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Non-invasive blood glucometer

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Abstract

Roughly 18 million individuals experience the ill effects of diabetes mellitus, otherwise called diabetes, just in the United States which is 5 % of the aggregate populace. It is the seventh driving reason for death. By 2020, the cost related with diabetic treatment is required to ascend as high as $192 billion. The worthy scope of glucose focus is from 70 mg/dL (milligram of glucose in 100 milliliters of blood) to 110 mg/dL or 3.9 to 6.0 mM/L. Be that as it may, not long after eating, glucose centralization of a man may ascend to a level as high as 140 mg/dL. Consequently, a non-obtrusive glucose observing gadget is an appreciated option. The non-intrusive blood glucose meter planned and manufactured in this examination made out of a circuit comprising two LEDs of a similar wavelength (Drove match) with one acting as emitter and other as detector. Near infrared ingestion spectroscopy (NIR) which utilizes a light emission with a wavelength in the scope of 600-2500 nm, which is centered around the body to decide the concentration of glucose inside the tissues. Two different set of experiments were performed, which depicted that with the increase of the concentration of glucose in blood. The average power of the resultant signal acquired increased consistently. Regression can be made of the acquired results to relatively calculate the output.

Keywords: Glucometer; Non-invasive; LED pair; Non-invasive glucometer

1 Introduction

Diabetes mellitus all the more usually known as diabetes has been an on-going issue the world over for a long time now and the quantity of diabetics is relied upon to ascend to 366 million universally by 2030 [1]. The present work concentrates on the plausibility of a screen that non-obtrusively measures blood glucose levels utilizing electromagnetic waves. The method depends on relating a checking receiving wire's full recurrence to the permittivity and conductivity of blood which thusly is connected to the glucose levels [2]. One of the measures of controlling diabetes is to screen it consistently. Checking can be an extremely important instrument for diabetics since they can design their sugar admission for the day. This tight control of glucose levels is known to expand survivability of patients of diabetes and diminish their odds of complexities [3].

Observing blood glucose levels includes pricking the finger which when done day by day can be very excruciating and in this way a decent option is to utilize non-intrusive glucose checking devices. Invasive method includes a procedure in which a blood test is set in contact with a protein (commonly glucose oxidase) which produces hydrogen peroxide from glucose and oxygen. The hydrogen peroxide amount is then measured by amperometric method with a (regularly platinum) cathode. The larger part of checking frameworks sold today, regardless of whether persistent or blood meters, utilize chemical covered terminals and amperometric examination [4]. Non-obtrusive blood glucose observing gadgets have as of now been being developed even as right on time as the year 2000 [1]. Infrared spectroscopy, all the more particularly, Close Infrared Spectroscopy (NIRS) has been an effective technique to grow such gadgets and has been produced in a wide range of labs. Non-intrusive glucose observing strategies have been intensely looked into over

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the previous quite a few years. The ebb and flow ranges of research will now be talked about. They have been separated into the accompanying classes: Interstitial liquid concoction investigation, Breath substance examination, Infrared spectroscopy, Optical cognizance tomography, Temperature modulated limited reflectance, Raman spectroscopy, Extremity changes, Ultrasound, Fluorescence, Warm spectroscopy, Visual spectroscopy, and Impedance spectroscopy [3].

Non-intrusive blood glucose observing is not yet a broadly financially accessible technique for checking among diabetics. Photo detectors and spectrometers are exceptionally costly and making glucometers utilizing these isn't monetarily achievable [5]. In this examination, a glucometer was made utilizing a photo emitter while another of a similar wavelength was utilized as a photo detector [1]. The PPG innovation has been utilized as a part of an extensive variety of economically accessible therapeutic gadgets for measuring oxygen immersion, circulatory strain and cardiovascular yield [6]. Because of progress in glucose level, the measure of blood volume in the figure changes, this variety can be measured by PPG. At the point when a settled wellspring of infrared radiation is utilized, the variety of blood volume go about as a phototransistor and the receiving signal is changed. This is the reason we utilize the PPG motion for perceiving the diabetic. In this work by filtering a photo plethysmography (PPG) signal, a strategy for perceiving diabetic is proposed [6].

2 Methodology

2 sets of experiments are performed to compare the invasive and non-invasive values of glucose in different subjects to make a standard non-invasive glucometer system.

2.1 Hardware design

The circuit was built on a bread-board. It has a photo-emitter that receives a 5 V voltage supply from a battery. The finger is placed on it through where the light is refracted to photo-receiver, it also receives a 5 V power supply. It has a low-pass and a high-pass filter with operational amplifier and a NPN-transistor.

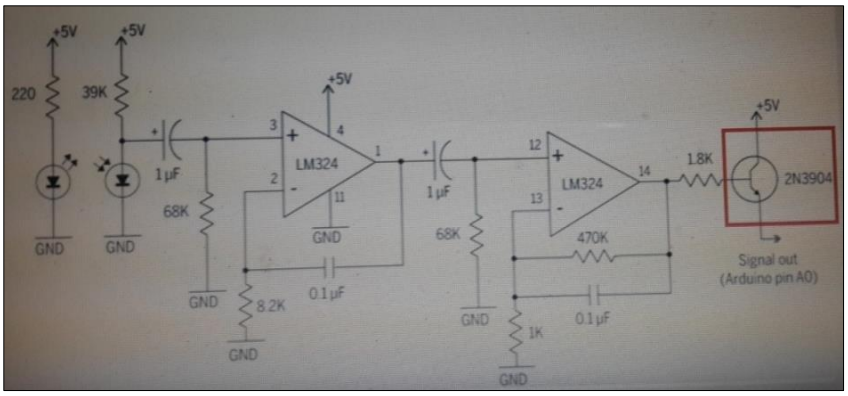

Figure 1 Circuit diagram

2.2 Experiment 1

About 15 subject data was collected, first invasively then non-invasively through the sensor circuit. Then they had the glucose drink. Again the data was recorded to see if glucose had any impact on the signal.

2.2.1 Procedure

A general protocol was defined for all the subjects. They were fully aware about the experiment procedure. The equipment was set on a table with a PC. First the subject was asked to give the invasive data. By using the Accu-check glucometer the glucose values were recorded. By pricking the finger and taking the blood drop out of the finger on the glucose strip. The strip is inserted inside the built-in meter that gives the accurate blood glucose values in mg/dl. The following steps are to be taken care while getting the invasive data

- First wash and dry your hands preferably using warm water which may help the blood flow.
- Turn on the meter and prepare the test strip. Many Accu-check meters turned on as strip is inserted.
- Choose your spot on the finger and don’t check on the same finger again.

- Prepare the lancing site on your finger and lance the fingertip.
- Touch and hold the test strip in-front of the lanced finger and collect the blood on the strip until it's filled with blood.
- View your test result and take the proper steps if your blood sugar is high or low, based on your healthcare professionals' recommendations.
- Discard the used lancet properly.

Right after the invasive process, the non-invasive data was recorded by asking the patient to fix his/her finger on the sensor and to remain static for 60 seconds. The data of 1 minute was recorded through the IR sensor of the circuit. NI, USB6009 DAQ card was attached to it. It is a 14-Bit, 48 kS/s Low-Cost Multifunction DAQ, with 8 analog inputs, 2 static analog outputs (12-bit), along with 12 digital I/O and a 32-bit counter. USB driven for high mobility and best of all it is compatible with Matlab Data Acquisition Toolbox that transferred the signal in the software where on the PC the signal was displayed.

Right after it the subject was asked to drink glucose mixed with water. The 20 g of glaxose-D was mixed in 75 ml of water. Glaxose-D has following nutritional info:

- Energy kcal: 360 g
- Carbohydrates: 90 g
- Sugars: 90 g
- Vitamin d: 17.5 ug
- Calcium: 150 mg
- Calcium: 150 mg

15mins after drinking glucose the invasive data was taken, following by the non- invasive data. As the glucose gets absorb in the blood by that time. Same steps were repeated which are described previously to get the post-glucose data.

After getting both the data, text files are saved for signal processing to find different variables that may have changed because of glucose in pre-glucose & post-glucose conditions.

As the text files are saved by giving them different names according to subjects, the subject data of height, weight, age, gender is also written down. It's also noted how many of the subjects were in complete fasting state and how many of them had meal before recording the data. By keeping these variables in mind we can evaluate results more accurately.

2.3 Experiment 2

In the second experiment 10 subjects were taken with fasting state. Their pre-glucose invasive data was recorded by using the glucose accu-check meter by following the same protocol as for the experiment 1. After recording the invasive values the subject's non-invasive glucose data was recorded by the hardware sensor on the LAB-view and text file was saved.

After this the subject was ask to drink the glucose mixed with water. The glucose drinking protocol was also the same as for experiment 1. And about 10 minutes after drinking glucose the first post-glucose data was recorded, by invasive and non-invasive method. Right after recording these data the subject was ask to drink the same amount of glucose again. And the data recording process was repeated again after 10 minutes. It was repeated for about 5 times on each subject. In the end we had 1 pre-glucose invasive & non-invasive value and about 4 post-glucose invasive & non-invasive values of each subject. The data was saved in text files along with subject info regarding their height, weight, age, gender

2.3.1 Signal processing

The signals from experiment 1 & 2 were displayed on MATLAB for signal processing. As some noise was also recorded with data we had to apply the filters on the signals first before we go into signal processing. So a low pass filter was made in MATLAB whose cut off frequency was 20 hz.

After filtering the signal we find different variables that may have changed by varying the glucose levels. To find out which variables it may have effected we find mean, power, average power & energy of the signal on MATLAB

We get the values of mean, power, average power, energy. They were tabulated in the excel file. After this a regression equation was formed from each data set.

3 Result and discussion

Table 1 Parameters analysis

	filtered	**original**	
Subject	**average power**	**average power**	**Invasive glucose values mg/dl**
s1pre	7.9389	5.8143	131
s1post	40.3984	4.84E+01	157
s2pre	47.7606	54.7222	88
s2post	26.8146	29.4604	112
s3pre	17.9286	21.5553	93
s3post	53.5981	60.3432	121
s4pre	12.9636	14.3185	102
s4post	48.0769	56.5469	114
s5pre	23.2106	27.0167	140
s5post	11.4966	12.3965	168
s6pre	12.4711	14.3164	123
s6post	22.6931	26.4847	142
s7pre	6.7455	7.1356	132
s7post	10.3434	12.4136	134
s8pre	8.5763	9.3704	109
s8post	45.6717	50.0644	122
s9pre	15.4027	14.6532	167
s9post	21.0647	23.2092	179
s10pre	6.8493	6.9211	117
s10post	35.652	40.2962	127
s11pre	14.6066	16.5589	92
s11post	32.1429	35.3176	125
s12pre	31.1333	37.0569	89
s12post	28.159	31.9146	105
s13pre	27.3301	33.2899	81
s13post	28.7407	33.7774	90
s14pre	11.5552	12.3758	96
s14post	15.5659	18.0638	154
s15pre	11.0358	11.974	85
s15post	18.1806	20.0535	94

This table clearly shows that with the increase in the glucose level of a person the average power also increases of the acquired signal

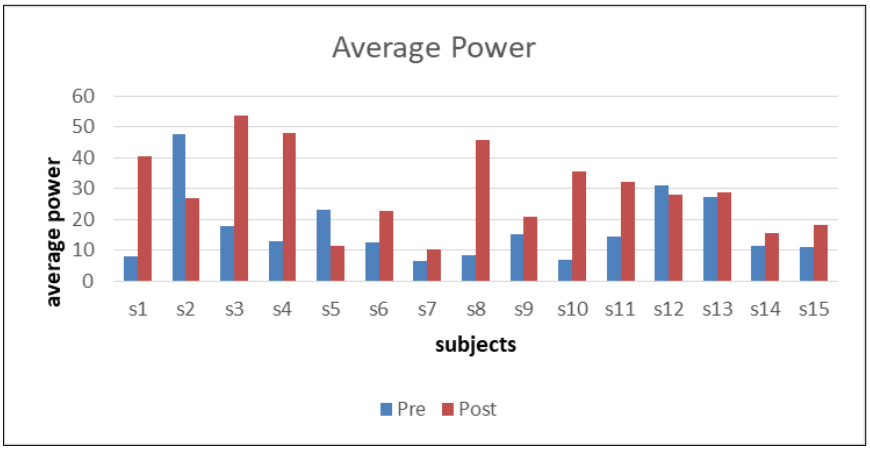

Figure 2 Visualizing trend of average powers

The above figure shows the pre and post analysis of the average powers of the signals obtained from the subjects

3.1 Experiment 2 results:

Table 2 Subject data after specific intervals

subject	average power	pre	post
s1pre	5.4368	95	
s1post1	11.4099		119
s1post2	23.2601		132
s1post3	32.8071		168
s1post4	37.5524		185
s1post5	42.9336		192
s1post6	57.5061		249

The above table depicts the pre and post invasive values and corresponding average power of a single subject.

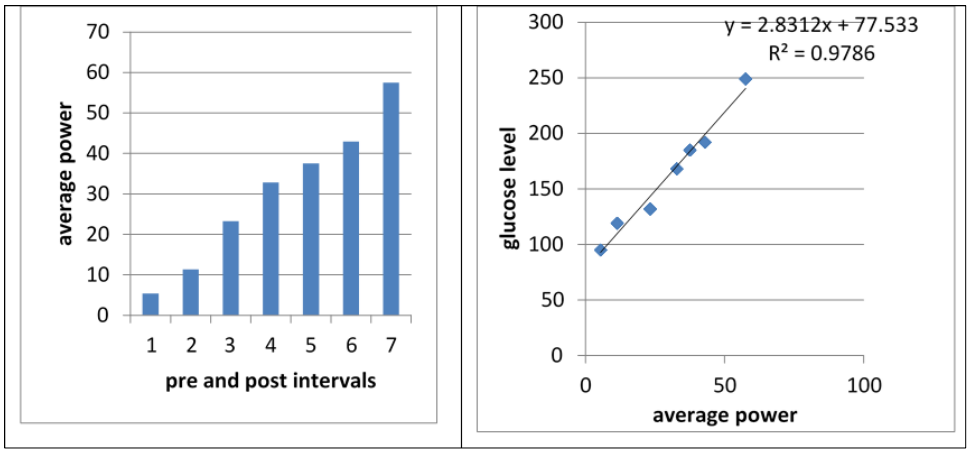

Figure 3 Pre and post power analysis and regression of a single subject

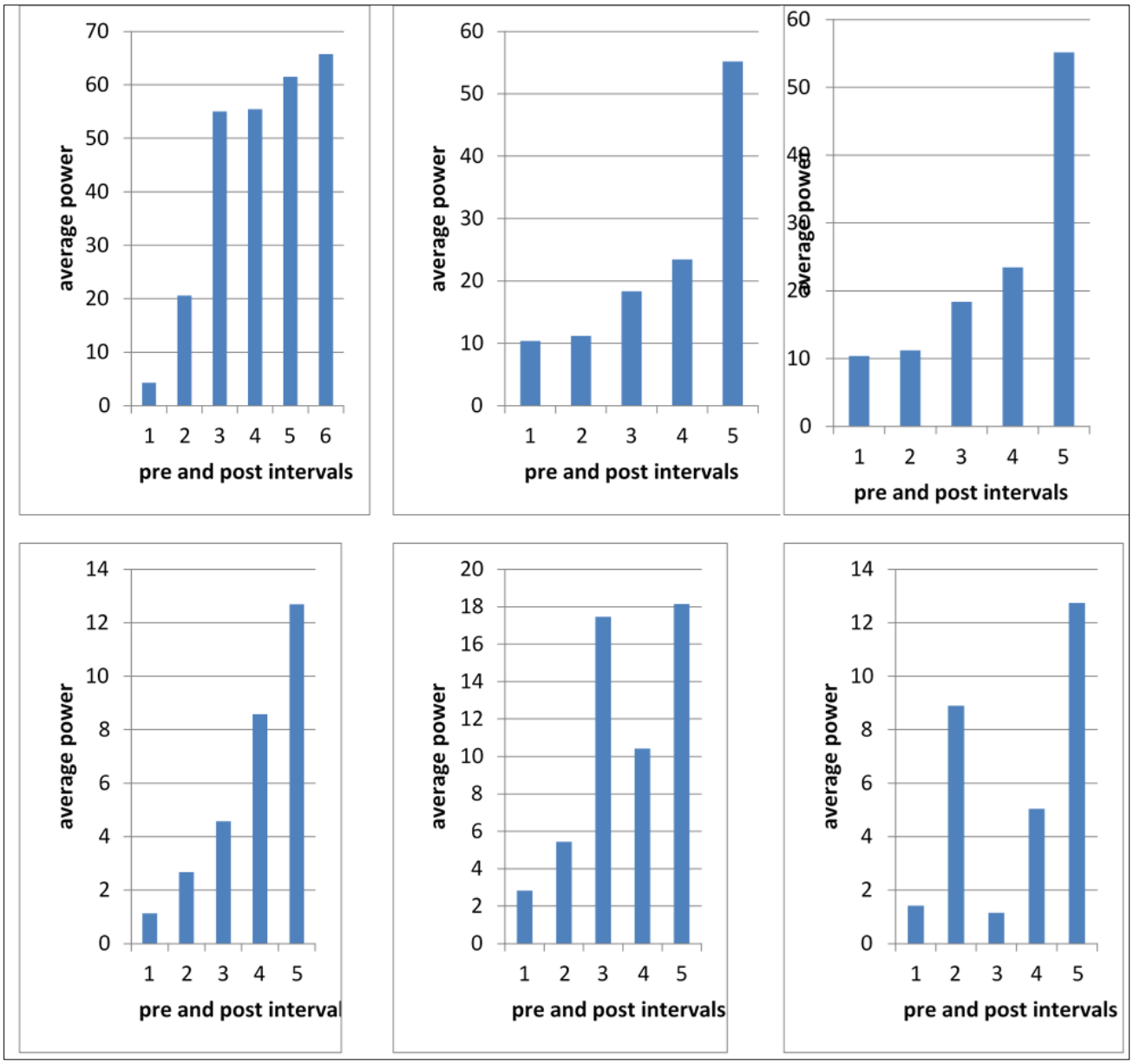

Figure 4 Average result of subjects showing glucose concentration v/s power

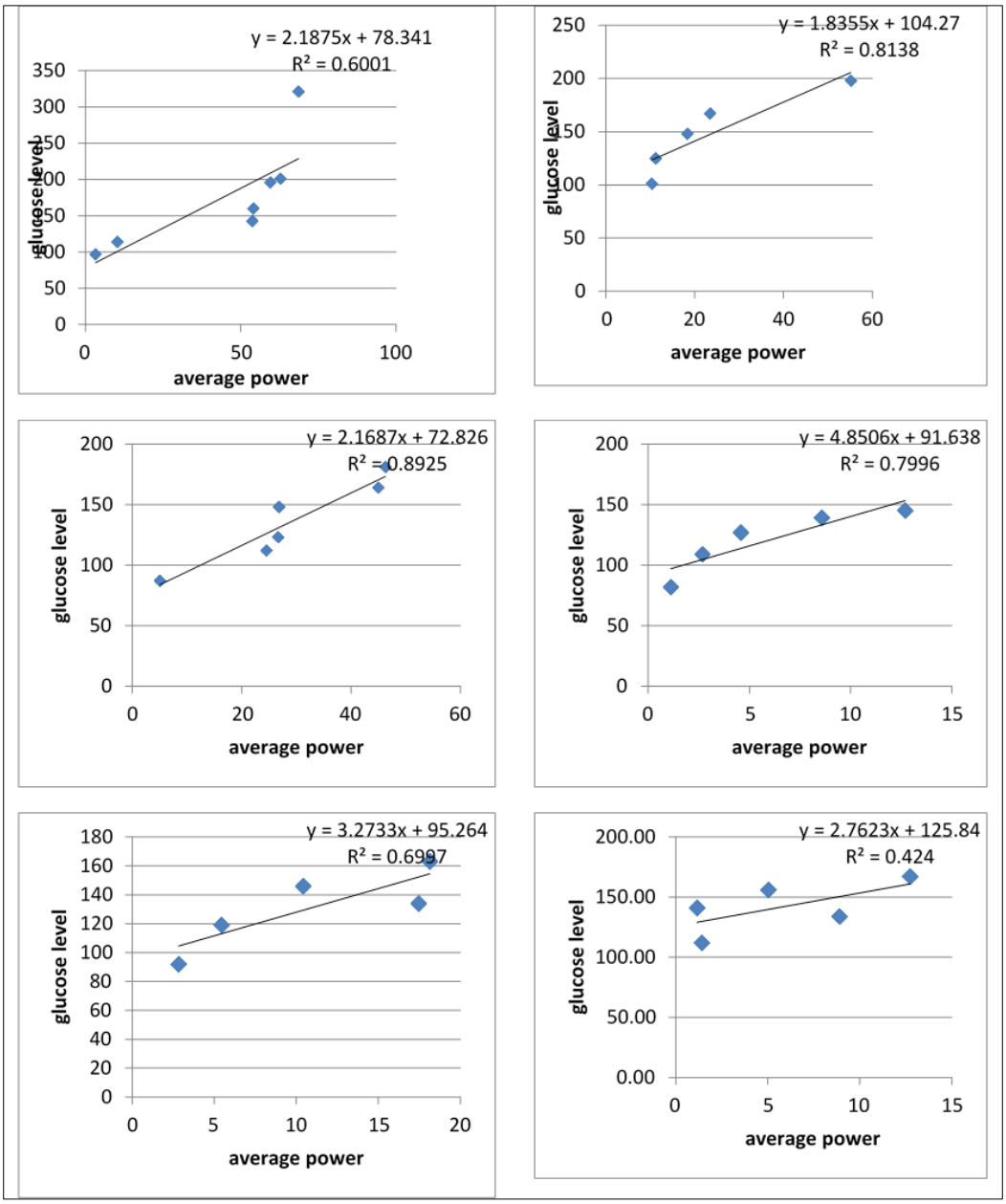

Figure 5 Regression analysis of average subjects

4 Conclusion

The results generally show an increasing trend in most of the subjects which means with the increase in the concentration of the glucose the average power of the acquired signals increases. To limit the impact of the hardware in such a high pick up application it is prescribed to locate a more delicate semiconductor photo detector that does not require an amplifier.

Compliance with ethical standards

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Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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