THE FRESHNESS OF FOOD DETECTION USING THE INTERNET OF THINGS

Prof. S.S. Punde[1], Kavita Varade[2], Akshada Ghuge[3], Shraddha Ranshavare[4]

[1] *Professor, Electronics and Telecommunication Department, Loknete Gopinathji Munde Institute of Engineering Education & Research, Nashik, Maharashtra, India*
[2,3,4] *Student, Electronics and Telecommunication Department, Loknete Gopinathji Munde Institute of Engineering Education & Research, Nashik, Maharashtra, India*

ABSTRACT

Around one-third of the food produced globally ends up as waste, totaling a staggering 1.3 billion tons annually. This waste is particularly prevalent at venues like hotels, family gatherings, and parties. The magnitude of this issue becomes apparent when considering its substantial environmental ramifications. Freshness plays a pivotal role in determining the quality of seafood and other perishable goods. The efficiency of food processing, storage, and marketing hinges on the ability to swiftly ascertain freshness. To address the limitations of existing freshness detection methods, this study introduces a rapid and non-invasive approach. The proposed method leverages IoT technology, employing an array of sensors and sophisticated algorithms to evaluate food quality and freshness. Initially, volatile organic compound (VOC) gases emitted by the food are collected and analyzed for distinctive features. Subsequently, a machine learning algorithm is employed for freshness assessment. To facilitate user interaction and interpretation of results, an application is designed to showcase the outcomes of food inspections conducted by the device. This innovative system aims to mitigate food waste by enhancing our ability to monitor and manage freshness levels effectively.

Keyword: - *food safety, machine learning, IoT, food freshness detection, food industries*.

---

1. INTRODUCTION

The global food industry faces a daunting challenge: approximately one-third of all food produced worldwide is wasted, amounting to a staggering 1.3 billion tons annually. This wastage isn't confined to large-scale operations but is a prevalent issue at hotels, family events, and gatherings where excess food often goes uneaten. Such substantial food waste not only represents a significant economic loss but also has far-reaching environmental implications, contributing to greenhouse gas emissions, water wastage, and land degradation. Addressing this problem requires innovative approaches that not only reduce waste but also ensure food quality and freshness, thus enhancing sustainability across the food supply chain. A critical aspect of food quality, particularly for perishable items like seafood, is freshness. The ability to accurately assess and maintain freshness is vital for food processing, storage, and marketing. Current methods of freshness detection often fall short, either being too time-consuming, destructive, or lacking in precision. To overcome these challenges, this project proposes a novel IoT-based system designed to rapidly and non-invasively detect food freshness using advanced sensors and machine learning algorithms.

The core objective of this study is to develop a comprehensive solution that addresses the drawbacks of existing freshness detection approaches. By capturing volatile organic compound (VOC) emissions from food products and analyzing them for specific indicators of freshness, this system aims to provide real-time and accurate assessments. The integration of machine learning algorithms further enhances the system's capabilities, allowing for continuous learning and improvement in freshness detection accuracy. Ultimately, this project seeks to revolutionize how we monitor and manage food freshness, contributing to a more sustainable and efficient food industry.

2. LITERATURE SURVEY

This study [1] introduces an innovative wireless sensor network (WSN)-based system aimed at monitoring key environmental parameters crucial for determining food freshness, including temperature, humidity, and gas emissions. By leveraging WSN technology, this system provides stakeholders with real-time data and alerts, empowering them to take immediate corrective actions to preserve food quality. This approach represents a significant advancement in food monitoring systems, offering a proactive solution to minimize food waste and ensure consumer safety.

In a related study [2], researchers delve into the integration of Internet of Things (IoT) technology within smart packaging to monitor the freshness of food products. Embedded sensors within the packaging continuously track variables like temperature, moisture levels, and gas emissions, transmitting this data to a cloud-based platform. This platform enables consumers to access up-to-date information regarding the quality and freshness of packaged food items, enhancing transparency and trust in the supply chain.

Another noteworthy contribution discussed by the author [3] involves the development of a comprehensive platform that incorporates RFID tags, one-dimensional codes, ontology-based context modeling, and tailored service functions to address food quality supervision needs effectively. This platform's technological components and implementation strategies are meticulously detailed, showcasing its potential to meet the rigorous demands of food quality assurance through rigorous testing and validation processes.

Furthermore, a recent endeavor by authors [4] has resulted in the creation of an Android application driven by Internet of Things principles to monitor diverse environmental parameters such as ammonia, methane, alcohol levels, and total volatile organic compounds (TVOC). Leveraging the capabilities of the ESP32 development board and a range of sensors, this application employs machine learning algorithms to analyze images and predict food conditions, complemented by a chatbot feature providing real-time food quality information and recommendations for nearby organic stores based on user location. This multifaceted approach highlights the potential of IoT-based applications in revolutionizing food quality monitoring and consumer experiences.

3. METHODOLOGY

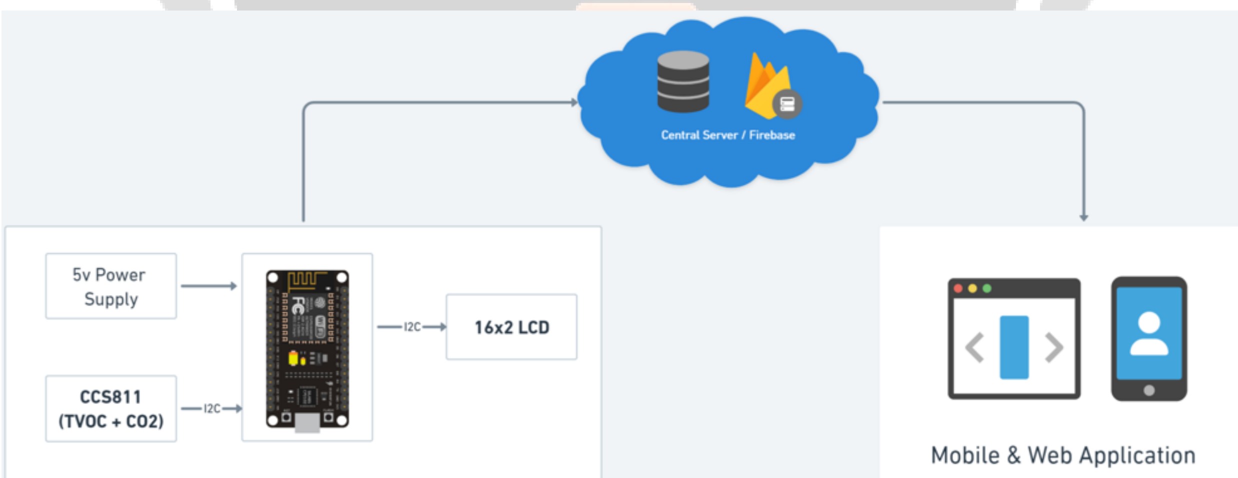

Figure 1 - System Architecture

The proposed system aims to develop an electronic device equipped with biosensors capable of detecting food spoilage. These biosensors are designed to measure various parameters of food, including total volatile organic compounds (TVOC), ethanol, and methane levels. The device's model is depicted in the block diagram below, featuring a microcontroller ESP32 and a range of electrical and biosensors such as the TVOC sensor, MQ135 sensor, and ethanol gas sensor. Through this setup, the system effectively senses TVOC levels, ethanol presence, and harmful gases in food items, enabling comprehensive monitoring of food quality.

The functionality of the system involves several key components:

- Sensors are employed to continually monitor the quality of food. Specifically, the TVOC and ammonia sensors are utilized to measure the respective content in food items, providing crucial data for assessing freshness and spoilage.
- A machine learning model is integrated into the system, utilizing a trained algorithm to predict whether a given food item is spoiled based on the TVOC and ammonia content detected by the sensors. This predictive capability enhances the system's ability to identify and flag potentially spoiled food items accurately.
- The ESP32 microcontroller is programmed to activate a buzzer as an alert mechanism when it identifies a spoiled food item. Additionally, the system transmits this data to a cloud platform, enabling real-time monitoring and data storage for further analysis.
- The system's data collection and analysis capabilities allow for the monitoring of the frequency of spoiled food occurrences. Moreover, the machine learning model can be periodically deployed to reevaluate and predict the average shelf life of various food items, contributing to more informed inventory management and waste reduction strategies.

In essence, this proposed system represents a significant advancement in food freshness detection, leveraging biosensors, machine learning algorithms, and cloud connectivity to enhance food quality monitoring and minimize food waste in various settings.

4. RESULT

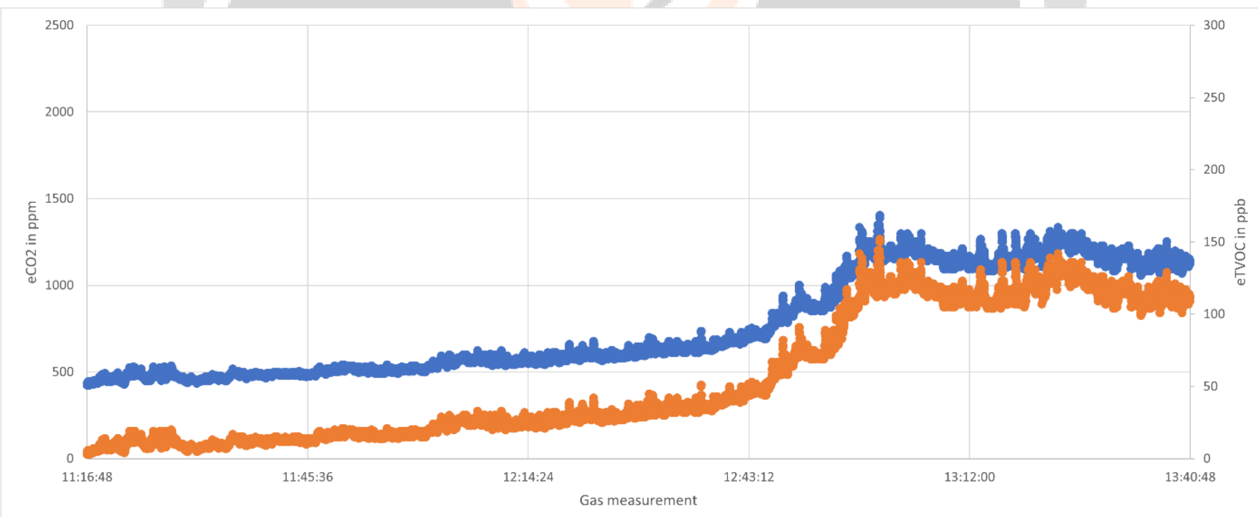

Figure 2 - CO2 and TVOC Graph

The demonstration above provides a comprehensive visualization of measurements taken over time, showcasing a dynamic interplay between different parameters. Represented in the graph are two key metrics: the equivalent carbon dioxide (CO_2) levels in parts per million (ppm), depicted in a striking blue color, and the equivalent total volatile organic compounds (TVOC) levels in parts per billion (ppb), represented in a vivid orange hue.

A notable observation from the graph is the point at which the measurements begin to exhibit accuracy, denoted by the gradual convergence of the plotted data points. This precision becomes notably evident around 11:35, marking a crucial juncture where the measurements reflect a more reliable and consistent depiction of the environmental conditions being monitored.

The graph's detailed depiction of the CO2 and TVOC levels over time not only provides valuable insights into the fluctuations and trends of these parameters but also underscores the significance of accurate measurement techniques. This visual representation serves as a powerful tool for understanding and analyzing environmental dynamics, facilitating informed decision-making and proactive measures in areas such as air quality management and pollution control.

No	Food Sample	No. of Reading	Expected Range	Average Result
1.	Juice, jam, jelly	10	180-320 ppm	250 ppm
2.	Pickles and chutneys	10	280-350 ppm	315 ppm
3.	Spoiled and alcoholic food	10	400-1000 ppm	700 ppm

Table 1 - Food Sampling

5. CONCLUSIONS

Foodborne illnesses continue to be a significant health concern, necessitating proactive measures to safeguard consumers. To address this challenge, the integration of biosensors and electrical sensors has become instrumental in assessing the freshness of household food items like dairy products, fruits, and various consumables. By detecting naturally emitted gases such as Ethanol, which signal food decay, these sensors enable early spoilage detection, providing crucial insights well before visible signs emerge. The implementation of advanced systems like the ESP8266/32 with specialized sensors allows for the detection of gas emissions, volatile organic compounds, and moisture levels in food items, ensuring timely intervention to prevent the consumption of spoiled food. Continuous refinement and expansion of these detection methods, including the incorporation of additional gas sensors and a broader range of food products, hold promise for further enhancing sensitivity and accuracy in identifying food spoilage. This comprehensive approach, coupled with user-friendly web applications, empowers consumers with the tools needed to make informed decisions about food quality and safety, ultimately reducing the risks associated with foodborne illnesses.

6. REFERENCES

[1] P. P. Ray, S. Pradhan, R. K. Sharma, A. Rasaily, A. Swaraj and A. Pradhan, "IoT based fruit quality measurement system," 2016 Online International Conference on Green Engineering and Technologies (IC-GET), 2016, pp. 1-5, doi: 10.1109/GET.2016.7916620.

[2] S. K. Panda, A. Blome, L. Wisniewski and A. Meyer, "IoT Retrofitting Approach for the Food Industry," 2019 24th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA), 2019, pp. 1639-1642, doi: 10.1109/ETFA.2019.8869093.

[3] Bing Jia and Yongjian Yang, "The design of food quality supervision platform based on the Internet of Things," Proceedings 2011 International Conference on Transportation, Mechanical, and Electrical Engineering (TMEE), 2011, pp. 263-266, doi: 10.1109/TMEE.2011.6199193.

[4] P. Kagale and S. H. Jangamshetti, "Development and Testing of IoT based Monitoring Interface for Solar Box Cooker," 2020 IEEE Bangalore Humanitarian Technology Conference (B-HTC), 2020, pp. 1-4, doi: 10.1109/B-HTC50970.2020.9297950.

[5] S. M. Mahidul Hasan, M. R. Ahsan and M. D. A. Satter, "IoT-Cloud-Based Low-Cost Temperature, Humidity, and Dust Monitoring System to Prevent Food Poisoning," 2021 3rd International Conference on Electrical & Electronic Engineering (ICEEE), 2021, pp. 21-24, doi: 10.1109/ICEEE54059.2021.9718789

[6] Zompanti, S. Grasso, M. Santonico and G. Pennazza, "A Sensor System for Non-Destructive Monitoring of Food Ripening Processes," 2020 IEEE International Workshop on Metrology for Industry 4.0 & IoT, 2020, pp. 80-83, doi: 10.1109/MetroInd4.0IoT48571.2020.9138308.

[7] P. P. Ray, S. Pradhan, R. K. Sharma, A. Rasaily, A. Swaraj and A. Pradhan, "IoT based fruit quality measurement system," 2016 Online International Conference on Green Engineering and Technologies (IC-GET), 2016, pp. 1-5, doi: 10.1109/GET.2016.7916620.

[8] M. -J. Lee, J. -T. Luo, J. -J. Shao and N. -F. Huang, "A Trustworthy Food Resume Traceability System Based on Blockchain Technology," 2021 International Conference on Information Networking (ICOIN), 2021, pp. 546-552, doi: 10.1109/ICOIN50884.2021.9334025.

[9] Bing Jia and Yongjian Yang, "The design of food quality supervision platform based on the Internet of Things," Proceedings 2011 International Conference on Transportation, Mechanical, and Electrical Engineering (TMEE), 2011, pp. 263-266, doi: 10.1109/TMEE.2011.6199193.

[10] Bing Jia and Yongjian Yang, "The design of food quality supervision platform based on the Internet of Things," Proceedings 2011 International Conference on Transportation, Mechanical, and Electrical Engineering (TMEE), 2011, pp. 263-266, doi: 10.1109/TMEE.2011.6199193.

[11] Bing Jia and Yongjian Yang, "The design of food quality supervision platform based on the Internet of Things," Proceedings 2011 International Conference on Transportation, Mechanical, and Electrical Engineering (TMEE), 2011, pp. 263-266, doi: 10.1109/TMEE.2011.6199193.

[12] M. Abbatangelo, E. N. Carmona, V. Sberveglieri, E. Comini and G. Sberveglieri, "Overview of Iot Mox Chemical Sensors Arrays for Agri-Food Applications," 2019 IEEE International Symposium on Olfaction and Electronic Nose (ISOEN), 2019, pp. 1-3, doi: 10.1109/ISOEN.2019.8823259.

[13] Sarmah and G. Aruna, "Detection of Food Quality and Quantity at Cold Storage using IoT," 2020 International Conference on Wireless Communications Signal Processing and Networking (WiSPNET), 2020, pp. 200-203, doi: 10.1109/WiSPNET48689.2020.9198348.

[14] S. K. Panda, A. Blome, L. Wisniewski and A. Meyer, "IoT Retrofitting Approach for the Food Industry," 2019 24th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA), 2019, pp. 1639-1642, doi: 10.1109/ETFA.2019.8869093.