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Spectral Analysis of Blood Glucose using Noninvasive Technique

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***Abstract*—** Diabetes is condition that affects your body's ability to consume the energy present in our diet. Glucose gives energy to your body cells. Body cells need insulin that is present in our blood for getting glucose and utilizes it for energy. Increase of glucose in blood can damage the small blood veins in your kidneys, heart. Blood glucose level can be monitored by two methods namely invasive and noninvasive methods. Currently invasive glucose monitoring methods are widely used. In this method, the skin is pricked to draw blood and put collected drop into a measurement device. Invasive blood glucose measurement methods are highly accurate and common but they are very uncomfortable. For this reason research on noninvasive method is being carried out worldwide. This method is painless and finger pricking is avoided. A noninvasive method based on NIR technique using occlusion is proposed. The body site is ear lobe or finger. The output of optical signal is analyzed by performing FFT analysis.

***Keywords*—**Diabetes, Noninvasive, NIR Spectroscopy

I. INTRODUCTION

Diabetes is a condition in which blood glucose level varies between its normal span of 70 mg/dl to 140 mg/dl. Glucose is consumed by our body in terms of insulin which is a type of hormone. In some medical circumstances our body cannot produce insulin; the result of this situation is sudden increase or decrease in glucose levels. Very high levels of blood glucose will affect the functioning of major parts of our body like kidneys or nervous system. There are mainly two kinds of diabetes, Type1 and Type2. Type1 is Insulin dependent and Type2 is Insulin Independent. In Type1 diabetes, the body does not produce insulin. Insulin allows body to use glucose for energy. So with lack of insulin, our body starves from lack of glucose. The most common form of diabetes is type2 diabetes which is also called as "adult onset", because normally adults with age above 35 facing this problem. The main reason is overweight. More teenagers are now developing type2 diabetes. Another type of diabetes is and Gestational diabetes. It occurs during pregnancy. [1]

This paper presents a spectral analysis of blood glucose using noninvasive method. The subsequent section describes different glucose monitoring techniques. Methodology and principles for glucose measurement are explained in section III and IV respectively. Results and discussion are provided in section V. Finally section VI concludes the paper.

II. BLOOD GLUCOSE MONITORING TECHNIQUES

Blood glucose monitoring systems are broadly classified in two ways namely invasive and noninvasive glucose monitoring method. Invasive blood glucose monitoring methods are high in accuracy but the main disadvantage is they are uncomfortable. With this method we have higher risk of infections. To avoid these discomforts noninvasive blood glucose measurement techniques are introduced. Mainly these methods are painless and more reliable. No pricking or puncturing the skin is required here.

In recent years many spectroscopy techniques are introduced. Spectroscopy means analysis of emission and absorption of light with different matters. Depending upon operating wavelength there are different types of spectroscopy like Mid-infrared (MIR) spectroscopy and Near Infrared (NIR) Spectroscopy. MIR spectroscopy use wavelength range 2500-10000nm and NIR spectroscopy use 730-2500 nm wavelength. NIR technique has more advantages over MIR spectroscopy. The penetration of light into the skin is more in NIR technique as compared to MIR. Absorption coefficient is also low. NIR spectra are made up of board bands corresponding to overlapping peaks. The overtone formed by molecular vibrations. It allows blood glucose measurement in tissues by variations of light intensity. [3]

Jyoti Yadav et al describe different measurement sites using NIR based noninvasive glucose measurement. [2] Different polarizers were with angle variation (45º, 90º and 180º) to study the state of glucose interaction with polarizer light. Two

different light sources of 640nm and 740nm wavelength were used with varying concentration of glucose in the solution. The results were better at 180º. At this point they were getting maximum variation in output detector voltage.

Hussan ali et al describe a method based on photo acoustic spectroscopy.[4] A system has been designed and implemented, as a result it was found that there is a linear relation between acoustic signal produced across measuring site and blood glucose concentration. Xiaoli Li et al describe a method based on power measurement.[5] Different glucose solutions were prepared and power measurement was done. Thermal sensors were used for measurement of approximate glucose level.

K.A. Unnikrishna Menon et al describe a method et describe a noninvasive blood glucose measurement method based on voltage intensity.[6] Researchers were getting voltage variations after reflection. Analysis of these variations was useful for predicting patient's current condition and approximate blood glucose concentration. They found correlation between change in voltage intensity and glucose concentration. Ola S.Abadalsalam et al describe a method one based on Rayleigh Scattering Theory and other is based on linear relation between glucose concentration and scattering angle.[7]

III. METHODOLOGY

Glucose is optically active substance, when light passes through it; the plane of polarization is rotated by some angle, which is correlated with the glucose concentration in the solution. Some researchers have utilized this property of glucose for non-invasive blood glucose measurement.

Near-infrared (NIR) spectroscopy uses the light in the 750-2500nm region, which interrogates the tissue with low energy radiation. Radiation in NIR range can penetrate the skin much deeper than visible or MIR radiation. The spectral region has several windows where hemoglobin, lipid and water absorption band intensities are low enough to allow light to penetrate into the tissue, enabling near-infrared spectral measurements. The specific absorption by compounds relevant for the diagnosis and monitoring allow safe and convenient in vivo measurement. [8-10]

IV. PRINCIPLES OF GLUCOSE MEASUREMENT

Near-infrared based occlusion technique has been selected from a number of methods because it is easier to implement and needs less complex hardware setup. The near-infrared light in the range of 750nm to 2500nm is the most suitable for detecting glucose concentration. The proposed system is based on the principle of transmittance measurement. The value of transmission of light energy is dependent on the number of molecules present in particular substance. Hence by measuring intensity of transmitted light through the measurement site, concentration of glucose in blood can be calculated. Glucose monitoring is made convenient with occlusion method. Occlusion spectroscopy is derived from generation of an optical signal which varies with time. The signal is induced by over systolic flow through the finger. A signal produced by occlusion method is stronger than normal pulse signal. The occlusion of blood flow generates a dynamic optical signal, which facilitates accurate glucose monitoring. Fig.1 below shows work flow of the system.

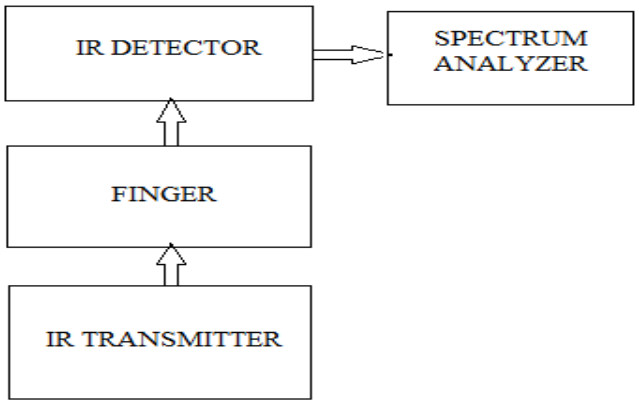

Fig.1. Work Flow Diagram of System

The proposed system uses near infrared technique for transmission and reception of light rays with the fingertip as a body site. The digital sensor with inbuilt Analog to Digital converter has an infrared transmitter and receiver. The sensor is used on finger-tip to measure the detected signal. The detected signal is given to spectrum analyzer.

V. RESULTS AND DISCUSSION

The proposed system contains different units like detection unit and processing unit. Detection unit consists of optical transmitter and receiver. Optical transmitter used here is LED with peak wavelength 950nm and at receiver we are using photo detector to detect the optical signal. At the output of detector unit there is a transducer which detects the signal and converts it to the electrical form and transmit it to the processing stage. Processing stage is used for amplifying weak signal detected from photo detector. The detector used here is an optical infrared sensor which is clipped with finger of the patients.

The spectrum analysis of glucose patients is done using spectrum analyzer. The experiment was performed on seventy patients having different conditions like sugar, BP, healthy, high BP between the age group 30 to 75 years. Here we are using occlusion method for analysis. Therefore the spectrum analysis is done with two conditions that before and after occlusion. In spectrum analysis we have taken Fourier transform of detected signal and then difference between two peak frequencies. Some of the patient's readings are listed below. Here we found some relation between the actual glucose values and the difference.ion is given in Table I and II respectively.

TABLE I. OBSERVATION OF PEAK FREQUENCY DIFFERENCE DURING FASTING CONDITION

Sr.No.	Age	Condition	Actual Glucose Value (mg/dl)	Difference (Hz)
1	49	Healthy	92	72
2	61	Sugar	109	243
3	33	Sugar	117	234
4	62	Sugar, High BP	162	334
5	58	Sugar, BP	168	350
6	55	Sugar	244	1383

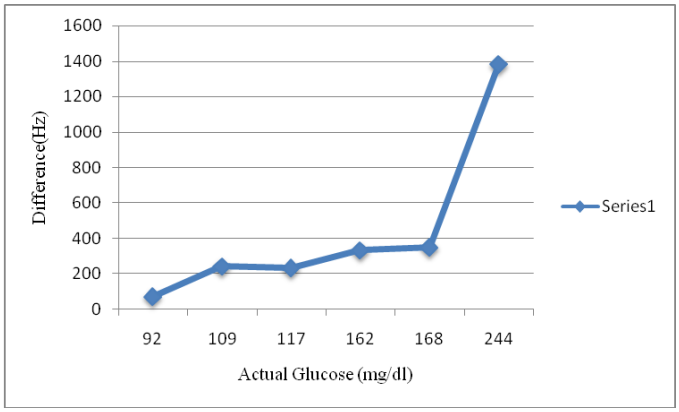

Fig.2. Relation between actual glucose and difference during fasting condition

TABLE II. OBSERVATION OF PEAK FREQUENCY DIFFERENCE DURING PP CONDITION

Sr.No.	Age	Condition	Actual Glucose Value (mg/dl)	Difference (Hz)
1	73	Sugar	105	287
2	60	Sugar, BP	122	335
3	58	Sugar	123	430
4	71	Sugar	165	1000
5	61	Sugar	171	1336
6	65	Sugar	223	3710

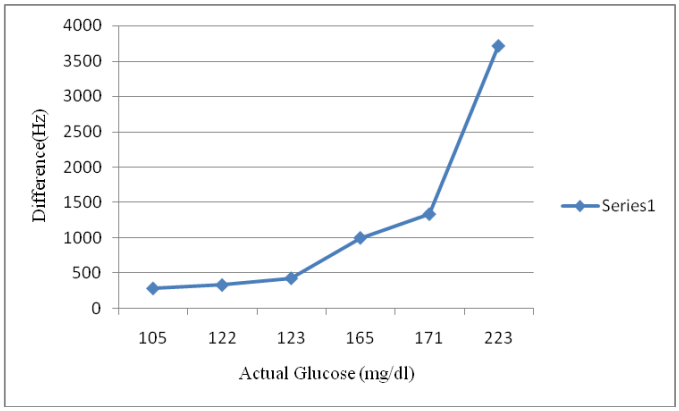

Fig.3. Relation between actual glucose and difference during PP condition

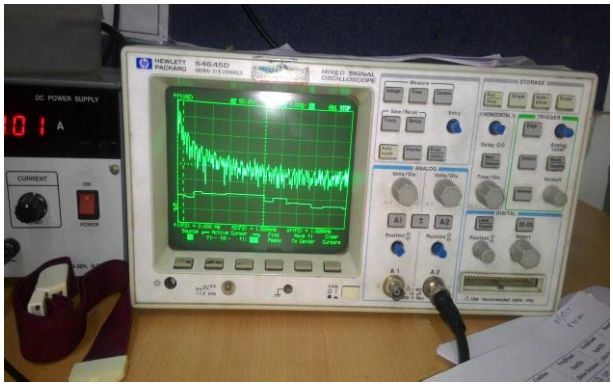

Fig.4. Snapshot of real time processing output on spectrum Analyzer

Fig.2 and Fig.3 shows a significant difference in peak frequencies before and after occlusion in Fasting and PP condition respectively. The snapshot of real time processing output on spectrum analyzer is shown in Fig.4.

VI. CONCLUSION AND FUTURE WORK

This study demonstrates the frequency analysis of output from NIR detector. The record of the peak frequencies for the condition (before and after occlusion) show that with increase in the value of glucose, difference in peak frequency also increases. This work can be extended to develop an algorithm to conduct further analysis by considering blood related parameters.

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