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Early Detection of Onion Spoilage Utilizing IoT and AI during Storage and Transportation

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Abstract:- This paper introduces an innovative approach to reducing crop wastage by converting traditional onion warehouses into smart warehouses using IoT and AI technologies. We propose an IoT-based monitoring solution that continuously analyses and communicates the health status of onion stock in real time. Additionally, our methodology aims to support farmers by providing them with essential information about their onion stocks, enabling informed decision-making. Traditionally, farmers rely on sensory cues such as onion odor to detect decomposition. However, we propose a technological intervention utilizing image processing and AI-driven sensory mechanisms to enhance the onion detection process. Specifically, cameras are employed to identify sprouted onions, while AI algorithms analyze sensory data to detect rotten onions. Our prototype achieves an impressive 87% efficiency in identifying sprouted onions using camera-based systems. Furthermore, the response of the gas sensing system in detecting rotten onions under prescribed chamber dimensions yields encouraging results. Through the integration of IoT and AI, our methodology offers a promising solution to minimize crop wastage and promote sustainable agricultural practices.

Keywords:- *Internet of Things (IOT), Smart Warehouses, AI (Artificial Intelligence), Informed Decision-Making, Image Processing, Crop Wastage Reduction, Sprouted Onion Detection, Rotten Onion Detection, Gas Sensing System.*

I. INTRODUCTION

Agriculture serves as the backbone of numerous economies, with a significant portion of the population engaged directly or indirectly in this sector. Recent years have seen the emergence of new cropping patterns aimed at transforming farming communities' economic landscape. Among crucial horticultural crops, onions are of immense commercial importance, especially in India, the world's second-largest onion-producing nation. The grading of agricultural produce, particularly onions, has become indispensable for both national and international trade, aligning with global standards and meeting specific consumer demands.

Manual sorting of onions by growers and traders results in subjective grading, leading to increased selling costs, inconsistencies, and reduced productivity. Additionally, the fragmentation of agricultural land into micro-holdings exacerbates labor shortages, impacting onion cultivation economics. Hence, there's a need for cost-effective engineering mechanisms to streamline agricultural processes.

The Internet of Things (IoT) revolutionizes computing by connecting everyday physical objects to the Internet, facilitating real-time insights and communication. In agriculture, IoT plays a vital role in monitoring and controlling operations, particularly in addressing challenges in onion storage. Smart farming, driven by IoT sensors, enables farmers to access critical field information, focusing on monitoring temperature and humidity levels. A proposed grid system for onion storage aims to mitigate degradation risks due to temperature and humidity fluctuations, promptly notifying farmers of storage issues to enhance yield quality and avert economic losses.

India, a significant onion producer, faces challenges in monitoring bulb quality and disease prevention during bulk storage. Enhanced management tools are needed for continuous quality monitoring, particularly to monitor temperature and relative humidity to ensure optimal storage conditions. This study investigates the microclimate surrounding onions in storage and examines its correlation with quality indicators, hypothesizing that diseased onions exhibit elevated respiratory heat and water vapor emissions, resulting in higher average temperatures and RH levels in storage.

II. LITERATURE REVIEW

Syed Musthak Ahmed et al. research describes the benefits of implementing the IoT-based monitoring system in onion warehouses to control losses and improve efficiency in onion storage practices [1]. The monitoring system alerts owners when onions are at risk of rotting, allowing them to take necessary actions to prevent spoilage.

Zahid khan et al. research describes the IoT-based smart farming monitoring system (SFMS) to reduce bolting in onion crops. The SFMS uses sensors to monitor environmental factors in both open and greenhouse environments [2]. The research focused especially on bolting and did not address other potential challenges in onion farming is a drawback though.

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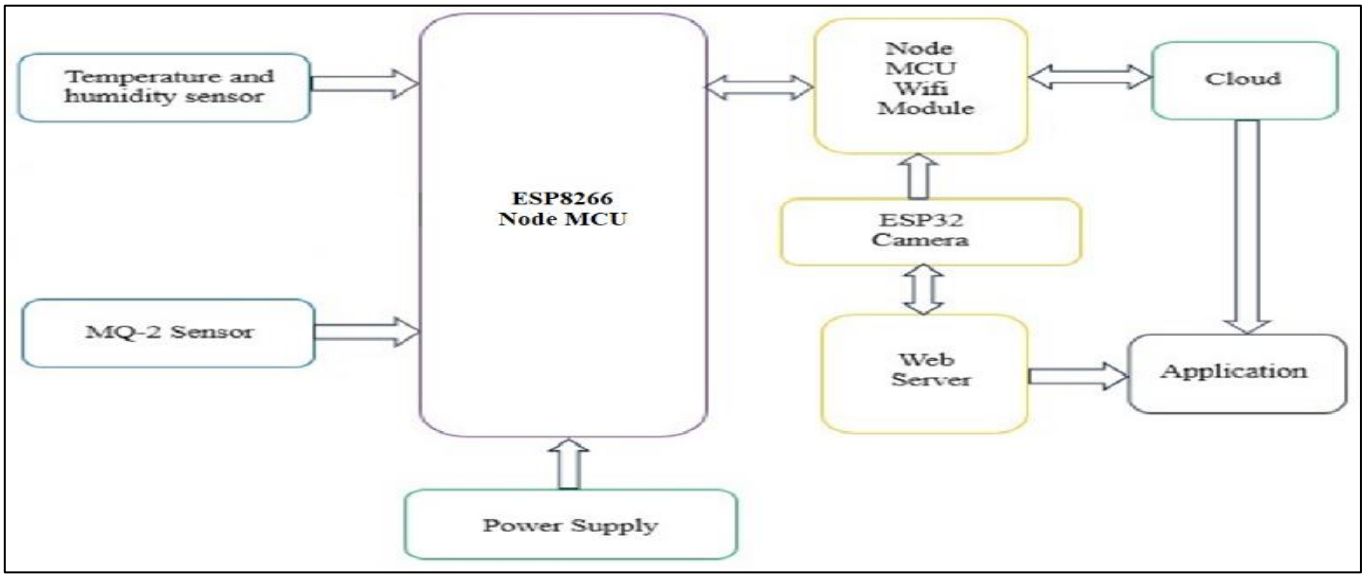

Fig 1: Block Diagram

Vinay S. Sidawadkar et al. presented IoT based system to preserve onions by monitoring and controlling temperature and humidity levels using sensors [3]. The system incorporates a thermoelectric cooling module and stores data on Google Cloud, where users can remotely monitor the onion storage conditions and receive notifications about the system status. The system includes complex setup and maintenance, and high implementation costs which could lead to some drawbacks.

A. Farha et al. discussed the cultivation of onion as a winter crop and their significance as a spice and vegetable, and the challenges faced in meeting the increasing demand for onions in Bangladesh, which ranks first in terms of production and consumption among spice crops [4]. The article highlights the need for structured and regulated onion production to reduce dependency on imports and meet the rising demand for onion.

Labanska et al. investigated the use of an electronic nose for detecting Fusarium Basal a Rot infection in onions and shallots. The study demonstrates the potential of electronic nose technology in the early detection and monitoring of fungal infections in post-harvest crops [5]. The research underscores the evolving nature of electronic nose technology, offering sensors and pattern recognition methods, making it a promising tool for rapid and non-destructive monitoring of crop health.

III. METHODOLOGY

A. Hardware Design

In the Early Detection of Onion Spoilage Utilizing IoT and AI During Storage and Transportation, the system collects data from various sensors such as DHT11 Temperature and Humidity Sensor, and MQ2 gas Sensor to monitor the environmental conditions of the onion storage facility. The collected data is processed to get relevant information regarding temperature, humidity, and gas levels in the storage environment.

The system utilizes image processing algorithms, such as Convolutional Neural Networks (CNN), to analyze images captured by the ESP32 Cam. This process helps in identifying sprouted onions by detecting visually, like sprout growth. A detection algorithm is implemented to classify onions based on their condition (healthy, sprouted, rotten) using the data from sensors and image processing results.

If the system detects any issues such as low-quality onions or variations in storage conditions, it generates alert notifications. These alerts can be sent to predefined mobile numbers through a mobile application integrated with the system.

B. System Workflow

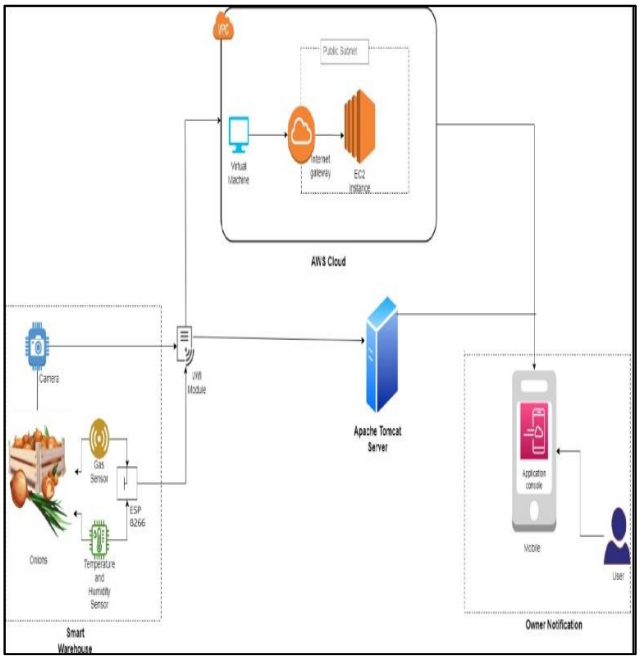

Fig 2: System Workflow

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The Early Detection of Onion Spoilage Utilizing IoT and AI during storage and transportation is a step taken to control the spoilage of onions, seamlessly integrating hardware components and powerful machine learning algorithms. The sensors of this system, which include DTH11, and MQ-2, continually collect real-time data necessary for monitoring the health of onions. The ESP8266 uses this data to power a decision-making mechanism that carefully examines sensor inputs. Its main objective is to reduce the loss in spoilage and early detection of sprouting and rotting of onions.

With the use of sensor inputs and image visualization ESP8266 processes its data and sends it to the server which compares the data with given threshold values and alerts farmers to segregate the onions from spoilage, sprouting, or rotting of onions.

Farmers can remotely able to monitor the onions ensuring the quality of onions during storage and transportation. This helps in the reduction of post-production losses.

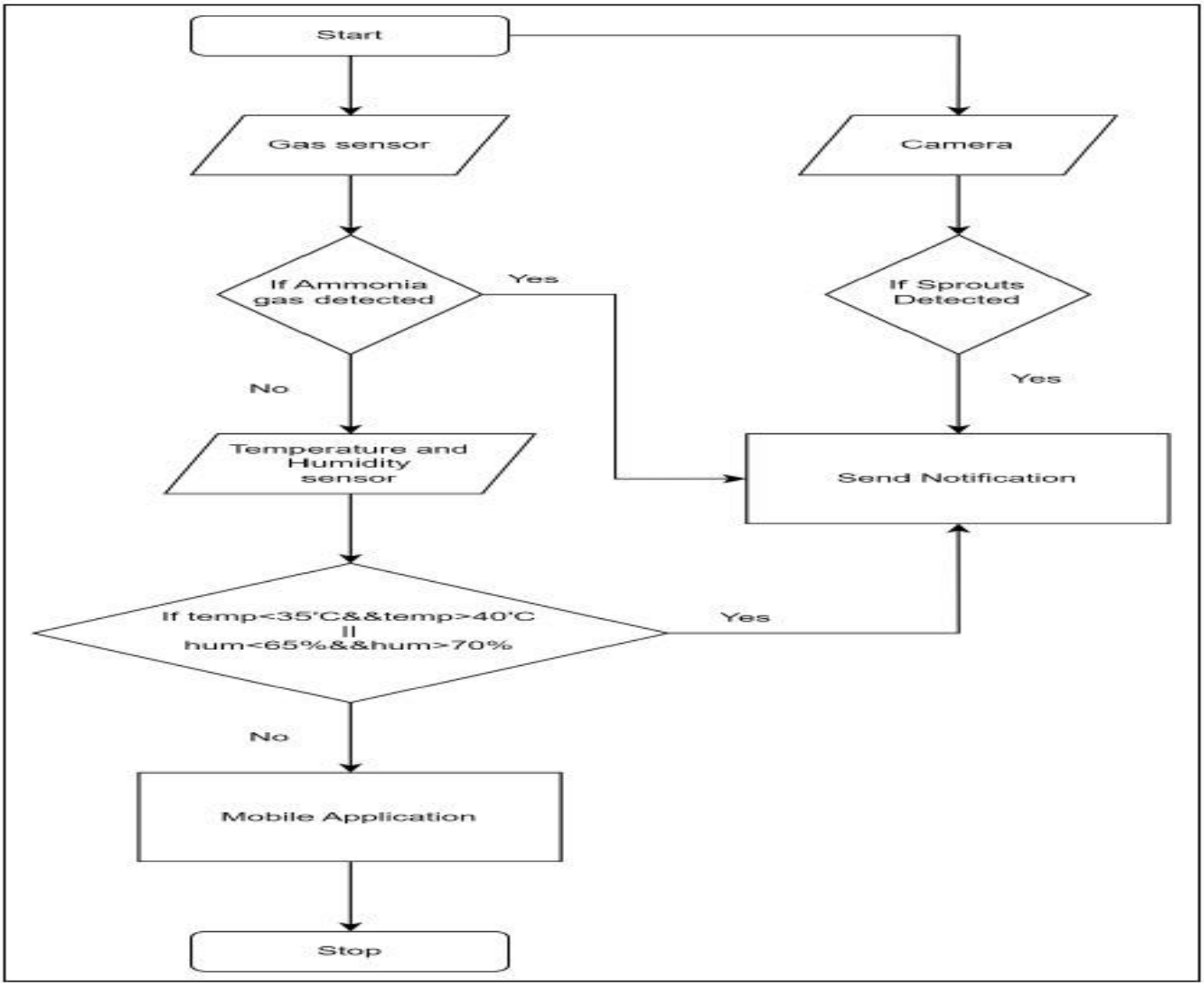

Fig 3: Flowchart

C. Software Design

The system utilizes a communication module, such as the NodeMCU ESP8266 Wi-Fi module, to establish connectivity and transmit data between the sensors, image processing unit, and alert generation system.

A user interface is designed to provide farmers with real-time information about the health status of onion stocks. This interface may display sensor readings, image analysis results, and alert notifications in a user-friendly format.

The system uses AWS Cloud, to store and analyze data collected from the sensors.

The software design ensures continuous monitoring of onion storage conditions, enabling measures to be taken in case of any spoilage or degradation issues. This real-time monitoring helps in reducing wastage and improving overall efficiency.

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Fig 4: Hardware Design

IV. RESULT

Fig 5 and Fig 6 show the hardware design of the system which consists of a set of sensors, a microcontroller, and a ESP32 camera. Fig 7 shows the output obtained in the software Arduino IDE software. Fig 8 shows the Apache Tomcat server that runs server applications which are made.

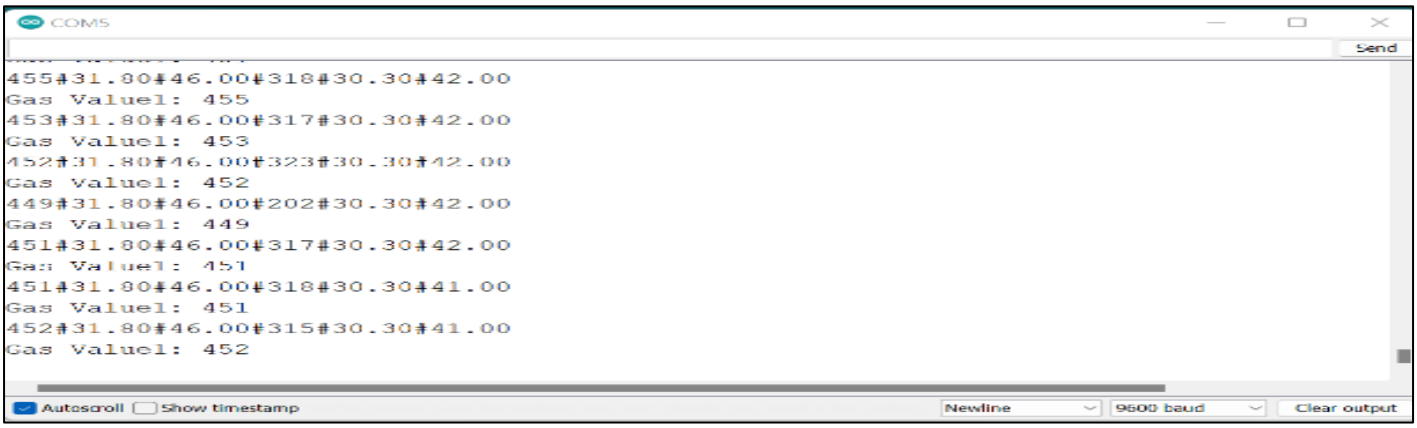

Fig 5: Sensor Output

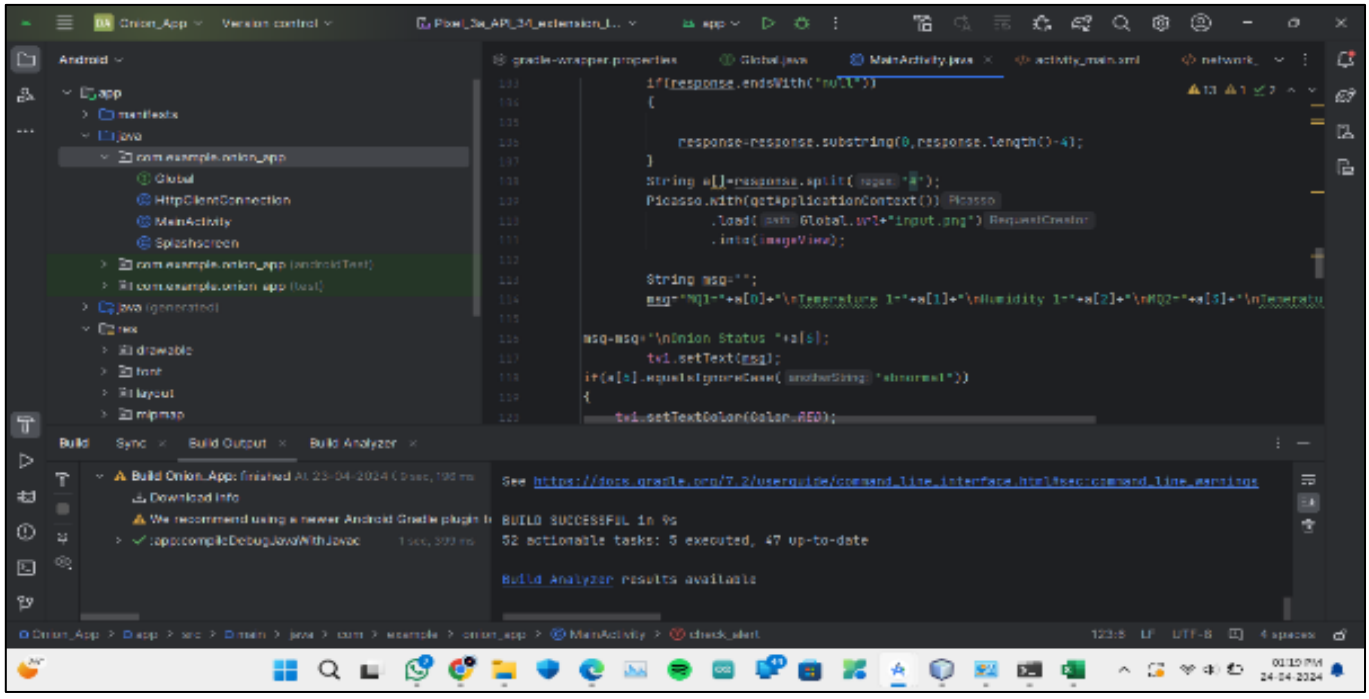

Fig 6: Android Studio – Application Development

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Fig 7: Mobile Alert System (Green – Normal, Red – Abnormal)

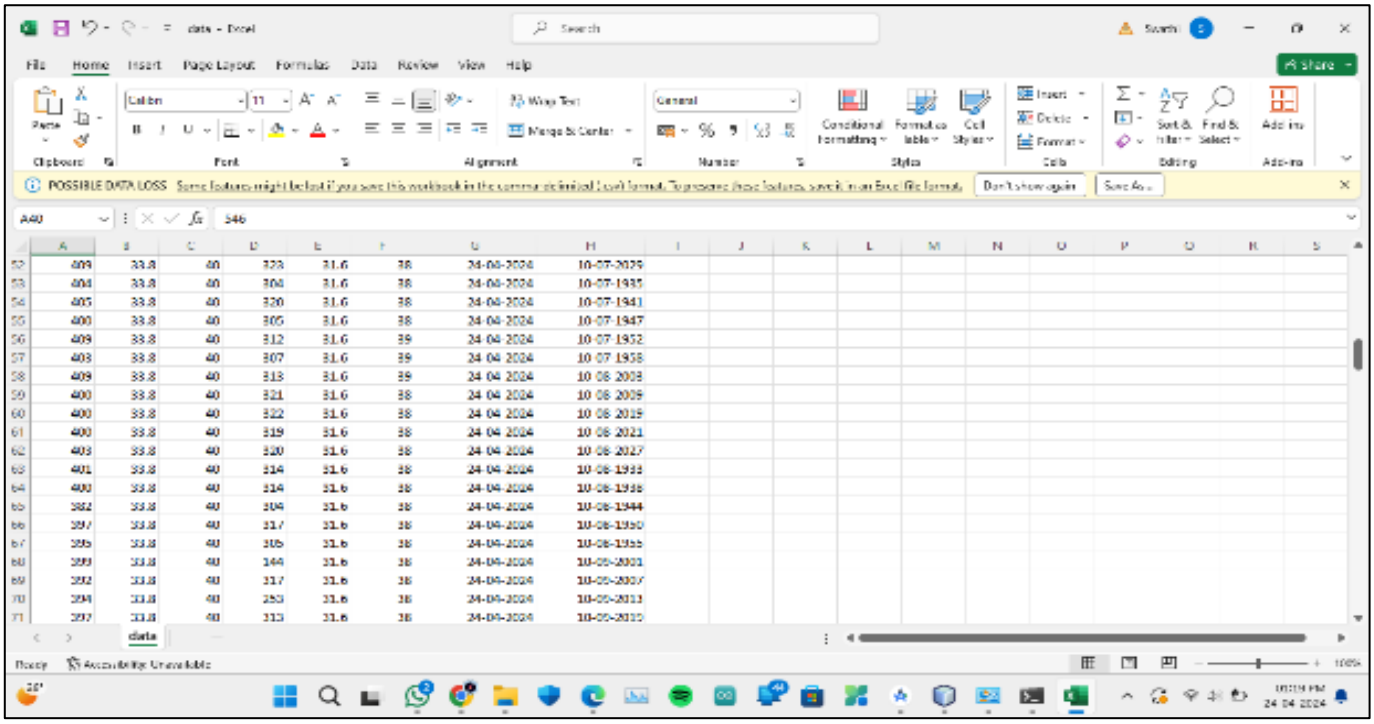

Fig 8: Storage of Real-Time Data

V. CONCLUSION

In this paper, Early Detection of Onion Spoilage during Storage and Transportation demonstrates the use of AI and IoT technology for monitoring Onions. The system integrates sensors, machine learning algorithms, and hardware components which has given positive results in monitoring the Onions.

Our methodology, utilizes gas sensors for detecting gases, a DHT11 sensor for measuring temperature and humidity, along with a camera for visual monitoring. The system can collect real-time data and transmit it to AWS Cloud for further analysis to improve efficiency in decision-making processes for post-production work.

The data collected from sensors has been processed by the ESP32 microcontroller and is sent to the server using a Wi-Fi module. Further, the server examines and provides the alert notification to the user's application console (mobile) through messages and picture format.

Our messaging platform allows farmers real-time insights at any time through alerts, which reduces hazards for farmers during the storage and transportation of Onions. In the future, implementing predictive analytic algorithms can help further potential spoilage events based on real-time sensor readings.

Conclusively, our AI and IoT-driven monitoring system for Onions degrades the spoilage during storage and transportation.

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