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NON-INVASIVE GLUCOSE ESTIMATION BASED ON INFRARED USING FINGER PLETHYSMOGRAPH

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ABSTRACT

Diabetes is the most commonly occurring diseases around the world; approximately 415 million people among the 7.7 billion population of the world suffer from diabetes. Diabetes is caused due to increase in the blood sugar concentration which may affect the heart, blood vessels, kidney and nerves, etc. The monitoring of blood sugar level is very important incase of diabetic patients, since it is necessary to keep the blood sugar level in limit. Hence, it is necessary to regularly monitor the blood glucose level of the diabetic patients. Currently, the measurement of the blood sugar level is done only by pricking the finger which is a painful process and may cause infections. The non-invasive procedure does not involve any pricking of the finger, hence there is no pain or chance of infections. Therefore, we propose a non-invasive method using infrared sensor for transmission and reception of rays to and from fingertip for real-time monitoring of the glucose level and to view the result in a mobile application and store it in the IOT based website.

Keywords: Blood Glucose, Diabetes, MAX30100, Arduino, HC-05, IR.

I. INTRODUCTION

The blood glucose level is the amount of glucose present in the human's blood. Glucose is a simple sugar contains approximately 4 grams of glucose which are present in the blood of a 70-kilogram (150lb) humans at all time. Glucose is stored in the form of glycogen in skeletal muscle and liver cells; in fasted individuals, blood glucose is maintained at a constant level at the expense of glycogen stores in the liver and skeletal muscle.

A continuous rising in the blood glucose leads to glucose toxicity, which contributes to cell dysfunction and the pathology grouped together as complications of diabetes. Diabetes mellitus is characterized by persistent hyperglycemia from any of several causes, and prominent diseases related to failure of blood sugar regulation. Diabetes mellitus can be classified into Type 1 diabetes, Type 2 diabetes and Gestational diabetes.

Nowadays even a newborn babies also affected by diabetes mellitus which leads to growth abnormalities. This condition motivate us to design finger plethysmograph for glucose measurement in non-invasive method.

II. METHODOLOGY

Block Diagram

The methodology contains various components. Each components plays an important role in the hardware. This block diagram provides a proper way to identify the process involved in the estimation of blood glucose level using infrared in non-invasive method. It consists of Arduino UNO which is a microcontroller acts as a signal processor, Sensor chip, IR transmitter, Photo detector, LCD and Bluetooth module.

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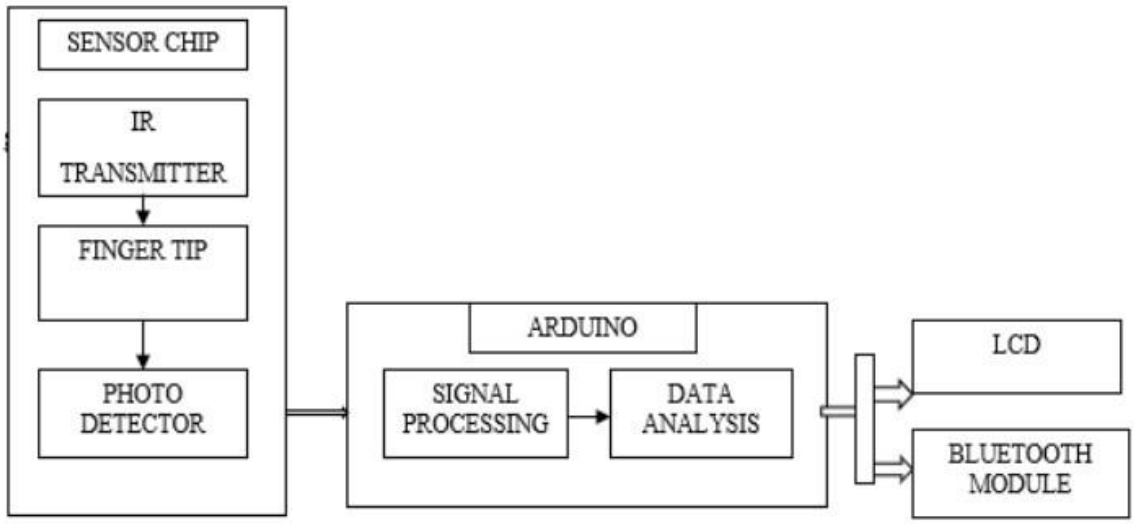

Figure 1: Block diagram of the proposed system

Working Principle

Diabetes is a metabolic disorder due to high blood glucose level. Existing method for determination of blood glucose concentration is only by using a self-monitoring glucose meter. This process involves pricking the finger and extracting the blood from the fingertip and doing the chemical analysis with the help of disposable test strips. The blood is placed onto the test strip, it reacts with a chemical called glucose oxidase which produces gluconic acid from the glucose in the blood. At the other end of the test strip, a current is transferred. The test strip has electric terminal which allow the meter to measure the current between the terminals. The current between the terminals changes depending on the level of gluconic acid that has been produced and with the use of it we can identify the blood glucose level.

In our project, a system is developed to monitor the blood glucose level of the diabetes patient in non-invasive method. An Infrared LED is used as a source to emit the light and a sensor called Max30100 which acts as a transmitter as well as receiver used to receive the reflected light by this we can know how much light is absorbed by the blood. The data can be forwarded to the Arduino UNO which acts as a microcontroller process the signal to measure the blood glucose level.

The blood glucose level which is measured can be examined through the LCD connected to the communication part. The Bluetooth module ,HC-05 is a wireless system connects the proposed system and the application in the smart phone. This Bluetooth module alerts the user or caretaker about the hypo or hyperglycemia condition.

Data Acquisition

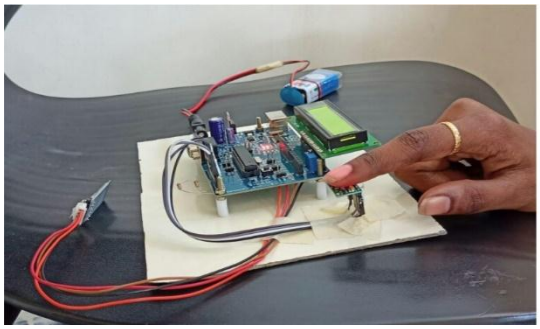

Figure 2: Data Acquisition

The above diagram shows how to place the finger on to the sensor properly. Only then the sensor can work properly else the light will be absorbed on to the finger but cannot be read by the sensor again.

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III. MODELING AND ANALYSIS

A. Arduino UNO

The controlling system of the glucometer is Arduino UNO which is an open-source electronic platform which is versatile for hardware as well as software based on a simple microcontroller board. It can be used to progress interactive objects, obtaining inputs from a different switches or sensors, and converts the input into output. Arduino projects can be communicate with the software running on the computer. The Duemilanove board features an ATmega328 microcontroller which operates at 5V with 2 Kb of RAM, 32 Kb of flash memory and 1 Kb of EEPROM . The board has 14 digital input pin and 6 analog input pins.

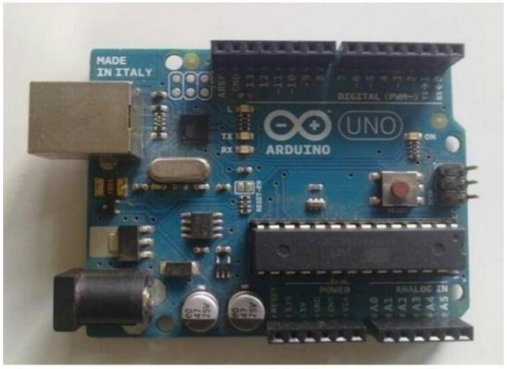

Figure 3: Arduino UNO

B. Max30100

The Max30100 is a sensor used to detect the patient's oxygen saturation level and acts as a heart rate monitor. It includes two LED's, a photo detector, optimized optics, and low-noise analog signal processing to detect oxygen saturation level and heart-rate signal. It operates between 1.8V to 3.3V power supplies. It has high sample rate capability and fast data output capability.

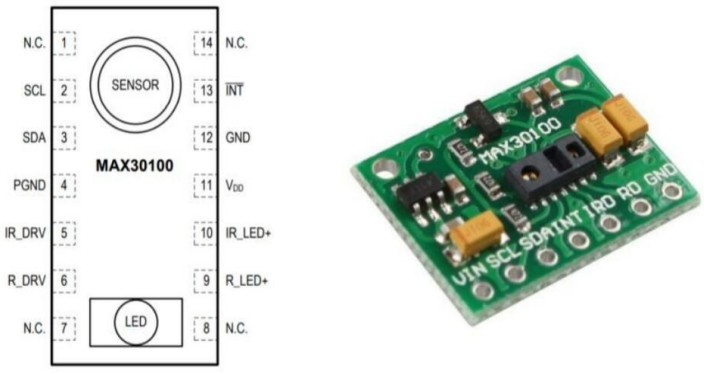

Figure 4: Pin Diagram and Module

C. Bluetooth Module(HC-05)

Bluetooth is a wireless technology used for transferring data over short distances from fixed and mobile devices. It creates a personal area networks (PANs) with high levels of safety. It can connect many devices which overcomes problem of synchronization. The Bluetooth module in the ISM band ranges from 2400-2480 MHz and directs where infrared was frequently used. It helps in the transmission of health sensor data from medical devices to mobile phone.

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Figure 5: Bluetooth Module

D. LCD Display

Liquid crystal displays (LCDs) combines the property of both liquid and crystals. They have a temperature range in which the molecules are almost unstable as they would be in liquid stage but are grouped together in order to form similar crystal. It consists of two glass panels made up of liquid crystal material sand witched in between them. The inner surface is coated with transparent electrodes. It consumes less power and compatible with low power electronic circuits which can be powered for long duration.

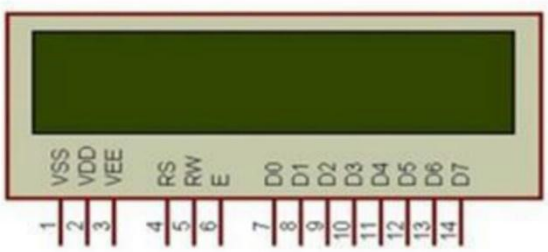

Figure 6: LCD Display

IV. RESULTS

After designing this technique, we had a reliability test was conducted on five subjects using both invasive technique with the finger prick method and the non-invasive technique with sensor method. Blood glucose measurement from both method were compared in below table. The percentage difference for each measurement between the two techniques were calculated.

Table 1: Comparison of Glucose Values

Subjects	Accurate Value(mg/dl)	IR Sensor(mg/dl)	Percentage Difference(%)
1	102	94	8.51%
2	98	93	5.37%
3	89	91	2.19%
4	108	98	11.22%
5	92	91	1.09%

This comparison showed that, there is a good glucose measurement agreement between the two methods (Accurate value and IR Sensor), which is proved from the low percentage difference when both glucose measurements of the same subjects were compared.

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Output Obtained

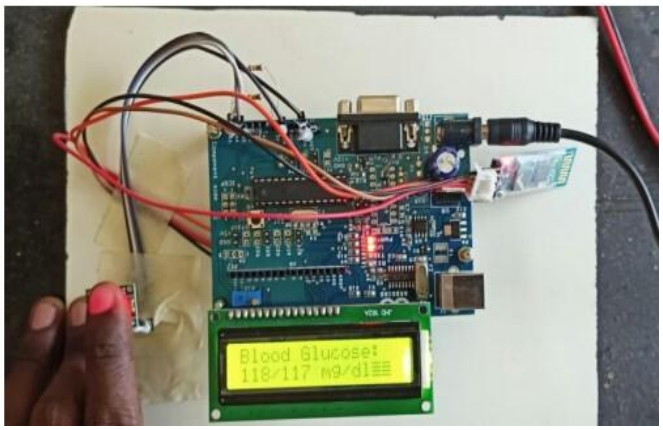

Figure 7: Output Obtained on Prototype

V. CONCLUSION

We conclude that with the application of new technology we can heavily innovate the device to make it cost efficient as a patient will need not to buy a glucometer kit and with slight innovation to the current design we will be able to feasibly produce significantly better treatment for diabetes. This could improve the life of diabetic patients in future.

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