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Needle Less Human Blood Glucose Monitoring

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***Abstract*: Diabetes is one of the most commonly found health condition globally. Early detection of Diabetes aids in better recognition & treatment. With this inspection, Real-time Continuous monitoring of the blood glucose level is highly desirable. A number of meddling and non-invasive techniques have been proposed in past. As an alternative, Needleless human glucose monitoring techniques are introduced to develop hurt free glucose measuring methods. In this paper, a needleless blood glucose monitoring device is developed using near infrared sensors. Besides being able to detect glucose concentration in blood, the device is also able to show the glucose level .The present work is focused on development of needleless blood glucose measurement sensor system using Near-infrared (NIR) approach. Initially glucose measurement prototype is developed using continuous wave (CW) from NIR LED to check the sensitivity of the system for different glucose concentrations. Later a Sensor patch was designed using LED and a photodiode to observe diffused reflectance spectra of blood from the human forearm. Diffused reflectance spectra of the subjects obtained with this technique was also compared with commercially available invasive fingertip glucose-meter. The results are promising and show the potential of using NIR for glucose measurement .The results show that our system is able to achieve continuous glucose monitoring remotely in real-time.**

***Keywords*: Glucose Monitoring System, LCD Display, NIR Sensor, Raspberry pi.**

1. Introduction

Diabetes is a medical case that occurs when the body is not able to relevantly utilize glucose as a form of energy. When glucose is at a normal level, it enables the body to operate effectively and provides a fundamental form of fuel for cell function [1]. High sugar levels in the bloodstream can cause complexity by slowly damaging the cells in the heart and preventing them from producing insulin, a hormone that allows the body to utilize glucose found in food as a form of energy [1]. High blood glucose levels can internally hurt the body, a condition known as atherosclerosis, and lead to critical health state such as victimize of the blood vessels. Regular events of hyperboles (high blood glucose) can cause permanent organ damage [1]. If blood glucose is not properly regulated, it may rise to dangerous levels that can cause internal organ failure, kidney disease, stroke, heart attack, vision loss, a weakened resistant system, low blood circulation to the feet, and slower healing of wounds. Blood glucose analysis is classify into three approaches; invasive, minimally invasive, and non- invasive. Invasive techniques in glucose analysis devices are widely used as it has high measurement accuracy. The blood sample will be used to measure blood glucose level using a glucometer. Some common method allow the blood eradication to be obtained from other sites of the body. Such as the upper arm, forearm, foul of the thumb and thigh. However the reading of blood glucose level might vary compared to the reading obtained from the fingertip [3] According to world health organization (WHO), every year 35 million people die because of diabetes [3]. At present none of the available methods can pickle diabetes completely. Occurrence of complexity can be prevented by keeping blood glucose levels in the normal range. Daily glucose monitoring, diet plan, insulin shots and oral aid are the foundation of diabetes treatment. Most of commercially feasible glucose measurement devices are invasive. Diabetic patients need to maintain their blood glucose two to three times a day. The invasive methods are agonizing, have high persist cost and crisis of growing infectious diseases. Needleless methods are more desirable and excellent substitute to these devices. Incensing glucose measurement techniques to allow easy and continuous monitoring has received a lot of consideration from both academic and technical researchers over the past three decades. Needleless glucose monitoring could make millions of people more relaxed and appropriate about blood glucose testing. Thus it is necessary to develop a needleless blood glucose method which can provide painless, convenient and cost effective glucose monitoring to diabetic patients.

Needleless glucose monitoring system will be a major breakthrough in the area of treating diabetes patients. Various optical non-invasive approaches have been explored for development of glucose monitor system. Optical methods are one of the painless and promising approaches that can be used for non-invasive blood glucose measurement. Near-infrared (NIR) is one of the most widely explored optical method [4] because of its high penetration in skin. This technique has been applied on various body chunks: finger, palm, arm, forearm, earlobe, check etc. Mauro et al. designed the fiber optical inquest to get spectra of forearms of type 1 diabetic individuals. The authors have reported that the results have good interconnection between the predicted and reference glucose values at 1600 nm. Shun-Jen et al. [6] utilized reflectance signal in bigger overtone region, where apperception of glucose is negligible. The latest technology which is needleless has been introduced as an alternative to reduce pain during the blood

extraction and insulin injection. Various techniques have been introduced such as infrared, photo acoustic, ultrasound and fluorescence to detect glucose in the blood. Most of the results showed a good correlation between non- invasive and invasive techniques. Diabetes mellitus (DM) is a constant and normally leading to hyperglycemia. This may cause much complexity. Thus, the role of blood glucose monitoring and measurement becomes very critical for diabetic therapies [1]. The number of diabetics is increasing. According to the world health organization (WHO), the number of people with diabetes has grown from 109 million in 1980 to 423 million in 2014. In 2012, an estimated 1.5 million deaths were directly caused by diabetes and another 2.2 million deaths were attributable to higher blood glucose. WHO projects that diabetes will be the 7th main cause of death in 2030[2]. Diabetic patients should frequently monitor their glucose levels at a normal range. A self - monitoring system is required to assure their glucose levels is always within the normal range and it may also help in maintaining their diet and physical activities. One of the earliest portable non-invasive blood glucose devices was introduced by Arlene Duncan et al. (1995) which used pulsed laser photo acoustic spectroscopy to detect the glucose concentration in blood from the finger [5]. Another approach of a portable glucose sensor was developed by J.R. Blanco et al. (2006) who designed a low cost portable potential state for ampere metric biosensors. The device measures the Faradaic current that originated by the electronic interchanges between specific substance and biological recognition system which was present on the electrodes and kept at an appropriate potential [6]. In 2013 Takahashi et al. has developed a portable glucose monitoring system by using implantable fluorescent-hydrogen sensor, hearable photo detector, microcontroller, wireless device and software for transdermal. Both approaches applied non-invasive technique to measure the glucose levels and shown to be reliable and accurate in measuring glucose level in blood [6]. In this paper, the model of a needleless glucose blood monitoring device using the absorbent principle is prospective. The prospective device is designed to be able to detect sugar level in blood using near infrared sensors. The construction of the device is not only designed for diabetic patients but also for non-diabetic patients, to help control a normal blood sugar level for a healthy life style.

2. Methodology

Figure 1 illustrates the block diagram of the prospective needleless glucose monitoring system.

A. Hardware implementation

The main hardware item in the system include a transmitter (LED1550E), a photodiode (FGA10), an operational amplifier (OP491), raspberry pi and a liquid crystal display (LCD) keypad shield. The NIR disclosure circuit consists of a transmitter circuit and receiver circuit with both transmitter and receiver positioned alongside and points to a reflective outward. Both transmitter and receiver operate at 5 V and are powered by the Raspberry pi. The receiver circuit consists of a photodiode, a noise filtrate and an operational amplifier. A low pass filter is conducted to the voltage source to reduce the noise frequency from the source.

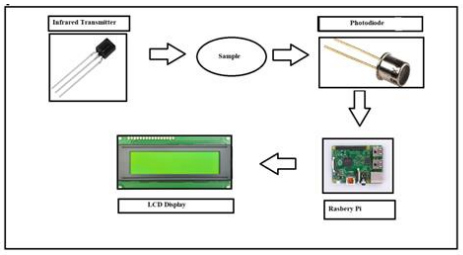
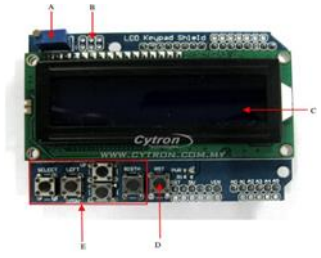


Fig. 1. Block diagram of the needleless human blood glucose monitoring device

The FGA10 photodiode is applicable to be used with the transmitter as it has a wavelength sensitiveness which is within 800 nm-1800 nm. The photodiode is used to measure continued wave fiber light source and converts the optical power received from the transmitter to an electrical present value. The value of the output voltage depends on the strength of the infrared signal it receives, which is between 0 V to 5 V. An operational amplifier is used to amplify the output signal. The LCD keypad shield, as in Figure 2 is developed to be used with any compatible Raspberry Pi boards. It consists of six (6) momentary push buttons and a 2x16 LCD screen pin. The LCD keypad shield is used to display the measured glucose concentration.



Label	Function	Label	Function
A	LCD Contrast potentiometer	D	Reset Button
B	ICSP	E	Push button connect to Analog Input Pin0
C	LCD Display		

Fig. 2. LCD Keypad shield

B. Software development

The main focal point of the software development is on the algorithm design of the Raspberry pi. The control system of the device uses the Raspberry pi .It can be powered by a (5 V-12 V) battery or by a serial connection to the computer. The Raspberry pi supplies voltages to bias both transmitter and photodiode. The output of the photodiode and amplifier are connected to the analogue pin of the microcontroller. The block diagram of the Raspberry Pi and the detection circuit is show in Figure 4. The algorithm for the microcontroller is designed to measure the absorption of glucose. The output voltage achieve from the photodiode is used as a parameter to determine the glucose concentration by using a mathematical equation acquired from the glucose calibration experiments.

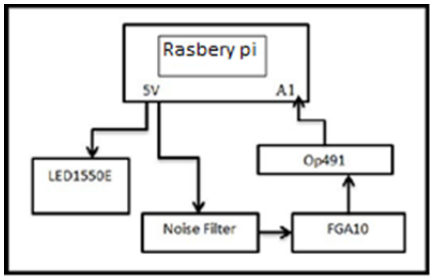


Fig. 3. Block diagram of the Raspberry pi microcontroller and the detection circuit

3. Results

To investigate the sensitivity of sensor patch, seven non-diabetic subjects (4 male and 3 female) between 25 and 35 years age are examined. The signal is taken before meal and after meal from each subject. The data achieve from the commercially available glucose-meter and NIR sensor patch for seven subjects before and after meal are shown in the Table 1 and 2 respectively.

Table 1
Glucose concentration before meal

Subject	Average voltage (V)	Glucose mg/dl
	NIR Sensor	
A	2.4745	85
B	2.578	92
C	1.827	94
D	2.522	100
E	2.510	112
F	2.758	89
G	2.12	98

Subject	Average voltage (V)	Glucose mg/dl
	NIR Sensor	
A	2.178	131
B	2.27	123
C	1.55	120
D	2.272	138
E	2.195	141
F	2.231	128
G	1.805	135

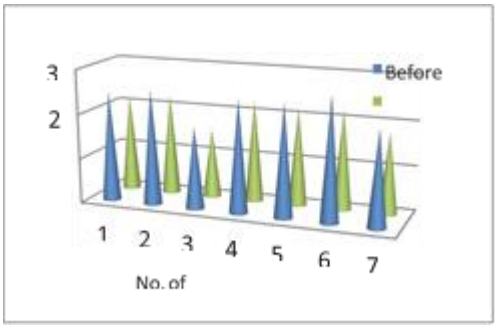


Fig. 4. Before and after meal in result using NIR sensor patch showing difference in the output signal

The result achieve by current sensor prototype are encouraging. The achieve result show the prospects Of the needleless blood glucose measurement system based on diffused reflectance through forearm .The performance of proposed method can be improved by reducing the error caused by positioning of sensor patch on forearm in each measurement. Moreover with use of suitable signal processing method to remove interferences by other biologically that can improve the results.

4. Conclusion

In this paper, we discussed our efforts towards design of a simple Real-time wireless blood glucose monitoring system which is useful for a diabetic for continuous monitoring of his/her health in home environment. Our proposed system helps one to cut short the regular visits to the doctors for a check-up, as the obtained information from the sensors; a better treatment can be provided to the diabetic.

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