Infra Red Light Emitting Diode in 1200 nm Range have Moderate Performance in Detecting Glucose in Human Blood Glucose Model

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Abstract. The diagnosis of diabetes in Indonesia is still invasive therefore hurting the patient in the examination process. Here we propose a new diabetes examination method using non-invasive optical technique. We apply for the detection a wavelength of 1200 nm a LED and photo-diode. The obatined data is then Fast Fourier Transformed (FFT) to get a better intepretation. Based on the data, we obtained a good correlation.

Keywords: 1200 nm, Infra-Red Light Emitting Diode (LED), Human Blood Glucose Model

1. Introduction

Diabetes Mellitus (DM) is characterized by elevated blood sugar levels as a result of the metabolic system disorders due to defects in insulin secretion, and causes hyperglycaemia with disturbances of carbohydrate, fat and protein metabolism [1]. DM can be classified into two main types: type 1 diabetes or Insulin Dependent Diabetes Mellitus (IDDM) and DM type 2 or Non-Insulin Dependent Diabetes Mellitus (NIDDM). DM type 1 is caused by loss of the insulin-producing beta cells in the islands of Langerhans of the pancreas [2]. Type 2 diabetes is due to the hormone insulin in the body that cannot function properly so that only a handful of glucose enter cells. As a result, cells deprived of glucose, resulting in glucose building up in the blood. Until recently, type 1 diabetes can only be treated by administration of insulin therapy performed continuously and sustainable so as to check their blood sugar levels every time [3].

DM disease have increased dramatically in recent decades, primarily due to changes in lifestyle. In Indonesia, the disease is increasing from year to year so that Indonesia is a country that ranks fourth in the number of diabetics in the world after India, China and the United States. This is because approximately 8.4% of the population in Indonesia suffer from diabetes in 2000 and would be expected to increase as many as 21.3 million people with diabetes in 2030. In addition, the current global projections estimate that the number of people with diabetes has increased by 50% year on year 2010, and will almost double by 2025 [4]. Word Health Organization (WHO) and the International Diabetes Federation (IDF) has predicted that the number of diabetics will increase significantly in 2030 to around 366 million, an increase of 214% compared to the percentage in 2006 [5].

Given the number of people with diabetes are growing each day, diabetes detection becomes regular namely by testing their blood sugar levels. A tool is needed that can detect blood sugar levels in the body that are practical, accurate, secure and cost-effective. Blood sugar measuring instrument that is circulating in the community is now a tool that works invasive glucometer [3]. Measurements of blood sugar by means of invasive is to put a needle into the skin of the patient's finger for a blood sample and measuring the glucometer can carry risks in addition to making pain from a needle prick

can also cause infections of the skin, while other risks which may be a risk of causing the deployment infectious diseases such as hepatitis, HIV, etc. through contact with body fluids [6].

To keep blood glucose levels to avoid distractions such as Type 2 Diabetes, it would require an effective measurement tool. Tools biomarker measurements of blood glucose levels that have the potential to be developed for the future is a tool based Discrete Fourier transform and the Beer-Lambert Law. Additionally, the non-invasive measurement will be preferred by users as compared to invasive methods that had been used extensively.

One of the main problems in the measurement of blood glucose non-invasively is that there is no consensus on the ideal wavelength to detect glucose in human blood in the human body. A wavelength of 1200 nm is proposed [7, 8]. The purpose of this study was to assess the ability of wave of 1200 nm LED to detect glucose in human blood glucose models.

2. Method

Research has been conducted in the Laboratory of Materials Physics, Department of Physics, Bogor Agricultural University, from March to August 2016. The model of human blood glucose is made with pure glucose in the aqueous solution mimics human blood, at 50 mg / dl, 100 mg / dl, 150 mg / dl, 200 mg / dl, 250 mg / dl, 300 mg / dl, 350 mg / dl, 400 mg, dl, 450 mg / dl and 500 mg / dl. 1200 nm IR LED and photo-diode provided by Thorlabs [9, 10], is controlled using the Arduino [11], is used to measure the glucose concentration in the model in the cuvette. LED fired using twin table model, in Width Modulation (PWM) 10 Pulse different intensity, and improved value using Fast Fourier Transform [12]. The correlation between the concentration of glucose intended and photo-diode reading is calculated using Libre Office Calc [13].

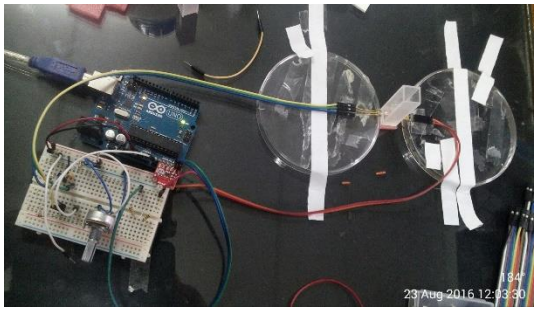

Figure 1. The circuit sensor blood glucose meter.

3. Results

3.1. Some are used as the reference blood glucose measurement tools, non-invasive design

Sensor works by spectrophotometry modulated [14, 15] near Infra-Red (NIR) [16]. Tool can continuously monitor blood glucose [17, 18]. NIR Light Emitting Diode (LED) and Photo-diode wavelength range used 1000 nm - 1700 nm, provided by Thorlabs [9, 10]. The wavelength selected by the work of Smith and Goodarzi [19, 20], which is confirmed by research that is not published on our own. Data modified spectrum using Fast Fourier Transform (FFT) [21] and will inference using correlation Cascade Artificial Neural Network [22]. The results are stored in a SQLite database [23]. The whole system developed with Qt Software Development Kit (SDK) [24, 25].

3.2. Sensor response is different for water and glucose.

We have tested our inception to pure glucose and pure water (Figure). We have proved that the photo-diodes give a different reading when given a different intensity LED (Figure). In addition, the photo-diodes respond differently to different substances. Research to find the relationship between glucose meter readings, the concentration of glucose water, and the photo-diode feedback.

4. Discussion

4.1 Research using Fast Fourier Transform as data transformation method for measuring blood glucose levels

Fast Fourier Transform used as a data transformation method for measuring blood glucose levels, this study confirm the possibility of monitoring wavelengths used in the system of non-invasion blood glucose.

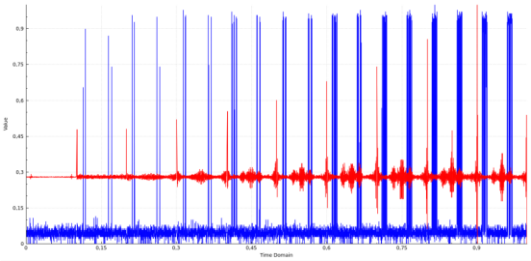

Figure 2. Correlation Results Fast Fourier Transform.

4.2 A Wavelength of 1200 nm LED

Has conducted testing of the glucose solution with various concentrations ranging from a concentration of 50 mg / dl, 100 mg / dl, 150 mg / dl, 200 mg / dl, 250 mg / dl, 300 mg / dl, 350 mg/ dl, 400 mg, dl, 450 mg / dl and 500 mg / dl using the 1200 nm LED and photo-diode provided by Thorlabs. The results obtained are as follows:

Table 1. Correlation between photo-diode readings at certain PWM intensity to blood glucose model concentration.

Correlations	Concentration (mg / dl)
Concentration (mg / dl)	1.000
Interval (cleaned) 01	-0.752
Interval (cleaned) 02	-0.341
Interval (cleaned) 03	0.239
Interval (cleaned) 04	-0.159
Interval (cleaned) 05	0.159
Interval (cleaned) 06	0.032
Interval (cleaned) 07	0.084
Interval (cleaned) 08	0.293
Interval (cleaned) 09	0.093
Interval (cleaned) 10	-0.003

4.3 Best Wavelength still being investigated

Reference wavelength is still in dispute to investigate and measure blood glucose levels. Ranging from 800 nm [19], to a high of 2500 nm [26]. We have confirmed some wavelengths in research that is not published, but only for glucose and water solution, so we're still doing tests with different wavelengths for a solution.

4.4 The solution proposed

Promoting testing glucose solution with varying concentrations using different LEDs ranging from 1050 nm, 1450 nm, 1550 nm, and 1600 nm, in order to find the best wavelength to produce optimal results. We did not use the LED above 1700 nm because the price is too expensive.

5. Conclusion

Based on research that has been done is made a conclusion that the measurement of glucose solution by using wavelength of 1200 nm LED that concentration value closer to 1 or -1 is said to be good.

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