Design and Implementation of E-Nose for Disease Detection

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Abstract - The use of portable health diagnostic tools has gained increasing attention due to their safety, convenience, and ability to provide quick and comfortable testing experiences. Among these tools, analyzing human breath has emerged as a promising non-invasive method for identifying various diseases. This approach works by examining the types and concentrations of specific gases present in exhaled air. Within current gas detection techniques, the electronic nose (e-Nose) stands out for its high sensitivity, fast response time, real-time detection capability, and user-friendly design. This review outlines the role of volatile components in human breath for disease diagnosis, summarizes existing breath-testing technologies, and examines the progress made in electronic nose systems. The discussion focuses particularly on the sensor materials, signal-processing algorithms, and device architectures used in e-Nose research. Finally, the paper highlights ongoing challenges and future directions for improving the technology's performance and clinical applicability.

Key Words: Exhaled breath, E-Nose, Disease Detection, Breath-testing

1. INTRODUCTION

Human exhaled breath consists of roughly 150 mL of "dead space air" and about 350 mL of "alveolar air". The alveolar portion represents the gaseous interface of bloodstream and reflects metabolic activity in real time. In healthy individuals, exhaled air primarily contains nitrogen, oxygen, carbon dioxide, water vapour, and trace amounts of rare gases and metabolic by-products. Human breath contains thousands of endogenous and exogenous compounds that reflect both metabolic processes and environmental exposures. Measuring the relative abundance of these biomarkers can reveal the body's physiological or pathological state. Currently, the detection of breath components relies primarily on analytical techniques such as gas chromatography and mass spectrometry. However, the electronic nose (e-Nose) has become a powerful alternative due to its ability to detect, classify, and quantify complex gas mixtures. The e-Nose integrates an array of cross-sensitive chemical sensors with pattern-recognition algorithms to interpret Odor and gas profiles. These features are then analysed by pattern-recognition algorithms to determine the identity and concentration of the detected gases. This method provides significant advantages, Including low operational costs, fast response, and excellent discriminatory capability for non-invasive medical diagnostics. Although e-Nose technology has achieved notable advancements over the past three decades, several technical challenges remain. The absence of precise response models and a complete understanding of sensor mechanisms further complicate efforts to establish accurate mathematical descriptions of sensor behaviour. These challenges continue to limit the long-term stability and generalization capability of E-nose systems.

2. Body of Paper

Sec 2.1 OBJECTIVES

1. To review the development of electronic nose (E-nose) technology for medical applications.
2. To analyse how e-nose detect disease-related biomarkers in exhaled Breath.
3. To evaluate the accuracy and reliability of e-nose systems in disease diagnosis.
4. To compare different sensor types and data processing methods used in e-nose devices.
5. To identify current limitations and challenges in using e-nose technology clinically.
6. To explore potential future improvement and application of e-nose system in healthcare.
7. Easy to use cost effective with a real time output.

SEC 2.2 METHODOLOGY

The proposed health monitoring system integrates environmental and physiological sensing to provide real-time feedback and cloud-based analysis. Initially, the system design begins with identifying the required health parameters such as air quality, temperature, humidity, heart rate, and SpO2. The hardware consists of two primary sensors blocks: the breath sensor Block and Hearth vital block includes sensors like MQ-135, MQ-2 or BME688 for gas detection, CCS811 for air quality monitoring, and DHT22 for measuring temperature and humidity. Simultaneously the heart vital block uses the MAX30102 sensor for heart rate and SpO2

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measurements, alongside additional temperature and humidity sensors to track environment comfort.

All the sensor data is collected and processed by a central microcontroller, either an ESP32 or Raspberry Pi. The ESP32 is preferred due to its integrated Wi-Fi capability and low power consumption. Data from the sensors is filtered, calibrated, and translated into meaningful values such as beats per minute (bpm), air quality index (AQI), and temperature readings. For immediate feedback, an OLED display is used to show real-time data to the user. To enable remote monitoring, the ESP32's Wi-Fi module uploads data to a cloud server using Firebase or AWS IoT, typically via HTTP or MQTTP protocols.

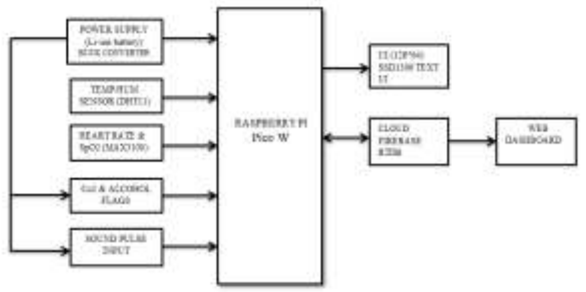

Fig -1: Block diagram of Design and Implementation of E-nose for Disease Detection

SEC 2.3 IMPLEMENTATION

The system begins with a power supply, which is stabilised through a buck converter to ensure safe voltage for all components. This regulated power operates the sensors that measure temperature, humidity, heart rate, SpO_2, CO_2, and sound levels. The Raspberry Pi Pico W then collects and processes all these readings as the central controller. After processing, the data is displayed locally for instant feedback, and the same information is uploaded to the Firebase cloud for remote access through a web dashboard.

Additionally, the system ensures that both local and online users receive real-time updates without delay. This dual output approach improves safety by allowing quick detection of abnormal readings. It also provides continuous monitoring even when the user is not near the device. Overall, the process creates a smooth flow from sensing to display, ensuring reliable health and environmental tracking.

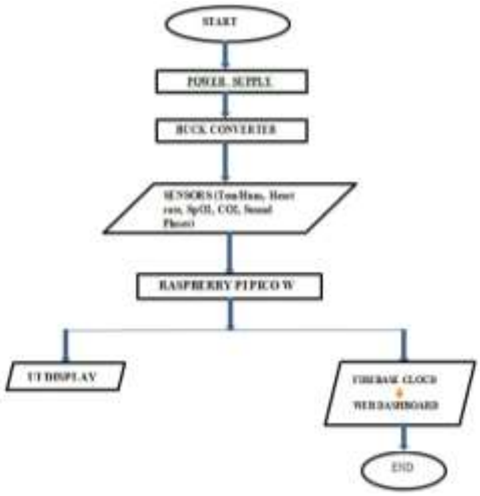

Fig-2: Flow chart for the Proposed Work

SEC 2.4 RESULT

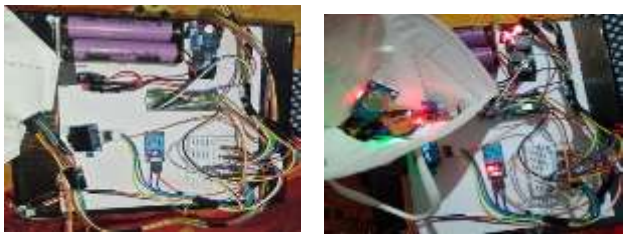

Fig-3 Physical Model of E-Nose for Disease Detection

Fig-4 Finger Calibration and testing

On the heart rate sensor, we should press and hold our finger for 60 sec then the calibration's will be started from 0 and will end at 10 and it will collect all the data from the body like Blood pressure, Humidity, Temperature, SpO2, Co2, and Alcohol level will be detected to detect the disease we should wear the mask and breathe through the mask so that the disease will be detected through the breathe and will be displayed on the Dashboard.

Fig-5 Combined Live vital signs and Disease Detection Panel

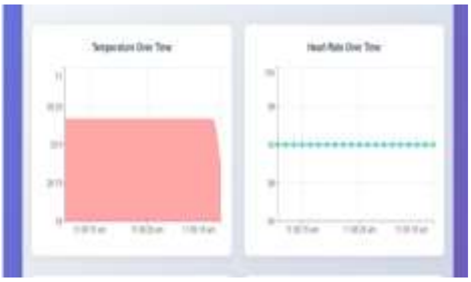

Fig-6 Temperature and Heart Rate Analysis Dashboard

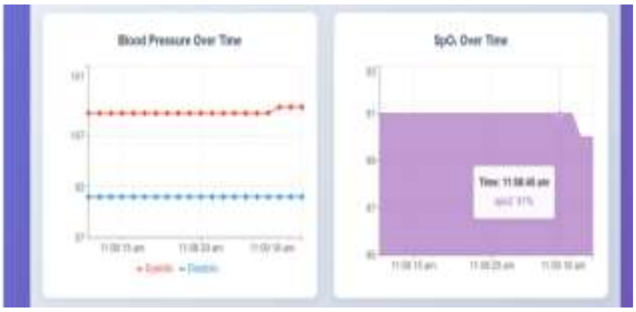

Fig-7 Blood Pressure and SpO2 trend monitoring

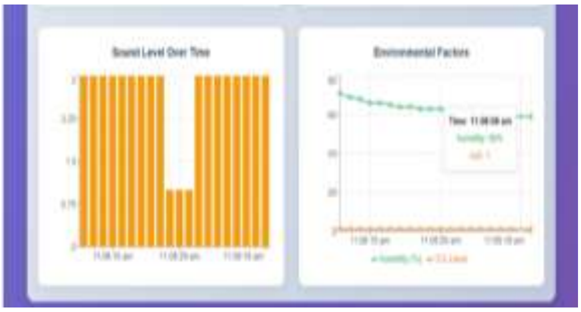

Fig-8 Sound Level and Environmental Factors Dashboard

Fig-9 AI Based Health Recommendations and Alerts

3. CONCLUSIONS

The design and implementation of an electronic nose (E-nose) for disease detection demonstrate the potential of using sensor arrays and intelligent algorithms as a non-invasive diagnostic tool by detecting disease-specific volatile organic compounds (VOCs). The system offers rapid, cost effective, and user-friendly diagnosis compared to conventional methods. The project highlights how combining hardware and machine learning can improve accuracy and efficiency in healthcare applications. Although further improvements and clinical validation are required, the E-nose provides a strong foundation for future research and real-world deployment in medical diagnostics.

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