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IOT-ENABLED MACHINE LEARNING SYSTEM FOR ONION SPOILAGE DETECTION

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ABSTRACT

Onion is one of the most important vegetable crops, widely cultivated and consumed across the world. However, a substantial amount of onion produce is lost every year due to improper storage conditions and late detection of spoilage. Factors such as excess humidity, temperature variations, poor ventilation, and microbial activity accelerate decay, resulting in the release of harmful gases and significant economic losses. Traditional spoilage detection methods rely on manual inspection, which is inefficient and unable to detect early-stage deterioration. The proposed work integrated with Internet of Things (IoT) and Artificial Intelligence (AI) based system for sustainable onion storage and early spoilage detection. The proposed system employs low-cost IoT components such as Arduino Uno, gas sensors (MQ series), and environmental sensors to continuously monitor storage conditions. Gases released during onion spoilage, along with temperature and humidity data, are collected and transmitted to a cloud platform for real-time analysis. When sensor readings exceed safe threshold levels, the system generates instant alerts to notify users, enabling timely corrective actions such as improving ventilation or isolating spoiled onions. To enhance accuracy and predictive capability, proposed AI-based machine learning algorithms as integrated K-Nearest Neighbors (KNN) with Logistic Regression are applied to the collected data and made comparison with other existing methods such as Decision tree, KNN and Logistic Regression. These models classify onion conditions into fresh, warning, and spoiled categories, allowing early intervention and reducing large-scale losses. The use of AI also

enables pattern recognition and prediction of spoilage trends over time. The proposed techniques aintegrated K-Nearest Neighbors (KNN) with Logistic Regression provides an efficient and reliable approach for modern agricultural storage management.

KEYWORDS: Internet of Things, Machine Learning, Arduino Uno, Gas Sensor, Environmental Sensor.

INTRODUCTION

Agriculture is very important for our daily food needs and for the country's economy. Onion is one of the most commonly used vegetables in every household, especially in India. Farmers grow onions in large quantities, but a big problem occurs after Harvesting [1]. Many onions get spoiled during storage because they are not kept in proper conditions. This leads to huge losses for farmers and traders [2].

Onions spoil mainly due to high humidity, temperature changes, poor air circulation, and bacterial growth. When onions start to

rot, they release harmful gases, which cause nearby onions to spoil faster. Usually, farmers or storage workers check onions manually, but this method is slow and not reliable. By the time spoilage is noticed, a large quantity of onions may already be damaged [3].

With the help of modern technology, this problem can be reduced. The Internet of Things (IoT) allows sensors to continuously check storage conditions like temperature, humidity, and gas levels. Artificial Intelligence (AI) helps analyze this data and predict spoilage early. When both IoT and AI are combined, they can warn users in advance so that action can be taken quickly [4]. The proposed work aims to develop a smart onion storage system using IoT and AI. The system helps detect spoilage early, reduce losses, improve storage quality, and support farmers by promoting better and more sustainable storage practices.

LITERATURE SURVEY

Onion spoilage during storage is a major problem faced by farmers and traders. After harvesting, onions are stored for long periods, but due to poor storage conditions such as high humidity, temperature changes, and lack of ventilation, they begin to rot. Spoilage is usually identified only through manual checking, which is slow and not accurate [5]. By the time rotten onions are noticed, many healthy onions are already affected. This leads to heavy financial losses and food wastage. There is no proper system to monitor storage conditions or detect spoilage at an early stage. So need to propose the better solution to monitor the onion

spoilage in the early stage [6].

PROPOSED METHODOLOGY

Onion spoilage during storage is a major problem faced by farmers and traders. After harvesting, onions are stored for long periods, but due to poor storage conditions such as high humidity, temperature changes, and lack of ventilation, they begin to rot. Spoilage is usually identified only through manual checking, which is slow and not accurate. By the time rotten onions are noticed, many healthy onions are already affected. This leads to heavy financial losses and food wastage. There is no proper system to monitor storage conditions or detect spoilage at an early stage for monitoring.

Artificial Intelligence (AI) is used to analyze the sensor data and identify early signs of spoilage. Based on the analysis, the system classifies the onions as fresh, warning, or spoiled. If abnormal conditions or spoilage are detected, instant alerts are sent to the user. This helps farmers or storage managers take quick action, such as improving ventilation or removing spoiled onions. The system reduces losses, saves time, and improves storage efficiency in a simple and cost-effective way.

The major components used in the proposed system are

1.1 Arduino Uno/Node Mcu(Microcontroller)

The Arduino Uno or NodeMCU acts as the main controller of the system. It reads data from sensors like gas sensor and temperature sensor, processes the information, and takes necessary actions.

- It controls all connected components.
- It processes sensor readings.
- It sends data to the display or cloud (if Wi-Fi is used).

NodeMCU has built-in Wi-Fi, while Arduino needs an external Wi-Fi module.

Fig 1: Arduino Uno.

1.2 Gas Sensor(Mq Series – Mq2 / Mq135)

The **MQ series gas sensors** are used to detect harmful gases released during onion spoilage.

- MQ2 detects smoke, LPG, methane, and other gases.
- MQ135 detects ammonia, benzene, and air quality-related gases.
- Helps in identifying rotting onions by sensing harmful gas levels.
- Provides analog output to the microcontroller.

Fig. 2: Gas Sensor.

1.3 *Temperature and Humidity Sensor(Dht11/Dht22)*

The DHT sensor measures temperature and humidity inside the storage area.

- DHT11: Basic, low-cost sensor.
- DHT22: More accurate and wider range.
- Helps maintain proper storage conditions.
- Prevents spoilage caused by excess heat or moisture.

Fig 3: Temperature and Humidity Sensor.

ONION STORAGE SETUP

This is the physical storage model where onions are placed for testing. The Sensors are installed inside the storage box and Detects gas, temperature, and humidity. Finally simulates real warehouse conditions and used to test freshness monitoring system.

Fig 4: Onion Storage setup.

PROPOSED ONION SPOILAGE DETECTION SYSTEM

The proposed model is shown below

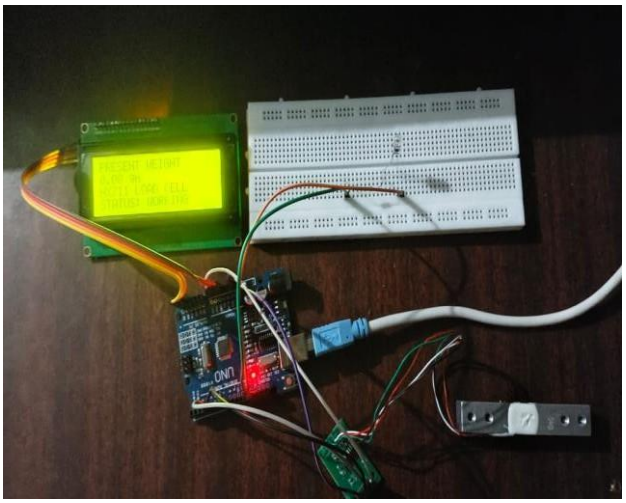

Fig 5: Proposed Model.

Fig 6: Output Screen to find the status of onion spoilage.

The proposed technology has several modules to find the onion spoilage and also intimate to the user. The various module is listed below

1. Sensor Module

This module contains gas sensors and temperature-humidity sensors. It continuously checks the storage environment. Gas sensors detect gases released from spoiled onions. Temperature and humidity sensors monitor storage conditions. The collected data is sent to the controller module.

2. Controller Module

This module uses a microcontroller like Arduino or NodeMCU. It receives data from all sensors. The controller processes and organizes the sensor values. It controls data transmission to the cloud. It acts as the brain of the entire system.

3. Communication Module

This module uses a Wi-Fi unit such as ESP8266. It connects the system to the internet. Sensor data is sent to the cloud in real time. It enables remote monitoring of storage conditions. It ensures continuous data transfer without manual effort.

Cloud & AI Module

This module stores sensor data on a cloud platform. It analyzes data using AI or logic rules. It identifies abnormal conditions and spoilage patterns. It classifies onions as fresh, warning, or spoiled.It supports decision-making and prediction.

4. Alert Module

This module generates alerts when spoilage is detected. Alerts are sent through mobile or web notifications. It informs users immediately about unsafe conditions. It helps take quick corrective action. It reduces losses and prevents large-scale spoilage.

2. WORKFLOW OF PROPOSED SYSTEM

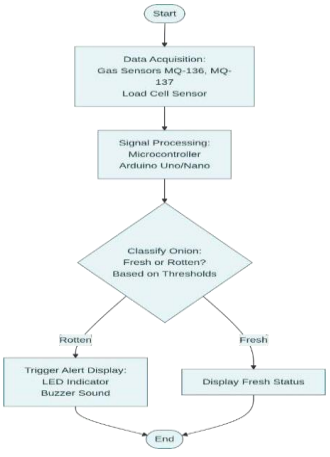

Fig 7: Workflow of proposed Technology

3. CONCLUSION AND FUTURE ENHANCEMENT

The proposed technique shows how IoT and AI can be used to reduce onion spoilage during storage. By monitoring temperature, humidity, and gas levels in real time, spoilage can be detected early. The system is simple, cost-effective, and helps farmers reduce losses while improving storage efficiency and sustainability. In the future, this system can be enhanced by adding more advanced AI models to improve spoilage prediction accuracy. Mobile applications can be developed for easier monitoring and control. Additional sensors such as camera modules can be used for visual inspection of onions. The system can also be extended to support other crops and integrated with automated ventilation and cooling systems.

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