



Near-infrared Spectroscopy based Non-invasive Blood Glucose Level Prediction

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ABSTRACT

This paper describes review on Non-invasive method of blood glucose level predictions using Near-Infrared sensor. This research work provides major contribution to the society. First, it provides unique solution for diabetic patient to monitor blood glucose level without pricking the blood. Second, it describes NIR spectroscopy technique to reduce healthcare cost and accurate results. Third, it gives different research approach towards non-invasive blood glucose measurement and monitoring.

Keywords: *Glucose level, Non-invasive, diabetes, NIR spectroscopy, Regression analysis.*

I. INTRODUCTION

Diabetes is major challenge of current century. It is non-communicable disease. Currently more than 150 million peoples are suffering from this disease and are expected to increase in future to 400 million by 2035[1-3].Diabetes people check blood glucose level more than two times per day. Hence they are inconvenienced every time. They are suffering the danger of infection by pricking the finger. Also expenses associated with strips and lancets are more because each test requires a new test-strip. Diabetes is considered as one of the major death contributors in non-contagious diseases [1]. The current method uses the self-monitoring glucose meter. These methods are invasive. The main disadvantage of such a method is that, it requires pricking the finger, extracting the blood from forearm and doing chemical analysis which uses test strips. Also it gives pain and discomfort due to frequent finger pricks. On-invasive techniques are more useful and user friendly. It reduces the healthcare cost and other difficulties involved in invasive method of glucose determination. Researchers are still not overcome many drawbacks of non-invasive glucose monitoring methods. Some problems are scanning pressure that must be applied, physiological differences such as width of tissues, correlation error, hardware sensitivity and stability. So, There is much interest in developing methods for the measurement of blood glucose concentration (BGL), especially for use in diabetic subjects where the method simple to use and painless. The objective of NIR spectroscopy techniques to measure blood glucose level and summarize the research work done in the field of NIR spectroscopy blood glucose monitoring till date.

II.MATERIALS AND METHODOLOGY

In NIR spectroscopy infrared sensor is used to determine the concentration of blood sugar [4-5], [7-11].IR light emitter with specific wavelength and photo detector having high sensitivity are used for analysis of results. Some methodologies are as follow:

2.1 Basic Principle of Glucose level Measurement

In optics Beer Lambert's Law of absorption is used to determine the quantity of material, it uses Near-infrared spectroscopy technique [12]. Beer-Lamberts law states the relationship between absorbance and concentration of absorbance through which it is travelling. When IR light is incident on a material, part of it is absorbed by the molecules in the material. The absorption of IR light is different for different wavelength. Beer Lambert's law also establishes the linear relationship between absorption of light to the light intensity of NIR light.

Light absorption of material is expressed as,

(Intensity of incident light)

$$A(\lambda) = \text{Log10} \frac{\text{Intensity of incident light}}{\text{Intensity of transmitted light}}$$

(Intensity of transmitted light)

From above expression absorbance of light is proportional to the concentration of material. The light absorption depends on how many molecules it interacts with. As infrared light passes through the material, the intensity of light exponentially decays because it is absorbed by molecules of material. Thus based on Beer-Lambert's law, a single wavelength is selected for glucose concentration evaluation and by using absorption theory glucose level is predicted.

2.2. Hardware Requirements

In measuring the blood glucose level by using absorption technique NIR sensor of specific wavelength is used. Very highly efficient GaAlAs-LED (950nm) is used as IR light transmitter and photodiode having spectral range of sensitivity- 750nm to 1120nm wavelength is used to detect attenuated light [6]. Fig.1 and 2 shows measuring setup. It consist of two different part, constant current IR emitter circuit having the capabilities of 100mA current and 2.5v voltage carrying capacities and signal conditioning circuit. At the output of photodiode signal is corrupted due to external and other factors. To reduce the noise two stage low pass filter is used to remove unwanted noise from signal. One passive low pass filter with cut-off approximately 160Hz and one active low pass filter with cut-off approximately 28Hz are used. Also one high pass filter with cut-off 0.86Hz is connected at initial stage of signal conditioning circuit.

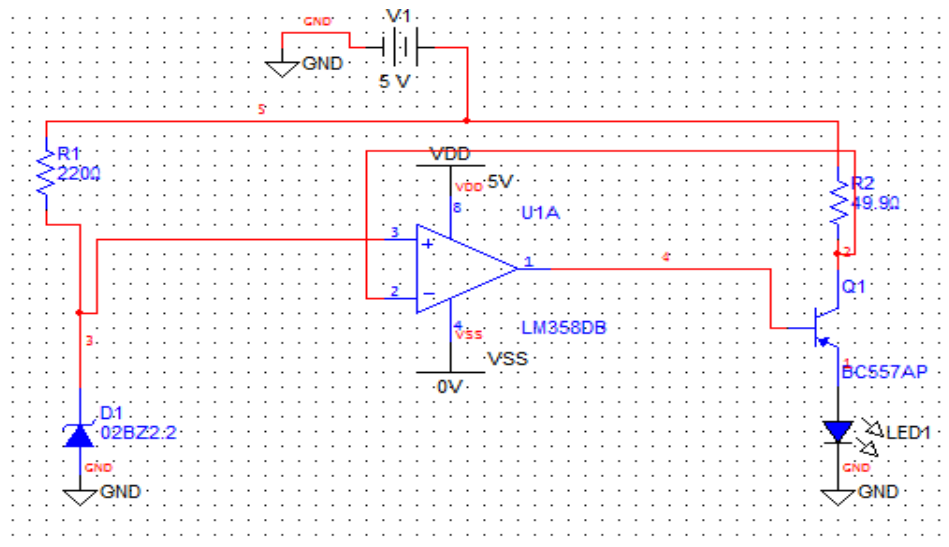


Fig.1: IR emitter circuit

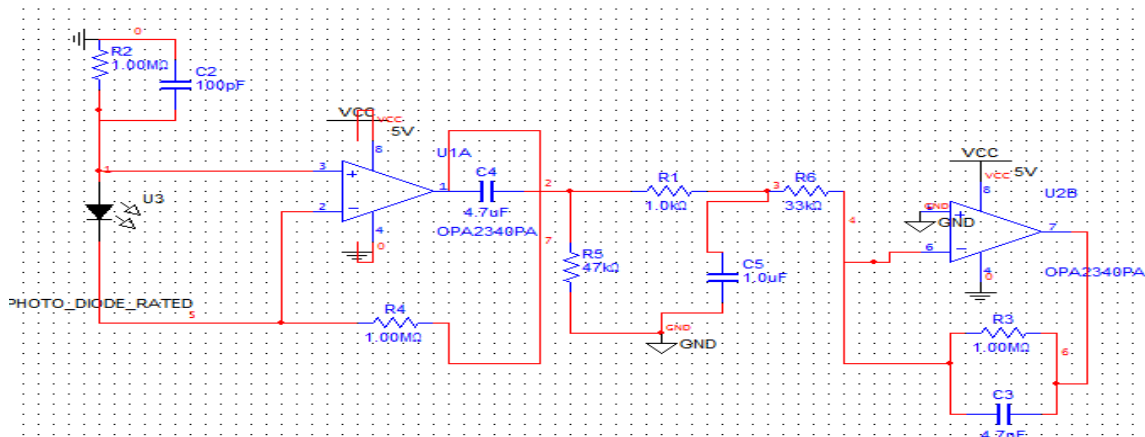


Fig. 2: signal conditioning circuit

2.3 Software Analysis

Sensor circuit is simulated using multisim software .Output signal from the circuit will be feed to MATLAB for further analysis using National Instruments data acquisition system (DAQ).It will samples analog data or voltage level to the equivalent digital data with 50 samples at 1.5 KHz.

2.4 Data Collection and Analysis

Data analysis is performed based on samples collected from 20 individuals as case study. Blood samples are collected and analyzed for glucose level predictions along with developed device experimentation. To determine the correlation between measured voltage level from sensor output and glucose level in the blood linear regression analysis is used SPSS software tool is used to determine the regression analysis. Figure 3 shows complete procedure to predict blood glucose concentration.

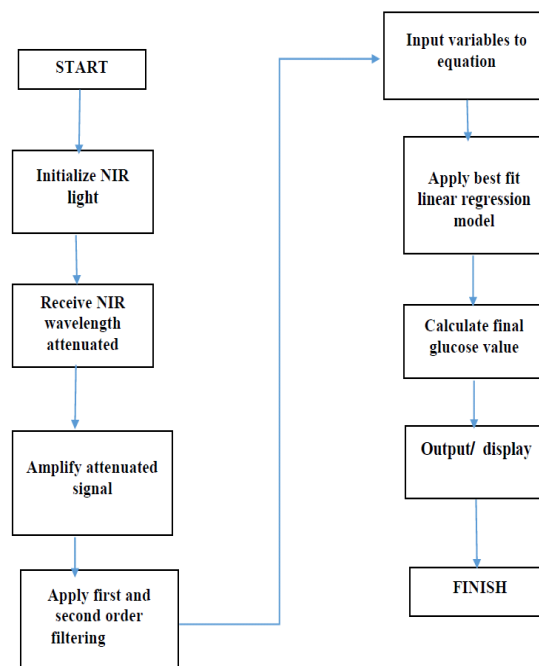


Fig 3: system flowchart

2.5 Data Processing and Real Time Sugar Level Display

For processing the raw data open source prototyping board is used and glucose level is displayed on the screen or display. It will then transmit to remote device using Bluetooth module to store the data for future analysis. By using server model we can access data remotely and it will also give update to medical expertise. System architecture for this method is shown in Fig 4.

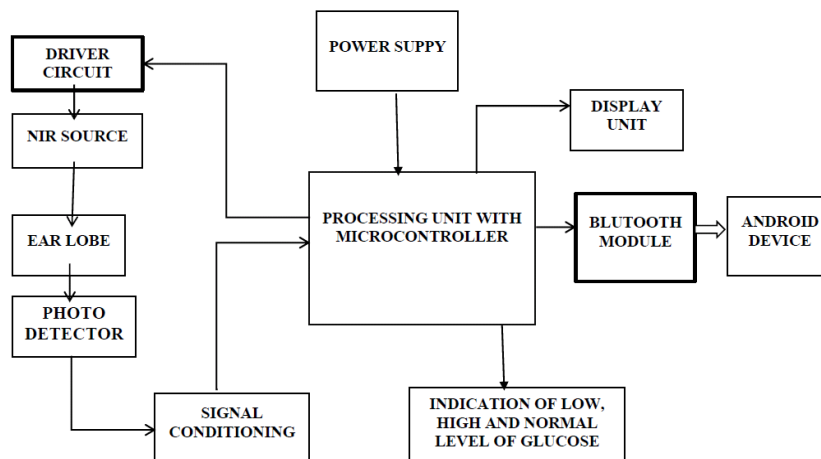


Fig.4: system architecture

III. EXPERIMENTAL RESULTS

Initially we tested our sensor with different human subjects and recorded voltage change with respect to human subject. As demonstrated in Fig. 5 as increase in glucose concentration voltage level starts decreasing. It gives linear relationship between transmitted infrared light intensity and concentration of sugar.

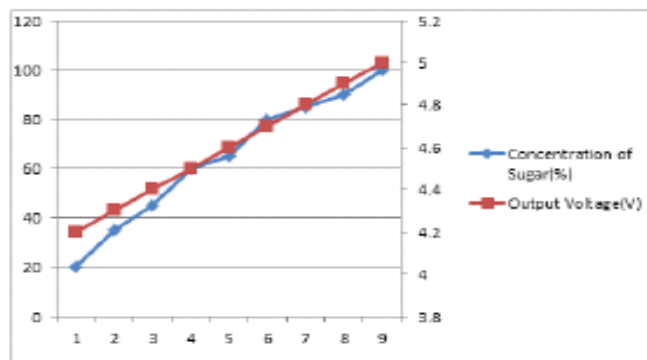


Fig.5: linear relationship between glucose concentration and output voltage

IV. CONCLUSION

From the experimental analysis with different samples, final output voltage is nearly linear with the concentration of sugar level. The obtained result shows that there is a correlation between intensity level after transmission and glucose level in blood. By using proposed methodology any diabetic or non-diabetic person can able to monitor their blood glucose level non-invasively with minimal cost.



V. FUTURE SCOPE

The experiment will need more data sampling for statistical analysis but for this time the human sample will be controlled by their food taken. This is to ensure the data collecting for glucose measuring is more precise for each measurement taken from the human sample. Due to time constraints, further improvement can be made to increase accuracy, efficiency in signal processing.

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