IoT Based Non-Invasive Blood Glucose Level Detection

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Abstract.

Over the past few decades, with the upsurge of diabetes, an increasing number of patients are suffering from infections and pain created by the invasive method of glucose detection meters. The WHO (World Health Organization) forecasted that population suffering from diabetes will grow drastically from 171 million in 2000 to 366 million in 2030. To eradicate this vital menace, we have come up with a non- invasive blood glucose measurement device, which is an internet-of-medical-things (IoMT) enabled edge-technology. The technology includes several other Sensors, which detects SPO2, heart beat and motion, which varies due to the fluctuations in sugar level. To validate the device, the approximated glucose, SpO2, Heartbeat values are compared with the values acquired from invasive method. Non-Invasive values are stored in telegram bot, which is an IOT platform used for collecting and monitoring the data. With an exponential growth in the different devices and technologies, non-invasive glucose detection device will become methodical, cost-efficient and sturdy in the market.

Keywords. Heart Beat Sensor; Non-Invasive Glucose Sensor; Blood Pressure Sensor; Mi

I. INTRODUCTION

Glucose is an essential type of sugar in blood and is the most prime form of energy for the body's cell. After eating food or drinking, our system breaks the sugar from the food and utilizes them for energy in our body cells. Several hormones, like insulin, control glucose level in blood. Abnormalities and high level of sugar in blood causes a chronic disease called as diabetes. A hormone called as insulin is produced by the pancreas which helps to lower blood glucose level in our body. Inadequate or deficient supply of insulin, or failure of the body to properly acquire insulin causes diabetes. Therefore, the body cells fall short of much-needed energy. This can lead the ways to possible issues including blurred vision, fatigue, heart attack, stroke and damages to blood cells etc. There are several varieties of glucose detection meters available in the global

market. However, these are invasive. These invasive glucose meters use finger pricking technique for collecting blood samples, which is sometimes painful and irritating. Same needles might be used for multiple patients which can cause infections, such as skin and vaginal infections. The main aim of using non-invasive method is to get better accuracy and higher precision. It decreases the manual functions and it gives incessant monitoring system. There will be no wastage on test strips, lancets and others. It is a one-time expense with unlimited measurements. Different types of hardware's and software's are involved in constructing the non-invasive glucose monitoring device. The device is advanced by establishing a platform to display glucose levels. The device is made portable which helps to monitor the data easily.

II. RELATED WORKS

[1]. Megha S. Asekar (2018) the researchers have used the absorbance principle to find out blood glucose non-invasively. A 940nm wavelength IR rays is allowed to pass into the finger. After certain permutations and calculations, they analyzed that the voltage varies with variation in glucose concentration. The relationship between voltage and glucose concentration helps to find the glucose value.

[2]. Alvaro Lopez Albalat (2019) investigated the clinical and technical essentials that enables to build a non-invasive device to measure blood glucose level. They previously concentrated on a single technique. Later on, a feasible study was conducted which presented a non-invasive sensor combined with three different techniques: electromagnetic, acoustic speed and IR spectrograph. The prototype was subjected to various forms of bias, however by cross compensation those three techniques were able to minimize the low performance offered by the single techniques.

crocontroller; IoT Platform; Internet of Medical Things; Cost Efficient.

[3]. Heungjae Choi, Steve Luzio, Jan Beuther (2017), and

Adrian Porch developed a microwave system (NIGBM) which operated at 1.4 Giga henry, add to increase performance regarding accuracy. They obtained data from the microwave source, which was converted to estimate glucose concentration by using the principle of linear correlation. There was no time delay and the error concluded that the system is not user friendly and portable.

[4]. Shyqri Haxha (2016) reported a study which utilized near infrared sensors for guaranteed blood sugar level. Near IR transmission spectroscopy was used and Vitro experiments were conducted. They found a co-relation between voltage and glucose levels.

[5]. SiWei Zhao, Wei Tao, QiaoZhi He, Hui Zhao (2017) used Laser Light as a medium, which increases the temperature and causes stress, which in turn increases the volume of the medium and produces thermoelastic wave. Using photo acoustic signal, they determined the amplitude and frequency of the sound spectrum which is essential to find glucose level. They inferred that increase in photo acoustic sound spectrum results in the increase in the glucose concentration.

As per research, reduce in the oxygen level at the cellular level might lead to the type 2 diabetes in humans. When there's decrease in the oxygen level, there's increase in the resistance of insulin levels in the body and vice-versa. The hypoglycemia (low blood glucose level) condition is associated with slow and abnormal heart rates, whereas the hyperglycemia condition (high blood glucose level) occurs when the heart rate is high. As Glucose concentration varies, heart rate also varies simultaneously. The blood glucose level varies in diabetic patient as in high or low levels, when the blood glucose level is high, it may affect them when the person feels tiredness, vomiting, blurred eye vision where as in low glucose levels, person feels dizziness, sweating, shivering etc. Therefore, to cover majority of parameters affected by variations in sugar level and estimate their results, we did an extensive literature survey on existing "Implementation of non-invasive blood glucose level monitoring device" and came up with a distinctive and innovative idea for implementation of non-invasive system. To make the device as portable and enable to data transfer to IOT platform using Wi-Fi-module. Design a feasible blood glucose level monitoring device using Noninvasive method. To implement a continuous self-monitoring device for Diabetic Patients.

IV. PROPOSED FRAMEWORK

This paper provides a device which provides information about glucose and other health parameters which are affected by variation in glucose. This device also consists of heartbeat, SPO2 and motion (fall) sensors. An IOT platform called as telegram bot is used to monitor the data to avoid any complications with respect to health. The device also consists of other apparatus such as a LCD, buzzer, switch, Arduino nano, node MCU, which perform required operations.

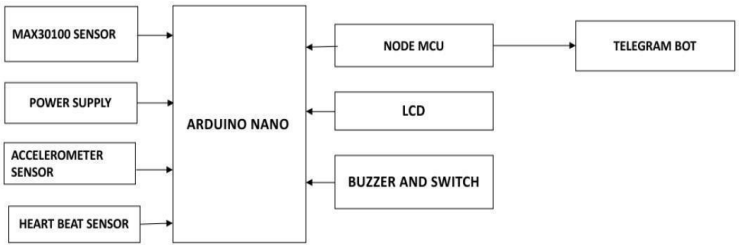


Figure-1: Block Diagram of Non-Invasive blood glucose leveldetector (Along with other parameters)

V. IMPLEMENTATION

In this project the blood glucose device provides glucose level, heartbeat, SPO2 level and fall detection measurement without using any blood sample or finger pricking methods. By placing a finger on a particular sensor, we can get the required results without damaging tissues or any body organ. The detection of heart beat, SPO2, and fall detection helps to find out whether there is a change in the glucose level. As heartbeat, SPO2 are biologically related with glucose, these are adequate parameters which provides additional information about glucose level variations. The connection is made between sensors and Node MCU with the help of Arduino. Once we provide the input feed to the Arduino the sensors start running and the software starts to identify the readings from the sensors and the values are shown in the LCD display and the readings are shown on telegram with the help of Node MCU software. We have constructed our project with different sensors such as, MAX30100, accelerometer and a heartbeat sensor, which havedifferent operational principles. We are also using other apparatus such as LCD, power supply, buzzer, switch andjumping wires.

The MAX30100 is a multi-purpose sensor used for measuring pulse oximetry and blood glucose level. This sensor consists of IR and red LED's. The oxygenated and de-oxygenated haemoglobin's ratio is taken to estimate the SPO2 level. Oxygenated haemoglobin imbibes majority of IR rays and allows red light to pass through. Whereas de-oxygenated haemoglobin takes red light and letting IR rays to transit through it. For detecting glucose, we follow the principle of Beer-Lambert law. The law relates attenuation of a light source with the material through which it travels. Here the material which we are analyzing is blood molecules. When IR rays passes through tissues, it is both imbibed and dispersed by the tissues. If a person is diabetic glucose molecules fuses with the blood, which changes the attenuation of the blood stream. With the help of deflected/attenuated light we estimate the glucose level.We make use of only IR radiations to forecast the blood glucose level.

Another main sensor which we are using in our device is the Heart beat sensor. It gives a digital output of the heartbeat when a finger is placed on the sensor. The sensor consists of a LED, which flashes every time when a finger is placed on it which indicates the generation

of pulses. The number of digital pulses within a stipulated time (10-15 seconds) is multiplied with a fixed value.

We use an accelerometer which measures acceleration and changes in the direction of an object or a human being. The sensor works on the three axes (x, y, z). Here we took only two planes for easy evaluation. It has a particular threshold value when it is in normal position. It also has a maximum threshold value when it is tilted in a particular axis. We observe these values and later set a particular threshold value to indicate whether the person is still or fallen down. If the person fell down, we have added an emergency switch. When the switch is pressed the buzzer makes sound and a message will pop up on the telegram app. The switch can used in some kinds of emergencies as well.

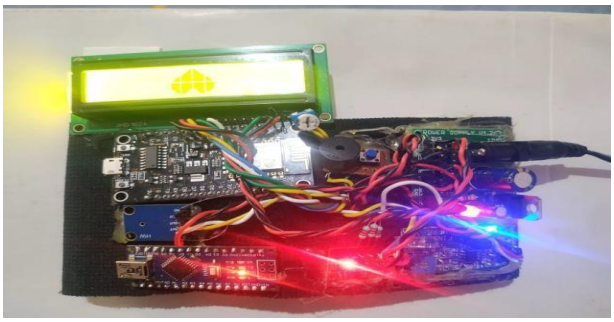


Figure-2: Implemented Circuit of Non-invasive blood glucosedetection (embedded on a band)

VI. HARDWARE AND SOFTWARE

VI.I HARDWARE DESCRIPTION

Figure-3: MAX30100 sensor

MAX30100

The max30100 sensor is an integrated glucose monitor and SPO2 monitor. It consists of LED's and diode which are responsible for determining glucose level and SPO2.

ARDUINO NANO

The Arduino Nano is a tiny board, which is user friendly. It offers similar specifications, quality and features of the Arduino Uno board but in a smaller size. Nano is programmable using the Arduino software (IDE).

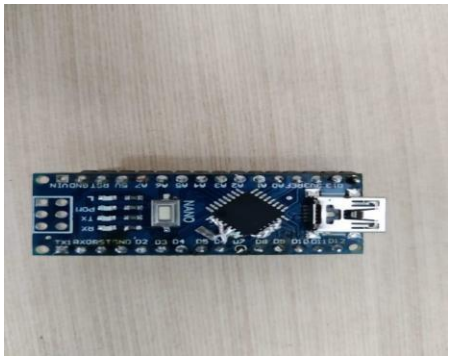
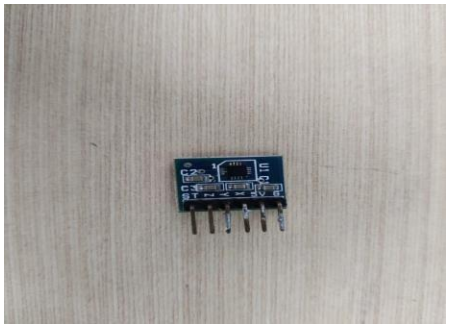


Figure-4: Arduino Nano

ACCELEROMETER

An accelerometer sensor is a device used to measure the acceleration of any object. It is used to detect the falling of a person due to variation in sugar level in our project. It works in three plane x, y, z, but we are using only in two plane x and y.

Figure-5: Accelerometer



REGULATED POWER SUPPLY

RPS is used to provide constant power supply across the circuit.

BUZZER

Buzzer is a piezoelectric type audio signaling device. It converts audio signal to sound. The buzzer is connected toa switch. As the switch is pressed the buzzer produces a sound.

SWITCH

Switches are used to turn on and off devices. Here in our project, we are using switch for emergency purpose.

LCD

A flat display which is used to display the output value of the sensors.

HEART BEAT SENSOR

A heart beat sensor is used to estimate heartbeat of a person. This sensor provides a digital output of the heartbeat. We have to place our finger on the sensor to get the required result. For each heart beat count, the LED on the sensor glows.

Figure-6: Heartbeat Sensor

VI.II SOFTWARE DESCRIPTION

ARDUINO IDE

Arduino is an open-source platform. It can be used to write and upload the software code to the circuit board.

TELEGRAM BOT

Here we are using an IOT platform called telegram bot which is a third- party application. By sending messages and commands user can interact with the bot. Using HTTPS requests to BOT API you can control your bot.

VII. RESULT

We have built the device on a band, which is presentable and comfortable. To measure the SPO2 and glucose we have to place our finger on the sensor for few seconds. To measure the heart beat we need to place the finger on the sensorrepetitively for 10- 15 seconds. To verify whether the accelerometer is working we can tilt our hand in different directions to find the fall detection. The information from the sensors will be updated in telegram bot and LCD.

Figure-7: Result Shown on LCD(FELL DOWN MESSAGE)

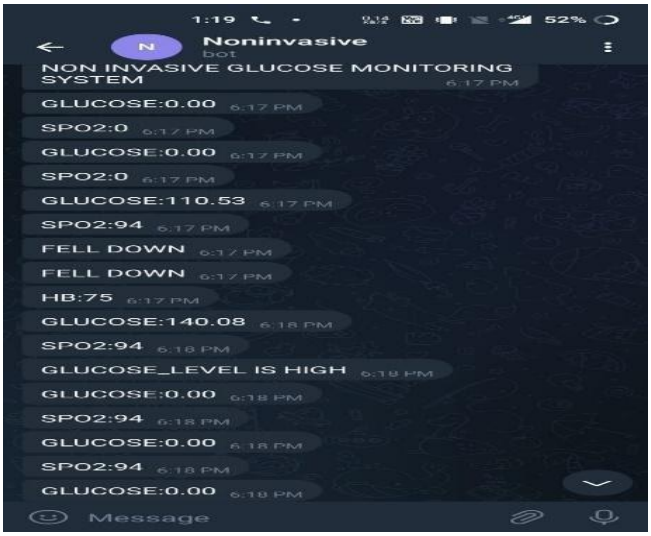


Figure-8: Result Shown on mobile (TELEGRAM APP)

SL. No	Invasive Glucose Values	Non-Invasive Glucose Values	Heart Beat Values (Non-invasive)	SPO2 Values (Non-invasive)
1	126.0	116.7	92	98
2	84.0	88.3	80	96
3	102.0	98.7	87	96
4	240.0	223.8	95	95

Figure-9: Readings from invasive and non-invasive methods

VIII. CONCLUSION

To conclude, we have developed a non-invasive blood sugar level detection device, which provides glucose levels of different samples and human specimens, which is pain- free and in a short period of time. It also provides data of heartbeat, SPO2 and fall detection by using different sensors. We have developed a telegram bot, which maintains data from different sensors.

IX. REFERENCES

[1] Megha S. Asekar. “Development of portable Non- invasive Blood Glucose Measuring Device using NIR Spectroscopy”.2018 second International Conference on Intelligent Computing and Control Systems (ICICCS), DOI:10.1109/ICCONS.2018.8663039.

[2] A. L. Albalat, M. Begona Sanz Alaman, M. C. Dejoz Diez, A. Martinez-Millana and V. T. Salcedo, "Non- Invasive Blood Glucose Sensor: A Feasibility Study," 2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC), 2019, pp. 1179-1182, doi: 10.1109/EMBC.2019.8857261.

[3] Heungjae choi, Steve Luzio, Jan Beutler, and Adrian Porch. “Microwave Non-invasive Blood Glucose Monitoring Sensor Human Clinical Trail Results”. 978-1- 5090-6360-4/17 IEEE- 2017.

[4] Ramaiah, N. S., & Ahmed, S. T. (2022). An IoT-Based Treatment Optimization and Priority Assignment Using Machine Learning. *ECS Transactions*, *107*(1), 1487.

[5] S. Zhao, W. Tao, Q. He and H. Zhao, "A new approach to non-invasive blood glucose measurement based on 2- dimension photoacoustic spectrum," 2017 First International Conference on Electronics Instrumentation & Information Systems (EIIS), 2017, pp. 1-5, doi: 10.1109/EIIS.2017.8298673.

[6] Haxha, Shyqyri, and Jaspreet Jhoja. "Optical based noninvasive glucose monitoring sensor prototype." IEEE Photonics Journal 8, no. 6 (2016): 1-11.

[7] 4Li, Dachao, Haixia Yu, Xian Huang, Fuxiang Huang, Xiaotang Hu, and Kexin Xu. "Prediction of blood glucose using interstitial fluid extracted by ultrasound and vacuum." In Optical Diagnostics and Sensing VII, vol. 6445, p. 64450I. International Society for Optics and Photonics, 2007.