WEARABLE GLOVE USING IOT FOR HEALTH MONITORING

A PROJECT REPORT

Submitted by

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Under the guidance of

Ms. S. M. UMARANI

In partial fulfillment for the award of degree

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS AND COMMUNICATION

HINDUSTAN
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BONAFIDE CERTIFICATE

Certified that this project report " **WEARABLE GLOVE USING IOT FOR HEALTH MONITORING** " is the bonafide work of **KUNAH MANOHARAN (15121006), TARA MANOHAR (15121009), G. VENKATESWARA REDDY (15121036)** who carried out the project under my supervision during the academic year **2015 – 2019**.

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ABSTRACT

The design of a wearable health monitoring glove using IoT is presented, the major motivation for designing such a device is the high health care costs which keeps on increasing and also the recent technological developments in miniature biological sensors, wireless communication. The proposed system will consist of Biological sensors, transmission modules and micro-controllers and thus can provide low cost meek solutions for real time health monitoring. The proposed design will have in all four biological sensors either implanted or fixed on the glove to measure different body parameters like temperature, blood pressure and heart beat rate. Instead of using different devices for the measurements of same parameters it will be more reliable and efficient if all of these sensors are implanted on a single platform. The proposed device will provide real time data of a patient's health by which premature decisions of symptoms and necessary steps can be considered in advance.

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CHAPTER 1

INTRODUCTION

Wearable health-monitoring systems (WHMS) has gained a lot of attention in recent times due to ever increasing health care costs and technological developments in the field of medical as well as electronics. It is very important to get the real time health status of a patient once the person is out the hospital. The proposed system will consist of a wearable glove which has a number of biological sensors either implanted or attached to it. Once the glove is put on the sensors will start to measure the parameters. These values or data will either be for user itself or to a hospital or directly to a doctor. The WHMS also consists a new method of approach for addressing issues of Chronic illness, Elderly patients, people in rehabilitation and people with special abilities.

The WHMS will contain various types of miniature biological sensors – wearable or implanted, these sensors will then collect the real time health condition of the patient like the body temperature, blood pressure, heart beat rate. The proposed system will also contain Flex sensors which will be implanted at any two fingers of the glove. Once the values are detected it will then be sent to the Arduino board placed inside the glove through wired means. The Arduino is then connected to a Node-MCU module which is a Wi-Fi Arduino module that collects all the data and transfers it to a cloud which serves a platform to display the real time values of a patient. The user can later send it to respective Physician or doctor consulted. The blood pressure sensor used here is of non-invasive type meaning an arm cuff will be strapped around the patient's upper arm or at the wrist in order to get the blood pressure values. The Wi-Fi module used here is ESP8266 which is preferentially small in size and is also available at a comparatively low cost.

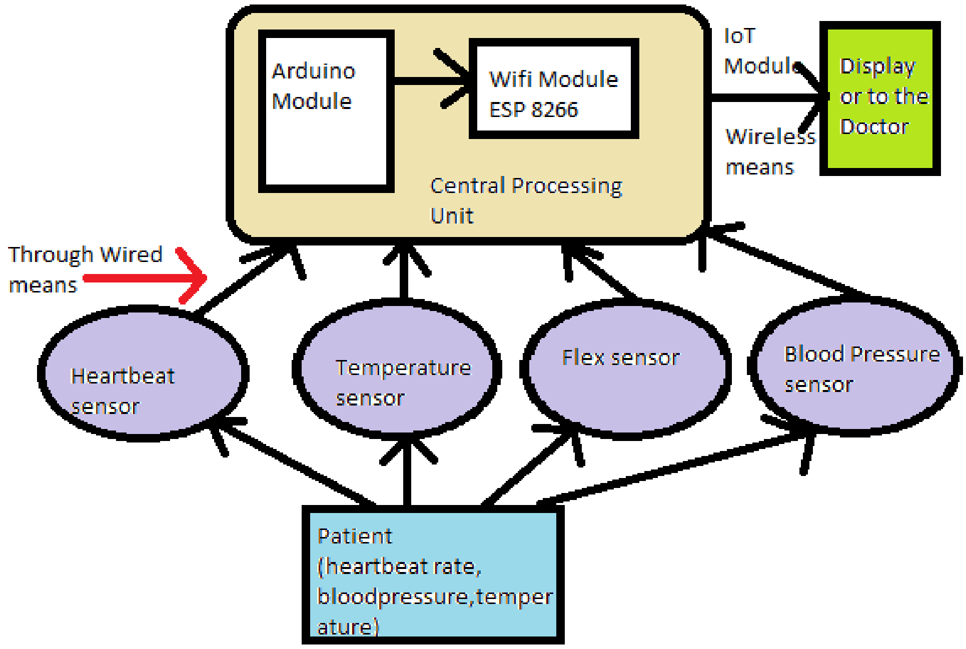


Fig. 1. The block diagram

As shown in Fig. 1. the Block which contains the Arduino UNO board and the Node-MCU is called the central processing unit. It is the main part of the system since all the collection and transferring of data takes place in this part. The Arduino board also provides the power supply to all the three sensors except the Flex sensors since it requires more amount of power supply. Values from Node-MCU can be represented either in pictorial or in scripts. Depending on the requirement with the use of Plotly software the values or data can be in a graphical or pictorial representation. The system will buzz if it detects any abnormal increase or decrease in the value so that the required safety measures can be taken into consideration. The values detected by the system can be for the user itself or it can directly be sent to the physician or doctor consulted. The various functions of different Bio-sensors and the various signals they detect or measure is described in the table 1. These Bio-sensors can be integrated in the glove in such a way that it meets wear-ability medical criteria.

Type of Bio-signal	Type of sensor	Description of Sensor
Body and/or skin temperature	Temperature sensor (LM 35)	A measure of the body’s ability to generate and get rid of heat.
Blood pressure	Arm cuff-based monitor	Refers to the force exerted by circulating blood on the walls of blood vessels, especially the arteries.
Heart rate	Skin electrodes	Frequency of the Cardiac cycle.
Resistive	Flex sensor	Resistance of the sensor varies accordingly with the finger movements.

Table 1. Bio-sensors and Bio-signals

The WHMS should be certain wearability medical criteria like the weight and size of the system. These both factors should be taken into consideration as the size and weight should be small and less respectively. It should not be difficult for the user to make movements once the glove is put on. The radiation emission should also be taken into consideration since its should not lead to health disorder. The important factor is to minimize the power consumption of the system as much as possible. The last criteria are that the system should be available at an affordable cost so that it can used by as many people as possible.

CHAPTER 2

LITERATURE SURVEY

2.1 RELATED WORKS

In the past, many such WHMS were proposed and some of which were and continues to be commercially available WHMS. These systems or devices has either one sensor or two sensors.

2.1.1 Heart rate and Blood Oxygen Saturation

In order to measure the heart rate and blood oxygen saturation manufacturers like Nonin, Nellcor, Agilent, Redding Medical are providing small, wearable, low cost and lightweight fingertip pulse oximeters, that displays real-time measurement of heart rate and blood oxygen saturation. Other manufacturers of heart rate monitors are Polar and Omron, uses the chest worn belt and wrist watch for display of measurements.

2.1.2 Skin Temperature

Vivago Wristcare manufactured aa wrist-worn device which measures the skin temperature, skin conductivity and movement. A same kind of device called the Sensewear Manufactured by BodyMedia which not only measures the skin temperature but also the heat flow through the body. Both of these devices contained a wireless transmitter for communicating and collecting the values and gives a premature alarm to the base station for further evaluation by a professional Physician.

Fig. 2.1 Vivago Wrist care

2.1.3 ECG Monitoring

A Micropaq Monitor was developed by the manufacturer WelchAllyn, this device was basically a wearable device which in a carrying pouch that can perform pulse oximetry and up to five-lead ECG monitoring. Another such example of commercially available health monitoring systems is a stationary polysomnography systems manufactured by CleveMed, that collects multiple channels of ECG, EEG, EMG, EOG, airflow, snore, thoracic and abdominal respiratory efforts, body position and can send the data through wireless means to any location by using a ISM band transmitter.

Fig 2.2 Micropaq Monitor and Lifeshirt

2.1.4 Washable vests

A washable lightweight vest called LifeShirt was developed by VivoMetrics which includes a respiratory rate sensors, one-lead ECG for heart rate measurement and an accelerator for activity monitoring. A garment based system capable of monitoring heart rate, respiration rate, posture, activity, skin temperature and GPS location was developed by Foster-Miller's Watchdog. In a similar case Smartshirt system developed by Sensatex which is actually a shirt based wearable system using conductive fibre sensors to measure ECG, respiration rate, and blood pressure.

2.1.5 Mobile related system

CardioNet has developed a mobile cardiac outpatient telemetry system (MCOT) for ambulatory ECG monitoring, alarming at helping physicians diagnose and treat patients with arrhythmias.

Fig 2.3 Zephyr Bioharness and Schiller's Bluetooth Portable ECG monitoring device

2.1.6 More Devices

A Bioharness monitor was developed by Zephyr. Inc which is a chest belt that monitors ECG, respiration rate, skin temperature and activity. Furthermore, Schiller and Corscience have also developed small portable Bluetooth ECG monitors.

CHAPTER 3

PROJECT DESCRIPTION

3.1 EXISTING PROBLEMS

The above-mentioned devices do have one or more of the following problems which are less versatile, small and not widely accepted.

3.1.1 Less versatile

Most of the WHMS includes only one or at the most two sensors and if the greater number of sensors are added to the device then the manufacturer has to compromise with the factors such as the weight and size of device. WHMS should include more number of sensors as it can be useful to detect various bio-parameters and there won't be any need to use different devices to detect various parameters. In chapter 2 most of devices mentioned suffers the same problem they are used only for one or two purposes.

3.1.2 Small

This is a very important factor since the WHMS has to meet werability medical criteria the size has to be small so that it can easily wearable by the user. The main drawback for this factor is if the size is reduced then the number of functions of a device will also reduce. For example, Micropaq Monitor, Vivago Wristcare are small size devices but they have a limited number of functions. If the patient needs to be checked for parameters other than skin temperature or ECG then the person requires to use other separate devices specially meant for those purposes.

3.1.3 Not widely accepted

These systems are not widely accepted since most of the people can't afford them due to high cost. Most of these systems are bought by hospitals. The main objective of WHMS is to be available for personal use even at home, or where ever required. These systems use sensors which does not give accurate readings This too is one of reasons that these are not widely accepted sine the patients need accurate readings to know the real time condition of a patient.

3.1.4 Cost

The cost of some of the devices are high which cannot be affordable by most of the people. When the system has more number of sensors then the cost of the device will also be high. WHMS should be available at an affordable cost.

3.2 FUNCTIONALITIES OF MODULES

The proposed system includes altogether four types of sensors and a Central processing unit which consists of Arduino UNO and an ESP 8266 which is basically a Wi-Fi Arduino module, that is then connected to an IOT module.

3.2.1 Materials

3.2.1.1 Types of sensors

The different types of miniature biological sensor used in the proposed system are Temperature sensor, Flex sensor, Blood Pressure sensor and Heart rate sensor.

3.2.1.1.1 Temperature Sensor

A temperature sensor is a device which is designed to measure or detect the hotness or coldness of an object. Basically LM-35 is a Temperature sensor which can measure or detect the temperature varying from -55 to 150ºC. Temperature sensor of type LM35 is preferred over Thermistor since it provides with more accurate reading. It also keeps control of low self-heating and does not cause more than 0.1° C. It can measure temperature in both the standard parameters that is in degree centigrade and Fahrenheit. In this project the temperature is measured in terms of degree Fahrenheit. The LM 35 does not need any external adjustments or trimming and maintains an accuracy of +/-0.4° C at room temperature and +/-0.8°C over a range zero to hundred-degree Celsius. The sensor includes two transistors which is placed in the centre. One of these transistors will have ten times the emitter of the other that is one of the transistor has tenth of the current density since the same current flows through both of the transistors. As discussed earlier it can display the measures in both the parameters the sensor contains an amplifier on the right side of it which converts the detected value to degree Celsius from degree Kelvin. As shown in the fig 3.1. the LM35 has three pins namely VCC, Ground and output pin. Pin 1 is the VCC or the power supply pin which requires IC low voltage of +5 VDC of power supply. To get the value in degree Celsius the value displayed by the sensor in degree Kelvin should be divided by 10- this gives the value in degree Celsius. While connecting the LM35 pins to an Arduino board.

Pin No.	Function	Pin Name
1	Supply Voltage: 5V (+35V to –2V)	VCC
2	Output Voltage (+6V to –1V)	Output
3	Ground (0V)	Ground

Table 3.1 Pin Description of LM 35

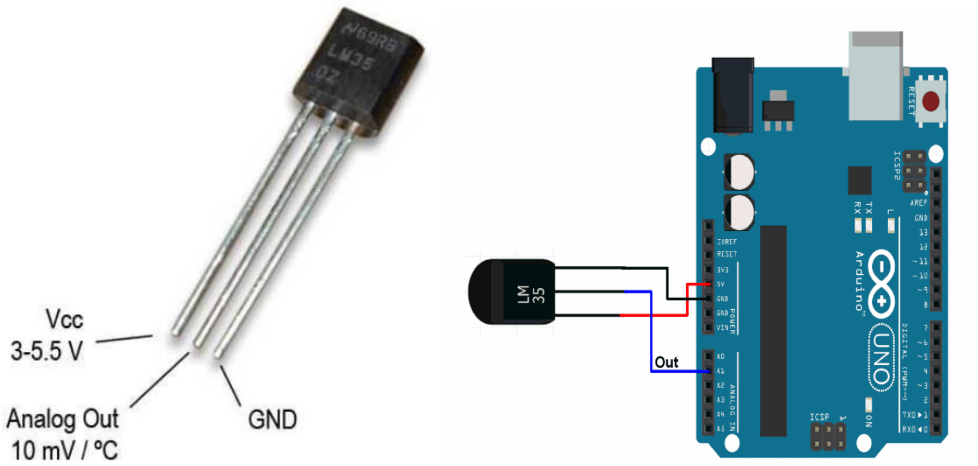


Fig 3.1(a).Temperature sensor (LM35) (b). Connection with the Arduino board

3.2.1.1.2 Blood Pressure sensor

High blood pressure is a common risk factor for heart attacks, strokes and aneurysms, so continuous or frequent monitoring of blood pressure is highly recommended by doctors for elderly patients. Also, a visit to a doctor can grow the feeling of anxiety in patients which naturally increases the blood pressure that can lead to false or inaccurate readings. For the proposed system the Blood pressure sensor used is of non-invasive type. Basically in non-invasive type it consists of a arm cuff which will be connected to the sensor through wired means that is situated in the glove. The cuff is wrapped around the upper hand or at the wrist. Working principle is the pressure exerted on the cuff determines the high or low pressure. The cuff is then inflated to its maximum so at a particular time no blood flows through the artery. The cuff then starts to deflate and when it is below the patient’s systolic pressure there occurs a vibration in the artery which detects the high blood pressure. Vibrations occurs at both the time indicating the high as well as the low blood pressure. The low blood pressure is detected when the cuff pressure falls below the diastolic pressure, at this time the blood through the artery flows through the artery smoothly. This way of checking the pressure is called the non-invasive type. Other method to check the blood pressure is by invasive means where a cannula is inserted in an artery. As shown in fig 3.2 the cuffs can either be placed at the Brachiallis which is the most commonly used place to measure the blood pressure. The second location is situated at the wrist below the Thumb bone where the pulse is also usually checked is called the Radalis. The third and the final location to measure the blood pressure is the Digitalis situated at the second and middle finger of a hand.

Pin No	Function	Pin Name
Pin 2	Supply Voltage: 5V, 200mA regulated	VCC
Pin 1,5,16	Ground 0V	Ground
Pin 7,8,9,10	Transmitter Out	Output

Table 3.2 Pin Description of Blood Pressure sensor

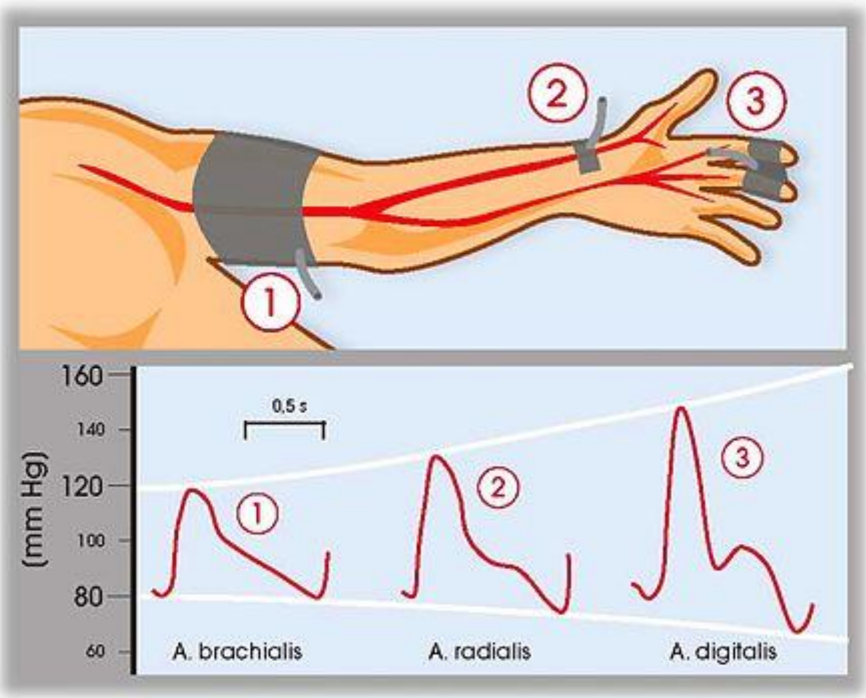


Fig 3.2 Non-invasive Blood pressure sensor using an Arm cuff

3.2.1.1.3 Heart rate sensor

A heartbeat is the sound of the valves when the heart is contracting or expanding as the heart forces the blood from one region to another. Heart beat sensor can be measured based on optical power variation as light is scattered or absorbed during its path through the blood as the heart beat changes. The principle on which the Heart beat sensor works is called the Photo phlethysmography. Photophlethysmography (PPG) is an economical optical approach that can be used to detect blood volume changes in the microvascualr bed of tissues. It is frequently used non-invasively to make measurements at the surface of the skin. The sensor measures the change in volume of the blood through any part of the body which causes the change in the light intensity through that organ. As shown in fig 3.3 this means the sensor uses Light emitting diode to transmit the IR rays through a vascular region like an earlobe or the tip of a finger. At the receiving end a light detector diode or a photodiode is placed in order to consume the incoming IR rays. Heartbeat causes air gap in the blood which in turn leads variation in the blood flow. The IR rays emitted by the diode then passes through the tissue later through the blood vessel in the absence of blood and get detected at the receiving end. The blood in the blood vessel plays like an obstacle for the IR rays. The amount of light absorbed depends on the blood volume in that tissue. The output of the detector is in the form electrical signal and is proportional to the heart beat rate.

Parameter	Value
Operating Voltage	+5V DC regulated
Operating Current	100 mA
Output Data Level	5V TT level
Heart beat Detection	Indicated by LED
Light Source	660nm Super Red LED

Table 3.3 Specification of Heartbeat sensor

The electrical signal is actually a DC signal relating to the tissue and the AC signal corresponds to heartbeat so in order to get the AC signal, the DC signal is passed through a low pass filter – High pass filter circuit and is then converted to the AC with the use of a comparator circuit.

Pin No	Functions	Pin Name
1	Power supply Positive input	+5V
2	Active High output	Output
3	Power supply Ground (0V)	Ground

Table 3.4 Pin Description of Heartbeat sensor

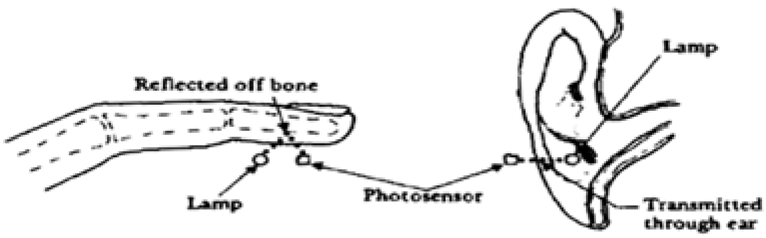


Fig 3.3 Working of Heartbeat sensor

3.2.1.1.4 Flex sensor

Finger has been used for interacting and manipulating with the environment in a huge number of tasks in everyday life. Flex sensors works on the principle of orientation. When the flex sensor is in the flat orientation the resistance is about 25KΩ. When the Flex sensor is in bent orientation the resistance changes to 125KΩ. These sensors are available in two different sizes one is 2.2 inch and the other is 4.5 inch long. The flex sensor consists of two pins of which one is connected to VCC and the second pin is connected to a resistor of 1KΩ to the ground and also it from this pin the output is measured. The output can either be in terms of voltage or resistance. In the project there are two flex sensors used which will be implanted in the glove. Depending on a particular finger movement when the resistance falls or rise beyond a certain default value the patient’s requirement will be displayed. As it is evident that not everyone is well versed with the sign language these sensors will be useful in order to know the patient's requirements. For this project the Flex sensors are being implanted in the second and middle finger’s glove area so depending on the position of either of the fingers the sensor will detect the patient’s requirements which will be processed by the Arduino board and will be displayed on the screen.

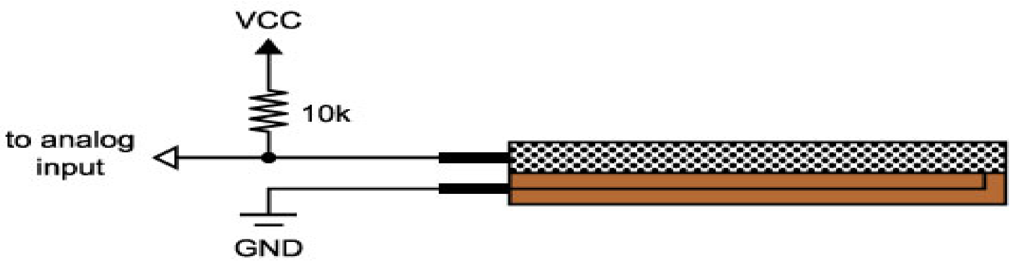


Fig 3.4 Flex sensor

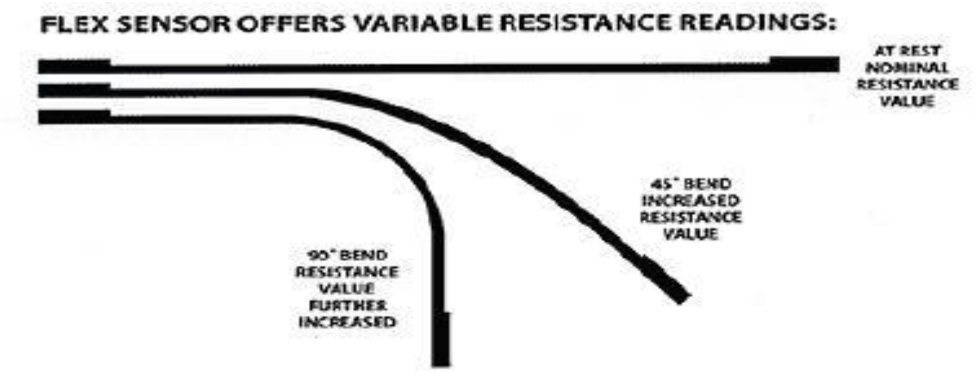


Fig 3.5 Flex sensor resistance change due to various orientation

3.2.2.2 Arduino UNO

The Arduino UNO is a microcontroller board where UNO in Italian language refers to “one”. This board consists of a set of analog as well as digital pins. In this project the flex sensor is provided with additional power supply board because these sensors require a power supply of 5V which cannot be supplied by the Arduino board. It has an in-built LED driven by a digital pin 13. It has an automatic reset button which when pressed the entire data will be lost.

Pin Category	Pin Name	Details
Power	Vin, 3.3V, 5V, GND	Input voltage to Arduino using an external power source
Reset	Reset	Resets the microcontroller
Analog Pins	A0-A5	Used to provide analog input in the range of 0-5V
Input/Output Pins	Digital pins 0-13	Can be used as input or output pins
Serial	0(Rx), 1(Tx)	Used to receive and transmit TTL serial data.
External Interrupts	2, 3	To trigger an interrupt
PWM	3, 5, 6, 9, 11	Provides 8-bit PWM output.
SPI	10(SS), 11(MOS), 12(MISO) and 13(SCK)	Used for SPI communication.
Inbuilt LED	13	To turn on the inbuilt LED.
TWI	A4(SDA), A5(SCA)	Used for TWI communication.
AREF	AREF	To provide reference voltage for input voltage.

Table 3.5 Arduino UNO Pin Description

The main reason to use Arduino UNO board is it is relatively cheap when compared to the Rasberry Pi board as the main objective of the project is to provide the system at an affordable cost.

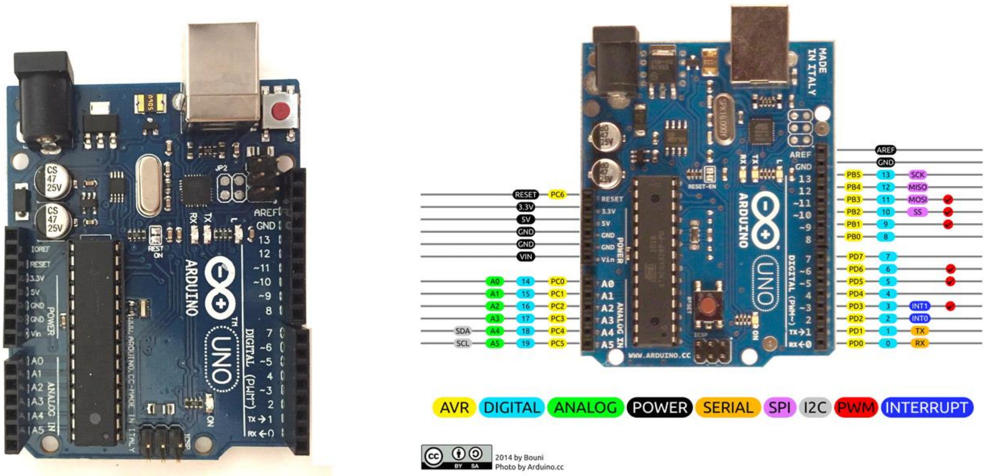


Fig 3.6 Arduino UNO and Pin configuration

3.2.2.2.3 Node-MCU (ESP 8266)

Node-MCU is an open source IoT platform. It uses the ESP8266 Wi-Fi SoC and hardware ESP-12 module. Node-MCU provides access to General purpose Input and Output. ESP8266 is a Wi-Fi Arduino module which will collect the varying values from sensors and will send it to the cloud through wireless means. After the ESP module has received the values, with the help of different platform the data can be interpreted in the required forms whether it is graphical representation or pictorial representation.

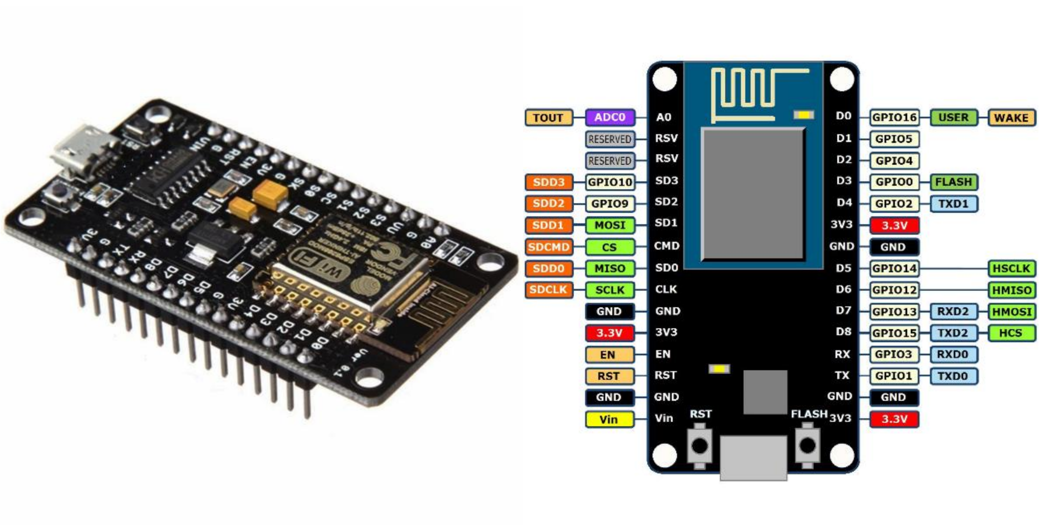


Fig 3.7 Node-MCU (ESP8266) and Pin Diagram

I/O index	ESP8266 pin
0[*]	GPIO 16
1	GPIO 5
2	GPIO 4
3	GPIO 0
4	GPIO 2
5	GPIO 14
6	GPIO 12
7	GPIO 13
8	GPIO 15
9	GPIO 3
10	GPIO 1
11	GPIO 9
12	GPIO 10

Table 3.6 Pin Description of Node-MCU

The pin D0 that is GPIO 16 can only be used for GPIO read or write. It does not support open-drain, interrupt, PWM, I2C or 1-Wire. Since Arduino UNO does not support wi-fi hence Node-MCU is used as it has a more powerful processor than the arduino uno, a 4Mb flash memory and much more RAM. The only drawback and the reason to use Arduino UNO for this project is MCU has fewer number of GPIO, ADC and PWM. AS the proposed project requires a greater number of GPIO pins an Arduino UNO board is used.

CHAPTER 4

METHODOLOGY ADOPTED

The main components used for a wearable health monitoring system are Temperature sensor, Heartbeat sensor, Blood pressure sensor, Flex sensor, Arduino UNO, Node-MCU. The temperature sensor which is of the type LM35 consists of three pins namely the VCC, Ground, Output pin. This sensor doesn’t consume much power so it is directly connected to Arduino board through wired means. Once the patient holds the temperature sensor close to the body it detects the variation in the temperature compared to the room temperature. The Heartbeat sensor works on the principle of Photo-plethysmography. By detecting the variation in blood flow through the artery. This heartbeat sensor consists of a light emitting diode and the transmitting end and a photodetector at the receiving end. The blood pressure sensor will be of non-invasive type that is it will consist of a cuff which can be easily wrapped around the upper hand or wrist. The cuff is then inflated in order to stop the blood flowing through the artery. The systolic and diastolic pressure are taken into consideration. The flex sensor is a sensor which calculates the resistance based on their orientation. When it is in flat orientation and in bent orientation the resistance is 25K and 125K respectively. All these sensors are connected to the Arduino board for power supply.

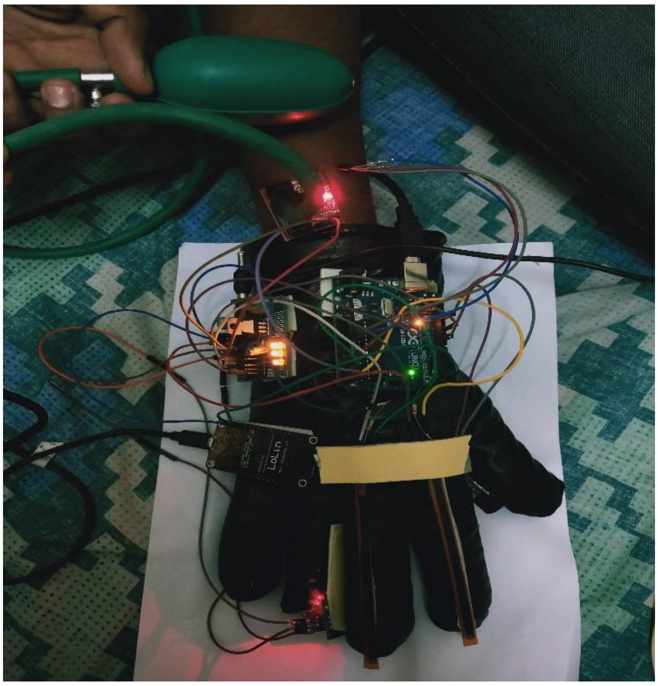


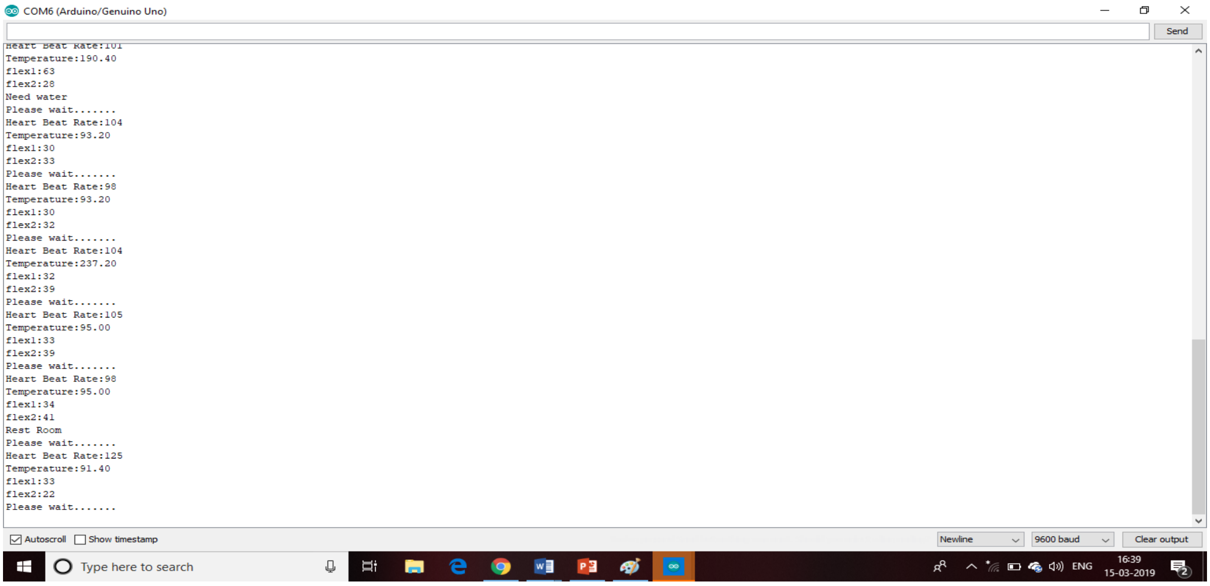
Fig 4.1 Actual kit in working condition

Only the flex sensor is connected to an external power supply since there are two flex sensors used and each one of them requires a power supply of 5V which cannot be supplied using a Arduino board. The system will also consist a buzzer which will ring an alarm if any of the parameters sensed are abnormally below the normal the required value. These all will be connected to Arduino board through wired means. The Arduino board is then connected to the Node-MCU which is an ESP8266 (Wi-Fi Arduino Module) which will then send to the cloud. The main reason to use the Node-MCU is it supports various different platform for any type of required output whether it is a graphical or pictorial representation. The cloud will then display the values whenever the patient or the person like a physician, Doctor. The system will give a real-time value of the parameters which are sensed. The system will be more useful for the patient's to needs to keep an update on their health even once they are out of hospital. Also, it will be very useful for daily needs.

CHAPTER 5

RESULT ANALYSIS

The following are the pictures of results obtained when the either of the flex sensors are bent.




```
Please wait.......
Heart Beat Rate:98
Temperature:95.00
flex1:34
flex2:41
Rest Room
```

Fig 4.1 Flex sensor 2 is bent

When the flex sensor 2 is bent and the resistance value goes beyond 35K then the message pops up is Rest Room implies that the patient or person needs use rest room.

```
Please wait.......
Heart Beat Rate:96
Temperature:93.20
flex1:57
flex2:28
Need water
```

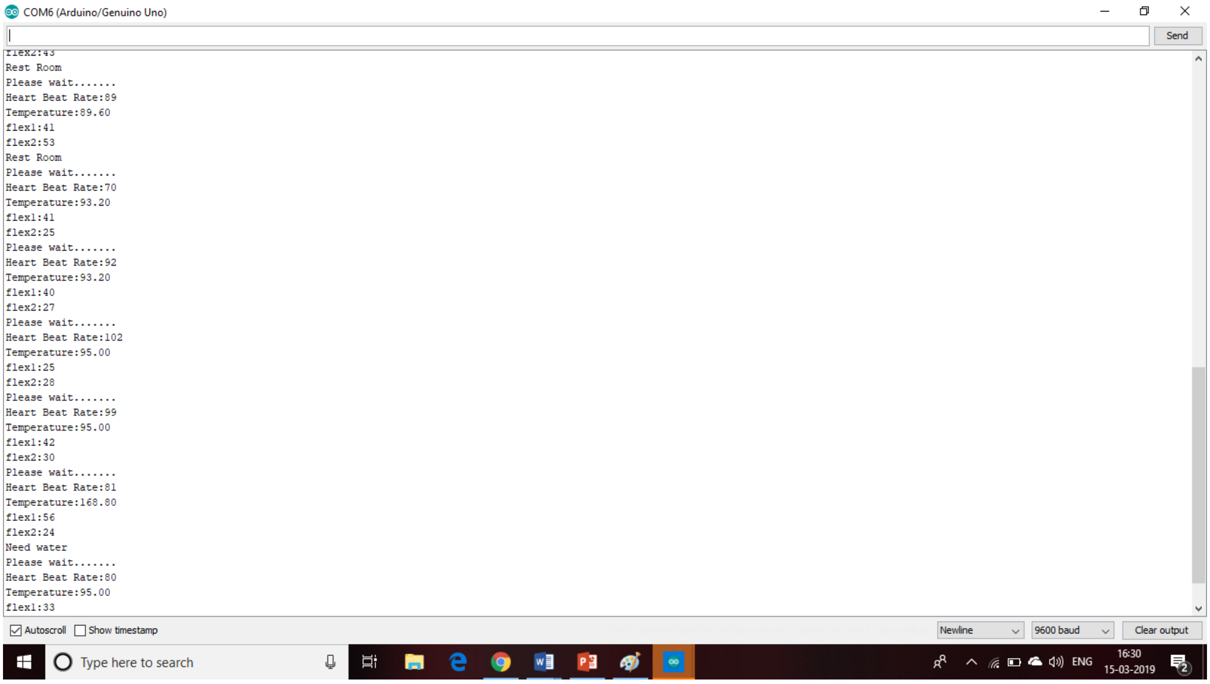


Fig 4.2 Flex sensor 1 is bent

When the flex sensor 1 is bent and the resistance value goes more than 55K then the message pops up on screen is need water which implies that the patient or the wearer needs water to drink.

The result might take a little while since the sensors and the exact orientation of flex sensor do requires a small amount of time in order to display the sensed values.

CHAPTER 6

CONCLUSION

The proposed system is designed to provide a real-time analysis of a patient's health. As of now, no such system with these many number of sensors has been proposed, so it is versatile. These sensors are programmed in such a way that they should provide with accurate readings. The range of the systems varies over a wide range, reliable. These systems will make it easy for the patient to know their real time health status. Since this system will be available at a low cost, it should be affordable by as much people as it can. The proposed system will have low power consumption also the radiation emitted by the system should not affect the patient's health. The proposed system has also taken into consideration medical criteria of wearability which refers to the size and weight.

CHAPTER 7

FURTHER ENHANCEMENTS

In the future instead of using a heart rate sensor, a clipper can be used which is more feasible in a glove. Also, an Oximeter can be used to evaluate the Oxygen level status of patients in different ways of clinical settings it can give continuous, non-invasive measure of patient's oxygen saturation of haemoglobin in arterial blood. Currently the system consists of an ESP8266 which can then sent the data to the cloud inorder to show the data in a pictorial representation, else a GSM module can also be added to the glove to get the output in the form of notifications or in text SMS. Invasive method can also be used where in the Blood pressure sensor or chip should be implanted in the skin of the patient to get continuous data whenever required. More Flex sensors can be added in future to indicate more number of patient's requirements.

CHAPTER 8

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CHAPTER 9

SAMPLE CODE

```
int tempin= A0;
int flex1=A4;
int flex2=A3;
int heartrate=10;
int k=0;
unsigned rate=0;
unsigned long time2,time1;
unsigned long time;

void setup() {
 Serial.begin(9600);
 pinMode(tempin,INPUT);
 pinMode(flex1,INPUT);
 pinMode(flex2,INPUT);
 pinMode(heartrate,INPUT);

}
```

```
void loop() {
unsigned  int temp=analogRead(tempin);
int sign1=analogRead(flux1);
int sign2=analogRead(flux2);
int tem=temp/2;

Serial.print("Temperature:");
Serial.println((tem*1.8)+32);
delay(500);
Serial.print("flux1:");
Serial.println(sign1);
delay(500);
Serial.print("flux2:");
Serial.println(sign2);
delay(500);

if((sign1>55) && (sign2<35))
{
 Serial.println("Need water");
}
if((sign1<50) && (sign2>40))
{
 Serial.println("Rest Room");
}
k=0;
Serial.println("Please wait.......");
while(k<5)
```

```
{
 if(digitalRead(heartrate))
  {
   if(k==0)
   time1=millis();
   k++;
   while(digitalRead(heartrate));
  }
}
   time2=millis();
   rate=time2-time1;
   rate=rate/4;
   rate=(60000/rate)-10;
   Serial.print("Heart Beat Rate:");
   Serial.println(rate);

}
```