International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 06 | June-2016 www.irjet.net p-ISSN: 2395-0072

Non-invasive sleep apnea detection and monitoring system

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ABSTRACT : *The point is to outline a completely utilitarian breathing screen with the end goal of recognizing occasions brought about by sleep apnea. This framework comprises of mechanical assembly that can distinguish the patients breathing rate, and tell a man observing the patient to a handheld screen. A caution is sounded at the handheld screen if the patient's breathing example changes, or stops. The breathing sensors that quantify the rate of progress of temperature in a given range. The utilization of this sort of sensor permits us to screen breathing with literally nothing connected to the patient. These components permit us to point the item at the buyer market where it can be acquired inexpensively, and is significantly less meddling. Counting extra body temperature sensors, and an alerting system, GSM, the framework can send this data to a versatile checking gadget to consider a completely included patient observing framework.*

Key Words: sleep apnea, obstractive sleep apnea, breathing rate, temperature,non invasive.

1. INTRODUCTION

1.1 Introduction to sleep apnea

In the recent years people started using wearable devices more. People attracted in the wearable health care monitoring devices both in industry and in research . world's aging population is increasing because of the use of these wearable health monitoring system, whose health is continuously and regularly monitor. Wearable devices need to be:a)Non-intrusive.b)Should be pleasant to wear.c)Power consumption should be efficient.d)User friendly interface by preserving privacy.e)Failure rate should be less.f)In diagnostic purpose the alarm triggers should be high.
The top priority of mothers, nurses, doctors is to monitor breathing of patient or a newborn child.The available breathing monitoring system are expensive and it also require attaching intrusive wires to the patient . The aim of this project is to produce a breathing monitor system that alleviates these two important concerns.

In the average life span of an human, 1/3rd of their lives spends on sleep [1] .our body repairs itself when a person sleeps. This rejuvenation goes for hormones and muscles as well as neural responses, like memory. When a person donot sleep,it affecrts body functions. the body lose function for the persons who have sleeping disorders. when a person cannot sleep that condition is sleeping disorder. Lack of sleep affects physiological, emotional and psychological functions. Till date researchers and doctors recognized 84 sleeping disorders.

When the breathing stops and starts while sleeping that condition is called as sleep apnea .it is associated with snoring . when the upper airway caliber is narrowed to a critical degree/ value that condition is known as snoring. Hypopnea is a condition of lack of breathing during sleep.

When the narrowing becomes too more it leads to blockage of airway that resulting in apnea. When the cessation of airflow lasts atleast for ten seconds that results in apnea and it is associated with decreasing oxygen level of the patient .

Types of sleep apnea:

- Obstructive Sleep Apnea (OSA) - caused by collapse of the upper respiratory airway.
- Central Sleep Apnea (CSA), - caused by an absent or inhibited respiratory drive.

When the apnea is not treated, it affects daytime functioning. The functionality of the monitoring system is enhanced by including extra features like, detection of body temperature, giving alarm signal when the breathing rate is less than that of threshold value, alerts nurse when the patient fails to breathe through wireless display monitor. All the sensors are attached to the controller. Basically controller process the data/ signal, and transmits that to LCD and zig-bee, which are used as a displaying and monitoring system.In this paper , it deals with the obstructive sleep apnea condition occurs when the muscle relax during sleep, which tends to collapse of soft tissue at the back of the throat.

1.2 Objective:

The objectives of this project is to design a system which is Non invasive ,Cost effective, Innovative, Non intrusive, Portable and Easy to use. And also system objective is to minimize the communication problem between doctors and patients.

2. LITERATURE REVIEW

2.1 Research background

Our thought for a breathing screen originated from another mother who was searching for an infant screen that could monitor an infant's breathing and cautions if the infant quits relaxing [2]. The gadgets she found available did not meet with her desires in light of the fact that either they were excessively meddling or not totally powerful. Our gathering first set-out to outline a child screen that could meet her prerequisites of being non-meddlesome and exact. We understood that there were more applications that could be adjusted for our sensor thus our planned advanced to a rest apnea identifier which could be used by babies or grown-ups.Sleep apnea is a basic subject and has been the reason for death for some newborn children. Henceforth it is very evident numerous organizations have attempted to think of arrangements and thoughts to counter rest apnea. A portion of the thoughts actualized by organizations include:

- Monitor that detects a patient's development and breathing through the sleeping pad amid rest.
- Electrode sensors connected to high hazard babies after birth.

For the screen utilizing weight sensors under the sleeping pad, there is an issue with dependability and precision. Components, for example, bedding thickness and thickness could influence how well the sensor can gauge the breathing of a child. Another element that can influence exactness is delayed stability amid rest. This could be translated as if the tolerant has quit breathing which would be a false alert. Current infant relaxing screens use anode sensors that are joined straightforwardly to the infant and require consistent supervision to guarantee that the child does not become involved with the wires. An issue could emerge if the infant is aggravated by the sensors and pulls them off their body. These physical connections could likewise bring about undesirable rashes in the territories where they are joined.

We plan to outline a framework that checks if a man is breathing legitimately and not stifling. Our primary objective in this anticipate is to screen a man's breathing remotely whether they are newborn children or grown-ups. However our methodology is distinctive and our configuration is less expensive than different activities that as of now have been investigated and actualized. Additionally our outline is non-intrusive on the grounds that it doesn't include connecting any wires or sensors to the child and capacities with little client direction. We will execute an infrared sensor to distinguish changes in temperature as a man takes in and out. Another application for this screen could be for grown-ups to screen their rest example to help specialists analyze sporadic rest designs. For instance, a patient from a rest facility could utilize this screen at home to screen their long haul rest example to decide the viability of medications.

2.2 Existing system

The current gadgets found available did not meet with desires in light of the fact that possibly they were excessively meddling or not totally compelling. For the screen utilizing weight sensors under the sleeping cushion, there is an issue with unwavering quality and precision. Components, for example, sleeping pad thickness and thickness could influence how well the sensor can gauge the breathing of an infant. Another variable that can influence exactness is drawn out stability amid rest. This could be deciphered as if the patient has quit breathing which would be a false alert. Current child relaxing screens use cathode sensors that are connected straightforwardly to the infant and require steady supervision to guarantee that the child does not become involved with the wires. An issue could emerge if the child is bothered by the sensors and pulls them off their body. These physical connections could likewise bring about undesirable rashes in the zones where they are appended.

2.3 Literature survey

a) Multimodality Sensor System for Sleep- Quality Monitoring, Ms. Snehal R. Sawale, Prof. Vijay S. Gulhane talks about Multimodality is the blend of literary, sound, and visual modes in mix with media and materiality to make meaning. The impact of rest conditions to human wellbeing and execution is as of now understood yet at the same time thought little of and observing gadgets are not across the board. This paper portrays philosophy and model outline of a rest observing. Rest checking is a vital issue and has attracted extensive consideration medication and medicinal service [3]. In this paper, they propose a framework utilizing ease multimodality sensors, for example, video, detached infrared, and heart-rate sensors for rest observing. This paper monitors the parameters for deriving rest idleness, effectiveness and spam for rest quality checking. This paper proposed more sensible offers and contrasted with current available standard methodology.

a) In Non-invasive analysis of sleep patterns via multimoda sensor input Vangelis Metsis , Dimitrios Kosmopoulos Vassilis Athitsos , Fillia Makedon talks about the monitoring of sleep examples is an important parameter for recognition and treatment that are related to sleep issues and conditions on the sleep quality and to know the dangers related with resting designs in adults and child.The proposed framework utilizes a blend of non-intrusive sensors to survey and report rest designs: a contact-based weight sleeping cushion and a

noncontact 3D picture securing gadget, which can supplement each other. The framework utilizes Machine Learning methods to naturally break down the gathered information and sleep designs. It is non-obtrusive, as it doesn't upset the client's standard dozing conduct and it can be utilized both at the center and at home with insignificant expense.

3. BLOCK DIAGRAM

System block diagram is shown in the below figure

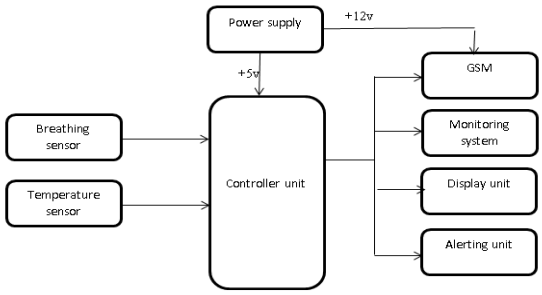

Figure 3.1 system block diagram of Non-Invasive Sleep Apnea Detection System for Continuous monitoring during daily life

3.1 Design Requirement Goals

Monitor Module

- Capture breathing rate from thermistor
- Determine body temperature
- Encode breathing rate, body temperature into packets.

Receiver Module

- Decodes the signal from the microcontroller
- Display the output on LCD screen
- Alerts if the breathing rate exceeds the threshold
- Receiver is operated by battery.
- Patient status is send as SMS through GSM to doctors.

4. MATERIALS AND METHODOLOGY

4.1 Temperature sensor

LM35 is used as temperature sensor. It is used to detect body temperature. It senses the variation of temperature across it. The unit it gives output is degree Celsius. The output of LM35 is linearly proportional to temperature.
Expectation When we Use An LM35?

- use a voltmeter to sense output signal.
- The output voltage is converted into corresponding.
- sensitivity is 10mV / ºC.
- conversion factor is 100 ºC/V.
- equation used to convert output voltage to temperature is:
  - Temp (ºC) = Vout * (100 ºC/V)
  - if Vout is 1V , then, Temp = 100 ºC
  - Output voltage varies linearly with temperature.

4.2Thermistor

Thermistor is a resistance thermometer, whose resistance depends on temperature. It consists of 2 words "thermal" and "resistor". It is made of metallic oxides, pressed into a bead, disk, or cylindrical shape and then encapsulated with an impermeable material such as epoxy or glass.

The thermistor goes about as the temperature sensor and it is put on the body whose temperature is to be measured. It is additionally associated in the electric circuit. At the point when the temperature of the body changes, the resistance of the thermistor likewise changes, which is shown by the circuit straightforwardly as the temperature since resistance is aligned against the temperature. The thermistor can likewise be utilized for some control which is reliant on the temperature.

In this paper thermistor is used to calculate breathing rate based on the temperature of exhaled air. This thermistor converts temperature of human breath into corresponding resistor and these values are applied to the microcontroller through ADC. The breathing rate is displayed on LCD and on to the monitoring system.

When a current flows through a thermistor, it generates heat which results in increase in temperature of thermistor above that of its environment. If the thermistor is being used to measure the temperature of the environment, this electrical heating may introduce a significant error if a correction is not made. Alternatively, this effect itself can be exploited.

NTC thermistor :NTC thermistors have temperatures that fluctuate contrarily with resistance such that as the temperature expands, the resistance declines, and the other way around. They are regularly utilized for temperature control and sign, and for current concealment. Normal materials utilized as a part of their development incorporate oxides of materials, for example, nickel, manganese, copper, iron, and cobalt. Some are likewise produced using silicon and/or germanium. They are normally bundled in an epoxy, and are the most widely recognized sort of thermistor.

4.3 Controller board

Arduino board is used as controller board .Arduino is a product organization, undertaking, and client group that

outlines and fabricates PC open-source equipment, open-source programming, and microcontroller-based packs for building computerized gadgets and intelligent items that can sense and control physical gadgets.
Arduino is an open-source prototyping stage in view of simple to-use equipment and programming. Arduino sheets can read inputs - light on a sensor, a finger on a catch, or a Twitter message - and transform it into a yield - actuating an engine, turning on a LED, distributed something on the web.

4.4 Microcontroller

The microcontroller used in this project receives the signal of breath sensor and temperature sensor output signal. Microcontroller continuously sends the signal to LCD and to the monitoring system and also to GSM to display the corresponding breathing rate and body temperature. It also sends the signal to the alarm when the breathing rate less than the threshold value as a sign of abnormal condition i.e detection of sleep apnea.
It sends a text message to the doctor when the person breaths normally and also when person stops or when he breaths abnormally.

The Arduino Uno is a microcontroller in view of ATmega328P. The ATMEGA328P chip consists of six simple inputs in particular such as A0 to A5 on the Arduino board. The chip highlights 10-bit ADC (Analog-Digital Converter). The ATMEGA328P can gauge only one simple contribution on the double. It contains of multiplexer, the six inputs are associated with ADC through multiplexer. This multiplexer allows programmed association of contribution to the ADC relying upon the system utilized. The board can be controlled through USB, power jack or other directed force supply. The correspondence of Arduino Uno with PC is possible through serial correspondence over USB.

The technical features of arduino uno are as shown in the Table 4.1.

Table 4.1 Technical features of arduino

Microcontroller used	ATmega328
Operating Voltage	5V
Input Voltage	7-12V
Digital I/O Pin	14
Analog Input Pin	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50A
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz

ATmega348P

ATmega328P is an eight-bit microcontroller. It executes each instruction in one clock cycle. It consumes very less power.
Table 4.2: Technical features of ATMEGA328P

Parameter	**Value**
Flash	32 Kbytes
Pins	32
Operating Frequency	20 MHz
CPU used	8-bit AVR
External Interrupts	24
I/O Pins	23

The Arduino Uno is programmed with Arduino software, which includes serial monitor

4.5 GSM (global system for mobile communication)

In this project sim900 gsm is used. When the person breathing rate goes beyond certain value it sends message to the doctor as person's breath is normal, when the person stops breathing or when the person's breathing rate goes abnormal it sends message to the doctor as person stopped breathing.
The SIM900 is a Quad-band GSM/GPRS arrangement in a SMT module which can be installed in the client applications. Including an industry-standard interface, the SIM900 conveys GSM/GPRS 850/900/1800/1900MHz performance for voice, SMS, Information, and Fax in a little shape element and with low power utilization. dimension is 24mm x 24mm x 3 mm

a) SIM900 is composed of powerful single-chip processor incorporating AMR926EJ-S center
b) Quad - band GSM/GPRS module with dimension of 24mmx24mmx3mm
c) SMT sort suit for client application
d) An inserted Powerful TCP/IP convention stack
e) Based upon full grown and field-demonstrated stage, went down by our support administration, from definition to plan and generation

The GSM module bolsters correspondence in 900MHz band. In Indiathe operating frequency band is 900Mhz band. For others countries frequency should be to checked to operate. The frequency band varies fron one country to another . For

example a dominant part of United States portable systems work in 850Mhz band (the band is either 850Mhz or 1900Mhz). Canada works in 1900 Mhz band

4.5.1 Associating GSM Module to Arduino :

There are two methods for interfacing GSM module to arduino. Arduino and GSM module is communicate serially. Hence utilize serial pins of Arduino (Rx and Tx). Connect Tx pin of GSM module to Rx pin of Arduino and Rx pin of GSM module to Tx pin of Arduino.

GSM Tx –> Arduino Rx

GSM Rx –> Arduino Tx.

Connect the ground pin of arduino to ground pin of gsm module.

4.5.2 Procedure to send SMS

In this project work, GSM is used to send the SMS to the doctor's mobile number which is stored in the microcontroller. This message consists of patient's breathing status whether the patient is breathing normally or stopped.

The following procedure is used to send a text message :

AT+CMG=1 press enter

AT+CMGS="mobile number", press enter

Once the AT commands is given '>' prompt is displayed on the serial port. When the SMS sending is successful, "ok" is displayed on the screen.

4.6 LCD

The display unit used in this project is 16x2 liquid crystal display (LCD). The microcontroller enables the LCD to display the breathing rate value, body temperature and to display normal or abnormal condition when the signal is obtained from the thermistor and from the temperature sensor. When the breathing rate is less than the setvalue it displays breathing level normal. When the breathing rate goes above the setvalue, it dispalys as breathing level stopped.
The main advantage of using LCD display is its low power consumption. LCD, an acronym for Liquid Crystal Display upset the present day show innovation with its smallness and flexibility

LCD's are accessible in different shapes and sizes relying upon the arrangements. A 16x2 LCD appeared in the picture beneath can show 32 characters with 16 characters in every line. It is able to show any character with ASCII values running from 0 to 255.

4.7 LED

This system uses red LED as an indicator. The parameter that is indiacted by LED are:

- No patient
- Breathing stopped

Focal points of LED's

a) Low voltage and current to drive the LED. b)1 to 2 volts voltage range. c)5 to 20 milliamperes current. d)Complete force yield will be under 150 milliwatts.

4.8 Hardware module preparation and installment

The model preparation that detects sleep apnea condition looks s shown in the below figures

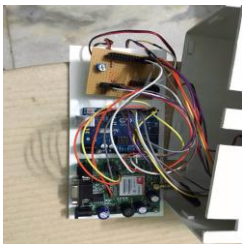

Figure 4.2 hardware circuit of the system

Figure 4.3 LCD module connected to the board

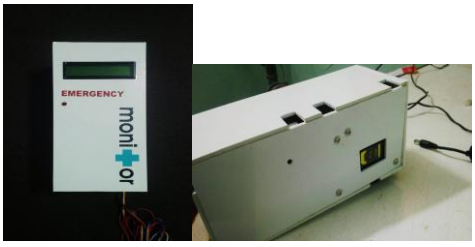

Figure 4.4 final monitoring system module

Sleep apnea detection and monitoring system implemented on a patient

Figure 4.5 System implemented on a real time patient

5. SOFTWARE DESCRIPTION

5.1 Arduino IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a word processor for composing code, a message territory, a content support, a toolbar with catches for basic capacities and a progression of menus. It interfaces with the Arduino and Genuino equipment to transfer programs and speak with them.The Arduino IDE uses the C and C++ language to sort out code. The Arduino IDE uses the project avrdude to change over the executable code into a content document in hexadecimal coding that is stacked into the Arduino board by a loader program in the board's firmware.

5.1.1 Select serial port :

Select the serial port from tool to display the physiological data on the serial port. This should be COM3 or higher (COM1 and COM2 are for equipment serial ports). Here it is COM7.

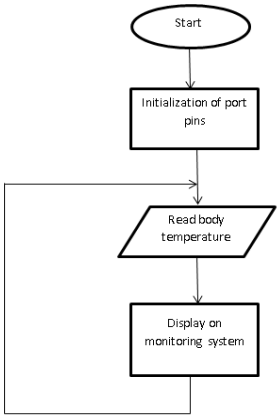

Figure 5.1 flow chart that detects body temperature.

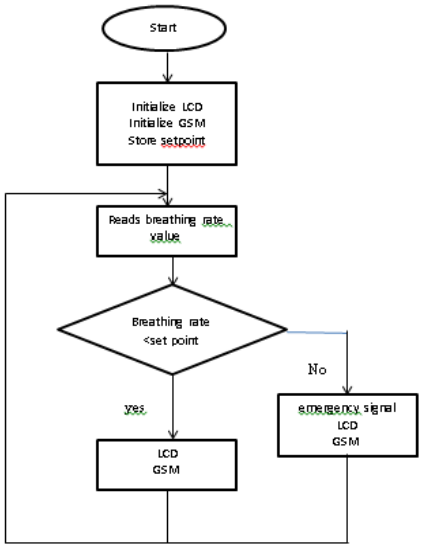

Figure 5.2 flow chart for breathing rate monitoring

6.RESULTS

6.1 Tests

a) Programming for GSM module to send SMS about the status of the patient to the doctor is tested.
b) Programming for LCD module to display the status of the patient is tested.
c) Programming for serial port to display the patient's status , breathing rate and body temperature are tested.
d) Programming for emergency module is tested t indicate patient's condition.

6.2 Results

a) The units interfaced to the microcontroller are working properly.
b) Successfully tested values of breathing rate of the patient.
c) Successfully tested body temperature of the patient
d) The status of the patient is successfully displayed on LCD
e) The status of the patient is successfully sent as SMS to the doctor through GSM modem.
f) When the patient stops breathing, it is successfully alerts by emergency signal going high.
g) It successfully alters the hospital people by giving a beep signal when there is no patient and when there patient stops breathing

The breathing rate results of the patient A in the serial port is shown in the below figure

```
B 476 Temp 30.76
B 474 Temp 34.67
B 472 Temp 34.18
B 472 Temp 33.20
B 471 Temp 33.20
B 471 Temp 30.76
B 470 Temp 34.18
B 469Patient Breathing Level NORMAL
 Temp 32.71

> B 468 Temp 32.23

+CMGS: 166

OK
B 468 Temp 31.74
B 468 Temp 33.20
B 469 Temp 32.71
B 470Patient Breathing Level STOPPED
 Temp 26.86

> B 473 Temp 32.23

+CMGS: 167

OK
B 476 Temp 34.18
B 480 Temp 34.67
B 482 Temp 33.20
B 484 Temp 34.18
```

Figure 6.1 Serial port output data of breathing rate and body temperature

The patient A status is sent as a SMS to the doctor through GSM is shown in the figure below

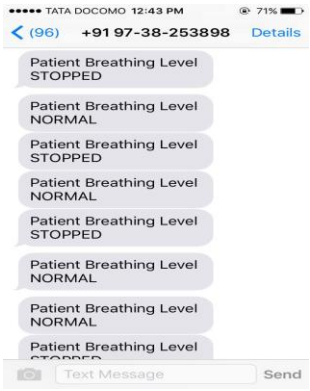

Figure 6.2 result of patient status sent as a SMS to doctor's mobile

The LCD displays breathing rate normal when the patient breats normally, idt displays breathing rate stopped when the patient stops breathing . The LCD output is as shown in the figures below

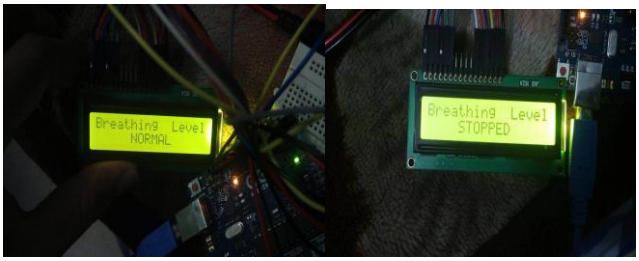

Figure 6.3 result of patient status displayed on LCD

7.CONCLUSION AND FUTURE WORK

This system presents following features:a)Easy to use.b)Low cost.c)Works in real time.d)Wearable.e)Light weight system,f)Non invasive. This system transforms physiological data to the doctor .This system detects whether the patient is finding difficulty in breathing or not so that it is helpful in detecting and monitoring sleep apnea condition. This system continuously detects and monitors the breathing rate and body temperature of the patient. It sends an alert signal of the patient condition. It also displays the patient's status on the monitoring system, on LCD and also alerts the doctor by sending SMS through GSM.

Monitoring systems are available and doctors are available but there is no communication that relates patient's status and doctors .Thus this system effectively minimizes the communication problem between patients and doctors.

Some additional areas can be included to explore in future research by adding other sensors to the system such as galvanic skin response, ECG, altimeter etc. collaborating with doctors for future user studies.

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