Project Prāṇa: Breath Analyser Machine for Early Disease Detection Biomedical Research

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Running Title: *Project Prāṇa: Breath Analyser Machine*
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Abstract: ***Project Prāṇa introduces a low-cost, non-invasive diagnostic system based on breath analysis for early disease detection. The device integrates gas and pH sensors with AI-powered prediction models to detect volatile organic compounds (VOCs) linked to diseases such as diabetes and lung infections. Using TensorFlow-trained neural networks, the system achieves less than 8% prediction error. A companion web application complements the hardware by combining sensor data with basic user inputs to generate personalized health reports. This study demonstrates the potential of Project Prāṇa as a scalable, affordable, and preventive healthcare solution for both rural and urban communities.***

Keywords: Project Prāṇa, breath analysis, AI healthcare, disease detection, preventive medicine

1. Introduction

Project Prāṇa aims to revolutionize preventive healthcare by introducing a low-cost, non-invasive diagnostic tool that leverages breath analysis for early detection of diseases. Using volatile organic compounds (VOCs) and pH variations as biomarkers, the machine integrates gas sensors, pH sensors, and an AI-based prediction model to analyze exhaled breath samples. The system focuses initially on diabetes and lung infection detection, but its modular framework allows expansion to multi-disease diagnostics. A dedicated web application supports users by combining sensor data with basic health inputs to provide personalized insights. The AI model, trained using TensorFlow, demonstrates less than 8% prediction error, highlighting the system's potential in scalable, affordable, and accessible healthcare solutions. By reducing dependence on invasive, time-consuming, and costly diagnostic methods, Project Prāṇa presents a practical step towards next-generation health monitoring.

Rationale

The need for early-stage disease detection is critical, as it significantly improves the chances of successful treatment and enhances survival rates. Traditional diagnostic methods such as gastroscopy, laryngoscopy, angiography, computed tomography (CT), and mammography are either invasive, expensive, time-consuming, or expose patients to harmful radiation. Project Prāṇa presents a sustainable alternative in the form of a breath analyser machine that detects biomarkers in exhaled air. Exhaled breath is rich in small molecules and VOCs, including acetone, ethanol, ammonia, CO_2, ketones, and hydrocarbons, which can act as reliable biomarkers for diseases. Detecting such compounds even at concentrations as low as parts per million (ppm), parts per billion (ppb), or parts per trillion (ppt) can reveal valuable information about the onset and progression of diseases. By leveraging these non-invasive biomarkers, Project Prāṇa promotes early screening, reduces diagnostic costs, and improves accessibility, especially in low-resource settings.

Scientific Principle

Exhaled human breath contains more than 1,000 different volatile organic compounds (Miekisch et al., 2004; Kwak et al., 2013) (VOCs) and gases, originating from metabolic processes, the respiratory tract, and blood circulation. Each disease alters the biochemical state of the body, leading to changes in VOC levels. For example, elevated acetone is linked to diabetes (Kaloumenou et al., 2022), ammonia is associated with kidney malfunction (Miekisch et al., 2004), and benzene derivatives can indicate lung cancer (Hakim et al., 2012). Project Prāṇa detects these gases using pH and gas sensors (Konvalina & Haick, 2014), which are integrated with a machine-learning algorithm trained to recognize disease-specific patterns. This provides a non-invasive diagnostic approach (Dragonieri et al., 2009; Nakhleh et al., 2017), replacing conventional invasive tests such as biopsies or blood draws. The integration of AI enhances the reliability of diagnosis, as the system continuously improves its prediction accuracy with more data inputs.

Understanding Breath Analysis and Early Disease Detection

Exhaled breath contains small molecules and complex volatile organic compounds (VOCs) such as H2O, CO2, NO, NH3, ketones, aldehydes, alcohols, and hydrocarbons. Analysis of VOCs can provide valuable information about health status (Di Natale et al., 2003; Amann et al., 2014), especially in several disorders and disease conditions. The concept of using Breath Analyser machine is sustainable alternative to conventionally conducted diagonsis using expensive, time-consuming, invasive techniques, applied by appropriately trained health care professionals. For instance, gastroscopy, laryngoscopy, and coronary angiography are used for gastric cancer (GCa), lung cancer (LC), and myocardial infraction diagnosis, respectively. Other commonly used methods, such as computed tomography or mammography, used for breast cancer (BC), may also be harmful due to radiation exposure. Most VOCs are present in exhaled breath at parts per million (ppm), parts per billion (ppb) and parts per trillion (ppt) levels only. Detection of VOCs even at such lowlevels can be correlated with certain diseases, and they can be regarded as biomarkers of such ailments. In Project PRANA, we trained an AI model in TensorFlow to analyze breath sensor data, focusing on compounds like acetone and benzene. We converted the breath samples into numerical features representing their chemical patterns, then fed these into a neural network so it could learn which patterns are linked to specific diseases. Over many training cycles, the model refined its accuracy, enabling it to predict the likelihood of a disease from a new breath sample. The companion app displays these results and tracks changes over time, making PRANA a practical and non-invasive health monitoring too. App easilly accessible by patient as well as doctors. Modification for the app can be ensured, to connect patients directly linked with hospitals and doctors.

- Breath-based diagnostics
- AI in healthcare using tensor flow created app
- non-invasive disease detection
- Personalized health monitoring
- low-cost medical technology

2. Components

- pH Sensors: Sensitive pH sensors capture acidity changes in breath samples, correlating them with metabolic processes or disease conditions.
- Gas Sensors: Multiple sensor types including Metal-Oxide-Semiconductor (MOS), electrochemical, and photoionization detectors are employed. They detect compounds such as acetone (diabetes marker), ethanol, CO_2, ammonia, and hydrogen.
- Breath Collection System: A hygienic, non-invasive system (mouthpiece or face mask) collects exhaled air for analysis.
- Data Processing Unit: Arduino Uno microcontroller and processor analyze sensor readings in real-time, display results on an LCD screen, and transmit data for further processing.
- AI Prediction Model: A TensorFlow-based neural network converts sensor readings into numerical patterns, learns disease associations, and predicts health conditions with <8% error.
- Web Application: A user-friendly dashboard allows patients to input age, weight, activity level, and other health metrics. It combines this data with sensor outputs to generate personalized insights and recommendations.

3. Project Overview

The Project Prāṇa device integrates low-cost sensors with AI-driven analytics to create a diagnostic tool for preventive healthcare. The hardware setup consists of Winsen WSP2110 Acetone sensors and liquid pH sensors connected to an Arduino Uno with a 16x2 LCD display. The sensors measure VOCs and breath acidity to detect disease markers, while the microcontroller processes and transmits the data. A companion web application complements the device, enabling users to input simple health parameters (age, weight, activity level) to refine predictions and receive personalized reports. The project has currently focused on detecting diabetes and lung infections, achieving prediction accuracy with less than 8% error. It provides affordable, non-invasive screening for both urban and rural healthcare applications.

4. Working Principle

- Breath Analysis: The gas sensors establish a baseline and then detect deviations in acetone and benzene levels, which are displayed in real-time on the LCD screen.
- AI-Powered Prediction: Sensor readings are processed by a TensorFlow-trained neural network. The model interprets numerical features of VOC levels and correlates them with known disease biomarkers.
- Web Application: Users input basic metrics, which are combined with sensor outputs to generate individualized health reports, including interpretations, summaries, and lifestyle recommendations.
- Error Minimization: With continuous model training, the system has reduced prediction error to less than 8%, ensuring reliable disease detection.

5. Applications

- Instant screening of diabetes and lung infections without invasive tests.
- Affordable health monitoring solution for low-income and rural areas.
- Portable health diagnostic tool for fieldwork, awareness camps, and remote communities.
- Educational tool to spread awareness about preventive healthcare.
- Non-invasive routine health checks at home without needles or laboratory tests.

6. Future Scope and Vision

- Multi-Disease Diagnosis: Expansion to detect additional diseases by tuning sensors for VOCs such as ammonia (kidney disease) and benzene derivatives (lung cancer).
- IoT Integration: Incorporating Bluetooth/Wi-Fi modules to sync sensor data with cloud platforms and mobile apps for real-time health tracking.
- Mobile App Development: Transitioning the web application into Android/iOS apps to provide continuous health monitoring, personalized alerts, and health tracking dashboards.
- Commercialization: Scaling Project Prāṇa into a startup-ready hardware and software solution targeting healthcare institutions, home diagnostics, and preventive healthcare markets.
- Global Impact: Offering affordable and accessible early screening tools in developing nations, reducing healthcare costs and improving survival rates through timely intervention.

7. Conclusion

Project Prāṇa demonstrates the feasibility of a low-cost, AI-enhanced breath analyser machine for early-stage disease detection. By integrating pH and gas sensors with machine-learning algorithms, the system identifies disease biomarkers in human breath with high accuracy. It offers significant benefits over conventional diagnostic techniques by being non-invasive, portable, affordable, and user-friendly. Beyond diabetes and lung infections, the system can be scaled to detect multiple diseases, thereby shaping the future of preventive and personalized healthcare. As an innovative fusion of biomedical engineering, artificial intelligence, and digital health tools, Project Prāṇa paves the way for next-generation health diagnostics with global applicability.

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