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Diabetic Ketoacidosis detection and Implementation with Internet Of Things

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***Abstract*—Diabetes, a very serious issue, has many extreme effects on humans. If the level of glucose in human blood decreases to less than 70 mg per dL known as hypoglycaemia, or when increases to more than 275 mg per dL, known as hyperglycaemia, leads to coma and when still persistent becomes fatal. The same condition of sudden death is also reported in the case of heart attacks. Thus a solution is proposed which includes an integrated device that detects diabetes using a non invasive method, heart pulse rate and finally body temperature. This diabetes detector does not use the formal method which requires the pricking of hand to test the blood glucose; rather this uses a breath of the person to detect the amount of glucose present in the blood. Along with the diabetes detector, this project aims to provide heart beat tracking which detects the heart rate. This also comes with a temperature sensor that shows the human body temperature. Thus these parameters that are Glucose level, Heart Rate, Body Temperature are connected to the internet, when any abnormality is detected the ambulance service is alerted and nearby hospital is provided with the information.**

Keywords—Integrated Patient Monitoring System, Non Invasive detection, Internet of Things, Glucose Level.

I. INTRODUCTION

The Internet of things (IoT) is the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and network connectivity which enable these objects to connect and exchange data [1]. With the help of IoT, devices begin to communicate with one another and thus becoming smarter. The important purpose of IoT is to provide more access to mass number of people. IoT is widely used in many applications in many domains like medical aids and healthcare, home automation, Industrial Automation, smart grids, traffic control system, smart cities. In nutshell the application of Internet of Things grows day by day thus leading to many numbers of connected devices. As the networking grows, approximately 50 billions devices will be connected to the internet by 2020 [2]. Each device contains a unique set of ID which enables the communication. These devices communicate with internet and thus providing useful solution. Pancreas secretes the insulin which is essential for converting the food into energy or glucose. When pancreas fail to produce the required amount of insulin for the conversion, this results in diabetes. Diabetes has two extreme conditions hyperglycaemia and hypoglycaemia. Hyperglycaemia refers to high glucose level in the blood sugar and hypoglycaemia refers to low glucose level in the

blood. When these conditions are not treated on time it may lead to coma and may become fatal too. It is reported that in the year 2014, over 422 million people suffered from diabetes. In the year 2015 around 1.6 million people died due to diabetes[3]. Another issue which is threatening to human is Cardio Vascular Disease (CVD) popularly known as heart attack. During a heart attack the artery is blocked due to fat content and thus not allowing the heart to pump the blood to other parts of the body. It is reported that Cardio Vascular Disease is the major cause for death. Around 17 million people died due to Cardio Vascular Disease in the year 2015[4]. Main cause of heart attack is unbalanced diet which increases the cholesterol content in the body thus leading to a block in heart valve. Major symptoms include pain in left hand that traverse till the heart and also shoulder pain sometimes causes fatigue, sweating. When a person suffers from diabetes are highly prone to CVDs and in the case of a diabetes patient, the symptoms of heart attack may not be evident. As the pumping of blood by heart is hindered during heart attack thus the pulse rate drops. Many techniques are available to detect heart attack like ECG which observes the pattern of the heart beat, Echo Cardiogram. These tests require a rigid and strong infrastructure requiring a lot of machinery. The present method of detecting this is by using a glucose meter where the blood sample of the human is injected into the test strip. Thus frequent pricking of hand would lead to callus which thickens the skin. The diabetes in the blood glucose is calculated by using a non invasive method by using the person's breath. Human breath contains a lot of organic compound when analysed gives an idea of type of disease the person is facing.[5][6]

This paper further provides an idea of utilising the necessary data and by integrating them Internet of Things for healthy living. Section II deals with the methodology of implementation and Section III deals with the result. Finally Section IV talks about the conclusion and further enhancement to this approach.

II. METHODOLOGY

This section below explains about the hardware design and the technology used in the project along with some software snippet.

A. Hardware Implementation.

Hardware that is being used is discussed below. For detection of diabetes, an acetone sensor is used and for detecting the pulse rate an IR light attached with the receiver is used. Finally for detecting the human body temperature thermistor(Thermal Resistor) is used. Figure of pulse rate sensor is given below.

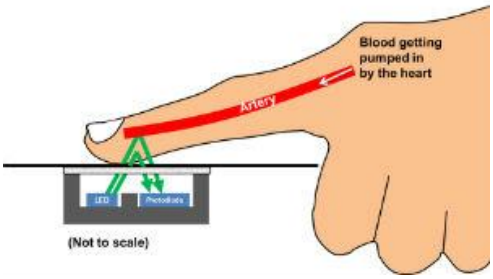


Figure1
(https://www.mdtmag.com/article/2014/09/designning-heart-rate-monitor-wearable-devices.)

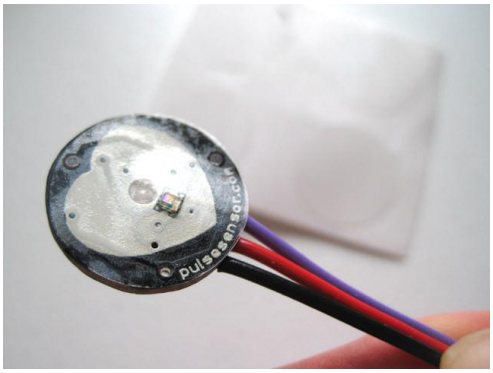


Figure 2

The IR light of appropriate wavelength is sent into human's finger where the light gets reflected after crossing through the artery. The blood flow determines the rate at which the heart pumps the blood. Beer Lambert's law states about the principle of absorption.

Beer Lambert's Law: $A=\varepsilon cl$,

Where A is Absorption

ε is Molar Extinction Coefficient

c is Concentration

l is path length

The light after reflection from artery is reflected to receiver which provides equalisation and amplification to the signal, thus making it noise free.

As discussed earlier diabetes can be detected using content of acetone in human breath. According to [7, 8] it is seen that the concentration of acetone levels in the breath vary for a healthy and a diabetic subject. It is seen that in all healthy samples acetone levels are less than 0.76ppmv and in all samples with diabetes acetone levels showed levels higher than l.71ppmv. The Table I shows the variation of the concentration of acetone levels.

TABLE I

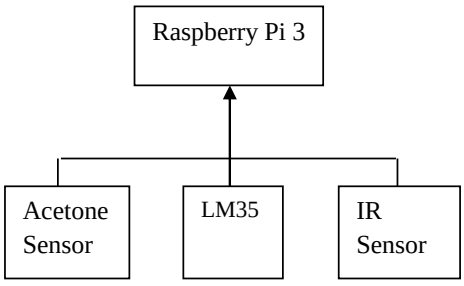
Sample	Conc. Of Acetone (ppm)
Healthy Subject	0.22 to 0.80
Type 2 Diabetes Subject	1.76 to 3.73
Type 1 Diabetes Subject	As High as 21 ppm

The above table depicts the amount of permissible acetone content in human breath. Thus with reference to the above table a solution is created. Organic sensor (Detects all organic compounds in breath) is calibrated to obtain the values of acetone (CH_3OCH_3) in breath.

Along with these an additional capability of measuring human body temperature is added with the use of thermistor.

A thermistor is a temperature dependent resistor. As the temperature varies the resistance is also varied and thus with the value of the resistance the temperature value can be found. LM35 sensor is used as the temperature sensor.

Then these are now integrated using a development board. The development board that is used is Raspberry Pi 3 which has an internal Wi-Fi access for easy use of Internet of Things. This board contains around 40 IO pins for communication and has Bluetooth, Wi-Fi in it and runs mainly on Linux Operating system.



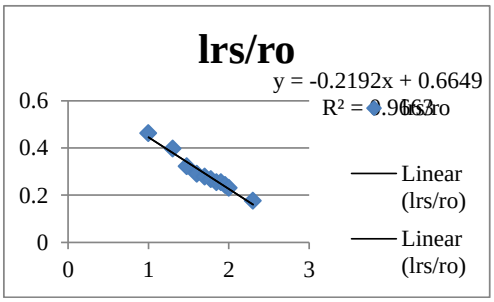
The built in Wi-Fi module inside Raspberry Pi 3 communicates after collecting the necessary data to the nearest ambulance. The alert after going to the ambulance is then arrived for first aid treatment and for further medical process. Further this ambulance, that communicates to the nearest hospital and provides the basic information regarding the patient.

B. Software Snippet

Below is the sample code for extracting content of acetone from other sensors.

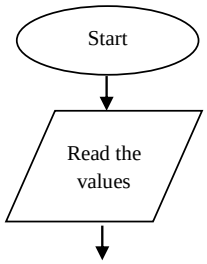
```
float ACETONECurve[3] = {1,0.462,-0.219};
```

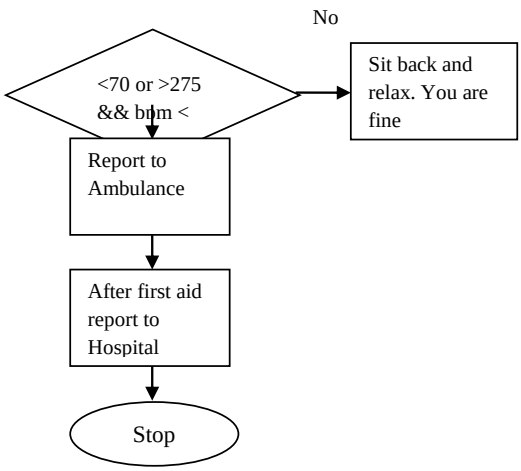
Above snippet determines the amount of acetone from the sensor which is obtained from the regression graph of acetone.



The equivalent resistance of acetone is calibrated from the above regression chart from which the acetone content is determined.

Flowchart of the idea is described below.





When there is a change in the value of glucose that is value goes below 70 mg/dL and above 280 mg/dL then heart beat (pulse rate) is checked. From Table I, the ppm of acetone is mapped to the corresponding band which is found by using the acetone curve.

Heart rate value is obtained in digital format that is the limits are from 0 to 255. Where the heart rate value is encoded into equivalent digital value.

Code Snippet for Pulse Rate

```
if (QS == true)
{
     fadeRate = 255;
     serialOutputWhenBeatHappens();
      QS = false;
 }
```

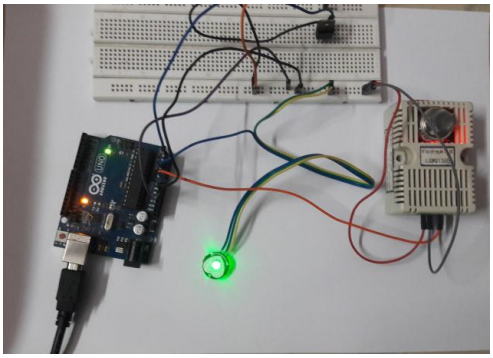
Code Snippet for Temperature

```
sensors.requestTemperatures();
float temperatureInCelsius
float temperatureInFahrenheit
```

The temperature is proportional to the resistance change, thus this value is used for determining the temperature value.

III. RESULT

The hardware setup is also given below using Arduino.



The difference between the value invasive and non invasive methods

$$\% \text{ Error} = \frac{\text{Glucose}_{\text{invasive}} - \text{Glucose}_{\text{non-invasive}}}{\text{Glucose}_{\text{non-invasive}}} \times 100\%$$

The error is approximately around 4-10%. This can be minimised by improvising the sensor's capability.

The Output of the setup is given below.

```
Calibarating.....
Detecting Values.....
Diabetes Level: 155 mg/dL
Pulse Rate: 73 bpm
Temperature: 98.2 F
```

Thus depending on the sensor values the alert can be sent to ambulance. More time for calibration higher will be the its efficacy.

IV. CONCLUSION

The integrated patient monitoring device was able to detect the glucose level, pulse rate and the body temperature using acetone sensor (Organic Sensor), IR sensor and Thermal Resistor. The accuracy levels were very close to that of the conventional method of testing and verification.

As a recommendation for future improvements idea of attaching ECG which tells heart beat waveform; EMG can also be attached in to this that collects essential parameter of the patient in case of emergency. Further insulin level(For patients dependent on external insulin that is type 1 diabetes) can be displayed to the patient for quick action.

V. REFERENCES

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