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Non-Invasive Optical Blood Glucose Measurement

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ABSTRACT

The method for noninvasively blood glucose monitoring system is discussed in this paper. Lot of research work has been done in developing the device which is completely noninvasive to avoid the pros & cons because of frequent pricking. In this paper we are trying to analyze the noninvasive blood glucose measurement study in the near infrared region which is the most suitable region for blood glucose measurement. For this purpose we use a technique which is similar to pulseoximetry based on near infrared spectrometry .An infrared light of particular wavelength is passed through fingertip containing an arterial pulse component are derived,thus minimizing influences of basal components such as resting blood volume,skin, muscle and bone.

Keywords- Glucose measurement, Non-invasive, Pulse-oximetry, photoplethysmography (PPG).

I. Introduction

Diabetes mellitus is a medical condition in which the body does not adequately produce the quantity or the quality of insulin needed to maintain the normal circulating blood glucose. Insulin is the hormone that enables glucose (Sugar) to enter the body cells to be used for energy. Two types of diabetes are common. Type I is known as Insulin dependent diabetes Mellitus (IDDM) & accounts for 5-10% of all cases. Type II or Non-insulin Dependent Diabetes Mellitus (NIDDM) occurs in childhood and requires insulin doses to maintain life, In addition to healthy eating & exercise. NIDDM occurs later in life perhaps after 40 years of age and may require insulin or to be controlled with an oral medication weight loss, a nutritious diet and a regular exercise.

Blood glucose measurements allow the detection of diabetic condition and are widely used by hospitals like Operation Theatre, ICU, ER and Labour Room.[1]

A noninvasive blood glucose measurement has many advantages including the prevention of pain and potential transmission of infectious diseases, reduced need for trained personnel, and relatively short measurement time, and the absence of bio-hazardous waste. Since the near infrared light is found to penetrate a great depth into biological tissues, near infrared spectroscopy has been developed into a noninvasive method for biomedical sensing and clinical diagnosis. The absorption of whole blood in the visible and infrared range is dominated by the different glucose derivatives and blood plasma that consists mainly of water. It is well known that pulsatile changes of blood volume in tissue can be observed by measuring the transmission or reflection of light through the blood volume.

Several methods are used to measure total blood glucose. The most common methods utilize spectrophotometric analysis of light absorbance based on Beer –Lambert law.[2]

II. Methods for Glucose Measurement

2.1 Invasive Methods

Laboratory methods used for blood glucose testing

A) Reduction method
B) Condensation method
C) Enzymatic methods

2.2 Non Invasive Blood Glucose Measurement Techniques

Noninvasive methods mostly depend on absorption or transmittance. Blood glucose gives different absorption spectrum for different wavelengths.

2.2.1 Optimal wavelength region in the near infrared [5]

The MIR light propagates only into a few scores or micrometer and may be applied for extracted blood sample. On the other hand, the NIR light has deeper penetration into biological medium up to a few milimeters. The NIR has a potential to be applied for non-invasive or minimally invasive blood analysis even though glucose absorption is not as high as in the MIR region Following are the most common noninvasive methods.

2.2.2 Near infrared spectroscopy:

Glucose produces one of the weakest NIR absorption signal per concentration unit of the body major component.NIR spectroscopy glucose measurement enables investigation of tissues depths in the range of 1 to 100 millimetres with a general decrease in penetration depth as wavelength value is increased.NIR transmission through an earlobe, web and finger cuticle or reflected from the skin.

2.2.3 FIR spectroscopy:

A second technology for non-invasive blood glucose monitoring through spectroscope measures absorption of FIR contained in natural thermal emission or body heat. FIR spectroscopy is the only type of radiation technology that does not require an external energy source.

2.2.4 Raman spectroscopy:

Raman spectroscopy measures scattered light that has been influenced by the oscillation and rotation of the scatter. Various Raman techniques have been attempted in blood, water, serum and plasma solutions. Analytical problems include instability in the laser wavelengths and intensity & errors due to other chemicals in the tissue sample and long spectral acquisition times [3]

2.2.5 Photo acoustic spectroscopy:

It uses optical beam to rapidly heat the sample and generate an acoustic pressure wave that can be measured by microphone. The techniques are also subject to chemical interference from biological molecules as well as physical interference from temperature and pressure changes. [4]

III. Basic Principle

Basic block diagram of noninvasive blood glucose measurement system is described in following figure.

The non-invasive sensor system allows a continuous measurement of the blood glucose concentration, which is based on a pulse photometric measurement method. Thereby an area of skin is trans-illuminated by light which is emitted by LEDs in the range SW NIR. Suitable wavelengths are selected for the analyses of relative blood glucose concentration.

3.1 Mathematical implantation

Blood glucose is responsible for providing the energy to body. For spectrophotometric experiments, Beer-lambert's law is utilized and developed the notation of absorbance to express light absorption as a function of blood glucose concentration given by following equation (1).

$$OD = \log_{10} \frac{I_0}{I} = \in \times C \times L \qquad (1)$$

Where OD-Optical density
I_0-Light intensity of incident light
I-Light intensity of transmitted light
ε-Extinction coefficient
C-Concentration of blood glucose
L-Length of light path through solution

3.2 Sensor Design

The developed glucose sensor system consist of number of hardware modules, which consist of appropriate light sources, constant intensity circuit, detector circuit. The sensor consist of emitter LED's with center wavelength as 660nm and 940nm.660nm LED is selected as reference and 940 nm wavelength shows the linear relationship with glucose concentration when experimentation is carried out with different glucose concentration made from distilled water and sugar.

The LEDS are designed to be placed opposite to a photo diode that detects the light from the LEDS. Absorption on each wavelength differs significantly for different glucose concentration. For maintain the constant intensity circuit is used. OPT 101 is used as detector. This single receiver photo diode is installed in the lower shell of finger clip. The probe is placed to the patient's body usually on the finger. The transmitted light is sensed by photodiode. Output voltage of photodiode varies linearly with intensity.

The amplifier is designed for single or dual power supply operation, making it ideal for battery operated equipment. Integrated combination of photodiode and amplifier removes the problems of leakage current, noise pick-up, and gain peaking due to stray capacitance. OPT 101 operates from +2.7v to 36v supplies and quiescent current is only 120microampere.

IV. Result and Discussions

An optical sensor is developed for blood glucose using wavelength 940nm. Output is obtained on Digital storage oscilloscope where AC and DC components can be separate out easily. Correlation is established between actual blood glucose concentration and measured output voltage at OPT 101 for more than 8 patients.

Curve is fitted in fig. 1 and correlation is obtained From results it is observed that though 940nm wavelength can be used for noninvasive measurement since it has linear relationship with glucose concentration provided other error causing elements are reduced S still there a is scope for further improvement like instead of taking more number of patients; some dedicated patients should be selected and more number of light sources or LEDs should be used for good results.

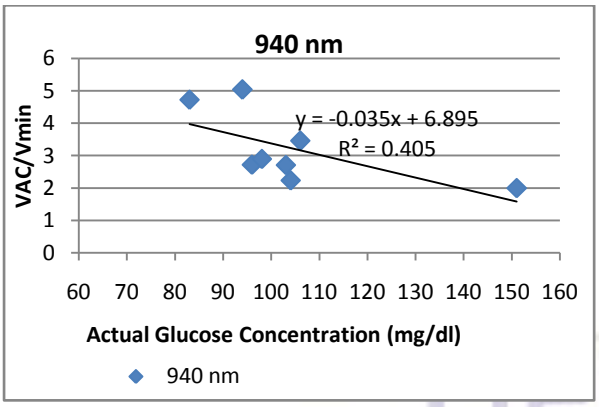

Figure 1

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