approach to transform food freshness detection by utilizing the synergy between IoT and AI in the field of Artificial Intelligence and Machine Learning. Smart packaging incorporates embedded sensors that continuously monitor critical characteristics such as temperature, gas composition, and visual changes. These essential facts are sent to a central AIML-powered platform via the Internet of Things network. With great accuracy, the AIML system assesses the sensor data to evaluate the food's condition. Through smartphone apps, consumers can make qualified choices by receiving real-time updates on the freshness of their food. The project's influence goes beyond specific users. This method has the potential to transform the food industry and enhance public health by optimizing shelf life and reducing waste. The primary focus of this study is the use of sensors to prevent food spoiling by continuously detecting signals from the food and notifying the registered mobile phone of any changes.
***Keywords* —: Food spoiling, smart packaging, real-time updates, public health, sensors.**

I. INTRODUCTION

Any living organism requires food to sustain its energy and ensure its survival. Nutrients and energy from a wholesome diet keep the body active and in good condition. Eating unhealthy food is akin to inviting illness, as most farmers use pesticides in agriculture to increase productivity, contributing significantly to food contamination. Illness and obesity often result from unhealthy eating habits and insufficient nutrition. The younger generation is actively pursuing healthy lifestyles, deeply concerned about their physical well-being. Thus, the quality of food plays a crucial role in maintaining fitness.

Another significant issue in today's lifestyle is food poisoning, which serves as the source of numerous illnesses. Extensive research is conducted to evaluate food quality, with a major emphasis on the types of bacteria found in food, aligning with public expectations. Technology and scientists play a pivotal role in shaping our perceptions of food quality. The current situation highlights the need for a device that can assess food quality. Our system utilizes temperature, pH, and odour sensors to determine the quality of food. The MQ3 sensor and MQ135 odour sensor measure the quantity of hazardous gases in food. These devices assess food quality by monitoring variables such as temperature, humidity, and hazardous gases. The goal of this study is to create a prototype for collecting data from intake sensors, displaying the necessary output that the system needs to produce.

The convergence of artificial intelligence (AI), machine learning (ML), and the Internet of Things (IoT) has recently transformed several industries. One area where this synergy shows great promise is in ensuring food freshness. The global food supply chain faces various challenges, with food spoilage being a major concern due to its detrimental effects on the environment, economy, and public health. To address these challenges, cutting-edge AI and ML algorithms, combined with IoT devices, offer creative solutions for real-time freshness identification in perishable items.

The idea is to integrate sensors and IoT devices at every stage of the food supply chain, from manufacturing and delivery to storage and retail. These gadgets gather abundant information about temperature, humidity, and gas concentrations in the surrounding air, all of which directly impact the quality and freshness of food items. This data is then processed and analysed using AI and ML algorithms to provide precise and fast estimates of food freshness.

One of the many benefits of this multidisciplinary approach is its capacity to forecast potential spoiling occurrences, optimize storage conditions, and minimize waste through focused interventions. Additionally, by utilizing machine learning models, the system can constantly learn and adapt, improving its accuracy over time and accounting for differences in various perishable commodities

II. LITERATURE REVIEW

In this section, we review some of the previous works in the field of IoT based cold storage. In [1], Sensor based food monitoring model was proposed. It consists of chemical & biological sensors for food monitoring. Highlights potential in smart packaging but calls for improved sensitivity & safety. In [2] they developed an aptamer/graphene biosensor for rapid, low-cost milk allergen detection. It shows promise for on-site food allergen testing. In [3] the proposed model highlights the need for further research on sub lethal injury and microbial stress resistance in frozen foods. Meanwhile, in [4] the model tackles the issue of food waste directly, proposing an IoT-based sensor system to prevent consumption of spoiled food. In [5] they demonstrated an Arduino-based gas sensor system with Wi-Fi and LCD display for early spoilage alerts. In [6] they proposed an IoT & machine learning system for automated spoilage detection. In [7] the model reviews existing food quality monitoring systems & proposes sensor-based system using pH, gas, & temperature sensors. Suggests future inclusion of nutrient sensors. In [8] they proposed an "eFresh" device for food freshness detection using biosensors & electrical sensors. It features Android app interface & emphasizes biosensor value in enhancing food safety. In [9] it emphasizes importance of freshness for food quality & advocates for IoT-based detection methods using spectroscopy, gas sensors, & machine learning. In [10] they proposed a vision-based framework for fruit freshness classification using various feature extraction methods & convolutional neural networks. Since our proposed models concentrate on food freshness detection using IoT (Gas Sensor) and machine learning algorithms, our work differs from all previously mentioned models.

III. EXISTING SYSTEM

Real-time spoilage detection is made possible by the combination of sensors, IoT, and machine learning. This system can be used in homes, businesses, and refrigerators to notify users through a buzzer when decaying is discovered. When it comes into contact with spoiled food, it sounds a buzzer. This information is transferred to a cloud platform.

IV. REQUIREMENTS

A feature of software program device is described in practical requirement and the conduct of the device is evaluated when presented with specific inputs or conditions which may include calculations, data manipulation and processing and other specific functionality. The functional requirements of the project are one of the maximum crucial factors in phrases of complete mechanism of modules. This includes:

i. Sensor Integration: The system shall integrate IoT sensors capable of measuring relevant environmental parameters, such gases, within the storage environment of the food.

ii. Data Pre-processing: The system shall pre-process the collected data to null values, Data type Checking, and EDA, ensuring accurate and reliable information for analysis.

iii. Machine Learning Model: Machine learning model trained on a dataset to analyse the collected data and predict the freshness status of the food items.

iv. Model Training and Updating: The machine learning model shall be trained initially using a labelled dataset and subsequently updated periodically to adapt to changing environmental conditions and improve prediction accuracy.

v. Freshness Thresholds: The system shall define freshness thresholds based on the type of food items, considering factors such as concentrations, to determine the freshness level.

vi. Alerts Notifications: The system shall generate and send alerts notifications to designated users food status such as Fresh or Spoiled.

V. OBJECTIVES

- Develop an IoT system with gas sensors and microcontrollers for real-time food spoilage monitoring.
- Implement machine learning to predict food spoilage likelihood and estimate time to spoilage.
- Continuously improve the model's accuracy through data and algorithm updates.

VI. PROPOSED SYSTEM

Food spoilage is a significant concern in the modern world due to the potential harm it poses to consumers who consume spoiled products. The objectives of our project are to monitor the gases released by specific food items and employ suitable sensors to detect spoiled food. When the microcontroller detects spoilage, it utilizes the Internet of Things to send out an alert, enabling prompt action. This technology is particularly relevant in the food industry, where manual food detection is the conventional practice.

To enhance the accuracy of predicting the likelihood and duration of food spoilage, we plan to integrate machine learning into this model, especially when sourcing food from specific vendors. This approach aims to encourage retailers to provide fresher, healthier food, contributing to a safer world for all consumers. Fig 1 shows the system architecture of the proposed system.

In the proposed system, gas sensors MQ2 and MQ135 measure the carbon monoxide, benzene, and ammonia concentrations found in a specific food item. Based on the oxygen and ammonia concentrations, a machine learning model uses a trained model to predict whether or not a specific food item is spoiled. When a spoiled food item is detected, the Node

MCU (microcontroller) emits a buzzer. This information is transferred to a cloud platform. It is possible to track the frequency of spoiled food and re-implement a machine learning model to estimate the typical shelf life of certain food items.

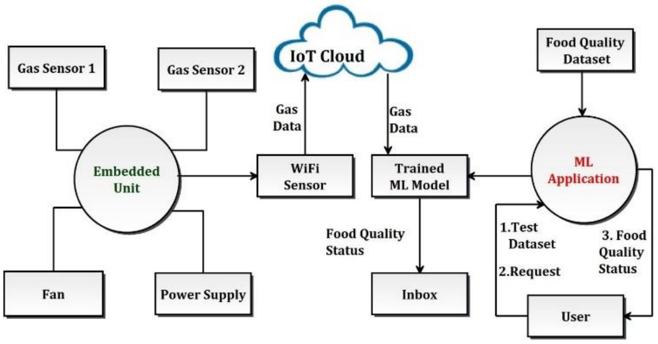

Fig. 1 Proposed System Architecture

We intend to use the cumulative value of the oxygen and ammonia sensors to make a judgement in order to optimise detection accuracy rather than depending solely on the value of one sensor. This decreases the chance of false negatives. Our smart sensor can also detect gases such as carbon monoxide, ammonia, and benzene in any food item by combining two gas sensors. Specific foods are spoiling more frequently and emitting these gases. Consequently, during peak hours, more workers might be hired, and during off-peak hours, fewer. This results in significant labour savings.

A. Modules Description

1) System Components:

- Gas sensors: Detects volatile organic compounds emitted by spoiling food, with different sensors for various food types.
- Embedded unit: Microcontroller collecting data from gas sensors and sending it to the IoT cloud.
- Wi-Fi sensor: Enables wireless communication between the embedded unit and the IoT cloud.
- Trained ML model: Recognizes VOC profiles of different foods to predict freshness.
- ML application: Software on the embedded unit that uses the trained model for freshness predictions.

2) *Operational Workflow:*

- Gas sensors collect VOC data.
- Embedded unit sends data to the IoT cloud.
- ML application predicts food freshness using the trained model.
- Freshness prediction is sent to the user's inbox.

B. Algorithm Description

1) Random Forest:

Random Forest is a machine learning algorithm that can be used to perform classification, regression, and feature selection tasks. It is an ensemble learning technique that builds a more reliable and accurate model by combining several decision trees. Random Forest constructs a forest of decision trees, each trained on a random subset of the data and a random subset of the features. During prediction, the results from all trees are combined to form the final prediction. Random Forest is well-known for its capacity to manage big datasets, high-dimensional feature spaces, and noisy data. It is effective in a number of applications, including finance, bioinformatics, and image classification.

The following steps and diagram explains the working process:

Step 1: From the training set, choose K data points at random.

Step 2: Create the decision trees associated with the selected data points (Subsets).

Step 3: Select the number N for the decision trees you wish to construct.

Step 4: Carry out Steps 1 and 2.

Step 5: For new data points, find the predictions of each decision tree and assign the new data points to the category with the most votes.

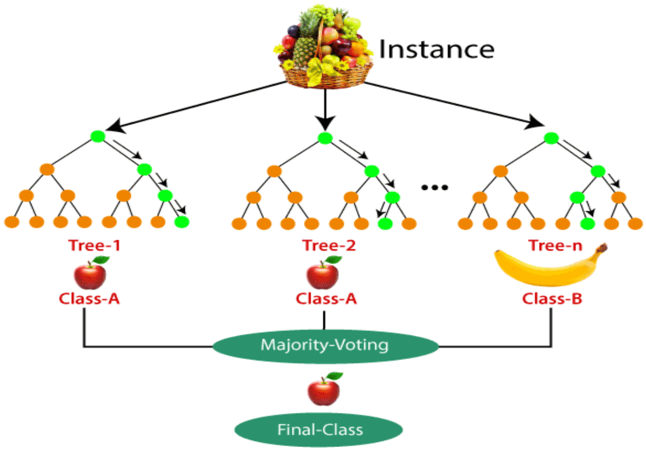

Fig. 2 Random Forest Architecture

VII. CONCLUSION

IoT and machine learning can be used together to develop a system for detecting the freshness of food. This system can analyse data from various sensors and sources to identify patterns and characteristics that indicate the freshness or spoilage of food. By training machine learning models on this data, the system can accurately classify food as fresh or spoiled in real-time, which can help prevent food waste and improve food safety. However, it is important to ensure that the system is properly calibrated and validated to ensure its accuracy.

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