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Non Invasive Estimation of Glucose by Monitoring Pancreas using NIR Sensor

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Abstract *To ensure normal body function, control of blood glucose levels is necessary. A network of various hormones and neuropeptides assure blood glucose. Hormones freed from the brain, pancreas, liver, intestine help to assure glucose level. The pancreas represents a major role in secreting the blood sugar-lowering hormone insulin and its opponent glucagon. However, disturbances in the hormones and peptides involved lead to metabolic disorders such as type 2 diabetes mellitus (T2DM).It is essential to understand the mechanisms underlying the various interactions of biological molecules with blood. Many methods help to measure glucose concentration. To measure the blood glucose level, a new method is proposed through the nanotechnology.*

Index Terms: Blood , Glucose, NIR Sensor, Non-Invasive..

I. INTRODUCTION

Diabetes is an incurable and non-communicable disease in the current century. Currently, millions of people are suffering from this disease and are expected to increase in future[1]. Monitoring of blood glucose level is significant to avoid knottiness of diabetic and impairment to organs. Diabetic people check blood glucose level more than two times per day. Current method uses self-monitoring Glucometer, which is an invasive method. Invasive method of glucose measurement is a painful sampling process, which causes irritation skin[2]. Non-invasive methods developed as an alternative for glucose level measurement. This paper describes the possible design of blood Glucose monitoring non-invasively.

The proposed method uses a Near Infrared Sensor for transmission and reception of rays from the pancreas. NIR sensor used for measuring Shrinkage of the pancreas. Biological parameter of pancreatic cells changes the intensity of the reflected NIR signal. By measuring, the recorded Reflected NIR signal the state of the pancreas due to diabetes can be measured. Wavelet transformation and statistical analysis used to analyze the recorded NIR signals.

The response of optical signal is obtained and studied by performing FFT analysis using spectrum analyzer. The results of the system compared with the lab values to measure the accuracy of the proposed method. The main aim is to develop a simple, reliable, painless, cost-effective method for blood glucose measurement

II. RELATED WORK

Yihao Chen[1] proposed a skin like nano-structured biosensor system (SNBS) is developed to measure glucose level. Reverse iontophoresis was used to transport glucose to the skin surface. Signal-to-noise ratio and sensitivity is high. Linear sensing range is large. Accuracy is improved. Challenge lies in the fabrication of the multilayer biosensor with small detection limit.

Kiseok Song[2] developed a multi-modal spectroscopy which blend impedance spectroscopy and multi-wavelength near-infrared spectroscopy. It has high accuracy in estimating non-invasive glucose level. IMPS circuit measure dielectric characteristics of tissues for glucose level estimation. NIR sensor uses three wavelengths, 850nm, 950nm, and 1300nm.

Jyoti Yadav[3] introduced the glucose sensor. The sensor works on the principle of a NIR LED. The method uses the 940nm sensor to analyse the glucose concentration.

Concentration of glucose is different for the experiment. The experiment tested on human forearm is with high accuracy.

Nina Korlina Madzhi[4] did the comparison of GaAs (950nm), GaAIAs (940nm) and InGaAsP (1450nm) sensors for measuring glucose level. The method first uses the various glucose concentrations. The method uses human blood samples. Voltage range is high in 950nm when compared to 940nm wavelength.

K.A.Unnikrishna Menon[5] introduced voltage intensity based Non- invasive blood glucose monitoring. The proposed methods use a near-infrared sensor. The NIR light passed through the fingertip, before and after barring of blood flow. Analyzing the voltages variation received after reflection, the diabetic condition as well as glucose level of an individual predicted. The result conveyed to smart-phone through Bluetooth.

Matthew sidley[6] estimated blood glucose level using a micro-strip antenna on patients arm. Antenna resonant frequency tracks the changes in glucose concentration. An equivalent circuit model developed to measure the input impedance with changing glucose level.

Jens Kraital[7] introduced the non-invasive measurement of blood component. The method uses principle of photoplethysmography and NIR spectroscopy. Various blood component measurements is non-invasive. The blood draws NIR light with different absorption coefficient.

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The characteristic measures blood component, haemoglobin and oxygen saturation in blood. 600nm to1400nm NIR sensor wavelength used in system.

III. METHODOLOGY

Figure. 1 shows the block diagram of the proposed non-invasive Glucose Monitoring system

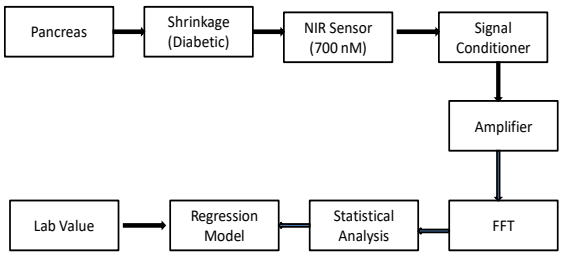

Figure 1. Block diagram of non-invasive blood glucose measurement

The proposed method uses the NIR optical technique with 700nM wavelength NIR sensor for measuring blood glucose concentration. Above 1550 nm, insight of human tissue is very depth but immersion of light in blood increases[3]. NIR LED act as NIR transmitter, that transmits infrared rays. NIR LED is 100mA current and 2.5v voltage capacity. To reduce the fluctuation in the current, a constant current circuit helps in emission of NIR light. NIR sensor placed on the pancreas. When NIR light disseminate pancreas, interaction is with a glucose molecule [4].

The signal conditioned is in signal conditioning circuit. The conditioned signal amplifies in the 3D Digital signal amplifier. After signal amplification, the LPF and the HPF filter removes noise. A two-stage filter removes unwanted noise from the amplified signal. One passive LPF with the f_c is 160Hz and other is active LPF with the f_c 28Hz. HPF with the f_c 0.86Hz connected at the initial stage of the signal conditioning circuit [5].

After receiving the signal from signal conditioning circuit, analog to digital conversion performed and stored in buffer. The signal converted transforms with continuous wavelet transform. Continuous wavelet transform is a powerful tool for signals in the time-frequency domain. Intensity variation analysis performance takes place. A Linear regression model used for intensity variation analysis. Glucometer measures the individual patients glucose concentration. The result compared with proposed system results.

IV. RESULTS AND DISCUSSIONS

Regression tool helps to obtain Polynomial regression equation. 20 diabetic individual samples of both gender taken for dataset. The Glucose level of the individuals measured in the lab by an invasive method and the proposed hardware set up. The readings shown in Table I and Linear Regression analysis of Glucose value with analog voltage value shown in Figure 2.

Table 1 Analog Voltage and Glucose Level of samples

S.No	Analog Voltage (mV)	Glucose Level (mg/dl)	S.No	Analog Voltage (mV)	Glucose Level (mg/dl)
1	499	142	11	627	225
2	509	150	12	695	230
3	519	152	13	701	248
4	519	154	14	612	215
5	548	160	15	724	256
6	568	170	16	750	298
7	573	175	17	935	300
8	583	180	18	999	320
9	597	191	19	1136	338
10	607	200	20	1538	516

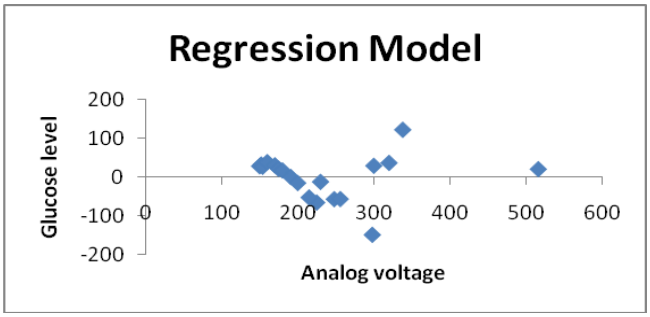

Figure 2. Linear Regression analysis of Glucose value with analog voltage value

The proposed method formalized in measuring the glucose reading of 30 individuals using both an invasive and non-invasive methods. Readings collected tabulated in Table II.

Table 2. Comparison of results of Glucose level obtained by invasive and non-invasive methods

S.No	Glucose level obtained by Invasive method	Glucose level obtained by Non-Invasive method	S.No	Glucose level obtained by Invasive method	Glucose level obtained by Non-Invasive method
1	120	119	16	108	110
2	143	145	17	175	170
3	160	163	18	199	197
4	185	185	19	156	160
5	166	165	20	184	190
6	88	90	21	116	120
7	110	112	22	124	119
8	211	215	23	149	150
9	205	203	24	267	265
10	230	225	25	280	270
11	90	90	26	99	100
12	116	118	27	89	89
13	135	140	28	152	160
14	219	225	29	266	264
15	250	240	30	287	280

The precision of the proposed glucose measurement device calculated using the Clarke Error Grid Analysis showed in Figure 3 and Surveillance Error Grid Analysis showed in Figure 4.

a. The Clarke error grid analysis helps in analyzing exactness commercial glucose monitoring devices in monitoring of Glucose concentration. The Clarke error grid analysis computed using MATLAB.

The reference glucose values and anticipated values from Table II given as input. Different regions observed from the Clarke error grid analysis and described in Table III

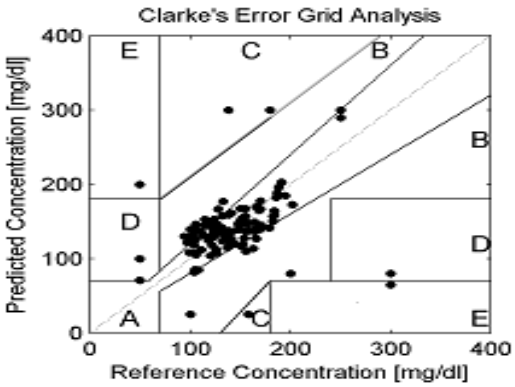

Figure 3. Clarke error grid analysis

(ii)The surveillance error grid analysis decide the clinical precision and hazard range of continuous glucose monitoring device used in ICU. The surveillance error grid analysis readings of Table II showed in Fig 4. From Fig 4,almost of the glucose readings are in the dark green zone (no risk chance) and little glucose readings are in the light green zone (slight risk chance).The proposed method of glucose monitoring for the measurement of glucose concentration in blood is safe and does not create harm.

Table 3 Regions of the Clarke error grid analysis

Region A	Values within 20% of the reference Glucose value
Region B	Values are outside of 20% does not lead to incompatible treatment
Region C	Values leading to unneeded treatment
Region D	Values showing a potentially severe loser to detect hypoglycemia or hyperglycemia
Region E	Values confound discourse of hypoglycemia for hyperglycemia and vice versa

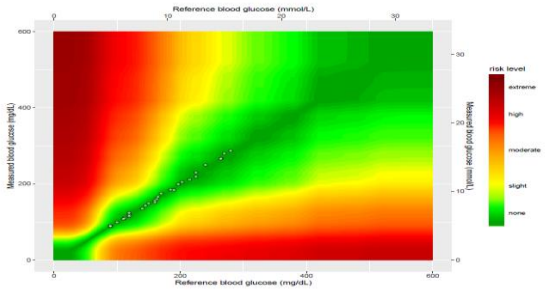

Figure 4. Result of Surveillance Analysis

The proposed block diagram implemented in Figure 5 calculates the glucose concentration level. The recorded signal analyzed using SIGVIEW software.

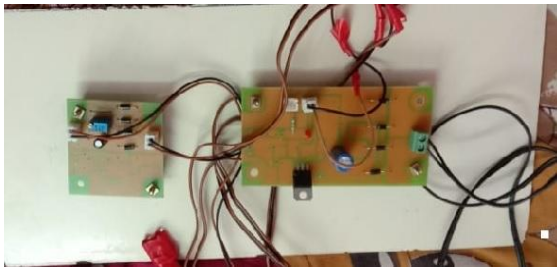

Figure 5. Hardware Module

V. CONCLUSION

Early detection and control of disease are necessary. Monitoring of blood Glucose level is fitter in the non-invasive method when compared to the invasive method. The Invasive method is a painful, sampling process with skin infection. The Non-invasive Glucose measurement is through NIR sensor of 700 nm wavelength. Pancreas shrinkage varies with diabetic and non-diabetic patients. Intensity is proportional to glucose level concentration. The Proposed method used for monitoring glucose level in a effective and more good way when compared to invasive systems.

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AUTHORS PROFILE

Kavitha Ganesan is a Research scholar in the Department of Electronics and Communication Engineering at Dr.M.G.R Educational and Research Institute, I started my career as a Lecturer in Vel Tech,an reputed Engineering College which is of a good standard till today. My research area is in Nanotechnology. I am much interested in real time research work which made me to have an interest in the Blood Glucose measurement.