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A Non-invasive Method for Blood Glucose Detection in Diabetes Patients with IOT Application

K. Nithyakalyani, S. Sathish, R. Abinaya, A. Murusidha Sumin and S. Poongodi

ABSTRACT

Diabetes is a common condition among the people, which occurs due to destruction of beta cells (type1), insufficient secretion of insulin into the cells by the pancreas (type2) and gestational type occurs during pregnancy. Invasive methods need pricking of the blood from the patient body which makes the diabetic patients panic and uncomfortable. For this reason, the introduction of non invasive methods to diagnose diabetes becomes an effective one. In this study, a non-invasive Near Infrared sensor is used to detect the blood glucose concentration and the patient data is transferred to the physician directly through IOT [Internet of Things] for further clinical diagnosis and medication.

Keywords: Diabetes, Invasive, Non invasive, IOT

1. INTRODUCTION

Pancreas plays a major role to maintain the equilibrium condition of glucose in blood. In pancreas, alpha cells (glucagon) responsible for control of hypoglycemic condition by secreting the glucose from the liver to the blood which is used by the muscles for the producing energy and hyperglycemic condition controlled by transferring the glycogen into the liver by secreting insulin from beta cells. The changes in the pancreas lead to the disturbance of blood glucose homeostasis which is called as diabetes.

The detection of blood glucose concentration is very important to maintain the equilibrium condition of glycolysis for diabetic patients. Invasive methods used for blood glucose concentration measurement are enzymatic, oxidation-reduction method and condensation methods[1][2]. These methods requires several ml of blood which leads to severe trauma and hemorrhagic condition, when the patients are frequently monitored for the maintenance of insulin level, that would take to control their glucose level externally[3][4]. Several different non invasive techniques[5] are in existence to detect the blood glucose level through ultrasonic, optical coherence tomography, Fluorescent Technology (using Fluorescent reagents)[6], bio impedance, Reverse iontophoresis(by using electrodes)[7] far Infrared, mid Infrared[8] and near Infrared methods[9]. Due to greater penetration, high SNR and noise immunity than the other techniques, Near–IR[10,11] is widely used as a source for detecting blood glucose concentration.

DETERMINATION OF WAVELENGTH

The specific chemical molecule absorbs the optical wave at specific frequency, likewise glucose has specific frequencies at which it absorbs NIR depending on the C-C, C-H, O-H bonds which is present in the glucose [Absorbance type], and the unabsorbed wave can be reflected by the molecules which also gives the concentration of molecules called as reflectance type[12]. The glucose has more absorbance in near infra red than the mid and far infrared ranges due to higher penetration [12].

Department of Biomedical Engineering, Vel Tech Multi Tech, Chennai–600062

The near infrared trans receiver used to transmit the wave into the tissue like finger at the fingerprint region of glucose in blood which will be reflected by the glucose due to absorption of energy from the transmitted wave and its vibration. The vibrated glucose molecule reflect the transmitted wave with some attenuation, from these effect the amount of blood glucose concentration can be detected based on the principle of Beer–Lambert law which states that the absorbance is directly proportional to the concentration of molecule[12].

The selection of wavelength in the finger print region of glucose makes the detecting system precise in the measurement. The normal near infrared wavelength range is from 750nm to 1400nm[9]. The wavelength of NIR used in this detection system is in between the range of 850nm to 950nm which is higher in precision than the other wavelength ranges and has the lower absorbance for the glucose molecules[1]. The infra red spectrum for propane molecule is shown in Figure 1.

2. IMPORTANCE OF INSULIN LEVEL DISPLAY

Insulin level which is injected externally plays a vital role because the injection of high insulin dosage than the required level leads to hypoglycemic condition and the injection of low level insulin makes the resistant to reduce the glucose level and also makes higher side effects in the body like fainting and others [12].The unmatched insulin level leads to makes the cells to resist the insulin absorbance and hyperinsulinemia called a type of cancer caused in pancreas [12].

3. MATERIALS AND METHODS

The blood glucose concentration is detected non invasively by using NIR sensor, and the transmitting band of the sensor is from 850nm to 950nm. The NIR sensor is a trans receiver type and the transmitter transmits near infrared light which is penetrated into the tissue. The specific chemical molecules (glucose) absorb the NIR at specific band and reflect the unabsorbed wave which is considered to estimate the level of glucose. The reflected wave captured by the InGaAs (Indium Gallium Arsenide) photodiode which has the higher

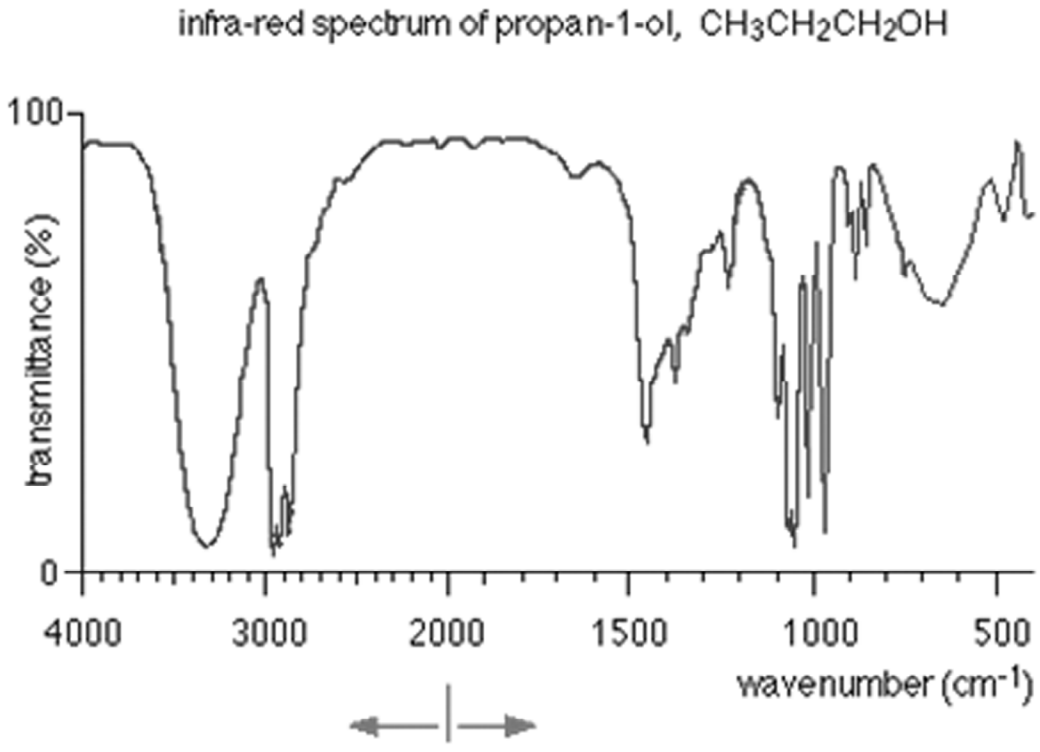

Figure 1: Infrared Spectrum

sensitivity in the nanometer range. The photodiode converts the light wave into an appropriate voltage [1][2]. From the circuit of AC-DC conversion, 5V DC supply is given to the sensor which gives the light output in the infrared or red band based on the energy gap. The light directly transmitted through the finger tissue and the reflected waves detected by the photo detector of InGaAs.

The blocks involved in the system are shown in Figure 2. The glucose signal is acquired by the use of SIGVIEW software as shown in the Figure 3 which is used to acquire live signals and further can be stored and processed on the MATLAB.

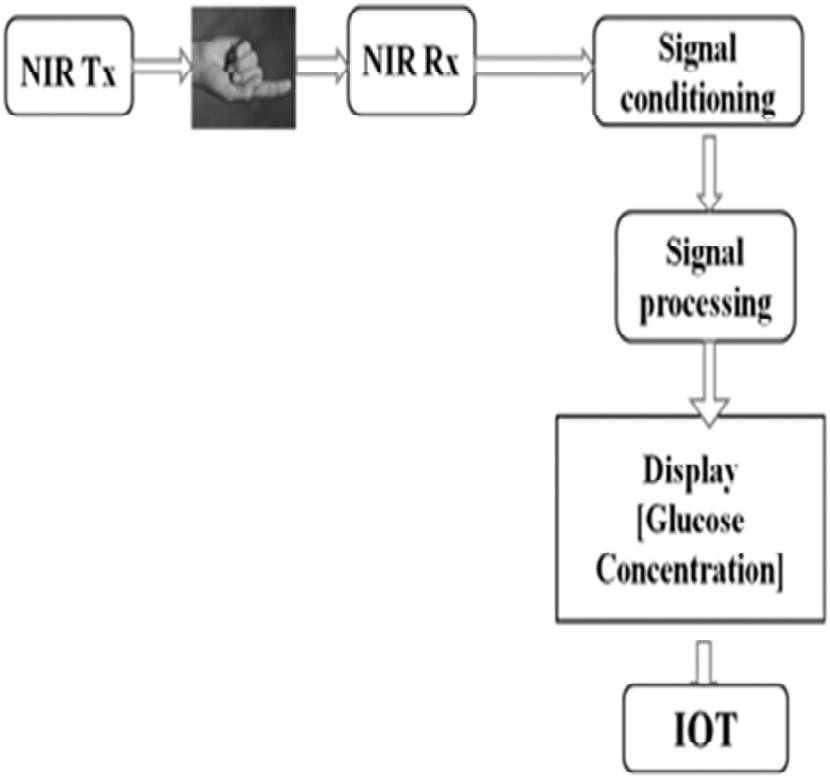

Figure 2: Block diagram

Figure 3: Acquisition of Glucose as Voltage Signal

3.1. Sensor connection

The NIR sensor transmits the infrared spectrum at the DC supply of 5V. The supply is given from the transformer (step down) with the bridge rectifier, capacitor filter and regulator 7805(5v). The unidirectional AC signal from the bridge rectifier circuit smoothened by the capacitor filter due to its low power requirements, and the regulator maintains the DC output constantly at 5V which is directly supplied to the NIR transmitter.

3.2. Data Acquisition

The reflected signal from the patient is captured by the photodetector of InGaAs which has higher sensitivity in the nanometer range which can be converted into voltage analog signal from the light signal [13]. The SIGVIEW software is used to record the real time signal by the use of sound chord and the recorded signal can be processed on the MATLAB to detect the glucose concentration through detecting the reflectance peaks.

3.3. Signal processing

The reflectance peaks from the acquired glucose analog signal is detected by using MATLAB. The pan tompkin algorithm is used to detect the higher peaks which can be used to detect the glucose values. The following are the steps involved in the signal processing

i. BAND PASSING

- Cascaded of both LPF and HPF
- LPF attenuates the muscle artifacts and power line
- Interferences, high frequency noises eliminated
- HPF reduces the baseline wander and passes the higher frequency components

ii. DERIVATIVE FILTER

- Differentiation is the standard technique to determine the peaks from finding the slopes
- It suppress the low frequency components
- Inflection points determination
- It causes the effect on the width of the signal with respect to change in the amplitude which is the n^{th} derivative of amplitude inversely proportional to the n^{th} power of width
- Also detect the peaks in the superimposed signals

iii. SQUARING

- To make the positive result, the signal squared
- The high frequency components enhanced

iv. AVERAGING WINDOW FILTER

- It produces the smoothening effect on the signal
- Threshold level for the amplitude also defined by it

The resulted signal will be glucose signal [13]

4. RESULTS AND DISCUSSIONS

The raw glucose signal is acquired and then combination of filtering (both high pass and low pass), derivative and squared filter is done by using pan tompkin algorithm. The maximum peak is the result of glucose value of the subjects.

4.1. Normal Condition

In normal subjects, the glucose level before the intake of meal is from 70-130 mg/dl and similarly glucose level after the intake of meal is less than 180 mg/dl (time duration is from 1 to 2 hrs)

4.2. Abnormal Condition

The acquired result is transferred to the Physician through IOT for the purpose of further medication.

5. CONCLUSION

The designed Non invasive Near IR based glucose detection system provides the glucose level of the subjects by observing the reflectance peak of the acquired signal without any discomfort to the patients.

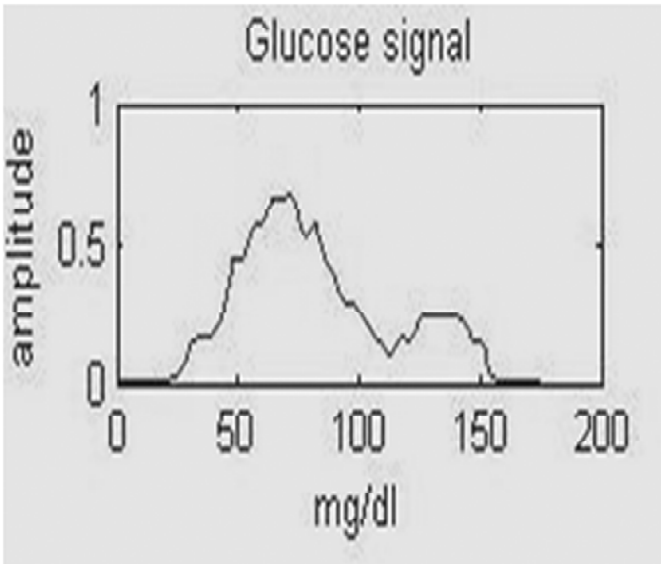

Figure 4: Glucose value before the intake of meal (Amplitudes are in volts)

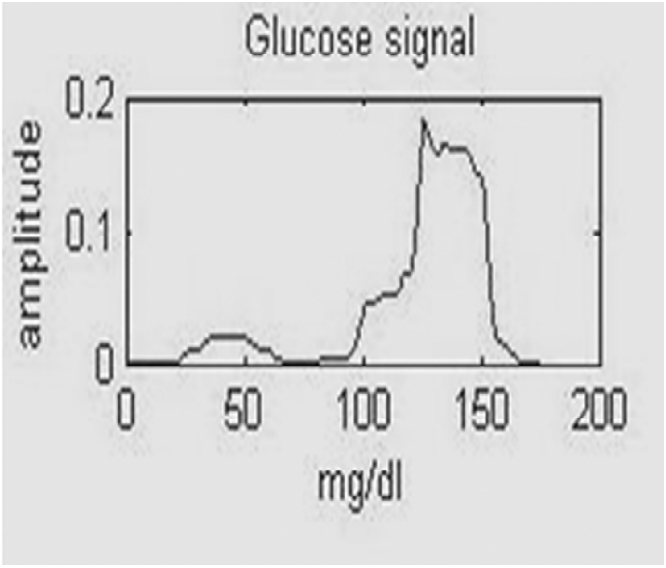

Figure 5: Glucose value after the intake of meal (time duration 1.30 hrs after meal) (Amplitudes are in Volts)

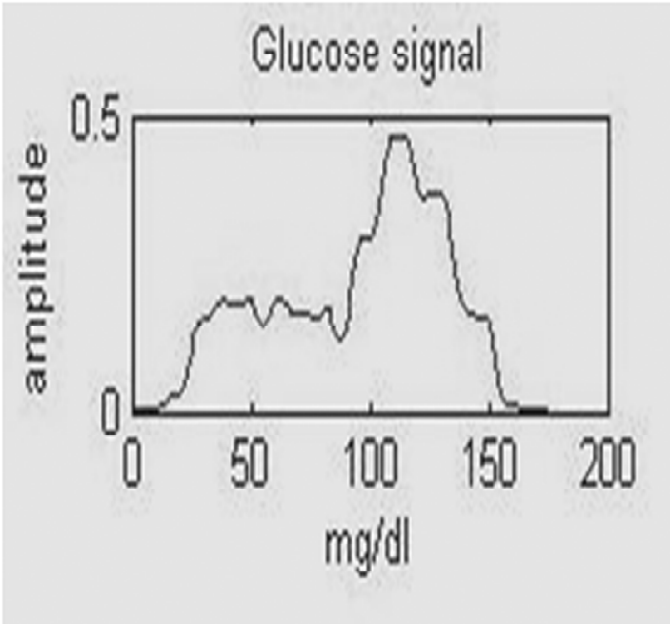

Figure 6: Glucose value before the intake of meal (Amplitudes are in Volts)

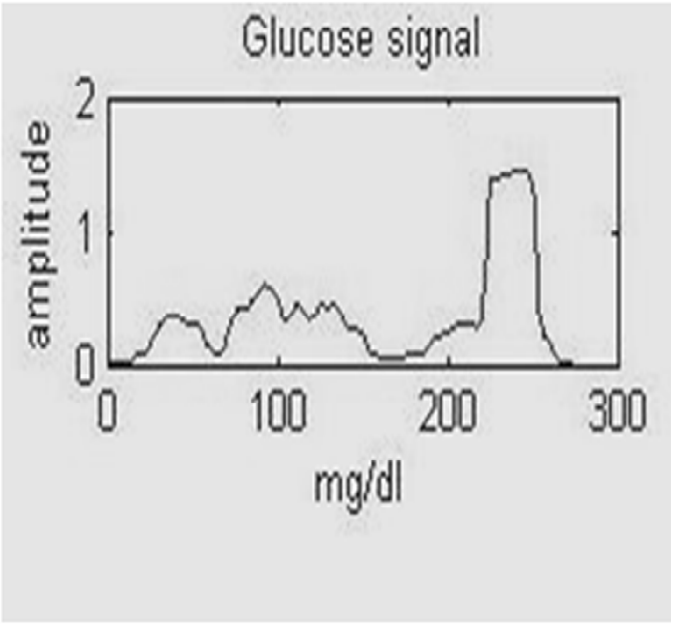

Figure 7: Glucose value the intake of meal (time duration 1.30 hrs after meal) (Amplitudes are in Volts)

The system provides the blood glucose value of the patients in a graphical format by which their glucose value is represented by the maximum peaks. This work favors the medical field for many advantages and relieves the patient from pain. In this study, the interfacing of IOT with the system is an additional advantage, which saves the time delay to report the physician for the further clinical diagnosis. Also, Patient can have time to time insulin dosage suggestions from their doctors through this IOT.

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