Proactive Healthcare Monitoring and Recommendation System based on IoT

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Abstract— In recent times indoor air quality has been depleting and the health issues are increasing worldwide. Since people are affected by the diseases regardless of the age, a remote health monitoring and recommendation system has gained importance. Nowadays, Internet of Things (IoT) system is used to facilitate the process of personal monitoring and patients' diagnosis. This project proposes a system which incorporates indoor air quality sensors and healthcare sensors with the arduino MEGA. The Bluetooth device (HC-05) is used for wireless communication with Bluetooth enabled devices (like smart phone). HC-05 communicates with microcontroller using serial communication (UART). The wi-fi module is used to send the data to the cloud. Cloud is used to store, manage and process data using a network of remote servers hosted on the internet. The readings taken from the sensors are sent through the Bluetooth module to the LCD. The data is analyzed and sent to the cloud. The user is alerted via LCD display.

Keywords— Internet of Things, Sensors, Health care, Indoor air quality, Monitoring, Prediction.

I. INTRODUCTION

Nowadays, due to the current busy lifestyle, health issues are rising everyday. According to World Health Organization (WHO)[1], every year 4.9 million people die from lung cancer, overweight causes 2.6 million deaths, 4.4 deaths are caused by elevated cholestrol and 7.1 million people die from high blood pressure. People are paying less attention to their health. Since health is something that changes on daily basis, it is important to monitor the early symptoms to prevent health deterioration. A personalized monitoring[2] and recommendation system can serve this purpose. Diseases are also caused due to pollution, especially indoor air pollution. The indoor air quality must be paid more attention than outdoor air quality since the indoor environment provides less opportunity for pollutants to dilute[3]. This system also detects indoor air pollutants which is major cause for various respiratory diseases.

The physical things can be embedded with sensors and software which enables them to communicate with each other and exchange data. This forms a network of physical devices known as Internet of Things (IoT)[4]. "Things" in IoT refers to variety of devices which collects useful data using existing technology and helps in flow of data between devices. Examples of physical devices are vehicles and home appliances.

The IoT creates opportunities for direct integration of the physical devices into the computer-based system. This allows the objects to be sensed or controlled remotely across the networks. The direct integration results in improved accuracy, efficiency and economic benefits along with reduction in human involvement.

Nowadays, the IoT applications are including analytics and prediction models[5] as an integral part of the systems. Predictive modeling is a process that uses data mining and probability to forecast outcomes. Each model is made up of a number of predictors, which are variables that are likely to influence future results. Once data has been collected for relevant predictors, a statistical model is formulated. Most often the event one wants to predict is in the future, but predictive modelling can be applied to any type of unknown event, regardless of when it occurred. Machine learning[6] techniques are used to find patterns in data and to build models that predict future outcomes. A variety of prediction algorithms are available, including linear and nonlinear regression, neural networks, support vector machines, decision trees, and other algorithms.

II. LITERATURE SURVEY

Technology enhancements have enabled most systems to be presented in web-based or online system[7]. Today, the IoT principles are already being applied to improve access to care, increase the quality of care and reduce the cost of care[8][9].

Arduino board is one of the platforms on which IoT can be implemented. Processing of measured data is done with the Arduino board [10]. Its designs use a variety of microprocessor and microcontroller. An embedded microprocessor [11] is a processor which functions like a computer's CPU on small integrated circuit. A microcontroller is a single IC which functions like a small computer. ATmega328P is a type of microcontroller [12] present in the Arduino. It contains one or more CPUs, memory and input/output peripherals. These are used in devices such as implantable medical devices, remote controls and other embedded systems which can be automatically controlled. Microcontrollers are economical to digitally control more devices and processes. Hence, Arduino provide a low -cost solution.

Fig 1 outlines an architecture in an environment where IoT devices are connected over an IoT gateway. This approach enables the IoT gateway to be very simple and not to contain any application logic—providing a kind of translation between

Layer 2 protocols towards simple IoT devices, such as sensors and actuators, on its southbound interface (e.g. ZigBee or Bluetooth) and the IP protocol on its northbound interface. IoT applications are running in the data center on a standard hardware shared among different applications. The data center is implemented in a layered approach. The HW layer offers a scalable and elastic hardware platform based on commercial off-the-shelf (COTS) components[13], the Virtualization layer uses the HW layer to provide virtual machines towards the applications, whereas the management and orchestration layer ensures lifecycle management of IoT applications, as well as the coordination of the resources and different IoT applications.

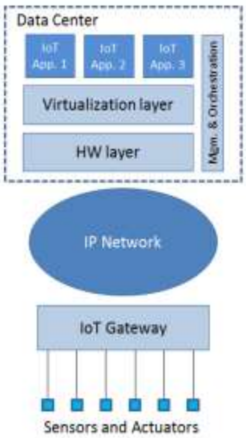

Fig 1: IoT Architecture

ThingSpeak[14] is an open source Internet of Things (IoT) application and API to store and retrieve data from things using the HTTP protocol over the Internet or via a Local Area Network. ThingSpeak enables the creation of sensor logging applications, location tracking applications, and a social network of things with status updates.

MongoDB[15] is a document-oriented database (not a relational one). Its NoSQL. It has a high performance and it is flexible and easily expandable. It uses "document" replace the "line" concept in relational DB i.e., the document can be any complex data model like value of an array, documents and others. The main idea behind mongoDB is that the operations that can be transferred to clients are transferred from the server to client. MongoDB tries to preserve features of a relational DB but whenever possible, the generation and logic is handled by DB server for the client to achieve. This is a compact design and is one of the reasons mongoDB is able to achieve high performance.

NodeJS[16] is a JS runtime environment written in C++. For good performance, it uses Google Chrome V8 engine and also provides system-level APIs like web programming and file operations. In NodeJS, event driven and asynchronous programming is used. (we can explain the example of net module if required) The advantage of this is that the system resources are used fully. A code can be implemented without waiting for other operations to complete. And also limited resources can be used for other tasks. This is suitable for backend n/w service programming which is the goal of NodeJS.

Various prediction models are used in deifferent systems. For example, multiple model classification[17]. Here, each patient has unique physiological reactions. Thus, in similar health risk conditions, the symptoms (and consequently the physiological data measurements and vital signs) may differ from patient to patient. In analytics systems, because the predictor model is established based on the features extracted from physiological data, designing a single model to perform the prediction for the entire dataset may fail to achieve accurate results. Thus, a major challenge in building the proposed framework is the lack of an accurate universal prediction model to support the entire dataset. To address this issue, we propose a multiple prediction modeling technique that includes a set of accurate prediction models rather than one single universal predictor for the entire dataset. Decision Tree Decision tree is the most fundamental classification algorithm. It builds classification or regression model in the form of a tree structure [18]. Feature selection is one of the characteristic of decision tree that suggests a tree from supplied set of significant features relevant to solution of a problem . Naïve Bayes The Naïve Bayesian classifier is based on Bayes' theorem with independent assumption between predictors. In Naïve Bayes classifier, the values of a predictor(x) on a given class(c) and values of other predictors are independent of each other. This assumption is called class conditional independence [19]. Proactive monitoring of one's health could avoid serious diseases as well as better maintain the individual's well being. In today's Internet of Things (IoT) world, there has been numerous wearable technological devices to monitor/measure different health attributes. With the increasing number of attributes and wearables, it becomes unclear to individuals which ones they should be using. The aim of this paper is to provide a novel recommendation engine for personalized advised wearables and IoT solutions for any given individual. The way the engine works is through first identifying the diseases that this person is at risk of, given his/her attributes and medical history. This is done via analyzing the individual's unstructured medical history using text mining, adding it to his/her structured demographic attributes, and then feeding this data to a machine learning classification model that predicts eventual diseases. Then, we map these diseases to the attributes that need to be measured in order to monitor them. Lastly, we use a mathematical optimization model that we developed to recommend the optimal wearable devices and IoT solutions for the individual. Thus, our solution enables proactive health monitoring and can thus provide a significant human benefit.[20]

III. PROPOSED SYSTEM

The proposed system uses Arduino MEGA controller. It incorporates 6 sensors, 1 Bluetooth module, 1Wi-fi module and 1 LCD display as shown in Fig 2. Arduino MEGA has 2 sets of UART pins. One set is used for Bluetooth module and the other for Wi-fi module.

Fig 2: Module Diagram

In the architecture diagram shown in Fig 3, the Wi-fi module sends the data to the Thinkspeak cloud. The user has to register with the cloud to access his data.

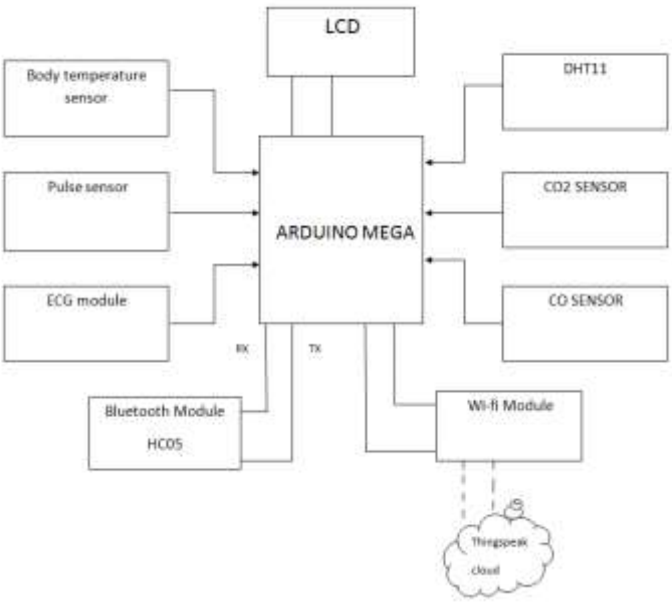

Fig 3: Architecture Diagram

IV. PROTOTYPE AND WORKING

The continuous monitoring and prediction system is implemented on Arduino MEGA. This system shown in the FIG 4 consists of 3 health care sensors and 3 environment sensors. The 3 health sensors are used to detect the body temperature, the heart rate and ECG. The 3 environment sensors are for humidity and temperature, CO and CO_2 levels.
The sensors detect the appropriate values and the controller sends these values to the appropriate module. Here, the values are sent to the Bluetooth module or the Wi-fi module. Since the MEGA controller has 2 sets of UART pins, 1 set is used by Bluetooth module and the other set by wi-fi module. These 2 modules enable data transfer. The Bluetooth module sends the data to the LCD display that is present in the system. The LCD will display the values at certain time intervals. This way the user will know the current parameter values. In addition, the Wi-fi module will also send the data to the cloud. The cloud used here is Thingspeak.
The Thingspeak cloud is an open source IoT application. This cloud requires the user to register first. Once the user registers, the user can download the specific data report. The date report is of the form of an excel sheet. As soon as the user downloads the report, a java program is implemented to extract the specific values and generate the result in a note pad. The result in note pad will have the prediction of what the user might get affected with if the values are exceeding the standard safe range. The user can take appropriate precautions.

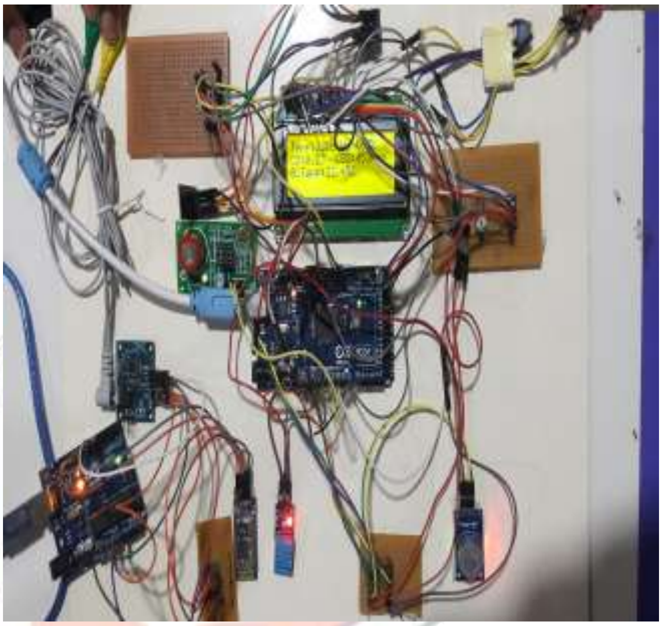

Fig 4: Prototype

Algorithm of working principle

Step 1: Start
Step 2: User switches on the power.
Step 3: The user registers with thingspeak cloud.
Step 4: The bluetooth and wi-fi connections are established.
Step 5: The controller fetches the data from the sensors and displays on the LCD screen at certain time intervals.
Step 6: The data is also updated to the cloud , from where the user can download the values.
Step 7: When the values recorded crosses the standard range, the user is notified by the LCD display.
Step 8: Repeat steps 5 to 7 in an infinite loop.
Step 9: End

V. PREDICTION ALGORITHM

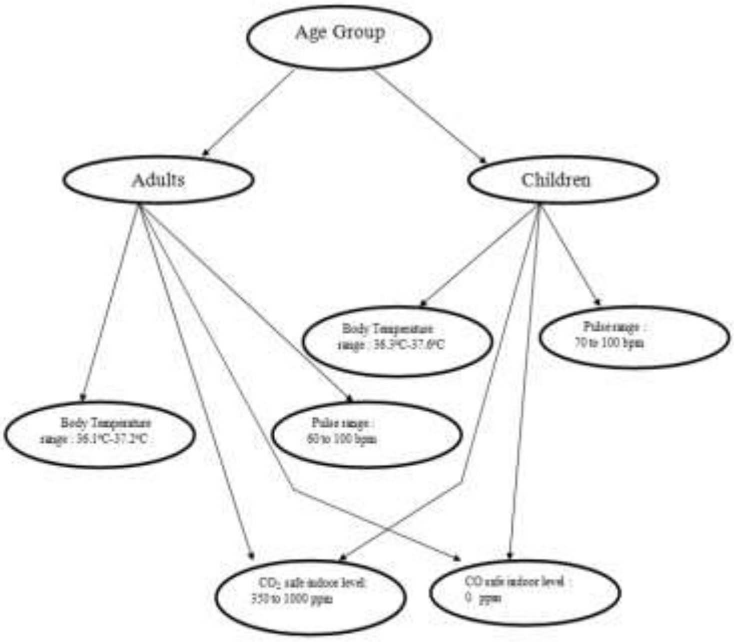

Fig 5 : Prediction Tree

Step 1: Start
Step 2: When the power is turned on patient registration is done
Step 3: The controller fetches data from the sensors attached to the patient's body
Step 4:

```
 if 36.1<body_temp<37.2
     then display "normal temperature"
 else display "temp not normal"
 if 60<pulse<100
     then display "normal pulse"
 else display "pulse not normal"
 if 350<CO2<1000
     then display "normal CO2 level"
 else display "high pollution"
 if CO=0
     then display "normal CO level"
 else display "high CO level"
```

Step 5: Repeat from Step 3 in infinite loop.
Step 6: End

VI. CODE

```
void setup() {
  Serial.begin(9600);
  Serial1.begin(9600);
  lcd.begin(20, 4);
  lcd.clear();
  lcd.setCursor(6,0);
  lcd.print("Welcome");
  lcd.setCursor(8,1);
  lcd.print("to");
  lcd.setCursor(3,2);
  lcd.print("Health Monitor");
  delay(3000);
  lcd.clear();
```

Code Snippet 1

```
void loop() {
  // put your main code here, to run repeatedly:
  if (isnan(h) || isnan(t)) {
    Serial.println("Failed to read from DHT sensor!");
    return;
  }

  h = dht.readHumidity();
  t = dht.readTemperature();

  val = analogRead(gasPin);
  val = val / 1023;
 value = analogRead(gasCOPin);

  vout = analogRead(lm35Pin);
  vout = (vout * 400) / 1023;
  tempc = vout;
  delay(10);
  lcd.setCursor(0, 0);
```

Code Snippet 2

```
    delay(10);
    lcd.setCursor(0, 0);
    lcd.print("Temp:");
    lcd.print(t);
    lcd.print("C");
    lcd.setCursor(10, 0);
    lcd.print("Hum:");
    lcd.print(h);
    lcd.print("%");
    lcd.setCursor(0, 1);
    lcd.print("CO:");
    lcd.print(val, 1);
    lcd.print("%");
    lcd.setCursor(9, 1);
    lcd.print("CO2:");
    lcd.print(value);
    lcd.print("%");
    lcd.setCursor(0, 2);
    lcd.print("B.Temp:");
    lcd.print(tempc);
    lcd.print("C");
    lcd.setCursor(0,3);
    lcd.print("ECG:");
    lcd.print(ecgdata);
  }
}
```

Code Snippet 3

The baud rate is the rate at which information is transferred in a communication channel. In the Code Snippet 1, the baud rate is 9600 this means that the serial port is capable of transferring maximum of 9600 bps.

In Code Snippet 2, To take the DHT11 sensor values we use isnan() function to check if the sensor is able to read the values. The values from all the sensors are read.

In Code Snippet 3, the sensor values which were read are displayed on the LCD scree

VII. RESULTS

Fig 6: LCD Display

The Real-Time sensor readings are given on the LCD display. In Fig 6, the Temperature value is in degree centrigade and humidity is percentage. The CO and CO2 concentration levels are calculated in ppm (parts per million). The body temperature values are in centrigade.

	A	B	C	D	E	F	G
1	created_a	entry_id	field1	field2	field3	field4	field5
2	2018-05-1	1	28	65	0.23	460	32.45
3	2018-05-1	2	28	65	0.23	461	32.45
4	2018-05-1	3	28	65	0.23	464	32.06
5	2018-05-1	4	28	65	0.23	462	32.06
6	2018-05-1	5	28	65	0.23	460	32.45
7	2018-05-1	6	28	65	0.23	457	32.45
8	2018-05-1	7	28	65	0.23	461	33.24
9	2018-05-1	8	28	65	0.23	459	32.45
10	2018-05-1	9	28	65	0.23	463	32.45
11	2018-05-1	10	28	65	0.23	459	32.45
12	2018-05-1	11	28	65	0.23	455	32.45
13	2018-05-1	12	28	65	0.23	453	33.24
14	2018-05-1	13	28	65	0.23	460	32.06
15	2018-05-1	14	28	65	0.23	459	32.06
16	2018-05-1	15	28	65	0.23	456	32.45
17	2018-05-1	16	28	65	0.23	456	32.45
18	2018-05-1	17	28	65	0.23	455	32.45
19	2018-05-1	18	28	65	0.23	457	32.45
20	2018-05-1	19	28	65	0.23	456	33.24
21	2018-05-1	20	28	65	0.23	452	33.24
22	2018-05-1	21	28	65	0.23	454	32.45
23	2018-05-1	22	28	65	0.23	454	32.45
24	2018-05-1	23	28	65	0.23	453	32.45
25	2018-05-1	24	28	65	0.23	453	32.45
26	2018-05-1	25	28	65	0.23	455	32.45
27	2018-05-1	26	28	65	0.23	454	32.45
28	2018-05-1	27	28	64	0.23	449	32.84
29	2018-05-1	28	28	65	0.23	448	32.45
30	2018-05-1	29	28	64	0.23	449	32.45

Fig 7: Excel Sheet

In Fig 7, all the tabulated values are stored in the Excel Sheet. Field 1 holds the temperature readings. Field 2 holds humidity values. Field 3 holds CO values. Filed 4 CO2 values and Field 5 holds body temp values.

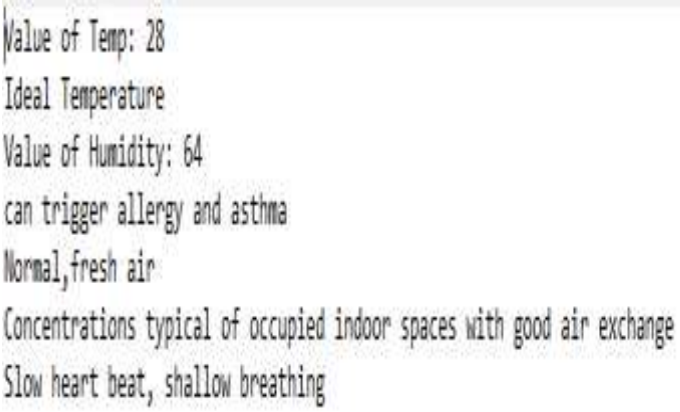
Value of Temp: 28
Ideal Temperature
Value of Humidity: 64
can trigger allergy and asthma
Normal,fresh air
Concentrations typical of occupied indoor spaces with good air exchange
Slow heart beat, shallow breathing

Fig 8: Predictions

According to the values read by the sensors, respective predictions are given as shown in Fig 8. As seen in field 3 i.e. CO values are in the range 0.23ppm so it gives the respective prediction as Normal, fresh air. Field 4 is CO2 it is in the range 350-1000ppm so the respective prediction is given as Concentrations typical of occupied indoor spaces with good air exchange. Field 5 is body temperature in the range 32-33 so the respective prediction would be Slow heartbeat, shallow breathing.

VIII. CONCLUSION

We have presented an integrated system consisting of sensors and other modules like Bluetooth and Wi-fi. The Wi-fi module is used to update values to the cloud. The user can also download the report from the cloud.
The LCD displays values received from the Arduino. The ECG sensor values which are plotted on a graph are sent through the Bluetooth module by the arduino.

IX. FUTURE WORK

The future work can include an android app or a web application instead of an LCD display. The user and the selected peers can be notified when the values exceed the specified range. The notification can also be sent to the nearby hospitals.

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