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Implementation of Non-Invasive Blood Glucose Monitoring System

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Abstract - *Diabetes is a disorder in the metabolism caused by rise of sugar level in the blood, and this disease stays for a long term which also affects people by growing rapidly. The existing techniques of monitoring the level of glucose in the blood is invasive method which requires a sample of blood through pricking of the finger. This method is more infectious and painful. Blood Glucose Monitoring (BGM) is much necessary to be aware of complex situations due to variations in glucose levels in diabetic patients. To develop a portable and creative Non-Invasive monitoring device of blood glucose level for diabetics to measure the blood glucose concentration as and when needed.*

Key Words: Diabetes, Glucose, Non-invasive, Portable, Monitoring, Smart phone, NIR, Microcontroller

1.INTRODUCTION

Diabetes as defined earlier is a disease due to which blood glucose keeps varying regularly. Diabetes occurs due to either insufficient insulin hormone secreted by the pancreas gland or due to the cells which stops responding to the produced insulin. If there's no proper management of the above-mentioned disease leads to dangerous health problems which are as follows: cardiovascular diseases, kidney and nervous system failures, blindness and stroke.

Diabetes mellitus is been classified as into three different types: Gestational diabetes, Type 1 and Type 2. Type 1 is the serious kind of diabetes. Type 1 diabetes is caused due to the amount of beta cell which are secreted from the pancreas that gets destroyed by the immune system resulting the body to fail in producing enough amount of insulin. Patients with Type 1 diabetes will have to take an injection of insulin or an insulin pump. This more likely develops during childhood or adolescence. Type 2 diabetes is the most common type. This occurs within the body when the production of insulin is more. When this insulin might not be used properly in the body or the cells are stops responding to the insulin, in people who have obesity or the adult people. The third type of diabetes mellitus is the gestational diabetes. It mostly occurs in pregnant women. Regular monitoring of blood glucose is important and necessary to prevent diabetes complications. There are two types of measurement of blood glucose levels. Such approaches are invasive and non-invasive.

The invasive method involves requirement of sample blood through finger pricks for measuring the amount of glucose in the blood, inconveniences are pain and infection. The test-strips are required every time we do the test. The invasive techniques include the following, Subcutaneous Implantable Biochip [11] Subcutaneous Implantable Bioelectrode for glucose sensing, Subcutaneous Implantable Biosensors for glucose and insulin. These techniques even though they give measurement continuously but still inconveniences cannot be avoided. To reduce the problems, the alternative method has been suggested that is non-invasive method. Non-invasive techniques help to be user friendly and prove to be more useful. It overcomes the problems occurred when using invasive method. The technologies have improved drastically for building commercial glucose meter which are available for the common people. The study helps to build a glucose monitoring system to determine glucose level using non-invasive method and the information will be done through wireless transmission to store the results and act accordingly to the readings with respect to the threshold fixed.

2.LITERATURE SURVEY

In NIR based blood glucose detection method transmitted signal strength decreases with increase in the glucose level, because of the absorption of light by blood glucose. This is an inverse proportion of the transmitted signal strength to the blood glucose level. A study on this shows the strong correlation between actual concentration of glucose and noninvasively measured concentration [1].

A study on Non-Invasive blood glucose monitoring based on Transmittance and Refraction of Laser Light results of the experiments showed that wavelength 650 nm red visible light is suitable for non-invasive blood glucose monitoring. Visible laser light with a wavelength of 650 nm has a transmittance by both the human finger and water 30 times higher than that of Near Infrared Light [2]. Results of an experiment showed that as the glucose concentration in the solution increases the refractive angle of laser light

decreases, the laser light intensity decreases on the photo detector, which in turn increases the output voltage [2].

In near infrared LED diffusion reflectance method, the main principle is Beer lambert's law. When the light interacts with human tissues attenuation will occurs due to absorption and scattering of the light. When the concentration of glucose is increases then absorption is also increasing but scattering is decreases. For this reason, the diffuse reflectance is decreases. In this method for error checking they used Clarke Grid Error analysis (CGE) [3]. The obtained prototype can be converted into a simple wearable device. The errors can be minimized by making the light reaching the photo detector and effect of sunlight should be more stable.

In Near-Infrared Spectroscopy with Remote Data Logging method [4] the absorbance of samples is greater at a wavelength of about 845 nm, so we prefer (SFH4550) NIR. When the light intensity on the photodiode increases, as the sample absorption of light also increases, there results a change in current passing through the diode then we use a current to voltage converter that results in a voltage which is proportional to the current. The photoplethysmography signal is obtained by filtering the unwanted signals from voltage by effectively designing the bandpass filter circuits. And the patient's data is transmitted to the remote server.

In NIR spectroscopy method the required measuring components are photodiode, LED light and arterial pulse. If the LED is passed through the finger the transmission will occur, attenuated light wave transmitted by the finger is measured by using a photodiode. To indicate pulse rate is measured by using an arterial pulse. DC supply of 5V is used for powering the LED [5]. The obtained current from the photodiode is converted into voltage. To obtain the actual visible output, the resulting output signals are given to the amplifiers. Using the 2nd order Butterworth low pass filter, the obtained signals are filtered with a cut-off frequency of 180 Hz. Butterworth filter removes all high-frequency noise from the signals. The finger is placed in the sensor we will get photo plethysmograph waveform as final results. Due to the variation in signal attenuation, the output voltage is obtained from the NIR sensor. To perform A to D conversion the signal can further give to the MSP430 microcontroller. These hardware results can be monitored on the LCD display and data will be sent through an android application to the doctors.

Absorbance of glucose is maximum at 940nm wavelength. The concentration of glucose and the voltage have the good linear relation. LCD displays or digital displays are interfaced with the obtained results can get by using MSP430 microcontroller or Arduino. Using cloud computing and IOT, you can send glucose results from a patient's blood to the smartphone device.[8].

The proposed glucose monitoring system results in the measurement of the dielectric epidermis, dermis and also subcutaneous tissues of the abdominal area of the body the system is developed for giving the resonant frequency of 1.4G Hz. The collected data from microwave sources was transformed by the theory of the subject-specific linear correlation to estimate the concentration of glucose.

Linear correlation coefficient R is used to provides information on the strength and also the direction by considering the relationship between the microwave reading and the glucose concentration. The accuracy can be verified with the help of the Mean Absolute Relative Difference [MARD][6]. There is no time delay for the measurement of data, the error grid, and MARD results are acceptable, but the currently available system is not user-friendly and it is not fully wearable or portable.

It determines the absorption of light radiated by glucose using spectroscopy in the proposed non-invasive blood glucose monitoring system. A beam of light is passed through a sample (finger), placed on the camera of a smart phone. In this setup the smartphone camera acts as a photo detector by capturing the image and analyzing the properties of the light beam being transmitted. After analyzing the image, Android software finds a correlation between blood glucose levels and certain transmitted light properties [7].

3.METHODOLOGY

In the proposed design system model, we are using Raspberry pi 3 Model B+ as microcontroller for monitoring the Max30100 sensor and for IoT communication system for data sharing using built in Wi-Fi module in Raspberry pi. In our design we are applying Beer Lamberts law principle. It states that the light absorption is directly proportional to the concentration of the medium. Beer lamberts Law Equation is given in equation. (1).

$$A \alpha C \quad \ldots\ldots\ldots\ldots \quad (1)$$

Where,
A = Absorption,
C= Concentration (mol /L).

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The implementation of block diagram of system designed is as shown in the Fig-1.

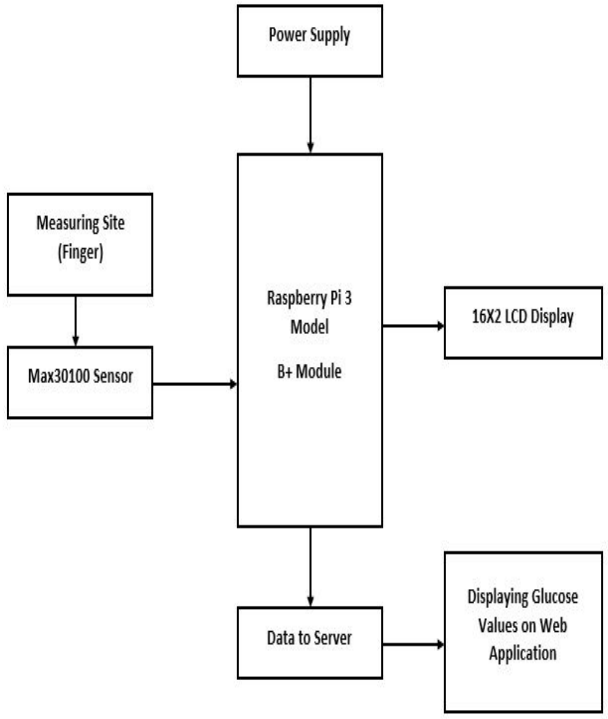

Fig- 1: Block diagram of Proposed system

When we would place the finger on Max30100 sensor, then due to the molecules present in the tissues light rays would interact with the molecules and results in attenuation the light. From the output signal of the Max30100 we obtain analog data this will be converted into digital value by using inbuilt ADC in Raspberry pi microcontroller. The obtained patients' blood glucose values from the output of regression equation are displayed on 16x2 LCD and web application along with an android application. IoT communication is done using web server along with MySQL database in order to record the data produced by the measurement. Testing is performed using non-invasive blood sugar level measuring devices to determine whether sensors are functioning effectively and produce greater precision.

In web application we added login feature for patient and doctor. Whenever they want to see their glucose reading history, they can login to the application using their login credentials. Once they login to the web application, it will display all the glucose reading taken so far.

4. FLOWCHART

The flowchart of designed system is shown in Fig-2.

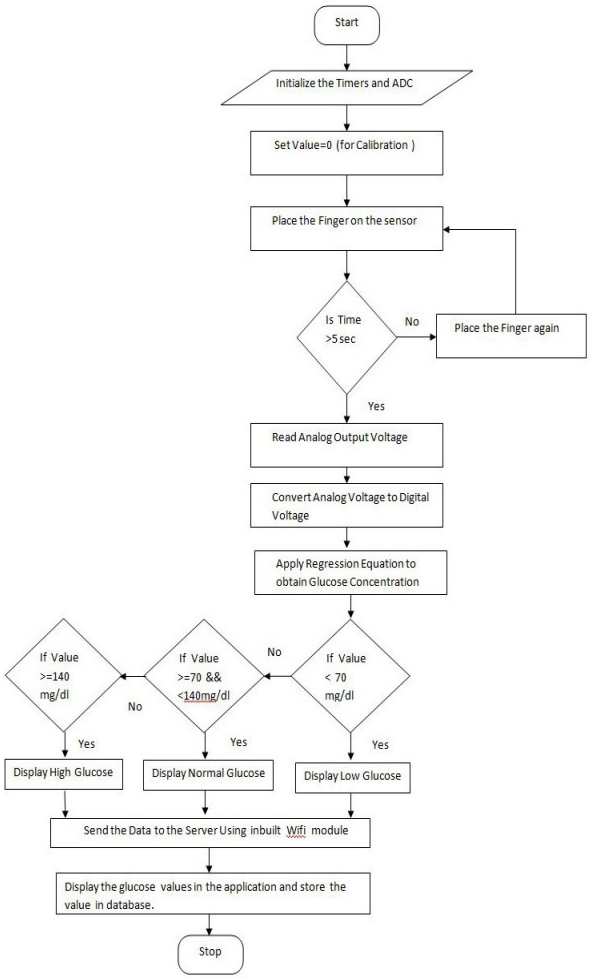

Fig-2: Flowchart of the Proposed system

5.RESULTS

This Experiment is performed on 15 people for both diabetic and non-diabetic person at different intervals using our designed system and the commercially accepted values from the invasive glucometer (Accu-Chek). Then we applied regression analysis. From obtained values or based on the Glucose level we can predict the Low, Normal, High glucose concentration along with the values and printed on LCD Display is as shown in Fig-3 and send the data to the web server using inbuilt Wi-Fi module on Raspberry pi. These values will be stored on the web server means in MySQL database. Whenever the patient or doctor wants to retrieve the glucose readings, they can login to the web/android application using their login credentials. The data will be displayed on the Web application for the user who logged in. Tests have been carried out on different patients and the performance of web application and the designed glucose monitoring system is checked and found to be accurate.

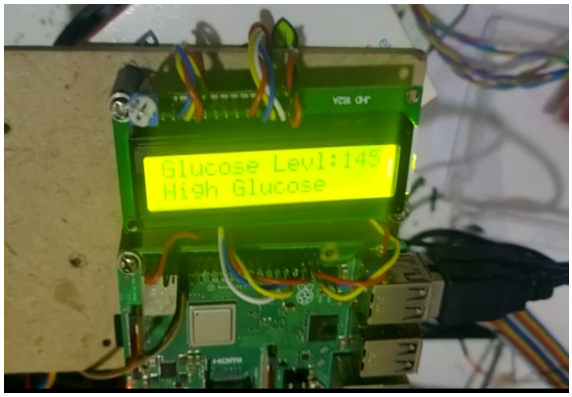

Fig-3: Result Displayed on LCD display

6.CONCLUSION

The obtained results were compared with the conventional invasive type glucometer's readings, it is concluded that the measurement of glucose by using non-invasive method is possible with the error of 10%. The designed glucose monitoring system is portable and also it is a self-monitoring device. By developing the web and android application, it is more helpful for the health care centers and doctors for assisting the patients easily.

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