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Non-Invasive Type Blood Glucose And Bilirubin Monitoring Kit For Rural Health Care System

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ABSTRACT: Diabetes and jaundice are one the major life threatening non-contagious diseases. The aim of this study is to provide a healthcare system for mobile glucose and bilirubin monitoring. It uses near infrared spectroscopy and optical method .In this technique we make use of a near infrared sensor for transmission and reception of NIR rays from human body. Near-infrared (NIR) is sent through the fingertip, earlobe tip. By analyzing the variation in received signal intensity obtained after reflection, glucose and bilirubin concentration can be analyzed.

From this research, it can be concluded that the noninvasive optical methods implemented on wireless sensors and smartphones, that can be used at any time and any place in the future as an alternative to traditional invasive blood glucose and bilirubin measurement methods. NIR method is used to overcome the current limitations.

I. INTRODUCTION:

Diabetes and jaundice are common life threateningdiseases. The variation in glucose or bilirubin affects the individual’s metabolism. So there is a need for continuous monitoring of glucose and bilirubin in the patients. There are various methods to measure blood glucose, mainly invasive and non-invasive methods. Glucose sensors are divided into two categories of (i) point sample glucose sensors and (ii) continuous glucose sensors. Point sample glucose sensors are carried out by finger prick glucometer or urine dipstick. However, continuous glucose monitoring is divided into three categories of invasive, minimally invasive, and non-invasive. Micro dialysis and intravenous implantable are two kinds of invasive sensors. Micropore or microneedle is a minimally invasive glucose sensor. Non-invasive methods offer painless and safe alternative for measuring blood sugar. Non-invasive glucose sensors are divided into two categories of transdermal and optical sensors. Impedance spectroscopy and skin suction blister technique are two kinds of transdermal sensors. Optical sensors include various types such as near-infrareds pectroscopy,mid-I nfrared spectros copy, fluorescence, Ramanspectroscopy and thermal infrared. NIR spectroscopy measures the change in light intensity when a light beam with 750–2500 nm wavelength is transmitted and reflected on the 1–100 nm thick skin tissue. This method provides a simple, affordable, safe, and comfortable. Three bands exist in the NIR range: (i) the combination overtone band (2000–2500 nm), (ii) the first overtone band (1400–2000 nm), and (iii) the second or higher overtone band (750–1400 nm).Non invasive bilirubin monitoring technique introduces another optical method to diagnose jaundice. It measures the blood bilirubin using 457–473 nm wavelength light. In jaundice, body produces high amount of bilirubin that cannot be excreted from the intestine and the skin and eyes turn yellow. Many babies have jaundice after birth. These conditions are usually due to a problem in the immature infant’s liver. A large number of bilirubin pigments can cause neurological disorders, irreplaceable neurological dysfunction, and even death. Jaundice needs immediate care and treatment if the concentration of serum bilirubin exceeds 10 mg/dL. Early diagnosis of jaundice can be carried out by three methods: (1) the Kramer’s rule, (2) an invasive blood test, and (3) non-invasive optical techniques. Kramer’s rule or visual inspection assessment is based on the yellowness of skin. In the invasive technique, blood samples are needed to check the concentration of bilirubin. However, the non-invasive technique has less pain and fewer traumas to the baby. In this research, a non-invasive technique incorporating the concept of absorption and reflection of light and Lambert law is used.

II. LITERATURE REVIEW:

Pavithra investigated the development of noninvasive methods for measuring blood glucose and hemoglobin using occlusion-NIR spectroscopy. The circuit consists of two NIR sensors using an 870-nm beam for detecting hemoglobin and a 1000-nm beam for detecting glucose. In this study, the device is tested on peoples with different glucose and hemoglobin levels. The minimum photodiode voltage was same for all participants, but maximum photodiode voltage changed in the range of 3–3.8 V [1].

Yadav tried to create a system for continuous and noninvasive blood glucose measurements. This study focused on the development of a noninvasive sensor of blood glucose measurement using continuous wave from the NIR transmitter. The proposed system of this paper used an infrared transmitter at 940 nm. In this system, the glucose sensor is connected to the person's arm. The system was tested in two stages of in vitro and in vivo [2].

The suitable wavelength for BGM is determined experimentally by measuring the transmittance and absorbance of different wavelengths of light ranging from 500 nm to 1200 nm in steps of 50 nm. The light is passed through water and the human finger. The results concluded that the absorption of laser light differs with the wavelength. The highest absorbance is of NIR of wavelengths from 700 nm to 1000 nm making it the least suitable for BGM applications. Red laser light of 650 nm has the capability of penetrating into the water and the human finger as it has the highest % transmittance as compared to other wavelengths[3].

For the bilirubin measurement. Baharuddin . in 2010 presented a cost-effective and portable bilirubin measurement device. In the proposed system, the visible light in the range of 380–760 nm has been emitted to the blood serum and the reflected light has been measured. The sample which is a yellow liquid with different concentration has been placed in a black box. The outputs of system consisted of LCD display, red and green LED, and a buzzer to show normal, mild, and critical conditions. The output voltage of the device decreased with increasing bilirubin concentrations. The method has not been evaluated on the body.[4]

Ali presented an optical technique for detecting jaundice without using a blood test. In their technique, the blue light was emitted to the sample and the light reflected was captured by the photodiode. In this research, the mock skin of SD rat has been shaved and soaked into fix calibrated bilirubin concentrations and was used to obtain a relationship between the device voltage and the bilirubin concentration. The reflected light produced a voltage. This voltage was processed by the Arduino, and the result was displayed on the LCD.[5]

III. METHODOLOGY:

The NIR spectroscopy is used to measure the blood glucose, and an optical method incorporating the visible light is selected to measure the amount of bilirubin. The wavelength selection of light is very important for optical methods. As mentioned in the first overtone region; and wavelength of 2100, 2261, and 2326 nm in combination region. In this study, NIR light with wavelength of 940, 1550, and 1650 nm is used to measure glucose. The wavelengths 1550 and 1650 nm has maximum absorption of glucose. Although glucose absorption at wavelength 940 nm is lower compared to the first overtone and combination overtone, it has minimum optical signal attenuation by other components. Therefore, the intended depth of penetration could be achieved at this wavelength. An infrared receiver in the range of 800– 1700 nm was used to receive the optical signal. In the same circuit, another LED for bilirubin measurement is added. The bilirubin will absorb wavelength of light between 457 nm and 473 nm. Therefore, in this study, light with a wavelength of 470 nm was used to measure bilirubin. Furthermore, an optical receiver in the range of 330–720 nm was proposed to receive an optical signal .In NIR method incident light on the body is partially absorbed and partially scattered, due to its interaction with the chemical components within the tissue. In our system,we used ATMega32 microcontroller is used to control the transmitters and the receiver. Microcontroller converts the analog signal to digital and carries out the processing. which calculates the average voltages received from the circuite caused by radiation of each wavelengths transmitters. The average voltage as the sensor output is shown on the LCD display.

Light can penetrate the skin up to 1–100 mm. This approach is also very cost-effective. In this method, the glucose can be measured from different parts of the body such as tongue, oral mucous, lip, earlobe, finger, forearm, and cheek.

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IV. TECHNOLOGY :

Near infrared spectroscopy:

Near infrared spectroscopy is a spectroscopic method that uses near infrared region of the electromagnetic spectrum(780 nm to 2500nm).

A NIR spectrometer with a fiber optic accessory can be used for the non invasive measurement of blood glucose. Near-infrared spectroscopy is based on molecular overtone and combination vibrations. One advantage is that NIR can typically penetrate much further into a sample than mid infrared radiation.NIRS can be used for non-invasive assessment of brain function through the intact skull in human subjects by detecting changes in blood hemoglobin concentrations associated with neural activity. NIR spectroscopy is used to measure bilirubin content as well.

NIR spectroscopy measures the change in light intensity when a light beam with 750–2500 nm wavelength is transmitted and reflected on the 1–100-mm thick skin tissue.[7] With the recent advances in the field of microelectronics, NIR spectroscopy has become a popular method for monitoring many physiological parameters since this method provides a simple, affordable, safe, and comfortable measurement.[8] Three bands exist in the NIR range: (i) the combination overtone band (2000–2500 nm), (ii) the first overtone band (1400–2000 nm), and (iii) the second or higher overtone band (750–1400 nm).

The incident light on the body is partially absorbed and partially scattered, due to its interaction with the chemical components within the tissue. According to the light transport theory, attenuation of light in the tissue is described by Eq. 1 where I is the reflected light intensity, I0 the incident light intensity, μeff the effective attenuation coefficient, and d the optical path length in the tissue.

$I=I_O e^{-\mu effd}$

$\mu_{eff}=f(\mu_a,\mu_s)$

According to μ_{eff} can be expressed as a function of μ_a and μ_s, where μ_a is the absorption coefficient corresponding to water displacement in tissue and μ_s is the scattering coefficient which relates to diameter and refractive index of scattering centers in the tissue. Increase in glucose concentration decreases these coefficients and shortens the optical path, which increases the light intensity.

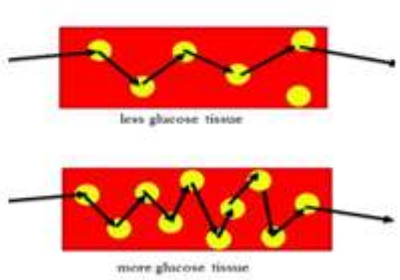

Fig1: The effect of glucose concentration on amount of absorption and optical path.

V. RESULTS:

These experiments were performed on the body. Finger is selected as a measurement location. First, 19 samples are used as the training data to obtain the relationship between the sensor output voltage with the blood glucose concentration and bilirubin concentration using Lambert law is shown in below figures.

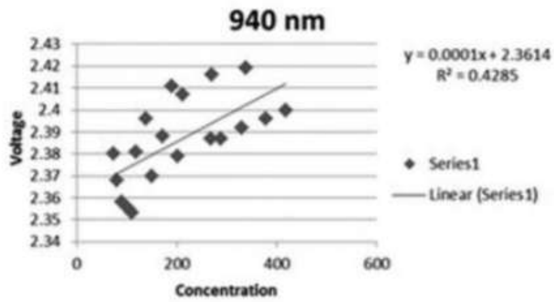

Fig2

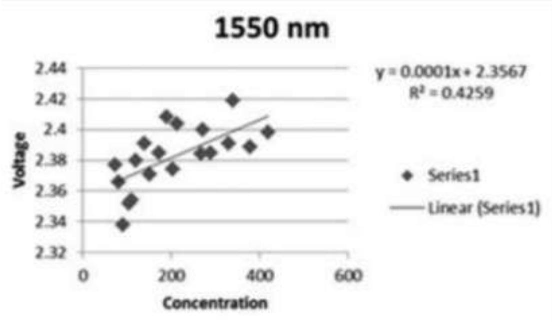

Fig3

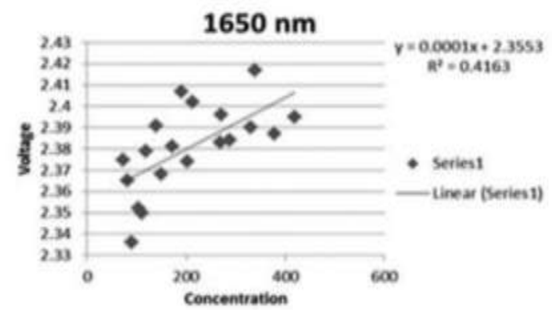

Fig4

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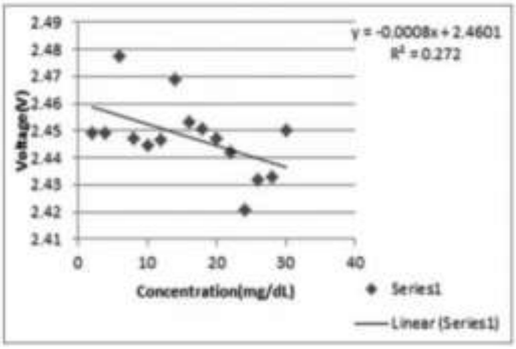
Fig2,Fig3,Fig4 Shows the relationship between the glucose concentration and the output voltage for 940, 1550, 1650 nm transmitters in transmittance mode



The relationship between the bilirubin solution concentration and the output voltage for 470nm transmitters in transmittance mode.

Whatever the results obtained from non-invasive blood glucose and bilirubin monitor is compared with invasive blood glucose and bilirubin measurement to determine the error rate.

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