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Advanced Non-Invasive Lung Monitoring System Using IoT

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Abstract

Lung monitoring is an important tool for maintaining lungs and detecting lung disorders and assessing overall health. Frequent lung monitoring can help the individuals and healthcare providers to detect the disorder early on, when they are more treatable. Lungs can be monitored through invasive lung monitoring method which involves inserting a tube or needle into lung tissues, which can result in infection, damage, discomfort to the individuals. Non-invasive lung monitoring is more efficient because there is no need of injecting any needles or tubes into the lung tissues. This method becoming more popular because it is easy to use, low cost and reduced risk. Non-invasive lung monitoring can detect lung problems by analysing body parameters such as flowrate, temperature, oxygenation level, etc. The sensors can be used to measure these parameters. These sensors communicate with the microcontroller to collect parameters and provide results based on those parameters real time and providing more efficiency.

1. Introduction

Lung monitoring is an essential tool for maintaining respiratory health and detecting lung disorders, allowing for early intervention and treatment. However, traditional methods of lung monitoring, such as CT scans and chest X-rays, can be costly and expose individuals to harmful radiation. This makes a non-invasive method of lung monitoring particularly valuable, as it eliminates the need for tubes, needles, or gels to be inserted or applied to the lungs, and reduces exposure to radiation. A new portable device has been developed that allows for non-invasive lung monitoring, which can be used in non-clinical settings, such as at home. This device uses external body parameters, such as oxygenation levels and respiratory flow, to detect lung disorders. It consists of three sensors that accurately identify these parameters and are interfaced with an Arduino microcontroller. The microcontroller compares the sensor readings with a set of pre-trained data sets, and the results are displayed on an LCD screen (Massaroni et al.) . The results can also be viewed remotely using an Android application on a smartphone. Real-time monitoring allows healthcare providers to quickly assess the severity of a patient's condition and provide appropriate treatment. The use of this device in non-clinical settings allows individuals to monitor their own lung function and take proactive steps to maintain respiratory health. (Emmanouilidou et al.) Overall, this non-invasive method of lung monitoring has the potential to improve respiratory health outcomes and reduce healthcare costs.

2. Existing system

E. Daniel Hurtado presents a novel method for non-invasive respiratory volume monitoring using machine learning techniques. Respiratory volume monitoring is essential for the diagnosis and management of lung disorders. The conventional methods for respiratory volume monitoring involve invasive techniques such as intubation or the use of masks, which can be uncomfortable and can cause distress to patients. (E et al.) This method provides a non-invasive approach to monitor respiratory volumes. The proposed method involves the use of a wearable temperature-based sensor which consists of the respiratory sensor and it is worked by the thermal resistor that measures the temperature of inhaled and exhaled air. (Ladjal et al.) The changes in temperature are used to calculate the flow of the respiration gases, and this flow is then converted into an electrical signal. This electrical signal is used to monitor the user's respiration and predict tidal volume and minute ventilation. (Yan et al.) The proposed method uses a machine learning algorithm to predict the respiratory volumes accurately. The machine learning algorithm is trained using a dataset of respiratory volume measurements taken from healthy subjects. (Lozano, Fiz, and Jane) The dataset includes parameters such as BMI, age and gender, which are used to train the algorithm. The trained algorithm can predict the respiratory volumes of individuals accurately (Liu and Huang) . The proposed method has several advantages over the conventional methods. It is non-invasive, which means that it is less distressing to patients. It is also cost-effective and portable, which means that it can be used in a variety of settings. The proposed method can provide accurate and real-time measurements of TV and MV, which are essential parameters in respiratory monitoring (Kwan et al. Ali et al.) . The proposed method provides an non-invasive approach to respiratory volume monitoring. The use of a wearable temperature-based sensor and machine learning algorithm provides accurate and real-time measurements of minute ventilation and tidal volume. The proposed method has the potential to revolutionize respiratory monitoring by providing a cost-effective, portable, and non-invasive approach (Marjanovic, Mimoz, and Guenezan) . The proposed solution is based on the use of a wearable temperature sensor, which may not be appropriate for all people. (Jacques et al.) Patients with skin sensitivities or allergies, for example, may feel discomfort or irritation if they wear the sensor for lengthy periods of time and the accuracy of the thermal resistor in the respiratory sensor can be affected by the ambient temperature.

3. Proposed System

Typically, when a patient wants to assess the health of their lungs, they must visit a healthcare center and wait for a physician to examine them. This process can be time-consuming and inconvenient for patients, particularly those with serious conditions who may not be able to travel long distances or wait for extended periods of time. Furthermore, it is not always the most feasible option for monitoring lung function. This paper proposes a non-invasive lung monitoring system that uses IoT technology, which is a portable device that can be used at home or in non-clinical settings. (Suresh et al.) This technology is simple to operate and does not require any experienced physicians, which makes it a suitable choice for individuals who are unable to travel to healthcare facilities. The device consists of three sensors: a flow sensor, an MQ135 gas sensor, and a MAX30100 pulse oximetry and heartrate sensor. (Bhutani et al.) The flow sensor detects the flow rate of the patient's breaths, while the MQ135 gas sensor detects the concentration of gases in the air exhaled by the patient. The oxygenation level is measured by placing the patient's fingertip on the pulse oximetry sensor (Miekisch et al.) . The data collected from these sensors are sent to an Arduino, where they are compared with trained datasets to detect lung disorders such as asthma, COPD, and SLE. The results are displayed on an LCD screen as well as an Android application, which can be accessed by healthcare providers remotely using their smartphones. (Osman) With this device, patients can frequently monitor their lung health without the need to travel to healthcare centers or wear invasive devices. It provides a comfortable and convenient option for patients to track their health and allows healthcare providers to remotely monitor and provide necessary treatment based on the collected data.

Threshold values of parameters

4. Hardware Description

Flow Sensor

TABLE 1. Threshold values of parameters

Disorder	Parameter	Threshold Value
Asthma	Flowrate	Less than 1700
COPD	Acetone	Greater than 800
SLE	Spo2	Less than 90

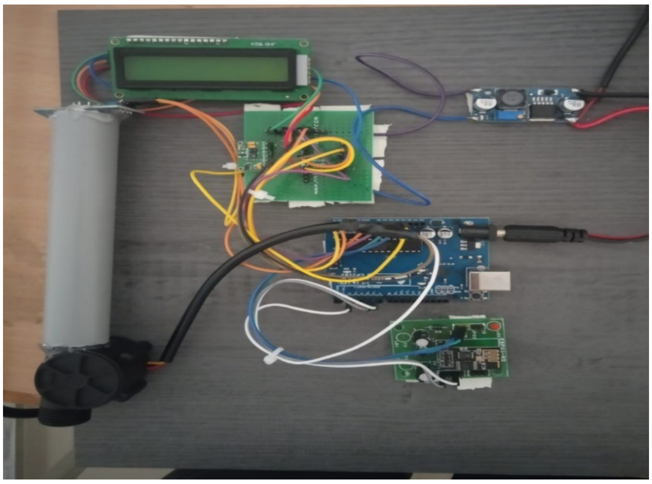

FIGURE 1. **Proposed System**

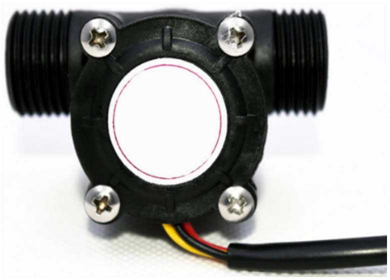

FIGURE 2. **Flow sensor**

The YFS201 sensor is a flow rate device that is designed to determine the flow rate of liquids in a variety of applications. It is commonly used in water flow monitoring systems, such as those found in industrial, commercial, and residential settings. The YFS201 sensor detects the rotation of a magnetic rotor inside the sensor using a hall effect sensor. As liquid flows through the sensor, it causes the rotor to rotate, and the hall effect sensor detects the rotations and converts them into electrical pulses.

Mq-135 Gas Sensor

The MQ135 is a gas sensor that can detect a variety of air pollutants like ammonia, nitrogen oxides, benzene, and other organic compounds.. It is commonly used in air quality monitoring applications and can be integrated into a variety of electronic devices. The MQ135 sensor is based on a metal oxide semiconductor (MOS) technology,

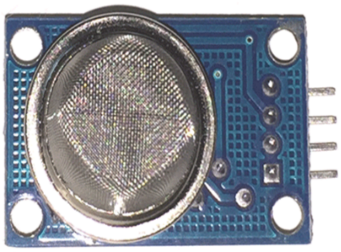

FIGURE 3. **Mq-135 Sensor**

which involves a ceramic sensing element coated with a thin layer of a metal oxide film.

Max30100 Pulse Oximetry and Heart Rate Sensor

FIGURE 4. **Max30100 Sensor**

The MAX30100 is a highly integrated optical sensor module that is designed for heart rate and pulse oximetry monitoring in wearable and medical devices.The MAX30100 sensor module combines three functions into a single compact package: a red LED, an infrared LED, and a photodetector. The wavelength of the red LED is 660nm, while the wavelength of the infrared LED is 880nm. The photodetector measures the amount of light that passes through or is reflected by the skin and turns it into an electrical signal.

Buck converter

Buck converters are a type of DC-DC converter that are often used in electronic devices to convert a higher voltage DC input to a lower voltage DC output. This sort of converter is widely employed in situations where the input voltage exceeds the intended output voltage, such as battery-powered devices.

Arduino UNO

The Arduino Uno is a well-known microcontroller board based on the ATmega328P microprocessor chip. This board is intended to be a simple and open-source platform for novices learning how to programme microcontrollers.

FIGURE 5. **Buck converter**

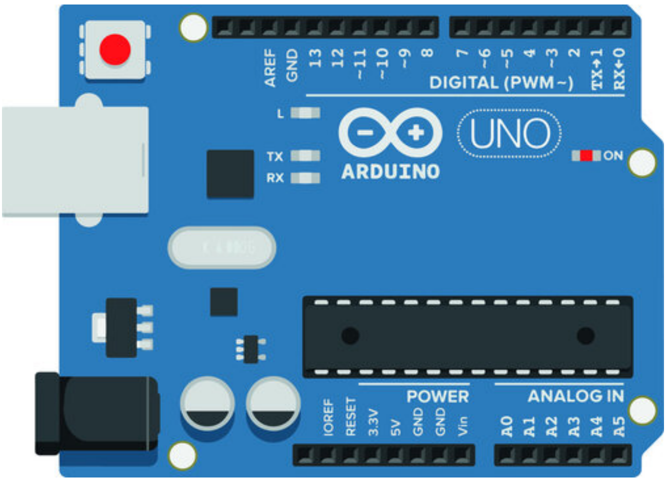

FIGURE 6. **Arduino UNO**

Display

A liquid crystal display (LCD) is an electronic visual display that is both thin and flat.

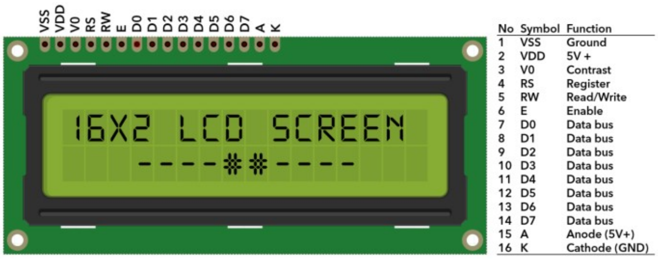

FIGURE 7. **LCD Display**

This technology utilizes the light-modulating properties of liquid crystals (LCs) to produce images. Unlike other types of displays, LCs do not emit light directly. Instead, they are used in combination with a light source or reflector to create an image in either color or monochrome.

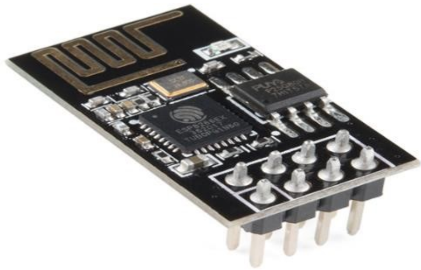

FIGURE 8. **ESP8266 Wi-Fi Module**

ESP8266 Wi-Fi Module

The ESP8266 is a highly popular microcontroller module that is used extensively for developing Internet of Things (IoT) applications. This module is designed to be low-cost, while still providing powerful Wi-Fi capabilities that are essential for IoT applications. The module has a compact footprint and is simple to integrate into a wide range of devices and systems.

Software Description

ThingSpeak

ThingSpeak is a powerful platform for IoT applications, providing data collection, storage, analysis, visualization, and integration capabilities. Its open-source nature and user-friendly APIs make it easy for developers to customize and extend its capabilities. With its built-in analytics and visualization features, ThingSpeak makes it easy to derive insights from IoT data, enabling businesses to make data-driven decisions.

Arduino IDE

Arduino is a basic hardware and software-based open-source electronics platform. A motor may be started, an LED can be turned on, and anything can be published online by utilising an Arduino board to receive inputs such as light on a sensor. Delivering a set of instructions to your board's microcontroller will tell it what to do. This is accomplished by utilising the Arduino Software (IDE), which is based on Processing, and the Arduino Programming Language, which is based on wiring.

Block Diagram

Figure 9 describes the block diagram of the proposed system.The flow sensor is an input module in which the person blows air to measure their individual flow rate. The MAX30100 is an input module that measures a person's SpO2 level by placing their fingertip on the sensor. The MQ-135 is an input device that measures the gas concentration of

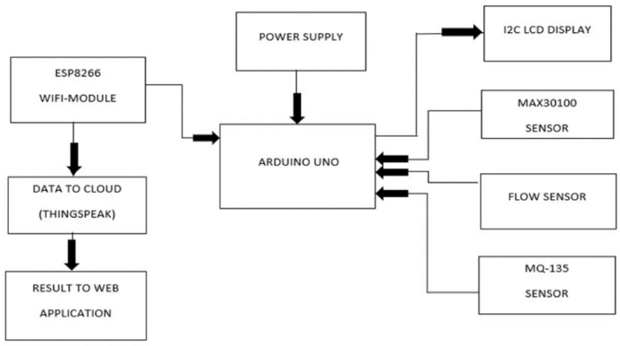

FIGURE 9. BlockDiagram of the Proposed system

exhaled air. The Arduino Uno is a processing module that processes all the collected data and sends it to the cloud. The ESP8266 is a Wi-Fi module that provides internet access to the Arduino, allowing it to send the data to the cloud. The LCD display is an output module used to display the results from the processing module.

5. Experiment Results

FIGURE 10. when all parameters are normal

Figure 10 describes when all the measured parameters are normal then the display will show it as healthy and the patient is healthy.

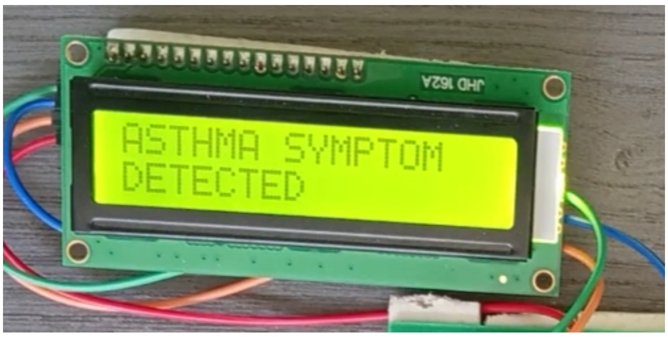

FIGURE 11. when flowrate is less than 1700

Figure 11 describes the flow rate of the patient is measured from the individual when the person blows the air into the flow sensor and the flow rate data is compared with the threshold value in the processing unit.

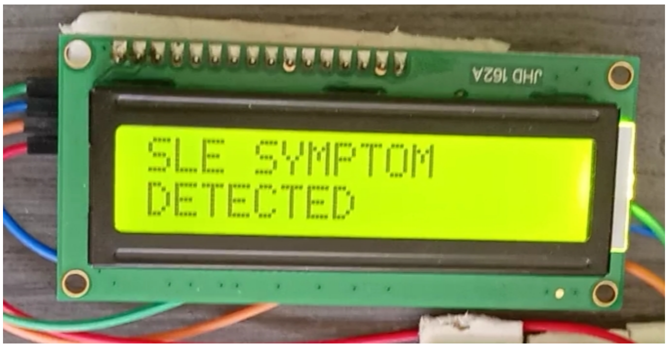

FIGURE 12. when Spo2 level is less than 90

Figure 11 describes the detection of SLE is identified through the max30100 sensor when the person placed his fingertip in the sensor that contains red sensor and IR sensor that detects the Spo2 level in the blood saturation level.

FIGURE 13. when acentone concenteration greater than 800

The detection of copd can be identified through the mq-135 sensor and the input for the sensor is given from the air blowed in the flow sensor and the gas concenteration is compared with the threshold value in the processing module and the result is shown as below if copd is detected.

Figure 14 describes the graphical representation of parameters. The microcontroller compares the sensor readings with a set of pre-trained data sets, and the results are displayed on an LCD screen. The results can also be viewed remotely using an Android application on a smartphone. Real-time monitoring allows healthcare providers to quickly assess the severity of a patient's condition and provide appropriate treatment. The use of this device

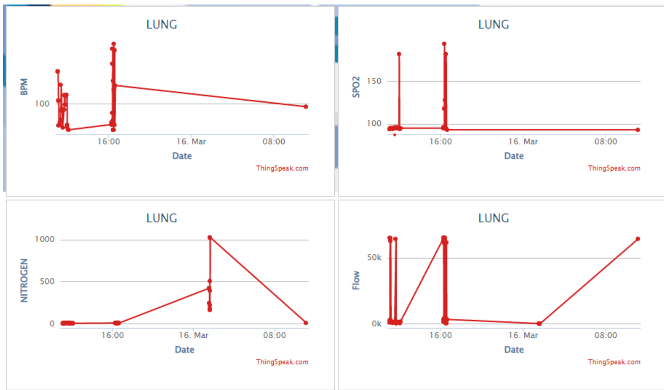

FIGURE 14. Graphical Representation of the measured parameters

in non-clinical settings allows individuals to monitor their own lung function and take proactive steps to maintain respiratory health. Overall, this non-invasive method of lung monitoring has the potential to improve respiratory health outcomes and reduce healthcare costs.

6. Conclusion

The proposed system aims to monitor and determine the severity of lung diseases in asthmatics by analyzing various parameters. The system's objective is to be simple and inexpensive, with quick access to data and excellent communication between patients and physicians. The system collects data on basic respiratory and environmental factors, as well as physical activity levels, which is then sent to the physician via a WiFi communication module. The physician can then examine the results and make informed decisions about medication and disease severity. The system is a quick and effective way to monitor asthma, providing timely feedback to both patients and physicians. Future developments will focus on advanced respiratory monitoring using flow sensors and pulse oximetry for breath analysis. Overall, the developed system provides a valuable tool for diagnosing and monitoring lung disorders in asthmatics, hence improving patient outcomes and quality of life.

Authors' Note

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the pa-per was free of plagiarism.

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