TEMPERATURE BASED BREATHING FREQUENCY DETECTOR

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ABSTRACT

Breathing rate measurement is an essential component of effective health monitoring. A deviation from normal breathing can be a sign of a number of medical disorders, including respiratory problems of the heart and metabolism. The COVID-19 pandemic has underscored the need for remote health monitoring solutions, emphasizing the urgency of accessible and affordable breath analysis tools. Our project aims to develop a thermistor-based breath analysis system for real-time monitoring and assessment of breathing patterns. By strategically placing a thermistor near the nose, we capture temperature fluctuations during inhalation and exhalation. This temperature data is collected and transmitted via a Node MCU to a computer for processing. In Python, we employ a real-time data processing script that not only visualizes the temperature changes as a live breath graph but also calculates the breaths per minute (BPM). We determine BPM by identifying peak temperature values within a specified time window, thereby offering insights into the user's breathing rate. To distinguish between normal and abnormal breathing patterns, we establish a BPM threshold range (12-20 BPM) for normal. Any deviation from this range is labelled as abnormal. This system offers the potential for early detection of respiratory issues or sleep disorders. It can be used for remote patient monitoring and can serve as a valuable tool in healthcare and wellness applications. This tool may be used to identify irregular breathing patterns and sleeping disorders.

Keywords*: Breathing rate – thermistor – temperature – inhalation and exhalation – frequency.*

1. INTRODUCTION

Breathing is a fundamental physiological process that sustains life, and its analysis provides invaluable insights into an individual's health and well-being. Breathing, an involuntary and continuous process, is fundamental to life itself. It is a process that often goes unnoticed, taken for granted, and yet, it plays a pivotal role in our overall health and well-being. The rate at which we breathe, known as our respiratory or breathing frequency, can provide vital insights into our physical and emotional state. The duration between inspiration and expiration must be recorded in order to calculate the respiratory rate. We are aware that eupnoea, which describes normal breathing, is called tachypnoea and bradypnea, which describes breathing that is below the lower limit of normal breathing. A healthy person's usual breathing rate is 14 to 16 cycles per minute. Individuals of different ages have varying breathing rates. Fresh air enters the lung during inspiration and expiration, and carbon dioxide is exchanged between the lung and deoxygenated blood. Expiration occurs when the air that contains carbon dioxide leaves the body through the lungs.

Changes in breathing frequency can serve as early indicators of various health conditions, such as respiratory illnesses, stress, sleep disorders, and more. Traditionally, monitoring respiratory rate has involved cumbersome and intrusive methods, including the use of sensors, wires, or uncomfortable chest straps. These methods not only disrupt daily life but also limit the duration and context in which data can be collected. Consequently, there has long been a need for a more convenient, non-invasive, and continuous means of monitoring breathing frequency. The composition and patterns of exhaled breath contain a treasure trove of information, from biomarkers indicating the presence of diseases to indicators of overall physiological and psychological states. As a non-invasive and readily accessible source of information, breath analysis has gained prominence in healthcare, diagnostics, and wellness management.

1.1 Background of the project:

The human breath is a complex mixture of gases, volatile organic compounds (VOCs), and aerosolized particles. Changes in breath composition and respiratory patterns can be indicative of various medical conditions, including respiratory diseases, metabolic disorders, and even infectious diseases like COVID-19. Consequently, there is a growing interest in developing innovative methods to monitor and analyse breath parameters. Despite the potential benefits of breath analysis, traditional methods often involve expensive, bulky equipment and can require specialized personnel. This limitation hampers its accessibility, especially for continuous monitoring in non-clinical settings. The necessity of our project lies in addressing the challenges associated with affordable, real-time, and non-invasive breath analysis. We propose a solution cantered around the use of a thermistor-based system for capturing temperature changes during inhalation and exhalation. By integrating this system with readily available hardware like the NodeMCU and a computer, we aim to provide a user-friendly, cost-effective, and portable breath analysis platform.

1.2 Advantages of thermistor-based breath analysis:

Thermistors, which are temperature-sensitive resistors, offer a non-invasive approach to breath analysis. Placing a thermistor near the nose or mouth allows for the collection of temperature data without the need for uncomfortable or intrusive methods. Our approach leverages widely available and affordable components such as the NodeMCU microcontroller and thermistors, making it accessible to a broad user base. This democratizes the field of breath analysis, enabling more individuals to monitor their respiratory health. The use of a NodeMCU facilitates real-time data acquisition and transmission. With the integration of a Python script, we can provide users with a live breath graph, allowing them to visually track their breathing patterns. By analyzing the temperature changes over time, we can calculate breaths per minute (BPM). This metric is fundamental in understanding the frequency of breathing cycles and can be a valuable indicator of respiratory health.

1.3 Applications and significance

Healthcare professionals can employ this system for remote patient monitoring, especially for individuals with respiratory conditions such as asthma or chronic obstructive pulmonary disease (COPD). Early detection of abnormal breathing patterns can lead to timely interventions and improved patient outcomes. Individuals interested in maintaining their overall health and fitness can use this system to monitor their breath patterns during exercise, meditation, or relaxation techniques. Sleep disorders like sleep apnea are characterized by irregular breathing patterns during sleep. Our system can be adapted for overnight monitoring to aid in the diagnosis of such conditions. As breath analysis has shown promise in detecting viral infections, our system can serve as a preliminary screening tool for COVID-19 and other respiratory illnesses. This proposed system aims to bridge the gap between breath analysis and everyday health monitoring. By utilizing thermistors and affordable microcontrollers, we offer a practical and accessible solution for real-time breath analysis. This project addresses the pressing need for non-invasive health monitoring tools, especially in the context of remote healthcare and wellness management. Through this research and development endeavour, we endeavour to contribute to the advancement of healthcare technology and the improvement of individual and public health.

2. LITERATURE SURVEY

The usage of thermistor-based sensors for respiratory rate monitoring and associated biological applications is explored in the literature review. Together, these findings highlight the promise of thermistors as adaptable and affordable instruments in the medical and scientific fields. The creation of a spirometer employing thermistor-based sensors is covered in the introductory paper, along with how it might be used to identify sleep problems. It emphasizes the need of tracking airflow using thermistors to measure temperature changes. The next work focuses on developing a low-cost respiration monitor utilizing thermistors so that it may be used in low-resource settings. For patient safety, it has features including a breathing alert and a low battery indication. The following academic paper provides a circuit-based technique to increase the precision of temperature monitoring using thermistors and its application to measuring respiratory airflow.

1. A Remote IoT-Based Breathing Rate Monitoring System for Healthcare Applications - S. M. Riazul Islam et al - This paper presents an IoT-based system for remotely monitoring breathing rates. It utilizes wearable temperature sensors placed on the body to collect temperature data, which is then processed in real-time and transmitted to a cloud-based platform. The system demonstrates the

feasibility of using temperature variations for monitoring respiration and shows promise for telehealth applications.

2. Wireless Breathing Rate Monitoring Based on an IoT System with a Flexible Self-Powered Sensor – Xuewi Liu et al - this research explores an IoT based system flexible, self powered sensors to monitor breathing rates. It combines temperature sensing with energy harvesting for a self sustainable solution. The study emphasizes the potential for continuous and unobtrusive respiratory monitoring.
3. Wireless and Remote Sensing for Respiratory Rate Monitoring – Xianjun Sam Zheng et al. – This literature survey discusses various wireless and remote sensing methods for respiratory rate monitoring. It reviews sensor technologies, data transmission methods, and applications in healthcare and wellness monitoring.

2.1 Identified Gaps and Challenges:

The literature review also identified several overarching gaps and challenges. Even while some studies stress the creation of low-cost monitoring choices, there is still a demand for even more accessible and cost-effective alternatives, particularly for healthcare facilities in regions with limited resources. It is essential to close this pricing gap if you want widespread adoption. Several studies go through how to make thermistor-based measurements more accurate. However, it is frequently lacking for these strategies to be validated in larger and more varied patient groups. A significant difficulty is determining how well these systems perform in realistic situations. Traditional thermistor-based approaches can be replaced by the contact-free thermal imaging method that is stated in one of the studies. However, further study is required to examine its limits and prove its efficacy, particularly in clinical applications. The data processing and analysis techniques are not usually fully covered in these articles, despite the fact that they show inventive hardware solutions utilizing thermistors. To transform unprocessed sensor data into useful insights, it is crucial to develop reliable signal processing algorithms and data interpretation tools.

2.2 Project Goals and Solutions:

- The main objective is to create a temperature-based breathing frequency detector that is both accessible and inexpensive. To guarantee its widespread acceptance, this detector should be created for use in healthcare environments, particularly those with little resources.
- The project's main goal is to increase measuring precision. We'll use exacting calibration and validation procedures to do this. These procedures are necessary to ensure the accuracy of the detector's observations of respiratory rate across a range of patient groups. The research will make use of thermistor sensors' capacity to extract respiratory waveforms.
- The detector's usefulness may be increased by this novel usage of thermistor sensors, especially in therapeutic settings. The project will create and use sophisticated signal processing techniques to enable accurate respiratory rate monitoring. These algorithms will make it easier to adjust and analyse data in real time.

3. OBJECTIVE AND METHODOLOGY

Our project, titled "Temperature-Based Breathing Frequency Detector" using thermistor and Node MCU for Remote Monitoring is driven by a clear set of goals aimed at creating a user-friendly, affordable system for tracking an individual's breathing rate based on the temperature difference during inspiration and expiration. The methodology of your project involves several key steps, including hardware setup, data acquisition, data processing, breath rate calculation, and breath analysis. Below is a detailed description of the methodology for our project.

3.1 Block Diagram

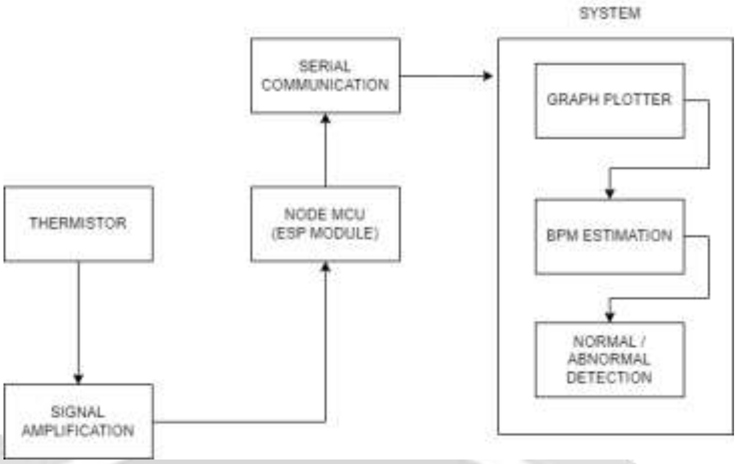

Figure 1.Process flow chart

3.2 Methodology of the Project

The methodology for temperature based breathing frequency detector involves several key steps:

1.Hardware setup: Build the hardware parts, including the thermistor sensor and NodeMCU (ESP8266), in the appropriate order. To sense temperature, attach the thermistor to the analog input pin of the NodeMCU.For stable functioning, check the power supply and connections.
2.Callibration: To translate temperature values into information about breathing frequency, calibrate the thermistor sensor. Under controlled circumstances, measure temperature changes corresponding to known respiration rates to create a calibration curve.
3. NodeMCU programming: Use the Arduino IDE to program the NodeMCU. Develop a code to read temperature data from the thermistor sensor. Implement signal processing algorithms to analyse temperature fluctuations and identify respiratory patterns.
4. Data acquisition: collect real time temperature data from the thermistor sensor. Sample the data at a high frequency to capture detailed respiratory patterns.
5. Respiratory rate calculation: apply the signal processing techniques to analyse the temperature data and calculate the respiratory rate. Implement algorithms to distinguish breathing patterns form noise and artifacts.
6. NodeMCU – PC communication: transmit the processed data to a computer for further analysis.
7. Data plotting with Thonny IDE: Utilize Thonny IDE(Python environment) on the computer to receive and plot the data in real time. Develop Python scripts to visualize the respiratory rate data as a dynamic plot.
8. Data analysis and validation: analyse the plotted data to validate the accuracy and reliability of the respiratory rate measurements. Compare the results with a reference standard or data from other respiratory rate monitoring methods to assess the performance.
9. Testing and optimization: conduct comprehensive testing under different conditions and with various subjects to assess the robustness.
10. Deployment and Integration: integrate the temperature based breathing frequency detector into the intended healthcare or research environment, ensuring compatibility and usability.

3.3 Significance of thermistor :

- Due to their extreme sensitivity to temperature changes, thermometers are perfect for recording the minute temperature changes brought on by breathing. Due to its sensitivity, it is possible to identify even minute changes in a subject's breathing rhythm.
- Thermistors respond quickly, making it possible to monitor respiration rate in real-time. This rapid reaction is essential for recording rapid breathing patterns or quickly

identifying changes in breathing rhythm. Thermistors are useful for wearable or portable monitoring systems since they are lightweight and tiny.

- The breathing frequency detector's adaptability for application in different environments is increased by its mobility. The mobility of the breathing frequency detector increases its adaptability for application in various environments.
- Many thermistors have low power consumption, which is beneficial for battery-powered or energy-efficient applications, ensuring prolonged device operation. Thermistors are useful for wearable or portable monitoring systems because they are lightweight and small.

3.4 Significance of data processing:

Python is a relatively easy language to learn and use, even for beginners. This makes it a good choice for developing temperature-based breathing frequency detector Python has a rich library of scientific and mathematical functions, which can be used to perform a variety of tasks, such as filtering and analyzing thermistor data. This makes it easy to develop temperature-based breathing frequency detectors that are accurate and reliable. Python can be used to read data from a thermistor. This data can then be stored in a file or in a database. Python can be used to filter the thermistor data to remove noise. This can be done using a variety of filtering algorithms, such as moving average filters and median filters. Python can be used to analyse the thermistor data to calculate the breathing rate. This can be done using a variety of signal processing techniques, such as Fourier transforms and autocorrelation.

3.5 Breath per minute calculation:

The Python code establishes a serial connection with the NodeMCU, reads sensor data from it in real-time, and plots the sensor data on a graph using Matplotlib. Additionally, it calculates the breaths per minute (BPM) based on the sensor data and provides a real-time BPM reading on the console.The code begins by configuring the serial port to communicate with the Arduino and initializes empty lists to store time and sensor data. It sets up a real-time plot using Matplotlib, defining a figure and axis. The `update` function is responsible for reading sensor data, updating the plot, and detecting breaths based on changes in the sensor data. The `detect_breath` function checks for sensor value rises and drops, and if a breath is detected, it increments the `breaths` count. After 60 seconds, it calculates the BPM and categorizes it as "Normal" or "Abnormal" based on a predefined range

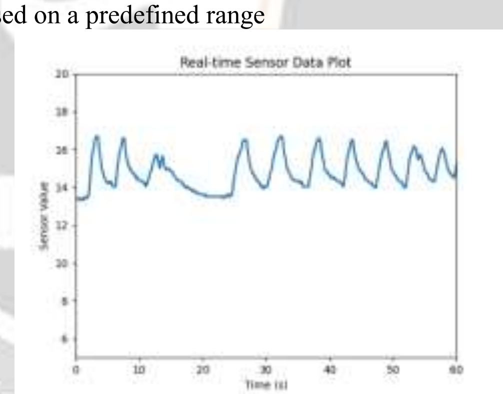

Figure 2 Abnormal breath pattern

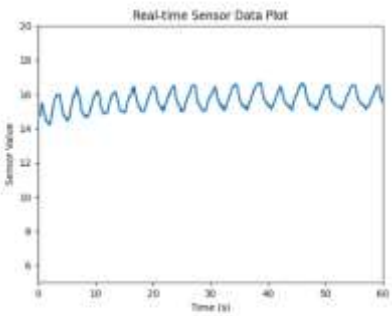

Figure 3 Normal breath pattern

4. CONCLUSION

In conclusion, our project has successfully demonstrated the feasibility of utilizing thermistors in NTC (Negative Temperature Coefficient) mode for breath analysis. We have designed and implemented a practical and affordable system that captures temperature variations during inhalation and exhalation, processes the data in real-time, calculates breaths per minute (BPM), and distinguishes between normal and abnormal breathing patterns. This project addresses the pressing need for accessible and non-invasive health monitoring tools, particularly in the context of remote healthcare and wellness management. By providing users with a user-friendly platform for continuous breath analysis, we contribute to the advancement of healthcare technology and empower individuals to take proactive measures towards better respiratory health. As we move forward, further refinements and validations of our system can pave the way for its integration into healthcare and wellness applications, ultimately improving the quality of life for individuals worldwide.

5. REFERNCE

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