ELECTRONIC NOSE

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Abstract - *Odour detection is essential in applications such as food quality monitoring, environmental sensing, and safety systems. Traditional odour identification relies on human perception, which is subjective and unsuitable for continuous or quantitative analysis. This work presents the design and development of a low-cost electronic nose system capable of detecting and classifying odours using a multi-sensor approach. The proposed system employs an array of MQ gas sensors (MQ-3, MQ-4, MQ-6, MQ-8, and MQ-135) to detect gases associated with organic decomposition and air quality. A DHT11 sensor is integrated to monitor temperature and humidity, enabling compensation for environmental variations that affect sensor performance. The Raspberry Pi Pico serves as the central processing unit for data acquisition and preliminary analysis, while the ESP32 module enables wireless communication. Sensor data is processed and transmitted in real time to the Blynk IoT platform, allowing remote monitoring and visualization. A 16×2 LCD display is used for local indication of sensor readings and detected odour conditions. The system identifies variations in gas concentration by comparing sensor outputs with predefined thresholds, enabling early detection of abnormal conditions. The developed electronic nose system offers a cost-effective, scalable, and real-time solution for odour detection. The integration of multiple sensors with IoT enhances reliability and accessibility, making it suitable for applications in food safety, agriculture, and environmental monitoring. This project demonstrates the potential of embedded systems and IoT-based solutions for efficient and continuous odour analysis.*

Key Words: Electronic Nose, MQ Gas Sensors, Raspberry Pi Pico, ESP32, IoT, Odour Detection, Blynk, DHT11, Air Quality Monitoring

1. INTRODUCTION

Odour detection plays an important role in many real-world applications such as food quality assessment, environmental monitoring, agriculture, and safety systems. In everyday situations, the detection of spoiled food, harmful gases, or environmental pollution is mainly dependent on the human sense of smell.

To overcome these limitations, electronic systems known as Electronic Noses (E-Noses) have been developed. An electronic nose is a device that mimics the functioning of the human olfactory system by using an array of gas sensors along with data processing techniques to detect and classify different Odours. These systems provide reliable, repeatable, and real-time Odour analysis.

In recent years, the development of intelligent sensing systems has gained significant importance in various fields such as environmental monitoring, food quality testing, and health care . One such innovative technology is the Electronic Nose (E-Nose), a device designed to detect and identify different types of gases and odors by imitating the human sense of smell. Unlike traditional chemical analysis methods, an electronic nose provides faster and more reliable detection with minimal human intervention.

The Electronic Nose works by collecting data from multiple gas sensors that respond to different chemical compounds. These responses are then processed using that learn to recognize specific odor patterns. The system can be trained to classify odors or gases accurately based on the sensor data, making it highly adaptable for real-world applications. This project aims to design and implement an electronic nose system that combines sensor technology, signal processing, techniques to detect and identify various gases efficiently. By using advanced algorithms, the system improves accuracy and reduces errors compared to traditional gas detection methods. The proposed system has a wide range of applications including air quality monitoring, industrial safety, medical diagnosis, and food freshness detection.

2. LITERATURE REVIEW

Electronic nose (e-nose) systems have emerged as an important research area in odour detection, quality assessment, and environmental monitoring. These systems typically utilize a sensor array to capture patterns of volatile organic compounds (VOCs), which are then processed using data analysis techniques for classification and decision-making. In recent years, the integration of Internet of Things (IoT) platforms has enabled real-time remote monitoring of environmental conditions and odour data, making such systems more efficient and accessible.

In this project, a multi-sensor array approach is adopted to improve the accuracy of odour detection. Instead of relying on a single gas sensor, multiple MQ sensors are used due to their varying sensitivity to different gases. The selected sensors include MQ-3 for alcohol and organic vapors, MQ-4 for methane and natural gas, MQ-6 for LPG and butane, MQ-8 for hydrogen, and MQ-135 for ammonia and volatile organic compounds. These sensors work together to generate unique response patterns for different odours. For instance, decomposing organic matter produces higher concentrations of gases like ammonia and methane, whereas mild or floral odours produce relatively lower and distinct patterns.

Environmental factors such as temperature and humidity significantly influence gas sensor performance, often causing drift and inaccurate readings. To address this issue, a DHT11 sensor is integrated into the system to continuously measure ambient temperature and relative humidity. These environmental parameters are considered during data processing to improve the consistency and reliability of odour detection.

The Raspberry Pi Pico serves as the central controller for data acquisition and processing. It reads analog signals from the MQ sensors using its built-in ADC channels and collects digital data from the DHT11 sensor. These readings are obtained at regular intervals to ensure continuous monitoring of the environment. However, raw sensor data often contains noise and fluctuations due to environmental and electrical factors. Therefore, data conditioning techniques such as averaging, normalization, and compensation for temperature and humidity variations are applied. This ensures that the data is stable and suitable for further analysis. Odour detection is performed by analyzing the combined response pattern of all sensors rather than relying on individual sensor outputs. Each odour produces a characteristic pattern across the sensor array, which is compared with predefined reference patterns or threshold values to classify conditions such as rotten odour, mild organic smell, or clean air. This pattern-based approach enhances detection accuracy and minimizes errors caused by cross-sensitivity of sensors.

For user interaction, a 16×2 I2C LCD display is used to provide real-time local visualization of sensor readings, including gas concentrations, temperature, humidity, and detected odour status. Additionally, to enable IoT functionality, the processed data is transmitted from the Raspberry Pi Pico to the ESP32 module using serial communication. The ESP32 then sends the data to an IoT platform for remote monitoring. This architecture improves system efficiency by separating data processing and communication tasks, making the electronic nose system more reliable, scalable, and suitable for real-time applications.

In terms of applications, electronic nose systems have wide usability across multiple domains. In the food industry, they can be used to detect spoilage and maintain quality control. In environmental monitoring, they help in detecting air pollution and hazardous gases. In healthcare, they can assist in diagnosing diseases through breath analysis. Additionally, they are useful in industrial safety systems for detecting gas leaks and preventing accidents.

Despite its advantages, the system has certain limitations. MQ sensors require a warm-up time and periodic calibration, and their accuracy may not match that of high-end industrial sensors. The systems performance can also be affected by environmental variations and network reliability in IoT communication. However, these challenges can be addressed by improving sensor quality, using advanced algorithms, and integrating cloud-based data processing.

The system also incorporates both local and remote monitoring capabilities. The 16×2 LCD display provides immediate on-site information, which is useful for testing, calibration, and quick observation. For remote monitoring, the ESP32 module enables wireless communication by transmitting data to an IoT platform such as Blynk.

Overall, the electronic nose system demonstrates an effective combination of sensor technology, embedded processing, and IoT communication. It provides a practical and scalable solution for real-time odour detection and monitoring, with strong potential for further development and real-world implementation.

3. PROBLEM STATEMENT

Odour detection in areas such as food storage and environmental monitoring is still largely dependent on human smell, which is subjective and unreliable. Most existing gas detectors are designed for single gases and cannot identify complex Odours like spoiled food or natural fragrances. There is a need for a low-cost electronic system that can accurately detect and classify different Odours in real time and allow remote monitoring.

3. OBJECTIVE

- To detect various gases and Odours using an array of MQ gas sensors
- To monitor temperature and humidity using the DHT11 sensor
- To process sensor data using Raspberry Pi Pico for Odour identification
- To transmit real-time data to the Blynk application using ESP32
- To display sensor readings and detected Odour locally on a 16×2 LCD
- To develop a low-cost and scalable Odour detection system

5. SYSTEM ARCHITECTURE

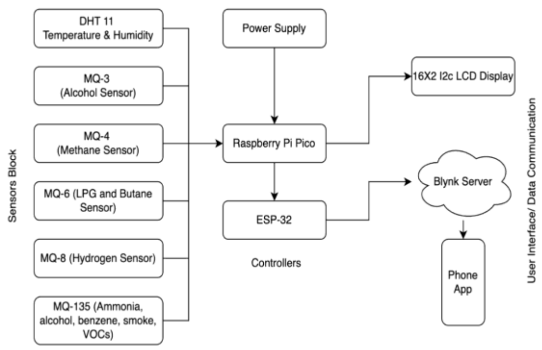

Fig. Block Diagram of Electronic Nose

6. METHODOLOGY

This chapter describes the systematic approach followed to design, develop, and implement the proposed electronic nose system. The methodology explains the step-by-step process starting from sensor selection to data acquisition, processing, Odour classification, and IoT-based monitoring. The aim of this methodology is to ensure reliable Odour detection using multiple gas sensors while maintaining low cost, scalability, and real-time performance.

The overall methodology is divided into sensor data acquisition, environmental compensation, processing and classification, local display, and wireless data transmission using IoT. The methodology of the Electronic Nose project follows a step-by-step process to ensure accurate detection and analysis of gases.

First, sensor selection and setup is carried out. Different gas sensors such as MQ-3, MQ-4, MQ-6, MQ-8, MQ-135 and the DHT11 sensor are chosen based on the types of gases and environmental parameters to be monitored. These sensors are interfaced with the Raspberry Pi Pico, which acts as the main controller.

Next, in the data acquisition stage, the sensors continuously sense gases and environmental conditions. Each sensor produces electrical signals depending on the concentration of gases present in the air. These signals are then collected by the controller. In the signal processing stage, the Raspberry Pi Pico processes the raw sensor data by converting analog signals into digital values, filtering noise, and preparing the data for analysis. Basic algorithms or predefined thresholds are used to interpret the sensor responses.

After processing, the system moves to data transmission, where the ESP32 module sends the processed data wirelessly to a cloud platform such as Blynk. This allows remote monitoring through a mobile application. Simultaneously, in the output stage, the processed data is displayed on a 16x2 LCD screen, providing real-time information about gas levels and environmental conditions. The methodology of the Electronic Nose project involves a systematic approach to detect and analyze different gases using sensor technology and data processing. First, a suitable set of gas sensors such as MQ series sensors and a DHT11 sensor are selected to sense various environmental parameters. These sensors are connected to a microcontroller (Raspberry Pi Pico), which collects the sensor data in real time.

7. RESULT & DISCUSSION

The Electronic Nose system was successfully designed and implemented to detect and classify different odours using a multi-sensor approach. During testing, the system demonstrated the ability to sense variations in gas concentrations using the MQ sensor array (MQ-3, MQ-4, MQ-6, MQ-8, and MQ-135). The sensors responded effectively to different environmental conditions and produced distinct output patterns for various odour sources such as clean air, mild organic smells, and decomposing substances. These variations confirmed that the sensor array approach is suitable for identifying odour patterns rather than relying on a single sensor.

The Raspberry Pi Pico efficiently collected analog and digital data from the sensors and performed basic processing such as noise reduction and normalization. The inclusion of the DHT11 sensor helped in monitoring temperature and humidity, which played an important role in stabilizing sensor readings. It was observed that environmental factors influenced gas sensor outputs; however, compensation using DHT11 data improved consistency and reliability.

The processed data was displayed locally on a 16×2 LCD, providing real-time information about gas levels and environmental parameters. Additionally, the ESP32 module successfully transmitted the data to the Blynk IoT platform, enabling remote monitoring through a mobile application. This feature allowed users to observe system behaviour in real time and receive updates without being physically present near the device.

The system also demonstrated the capability to detect abnormal conditions. When gas concentrations exceeded predefined threshold levels, alerts were generated, indicating potential hazardous situations. This confirms the effectiveness of the system for safety applications such as gas leakage detection and air quality monitoring.

However, certain limitations were observed during testing. MQ sensors require a warm-up period and proper calibration to provide accurate results. Sensor readings were occasionally affected by environmental variations and cross-sensitivity, where a sensor responds to multiple gases. Additionally, reliance on Wi-Fi connectivity for IoT communication may cause delays in data transmission under unstable network conditions.

Overall, the results indicate that the developed Electronic Nose system is a cost-effective and reliable solution for real-time odour detection and monitoring. The integration of multiple sensors, environmental compensation, and IoT connectivity enhances system performance and usability. With further improvements such as advanced data analysis techniques and high-precision sensors, the system can be made more accurate and suitable for a wide range of real-world applications.

8. ADVANTAGES

- Uses multiple MQ sensors for improved Odour detection accuracy
- Provides real-time monitoring through Blynk IoT platform
- Low-cost and easy-to-implement hardware design
- Local display and remote access available simultaneously.

9. CONCLUSION

The electronic nose system developed in this project successfully demonstrates the detection and classification of different odors using a combination of MQ gas sensors and a DHT11 sensor. By using a sensor array instead of a single sensor, the system achieves better reliability and improved odor recognition.

The Raspberry Pi Pico efficiently handles sensor data acquisition and processing, while the ESP32 enables real-time wireless communication with the Blynk IoT platform. The inclusion of a 16×2 LCD allows local monitoring alongside remote access through a mobile application.

Overall, the project provides a low-cost, scalable, and practical solution for odor detection with applications in food quality monitoring, agriculture, and environmental sensing, and it serves as a strong foundation for further enhancement using advanced data analysis techniques.

10. FUTURE SCOPE

1. Integration of Machine Learning Algorithms

- Advanced algorithms such as Artificial Neural Networks (ANN), Support Vector Machines (SVM), and K-Nearest Neighbors (KNN) can be implemented for intelligent odour classification.
- These techniques can analyze complex sensor patterns and improve accuracy compared to basic threshold methods.

The system can also be trained using datasets to recognize new odours over time.

2. Use of High-Precision Sensors

- Replacing MQ sensors with industrial-grade sensors can significantly improve sensitivity and selectivity.
- Advanced sensors provide faster response time, lower error rate, and better stability in harsh environments.
- This will make the system suitable for commercial and industrial applications.

3. Cloud-Based Data Storage and Analytics

- Integration with cloud platforms (such as AWS, Firebase, or ThingSpeak) can enable real-time data storage. Historical data can be analyzed to identify trends, patterns, and abnormal conditions.
- Predictive analysis can be applied for early warning systems and maintenance.

4. Development of Advanced Mobile/Web Applications

- A dedicated application can be developed with graphical dashboards, real-time charts, and notification systems. Features like push alerts, data history, and remote control can enhance user experience.
- Multi-user access can be enabled for industrial monitoring.

5. Automatic Calibration Mechanism

- Sensors can be equipped with auto-calibration techniques to maintain accuracy over time.
- This reduces the need for manual calibration and minimizes human error.
- Calibration algorithms can adjust sensor baselines dynamically.

6. Miniaturization and Portable Design

- The system can be redesigned into a compact and lightweight device.
- Portable devices can be used in field applications like agriculture, pollution monitoring, and safety inspections.
- Wearable e-nose devices can also be developed.

7. Power Optimization and Energy Efficiency

- Implementing low-power components and sleep modes can reduce energy consumption.
- This allows the system to operate for longer durations on battery power.
- Suitable for remote and continuous monitoring applications.

8. Integration with Smart Home and Industrial Automation

- The system can be connected with automation systems to take immediate actions.
- Example: Automatically turning on exhaust fans, alarms, or ventilation systems when gas levels rise.
- Improves safety and reduces human intervention.

11. REFERENCE

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