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Non-Invasive Blood Glucose Monitoring Device

Jaya Rubi , Thella Shalem Rahul, G.Srividhya , A.Keerthana

Abstract*: Diabetes Mellitus is chronic disease affecting the people of all age groups around the globe. It is a very common disorder which causes high levels of sugar in the blood stream. High levels of blood glucose can damage the tiny blood vessels in our heart, eyes, kidneys and nervous system. Diabetes is fast gaining the status of a potential epidemic in India with more than 62 million diabetic individuals currently diagnosed with the disease. Invasive method is the most common method used to measure the blood glucose level which involves blood loss and pain. In the proposed proposal, a novel device has been designed to measure and monitor the blood glucose levels non-invasively. This device measures the blood glucose by spectroscopy technique using Red laser, in which the red laser shows better transmission and linearity when it passes through the blood. It measures the glucose value by detecting refractive index of transmitted light which is based on the principle of Snell's law. The device will be further designed and fabricated in the form of a band to monitor blood glucose continuously.

Keywords: Diabetes Mellitus, Blood glucose, Non invasive, Spectroscopy, Red laser

I. INTRODUCTION

Diabetes mellitus is a most common affected disease caused by inheritance or deficiency of pancreas to produce enough amount of insulin. The insulin deficiency results in higher amount of glucose in the blood. Severe condition of diabetes causes visual disability, kidney damage, heart diseases, neurological disorder foot damage, depression and sensory loss. Based on the lifestyle, the individual may get affected by diabetes. It can be controlled by oral intake of diabetic drugs. The diabetes can be prevented by regular physical activity, intake of healthy diet and weight control.

There are several methods to diagnose the amount of glucose in blood which includes invasive and non-invasive techniques. Invasive method is the most used technique to measure the glucose level in blood. It measures the glucose in the form of millimoles per litre (mmol/L)

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***** Correspondence Author
Jaya Rubi ,Assistant Professor, Department of Biomedical Engineering, VISTAS, Chennai , India , Email: jayarubi.se@velsuniv.ac.in
Thella Shalem Rahul , Final Year Student, Department of Biomedical Engineering, VISTAS, Chennai , India , Email: jayarubi.se@velsuniv.ac.in
G.Srividhya ,Assistant Professor, Department of Biomedical Engineering, VISTAS, Chennai , India , Email: srividhya.se@velsuniv.ac.in
A.Keerthana ,Assistant Professor, Department of Biomedical Engineering, VISTAS, Chennai , India , Email: keerthana.se@velsuniv.ac.in

Non-invasive glucose measurement involves various methods such as NIR spectroscopy, Raman spectroscopy, photo acoustic spectroscopy. Blood glucose can also be measured from saliva, tears, breath etc. These non-invasive techniques are pain free which may not be accurate as invasive method. But still the values can be rectified by implementing data processing in the devices. Most of these non-invasive techniques involve spectroscopy basedon transmission and absorption technique

II. LITERATURE REVEW

[1]ShyqyriHaxha et al, developed a spectroscopy based non-invasive glucose monitoring system to measure the glucose concentration. It works on the principle of absorption spectroscopy using NIR transmitter and NIR receiver. As the light incidents on the sensor, the voltage value of sensor which will be noted after the laser through the blood sample. It works mainly on the principle of Beer-Lambert's law

[2]Haider Ali et al, proved that laser light has higher potential for blood glucose monitoring. They have designed a simple, compact and cost-effective non-invasive device which uses visible red laser light of wavelength 650 nm for blood glucose monitoring. This monitoring device has three major technical advantages over near infrared. Unlike near infrared, this laser light has ~30 times better transmittance through human tissue. Red laser also posses both higher linearity and accuracy in the case of blood glucose monitoring.

[3]Brent D. Cameron et al, designed closed loop controller based polar metric glucose sensor. They measured the glucose level by rotation of polar metric laser. They tested this device on anterior position of eye. Based on the angular rotation of reflected laser, the glucose level in the subject can be measured. They achieved success rate of 95%.

[4] Chuan Pu et al, illustrated highly sensitive polarimetric sensor for detecting glucose levels in blood with the help of self-homodyne coherent detection method. They measured glucose levels by detecting a minute change in polarised rotation in laser light after transmitting through the glucose samples. They have achieved success rate of 85%.

[5] Katsuhiko Maruo et al, developed a novel method for blood glucose monitoring using fibre optic probe. They created dermis tissue spectra by fibre optic probe which consists of both near infrared source and detector. By using Monte Carlo method, the light will be simulated in skin tissue using fibre optic probe. They used reflective spectroscopy in which the light passes through the epidermis and dermis will be reflected back. The reflected light will be captured by detector in the probe with a distance of 0.65 from the source. Based on absorption coefficient, scattering coefficient, path length the results will be calculated and displayed.

They concluded that their method contains standard error of prediction is 32mg/Dl.

[6] Gerald L. coté et al, developed and tested true phase optic device to measure the glucose concentration in the blood. This device uses helium-neon laser which placed near the anterior region eye and then on the excised eye. The two polarisers and two detectors are implemented to measure the reference and signal outputs. Based on the rotation of polarised light the glucose level will be detected. They have tested the device on animals.

[7] Yitzhak et al, used co2 laser as infrared source for absorption spectroscopy to measure the glucose concentrations in blood. They implemented multiple attenuated total reflection which will be detected by YSI 23A laboratory analyser. Based on the total internal reflection the glucose level in the blood will be measured. They have tested this mechanism on animals which will be implemented on diabetic patients.

[8]Shao Ying Huang implemented MLIN based glucose sensor for measuring the concentration of glucose. It uses the skin as substrate on MLIN. It calculates various parameters and its contribution on the basis of sensitivity. Based on the impedance of the skin the glucose level is measured.

III. PROPOSED METHODOLOGY

The existing methods for the optical glucose detection involve detection of change in refractive index of the transmitted laser light and also include measurement of intensity of transmitted light with He-ne laser. However, the existing method leads to absorption of light in human tissue which results in high signal to noise ratio and low accuracy. The proposed method comprises of a simple, compact and cost effective non-invasive device that uses visible red laser light. In the proposed method the voltage is calculated by using principle of Beer Lambert law. The rate of absorption of red laser will be very less. These result in better linearity and accuracy.

Block diagram

The overall block diagram of the device has been given in the Figure 3.1. Its components and working are explained below as follows.

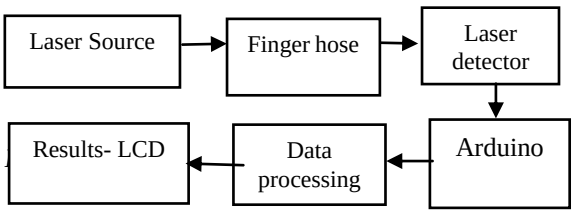

Fig 3.1: Block Diagram

The laser source emits the red laser, which transmits through the finger through finger hose. Then laser light is detected through the laser detector, Then the analog reading is read by Arduino with the detector. The beer-lamberts law is used for the glucose measurement. Based on the intensity difference in the laser light, the glucose level in the blood is calculated. Then the results are displayed out in LCD display.

IV. RESULT AND DISCUSSION

The glucose measurement device is designed and processed as per the block diagram. The hardware includes laser source that emits 650nm wavelength, finger hose of 3-incharea for placing the finger for the glucose measurement, CMOS laser sensor for the laser intensity measurement, Arduino Nano for the processing the data from the sensor, i2c LCD for the results display. A DC power cord is used for the power supply to the device through the Arduino Nano and a battery for the laser diode.

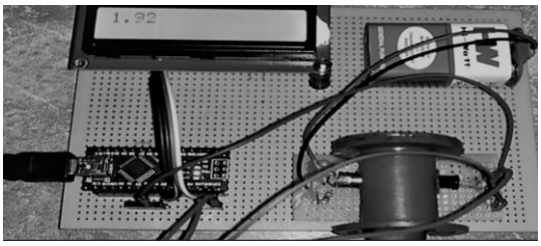

Figure 4.1 Glucose measuring device

After the designing the device, the device is compared with the invasive glucose measurement device. The device is performed on 30 subjects including hyperglycaemic, normal and hypoglycaemic subjects.

Sub.no	Voltage values	ADC	Condition
1	3.8 V	635	N
2	3.9 V	630	N
3	4.1 V	615	N
4	1.9 V	730	Hyperglycaemia
5	4.2 V	610	N
6	3.9 V	630	N
7	4.0 V	624	N
8	3.8 V	635	N
9	4.2 V	610	N
10	2.1 V	720	Hyperglycaemia
11	4.3 V	605	N
12	4.5 V	595	N
13	4.4 V	600	N
14	4.3 V	605	N
15	4.4 V	600	N

The device achieved 98.5% accuracy. the voltage values ranging from 2.5V to 4.5V were considered as normal ranging from 90 to 160 mg/dl. The voltage values below 2.5V were considered to be hyperglycemic and the values above 4.5V were hypoglycemic. As the intensity of laser light decreases / increase after transmitting through the finger. Other factors which affect the glucose levels in the blood includes diet, age, time of intake of diet.

V. CONCLUSION

The device is not yet fully developed, it will be miniaturised and made in a form of a wearable band to provide comfort and as well as for the continuous glucose monitoring. The existing methods for glucose measurement have several shortcomings. The proposed method has given a relation between the voltage values and glucose concentration in blood.

Further the same device can be calibrated to measure several more parameters which will provide accurate glucose concentration in blood. This will lead to completely non-invasive technique providing comfort to the subject without any blood loss.

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AUTHORS PROFILE

Jaya Rubi ,Assistant Professor, Department of Biomedical Engineering, VISTAS, Post Graduate in M.tech Medical Instrumentation from Sathyabama University, Specialisation in Prosthetic Engineering

Thella Shalem Rahul, Final Year Student, Department of Biomedical Engineering, VISTAS

G. Srividhya, Assistant Professor, Department of Biomedical Engineering, VISTAS, Post Graduate in Biomedical Engineering from Anna University, Guindy, Specialisation in Biosignal and Image Processing and Bio Instrumentation.

A. Keerthana , Assistant Professor, Department of Biomedical Engineering, VISTAS, Post Graduate in Medical Electronics from Anna University, Guindy, Specialisation in Bio Instrumentation and Rehabilitation Engineering.