NON INVASIVE BLOOD GLUCOMETER

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ABSTRACT

Diabetes is a metabolic pathological condition of concern, which affects vital organs of body if not diagnosed and treated on time. Regular monitoring of blood glucose is important to avoid complication of diabetes. Commonly used glucose measurement methods are invasive which generally involves finger puncturing. These methods are painful and frequent pricking cause calluses on the skin and have risk of spreading infectious diseases. Therefore there is need to develop a non-invasive monitoring system which can measure blood glucose continuously without much problem. The present work is focused on development of non-invasive blood glucose measurement sensor system using Near-infrared (NIR) technique. In this study, near infrared optical measurement is applied to overcome the invasive issues. The designed device consists of an infrared emitter which placed over the fingertip for measurement of blood glucose optically. The near-infrared light will be sensed by the photo diode which having a certain wavelength. The intensity of received light is depending on the glucose molecules inside the blood. By analyzing the variation in voltages received after reflection in the cases the current diabetic condition as well as the approximate glucose level of the individual is going to be predicted. The obtained results are going to be validated with glucose meter readings and statistical analysis of the readings is to be done.

Keywords: Diabetes, Non Invasive, NIR, Intensity

I. INTRODUCTION

Diabetes mellitus has become the serious medical condition in which it may cause blindness, obesity, heart disease, renal failure and the stroke. These killer disease effects on the ability of human bodies in producing and utilization of the insulin. It is a hormone which is essential in processing the blood glucose. The World Health Organization estimated that there will be 177 million who suffered diabetes in 2000[1]. By the year 2025, the value will increase up o 300 million minimally. Regular blood glucose monitoring is the key step in efficient management of diabetes to control blood glucose. Most of commercially available glucose measurement devices are invasive. Diabetic patients need to monitor their blood glucose two to three times a day. The invasive methods are painful, have high recurring cost and danger of spreading infectious diseases [2]. Non-invasive methods are more desirable and excellent alternatives to these devices. Enhancing glucose measurement techniques to allow easy and continuous monitoring has received a lot of attention from both academic and industrial researchers over the past three decades. Non-invasive glucose monitoring could make millions of people more relaxed and comfortable about blood glucose testing. Thus it is necessary to develop a non invasive blood glucose method which can provide painless, convenient and cost effective glucose monitoring to diabetic patients. Non invasive monitoring system will be a major breakthrough in the area of treating diabetes patients.

There many new methods in order to improve the blood-glucose measurement and the optical method has become interest in the most research studies. It is more reliability and has effective cost. The optical method of blood-glucose measurement is the most popular method which has been studied and research in regard to provide a non-invasive measurement. There are a variety of the optical methods for the non-invasive technique, including near-infrared (NIR), Raman's spectroscopy, photo acoustic spectroscopy, polarization technique, polarimetry and light scattering.

So, developing a non invasive way of measuring blood glucose would be much more user friendly from the end user. The main advantage of non invasive methods is the aid from pain and malaise due to frequent finger pricks. Non invasive determination of the glucose reduces all the above difficulties involved and hence reduces the healthcare cost. The method proposed, represents a possible design and development of a sensor system to detect blood glucose non-invasively using Near-infrared (NIR) radiation. It describes the principle of glucose measurement using NIR method .System details are presented along with the criteria of selection of wavelength and sensor. System makes use of the difference in voltage measured in both the before and after meal of the received signal from the NIR sensor, to detect whether the patient is diabetic or not along with the approximate glucose level.

The remaining portion the paper is organized into different sections. In section II related works done in noninvasive field have been discussed, while section III discusses the theory of operation, section IV discusses the proposed system architecture and section V discusses about the measurement procedure and VI the experimental results and application . Conclusions and future developments have been illustrated in section VII.

II. RELATED WORK

Current methods for measuring blood glucose include pricking the finger piercing the vein and collecting the blood. But the major problem with the existing method is that it is not proper for continuous monitoring of blood glucose level. The difficulties associated with this can be removed by making used of the proposed non-invasive way of measurement.

Gelao et. al describes an architecture based on dielectric spectroscopy for non- invasive, continuous blood glucose monitoring using a blood glucose sensor [3]. The electrical circuit, schematic and the PCB design were made. Using a dielectric constant for measurement, the frequency of both, amplitude and phase indicate the blood glucose level. Using dielectric spectroscopy through the change in tissue permittivity glucose level is measured. Ashok et. al describes a method for assessment of blood glucose level of diabetic and non-diabetic patients using Transilluminated laser beam. The laser used here is an atomic gas laser also called a He-Ne laser, operating at a 632.8 nm wavelength [4]. Here a single mode laser was used as a monochromatic light source to eliminate mode interference noise. Making use of this method it was able to monitor blood glucose level of the diabetic patient continuously and non invasively. The result obtained shows that blood flow is directly proportional to blood glucose level. Abdallah et. al describes different kinds of methods for detecting blood glucose. Elastic and inelastic (Raman) scattering as well as fluorescence and IR Spectroscopy measurements was discussed for the development of a solid non-invasive device for home monitoring [5].

Burmeister et. al describes collecting non-invasive human spectra by an experimental protocol that is designed to minimize correlation with blood glucose. In this paper, a series of first overtone transmission spectra is passed

across the tongues of five humans who have diabetes [6]. Despite the high degree of scattering, it was observed that correlations were not related to temporal variances as the protocol separates glucose concentration and time. Wang et. al describes a method based on metabolic heat conformation (MHC) and developed a prototype. In this method glucose level is estimated from the quantity of heat dissipation, local tissue blood flow rate and degree of blood oxygen saturation [7]. Clinical tests were conducted and correlation coefficient of the blood flow rate between this method and the Doppler blood flow meter were found to be equal to 0.914. This result is closer, yet still not acceptable for clinical use. Amir et. al has developed a successful method acceptable for clinical use, which was used in our research. Amir et. al describes a noninvasive method for detecting blood glucose using the technology of occlusion spectroscopy, developed using a NBM device by Orsense Ltd. Here the technology is being presented and the efficiency of the device is evaluated [8]. In this experiment a light is passed through the finger and the amount of light present on the other side of the finger is measured as photons. The presence of glucose blocks the light from passing through the finger. Therefore, the blood glucose can be measured as light intensity varies. Analyzing the transmission spectra shows that with a decrease in transmitted light intensity concentration, hematocrit increases.

III. THEORY OF OPERATION

Basically, the non-invasive technique designed is based on the principle of the absorbance transmittance photometry. In the process to develop the system, it is divided into several main parts and need crucial designs in each stage. The absorption value of light energy is dependent on the number of molecules present in absorbing material. Hence, the intensity of the light energy when leaved the absorbing material is consumed as an indication of concentration of that particular material. In quantitative, the absorbance is expressed by the Beer Lambert Law [11].

As the radiation interacts with biological tissue, it is attenuated by absorption as well as scattering. The attenuation of light can be described by light transport theory:

$$I = Ioe^{-\mu eff\ L} \quad (1)$$

In equation (1) I is the reflected light intensity, *Io* the incident light intensity, L is the optical path-length in tissue, and the term μeff is defined in equation (2) in terms of absorption coefficient μa and reduced scattering coefficient μs′.

$$\mu eff = 3\mu a\,[\mu a + \mu s]^{1/2} \quad (2)$$

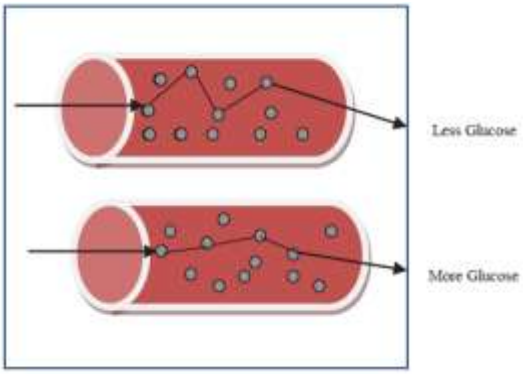

Figure 1: Affect Of Glucose on Light Path [9]

With the addition of glucose concentration in blood, leads to decrease in the scattering properties of tissue. This leads to a smaller scattering coefficient and consequently shorter optical path. Thus with the increase in glucose concentration, scattering properties of skin decreases [13]. Fig. 1 shows the Schematic description of affect of glucose on light path.

IV. METHODOLOGY

In the process to develop the system, kindly it is divided into several main parts and need crucial designs in each stage. The research paper [12] state that, to analyze and predict glucose concentration, it is possible by using glucose spectroscopy between wavelengths 1100nm to 2450nm.The proposed system setup consists of a reflective optical sensor, for transmission and reception of NIR rays with the fingertip as the body site. The proposed system architecture is shown in Fig 2.

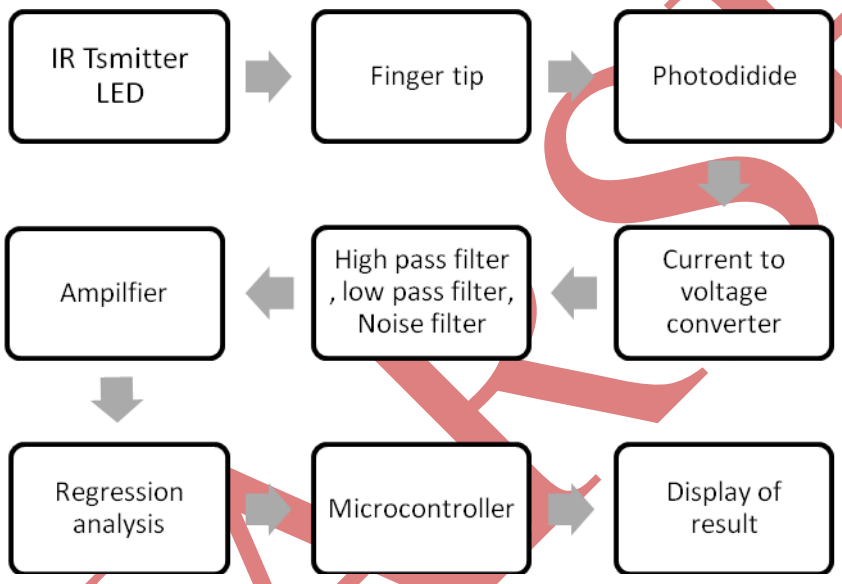

Figure 2: Block Diagram of Proposed Method

The optical sensor used is Infra red sensor operating at a wavelength of 1550nm. NIR signals are passed through the fingertip and detected at photodiode. The photodiode current output s converted into voltage signal by current to voltage converter. This output is filtered and amplified and conditioned for better result. The output is then fed to a microcontroller unit, to perform voltage variation analysis of the received signal, so as to monitor whether the obtained value is within threshold. Here intensity is inversely proportional to voltage. LED based sensor system is preferred for present work as it overcomes all the limitations of LASER [10].

V. MEASUREMENT PROCEDURE

The experimental procedure established is to have an accurate and valid data among the subjects. Figure 3 hows the block diagram on procedure of experiment. There are some assumptions would be made during the experiment as the skin temperature for each subject is almost the same, 36.5°C. The fingertip diameter is assumed same among the subjects. The skin color is light intermediate among the subjects which is depends on the presence of the melanin in the skin.

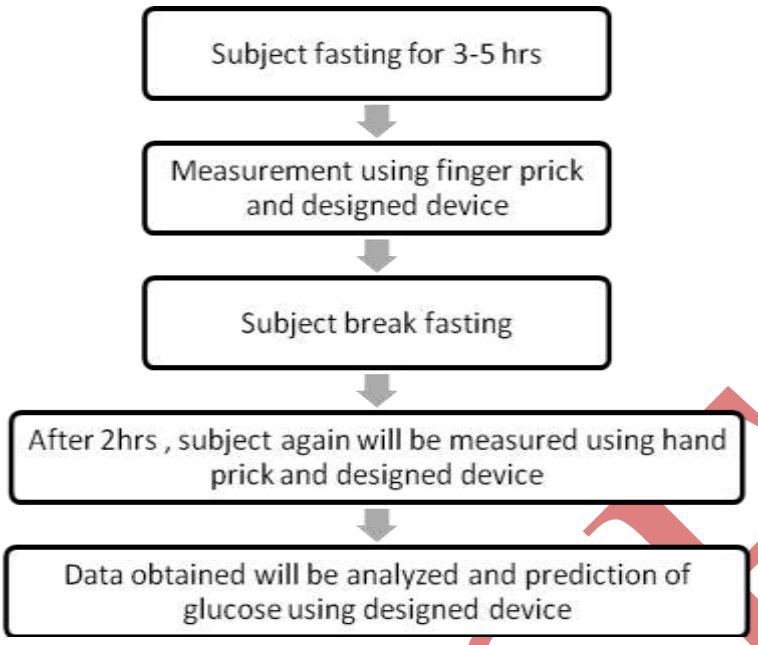

Figure 4: The Measurement Procedure

Data obtain will be analyzed using simple polynomial regression. Regression analysis is the statistical technique for the purpose to identify the relationship between two or more quantitative variables. The relationship is focusing at a dependent variable whose value is to be predicted with the independent variable. This analysis is used to determine and predict the relations between an independent variable X (Voltage measured, (V)) and a dependent variable Y (Blood glucose concentration).

VI. APPLICATION

The designed system gives the waveform of pulse signal. The amplitude of the waveform will corresponds to the amount of blood glucose. Next, the prediction of the glucose is determined. By using the 2nd order of the polynomial regression, we will give the corresponding voltages measured and the blood glucose concentrations. The voltage value is chosen and substitute in the formula. As a result, it will induce prediction for the glucose prediction. This will summarize the correlation between the voltage values with the estimation of the blood glucose concentration.

The purpose of this design system is to determine a method for the prediction of blood-glucose level for human. This invented system would enable the monitoring blood glucose level continuously and noninvasively. When the use of the noninvasively technique coupled with the several advantages such as the absence of pain, it will offer securely a technique to the user.

VII. CONCLUSION AND FUTURE WORK

A lot of research work has been performed over the years to develop noninvasive measurements of glucose. Our research work provides an innovative idea to solve the existing problems, which patients are facing with the current glucose meter technique. A framework for non-invasive blood glucose measurement is been designed. The results obtained from intensity variation analysis shows that there exists a correlation between the variation in intensity and glucose level. In the future, research will be extended to increase the accuracy of the device for making it clinically available in near future.

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