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A wireless alert system with gas sensor for pre-alert respiratory diseases

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***Abstract* - In our environment there are many harmful gases. These gases are affecting the asthma and to alert the asthma patient . In this paper sensors are used to detect the harmful gases(ie sulpur dioxide,co2 ,ozone).We intreface the sensor by using controller, if the sensor is above the threshold value, with the help of IOT(internet of things) we alert the person. The sensors enabling that allows the link of individual environmental exposures with physiological and following difficult health response.This system will permit a better understanding of the impact of increased ozone levels and other polluntants on chronic asthma condition. The arduino is used to combine the multiple sensors and also used in both transmitter and receiver. LCD module is used to display the level of the sensors. Mobile App is developed and installed in the android mobile to detect and alert the patient and also their kinships using IOT.**

Keywords— Harmfull Gases,Sensor SystemArduino Controller, IoT, Chronic Disease.

I. INTRODUCTION

1. Chronic inflammatory is a unsolved problem in airways of lungs, that minimize the amount of airflow in and out from lungs. Asthma has no cure , but we can able to control it. Common asthma symptoms are coughing ,wheezing, shortness of breath, chest tightness. Treatment is usually with inhalers. A typical person may take inhaler every day to prevent symptoms developing. There are two types of asthma such as allergic and non allergic. By using sensor system we can able to identify the harmful hazardous gases region which creates asthma .the objective of this project doing is to alerting the patient before they enter to harmful region. Asthma is a disorder that causes the airways of the lungs to swell and narrow, leading to wheezing, shortness of breath, chest tightness, and coughing. In America, over 18 million people suffer from OSA and an estimated 10 million people remain undiagnosed [2], [3]. As of 2010, 300 million people have been affected by asthma, and there were 250000 deaths due to asthma in 2009 globally [5]. COPD is one of the most common lung diseases.

Based on polysomnography (PSG) is to diagnose OSA. PSG examination is complicated and time consuming. Consequently, a portable monitor (PM) has been proposed as a substitute for PSG in the diagnostic assessment of patients with suspected OSA. According to the report of the American Sleep Disorders Association (ASDA). There have been several studies devoted to developing portable monitors for OSA since 1993 [6]. Changes are developed at a wireless portable sleep monitor with an electrocardiogram and a tri axis accelerometer. They used the portable monitor to monitor the effects.Accelerometer to monitor sleep posture and Bluetooth for wireless transmission of information[7].We developed a ubiquitous health monitoring system for diagnosis of sleep apnoea with Zigbee network and wireless LAN. The system supported monitoring five different biomedical signals: electrocardiogram, body motion by a gyroscope, nasal airflow by a pressure sensor, abdomen/chest efforts by a piezoelectric sensor and oxygen saturation [8]. Rofouei et al. developed a non-invasive, wearable neck-cuff system capable of real-time monitoring and visualization of physiological signals system monitored oximetry,breath,and body movement. Body posture can provide complementary information for analyzing the respiratory movement and a wireless transmission can further facilitate the ease of use of the portable monitor. The testing approach for COPD includes a lung function test called spirometry, and the oximetry [10]. Therefore, a monitor with a respiratory monitoring. The system monitored oximetry, breath, and body movement. They used a microphone to record the breathing sounds and provided an end-user view and a clinician view of the monitoring results [9]. According to a forementioned examples, respiratory airflow and oximetry are necessary parameters for monitoring and diagnosing OSA. Body posture can provide complementary information for analyzing the respiratory movement and a wireless transmission can further facilitate the ease of use of the portable monitor. The testing approach for COPD includes a lung function test called spirometry, and the oximetry [10]. Therefore, a monitor with a respiratory monitoring and an oximeter can help to test COPD. Similar with COPD, testing blood oxygen saturation, lung function, and peak flow help to diagnose asthma. During the treatment and recovery of asthmatics, spirometry generally needs to be conducted regularly over a long period of time. In summary, a simplest monitor for such respiratory diseases must be capable of monitoring the respiratory airflow and deducing certain respiratory parameters based on the airflow. There have been a variety of methods for monitoring respiratory airflow, which can be classified into two categories: the direct and the indirect way .

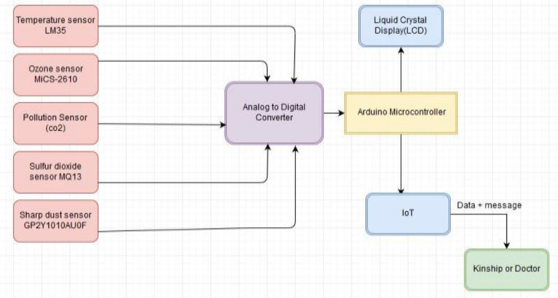


Fig. 1. Schematic diagram of the monitoring system.

The above block diagram describes about the chronic inflammatory disease for recording the breathing sounds. Monitor the chest movement with capacity, impedance or optical sensors, recording the breathing sounds and so on [11]. Respiratory monitors in the indirect way can only monitor respiratory frequency and relative intensity, but not the respiratory flow rate and can easily be altered by body movement. Ultra sonic flow meters, and soon[12]. The commonl3y used micro flow meters are the pressure sensor and thermal flow sensor. The pressure sensor has lower sensitivity when working at low flow rate; in contrast, the thermal flow sensor has higher sensitivity at low flow [13]. Many motion sensors have been applied to the assessment of physical activity from the mechanical pedometer to the electronic accelerometer [14]. A triaxial accelerometer has been widely used for physical activity detection [15], [16]. Zhu et al. developed a human motion-tracking system with a triaxis microelectromechanical accelerometers, rate gyros, and magnetometers.

They also proposed a series of algorithm to assist motion tracking [16]. Chang *et al.* developed a sleep activity monitor, which can identify seven body postures using a triaxial accelerometer [7]. As for the oximetry monitoring, a photo-electric sensor to test saturation of peripheral oxygen (SpO_2) is commonly used and there have been varieties of commercial blood oxygen sensors.

A wireless body sensor network (BSN) is usually adopted based on the concept that a good portable physiological mea-surement system needs to be low-cost, low power consuming and wearable [17].

Fig.3 sulphur dioxiode

fig.2 arudino microcontroller

Wi-Fi, are certified according to their applications in BSN. Among the transmission modes, Bluetooth may be the most promising method as it is the most common technology in mobile applications.

There have been several portable monitor devices aiming at respiratory diseases. These devices serve as one of a sleep recorder or a spirometer. A portable device that functions as both sleep recorder and spirometer has been rarely reported. Additionally, some of the previous devices were complicated with too many sensors, some lacked wireless transmission, and some with wireless but were less than telecommunication that limited its application and popularisation sense. There is also commercial sleep monitor such as Philips' "Stardust II" sleep recorder that is used for sleep apnoea diagnosis [20]. "Stardust".

In this paper, we propose a wireless portable system for mon-itoring respiratory diseases using a micro thermal flow sensor to monitor respiratory airflow, a tri axis micro accelerometer to monitor body posture, and a micro photoelectric sensor to mon-itor blood oxygen saturation. The system adopts Bluetooth as data communication approach to achieve ubiquity via mobile cellular networks or Internet. Algorithms for derivation of res-piratory parameters and estimation of body posture are pro-posed. A cellphone or a PC connected to the Internet can serve as the monitoring and transfer terminal, so that testing results can be analyzed, recorded, and transmitted to a remote center or physicians. Compared with previous studies and commer-cial products, the system proposed in this paper has several advantages. First, this system uses an enhanced micro hot-film flow sensor which monitors respiratory flow directly and is ex-tremely sensitive to weak airflow, so that be capable of detecting such as infants' respiration. The flowmeters with a threshold of 0.6 L/min (preterm infants and newborns) or 1.8 L/min (infants beyond the neonatal period) and a range of 0∼10 L/min are necessary in monitoring infants' respiration [22], [23]. Second, this system can be used as both sleep recorder and spirometer, so that it is capable of monitoring and diagnosing OSA, asthma, and COPD. Third, a mobile phone or a PC connected to the In-ternet serving as the monitoring and transfer terminal makes the system capable of remote, ubiquitous monitoring, and timely risk alarming if a severe respiratory distress occurs.

II. SYSTEM DESIGN

A. System Overview

Fig. 1 shows the system configuration, which is comprised of a micro respiratory sensor, a body posture sensor, an oxi meter, wireless transmitters and a PC or cell phone that connects with the Internet. The respiratory sensor and the body posture sensor are integrated in one circuit and incorporated with a Bluetooth module to compose a respiration-posture sensor node. Another sensor node called oximetry sensor node is the combination of the oximeter and another Bluetooth module. The test subject should wear the respiration-posture sensor node on his upper body and the respiratory airflow is collected using a nasal can-nula or a facemask connecting. sensor is installed. The oximeter sensor node is a clip worn on the fingertip. The outputs of two sensor nodes are transmitted wirelessly via Bluetooth to a PC or cellphone on which the data are processed and respiratory flow waveform, triaxial ac-celeration, and blood oxygen saturation are displayed and the respiratory parameters and body posture are figured out. The PC or cellphone can also transmit the signals to the remote monitoring center or physicians through the Internet, creating telemedicine capabilities.

The signal flow chart of the system is also shown in Fig. 1. In the respiration-posture sensor node, a laboratory created micro hot-film flow sensor is applied to detect the respiratory airflow, and a triaxial accelerometer is applied to detect body posture. The outputs of the hot-film flow sensor and the triaxial ac-celerometer are sampled and processed (called data process I) by a microprocessor before transmitted via the Bluetooth mod-ule. The Bluetooth module acts as a transmitter to transmit data to the Bluetooth receiver wirelessly through Channel I. Simi-lar to the respiration-posture sensor node, the oximetry sensor node detects the blood oxygen and transmits data by Bluetooth through Channel II. A Bluetooth receiver connected with a PC or cellphone receives data from two channels including respira-tory data, acceleration data, and oximetry data simultaneously. In data process II, the calculation of respiratory flow rate, triaxial acceleration, and SpO_2 and derivation of respiratory parameters and body posture are then conducted. A friendly user interface is designed to display the monitoring results. The monitoring results can also be transmitted to a remote center or person via the Internet.

B.Sensors

Temperature sensor- LM 35:

The LM 35 is an integrated with Arduino that can be used to measure temperature with an electrical output propotional to the temperature in degree Celsius.

Co2 sensor:

The way to measure air quality is to measure the carbon dioxide that is present in the environment. In deed high level of co2 in our environment can lead to getting drowsy,having head aches and functioning at lower activity levels.

MQ131 GAS sensor:

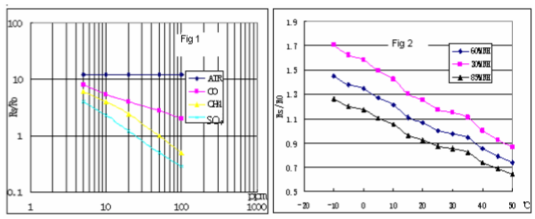
It is an o3 Sno2,which with lower conductivity in clean air.when ozone gas exists. The sensor conductivity is more higher along with the gas concentration rising.MQ131 gas sensor has high sensitivity to O3 cl2,no2,etc

Fig .4 pollution sensor

Sulphur dioxide sensor:

Sensitive materials of MQ136 gas sensor is Sno2 which with lower conductivity in clean air.when the target So2 gas exist,the sensors conductivity ismore higher along with the gas concentration rising.this can convert change of conductivity to correspond output signals of gas concentration.

This has high sensitivity to S02,also could be used to detect other vapor which contains sulphur.it has lower sensitivity to normal combustible gases ,which is with low cost and suitable for different application.



MULTI-SENSOR SYSTEM :

It requires many signal processing components and post-processing works so that it makes the overall system complex and expensive. That is, it gives bigger size, more cost and power consumption while the system becomes more susceptible to various noises due to many external connections

among components. Accordingly, there needs to be an effective approach to integrate multiple sensor interfaces and also to accommodate various inherent characteristics depending on service fields, instead of reliance on simplistic single-chip implementations of individual sensor interfaces. Most sensors, except those for light or radar, can be classified into four types: voltage, current, resistive, and capacitive [15], [16]. Recent research reviews have shown that environmental sensors are mostly resistive or capacitive [17] and conventional healthcare sensors are typically measured based on voltage or current [18]. Therefore, this paper proposes a heterogeneous multi-sensor interface that is implemented with two chips: an environmental sensor readout integrated circuit (E-ROIC) for resistive and capacitive sensor types and a healthcare sensor readout integrated circuit (H-ROIC) for voltage and current sensor inputs. The commonality in both interfaces is that their outputs are converted to digital data, which is sent to a smart phone where all signal processing, including calibrations and calculations, are performed. A simplified diagram of the overall multi-sensor system architecture is shown in Fig. 1a, where sensor readout circuits are integrated as two chips of E-ROIC and H-ROIC, which can be utilized separately in each homogeneous application. Analog-to-digital conversion for the H-ROIC is provided by the E-ROIC, which includes a dual-mode data converter. After converting sensor signals to digital data, the multi-sensor interface sends the data directly to a smartphone through a wireless connectivity module utilizing the Bluetooth which is the standard for healthcare services [9]. Fig. 1b presents a mobile sensor system prototype of the multi-sensor interface whose details are explained in Section IV. This mobile platform provides various real-time sensor-signal acquisition capabilities through the E-ROIC and H-ROIC, and wirelessly transferred data are post-processed.

C. Algorithm and Software:

1) Derivation of Respiratory Parameters: The output of the flow sensor is calibrated and analyzed. A variety of algorithm to derive related respiratory parameters, such as minute ventilation (MV), peak inspiratory flow (PIF), respiratory rate (RR), and tidal volume (TV), are designed. Table I shows the calculation methods for the four respiratory parameters. 2) Estimation of Body Postures: The 3-axis accelerometer measures the 3-axis accelerations of the human body along the directions of the three axes shown in Fig. 4. An algorithm is designed to estimate body postures using measured3-axisaccelerations.Bodypostures areclassifiedinto two categories: motion and rest. In the motion state, walk/run and other states are identified, and the stride frequency is calculated. In the rest state, different postures of sit/stand, lie on the back, lie on the face, lie on the right, and lie on the left are identified. To discriminate motion and rest, a parameter called signal vector magnitude (SVM) of the 3-axis acceleration is introduced. SVM is the square root of the sum of 3-axis accelerations, the amplitude of which reflects the motion intensity of the body. In the rest state, the ranges of accelerations along the X–Y–Z axes are utilized to determine body posture. Table II shows the look-up table for determining body postures. ALabVIEW-baseduserinterfaceshowninFig.5isdesigned to display the waveforms of the respiratory airflow and the 3axisaccelerations,respiratory parameters, body posture, and the value of SpO2.

TABLE II ESTIMATION METHOD OF DIFFERENT BODY POSTURES:

User interface of the monitoring system.

D. Performance Comparison as mentioned in Section I, there are several portable devices reported by others. A comparison between our device and typical ones is listed in Table III. Through the comparison, it is evident that our monitoring system has as implers ensor configuration, and is able to act as both sleep recorder and spiro meter. In particular, the thermal flow sensor facilitates the detection of the weak air flow compared with the pressure sensors. Additionally, a mobile phone or a PC connected with the Internet serving as a monitoring and transfer terminal is available in our device, which is compatible with telemedicine applications. The remote monitoring also helps to implement a risk alarm automatically when a serious illness occurs. Furthermore, our device is superior in size, weight, and power that are more convenient and suitable for home use.

III. EXPERIMENTAL TESTING AND RESULTS

In order to measure respiratory airflow and acquire the relationship between the output of hot-film sensor and airflow, a calibration experiment was conducted. To verify monitoring and diagnosing respiratory diseases, a series of monitoring and diagnostic tests were conducted using the developed system. The tests include the respiration versus motion intensity, the respiration experiment under differentresting postures, and diagnosing and monitoring of respiratory diseases. In the experiments, the test subject wore the respiration-posture node on his upper body and the respiratory airflow was collected using an as al cannulaor facemask and detected using the microhot-film sensor installed.

In the calibration experiment, a precise flowmeter was used to calibrate the hot-film flow sensor. The cylinder full of compressed air provided airflow at certain flow rates passing through the hot-film sensor. We adjusted flow rates (covering 0.1 L/min∼100 L/min) and recorded the corresponding output voltage of the flow sensor. The acquired voltages and the corresponding flow rates were used to do polynomial curve fitting as shown in Fig. 6. The results indicate that the sensitivity of the flow sensor increases with the decrease of the flow rate and the threshold of the flow sensor reaches 0.1 L/min.

B. Respiration Versus Motion Intensity In the experiment, the test subject did the actions (running, walking, and sitting) in sequence for minutes. The respiratory airflow rate and 3-axis accelerations were recorded and analyzed. Fig. 7 shows the testing results. We found there was a good relationship between the respiratory intensity and motion intensity. SVM of the 3-axis accelerations is defined to evaluate

Fig. 7. Testing results: (a) respiratory airflow rate, (b) accelerations along the X-axis, (c) Y-axis, and (d) Z-axis are illustrated.

the motion intensity. SVM = ax2 + ay2 + az2. (1) SVM of running, walking, and sitting is shown in Fig. 8. Considering that the amplitude of SVM directly reflects the motion intensity, we define the standard deviation (STD) of SVM as the parameter of the motion intensity. Fort he respiratory intensity, we define the minute ventilation (MV) of respiration as the parameter of the respiratory intensity. The STD of SVM and MV in different motion types is listed in Table IV. The results indicate that the respiratory intensity highlydepends on the motion intensity. Based on this fact, monitoring the body motion is necessary in respiratory monitoring as the motion info can provide a respiration reference.

C. Respiration Test Under Different Resting Postures An experiment of respiration test under different resting postures was further conducted. In the experiment, the test subject lay on the bed with the postures of lying on the right, on the back, and on the left in sequence. Then the subject got up and

D. Diagnosis and Monitoring of Respiratory Diseases To demonstrate the functions of diagnosing and monitoring respiratory diseases, a sleep apnea recognition experiment and a spirometry experiment were conducted. 1) Sleep apnea can be diagnosed by using a respiratory parameter AHI (apnea-hypopnea index) and oxygen saturation [21]. AHI is defined as the total number of apnea and hypopnea of breathing occurring per hour of sleep. When AHI≥5inairflowortidalvolumeandoxygensaturationis lessthan90%,asleepapneaisconfirmed.Ingeneral,AHI can be also used to evaluate the severity of disease (mild 5–15, moderate 15–30, and severe > 30). The key point to diagnose sleep apnea is to recognize the occurrence of apnea and hypopnea. An experiment to recognize apnea and hypopnea was conducted in the way that the subject wearing a nasal cannula simulated apnea and hypopnea while the respiratory flow was recorded. The proposed algorithm was applied to recognize apnea and hypopnea in real time. The testing results are shown in Fig. 10, where the apnea and hypopnea were identified and the number of the apnea and hypopnea episodes (AHI) was counted automatically. 2) Pulmonary function test is the primary diagnostic approach for COPD and asthma. Most commonly used parameters for interpretation are as follows: 1) forced expiratory

volume after 1 s (FEV1), 2) forced vital capacity (FVC), and 3) forced expiratory flow at 25%-75% of maximal lung volume (FEF25-75). In lungs with COPD or asthma, the ratio of FEV1/FVC falls below 70–75%.
Theseveritycanbeclassifiedintothreelevels:1)<50%–69%,moderate;2)<35–49%,severe;3)and<35%,very severe. Isolated reduction in the FEF25–75 is considered an early detector of very mild obstruction. An experiment was conducted to test the pulmonary function using our device as a spirometer. The subject wearing a facemask expired out. The system measured expiratory flow shown in Fig. 11. According to the result, the FEV1/FVC is calculated as 78.12%, which is normal for a healthy person. TheFEV1,FVC,andFEF25-75werealsoacquired,which could be used for diagnosing COPD/asthma.

IV. CONCLUSION

A wireless portable system with microsensors for monitoring respiratory diseases is presented in this paper. The monitoring system consists of two sensor nodes: the respiration-posture sensor node and the oximeter sensor node. Two sensor nodes are integrated with Bluetooth transmitters and they are in small size due to the use of microsensors. The measuring range of the respiratory flow sensor is 0.1–100 L/min and its threshold reaches 0.1 L/min, which indicates that the monitor can detect weak respiration. The utility of hot-film flow sensor also makes comprehensive respiration parameters acquirable which are important in the diagnosis of OSA,COPD, and asthma. Employing the triaxis accelerometer to detect motion and body posture provides a reference for respiration movement. The Bluetooth data transmission makes the monitoring system wireless and mobile so that the user can use it freely. The mobile phone or the computer connected to the Internet as the user interface terminal makes telemedicine achievable. A series of monitoring and diagnosing tests were conducted using the proposed system and the feasibility of the monitoring system was verified. The proposed wireless portable devices with microsensors servingasbothsleeprecorderandspirometercanbeappl iedfor remote monitoring and diagnosis of OSA, COPD, and asthma.

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