Non-Invasive Glucometer Review Paper

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Abstract

According to the International Diabetes Federation (IDF) in 2017, approximately 425 million adults (20-79 years) were living with diabetes, and this number is projected to rise to 629 million by 2045. Diabetes is a metabolic pathological condition that affects vital organs if not diagnosed and treated promptly. Regular monitoring of blood glucose is crucial to avoid complications. However, commonly used methods involve invasive finger puncturing, causing pain, tissue damage, and potential infections. To address this issue, there is a need to develop a non-invasive glucose monitoring system for diabetic populations.

Keywords: diabetes, glucose, non-invasive, optics, spectroscopy, infrared, Raman, terahertz, fluorescent, photoacoustic

1 Introduction

1.1 Project Background and Motivation

Various methods, such as Near-infrared spectroscopy, photoacoustic spectroscopy, Raman spectroscopy, and Polarisation, can be used for non-invasive blood glucose measurement. Among these, Near-infrared spectroscopy (NIR) is widely used for its accuracy and ease of implementation in hardware. However, challenges arise due to the presence of multiple internal features in blood, such as hemoglobin, water, tissues, and melanin, which absorb infrared light, making it difficult to distinguish the effects caused solely by glucose. A solution to this problem is to use monochromatic infrared light to focus solely on glucose's effects, leveraging its unique absorption peaks at specific wavelengths.

1.2 Project Objectives

The objectives of this project are as follows:

To predict the level of glucose in blood non-invasively and display it on an LCD with maximum possible accuracy.

To deliver an alternative low-cost solution to traditional invasive glucose testing methods for the control of glucose-related diseases.

1.3 Deliverables Planned

To achieve the project objectives, the following deliverables are planned:

Use of NIR Spectroscopy on a part of the ear lobe to predict the relative glucose level. Design an analog circuit model to amplify the voltage level corresponding to the relative glucose level and feed this voltage to the microcontroller. Achieve a Multiple Linear Regression Model for predicting glucose levels from the voltage value received. Show the voltage value and the corresponding glucose level on the LCD screen

2 Principles Used

The model is based on the Beer-Lambert Law, which states that the amount of light absorbed is directly proportional to the concentration of the solute in the solution and the thickness of the solution under analysis. The glucose measuring principle is based on the attenuation of light as it interacts with biological tissue, leading to changes in the optical paths due to variations in glucose concentration.

3 Existing Works in the Field

Conventional devices like self-monitoring blood glucose (SMBG) devices and continuous-glucose-monitoring (CGM) devices follow invasive and minimally invasive methods, respectively, based on electrochemical biosensors. Non-invasive glucose monitoring techniques, such as near-infrared, mid-infrared, Raman, and terahertz spectroscopy, offer promising results and better selectivity for glucose sensing compared to invasive methods. Near-infrared spectroscopy (NIR) is chosen for this project due to its affordability, compactness, and ability to measure glucose without prior manipulation.

4 Components Used

The hardware components used in the project include:

Arduino Board (UNO)

LCD (RG1602 A)

Op-amp TL072

Photodiode and Phototransistor

5 Significance

The non-invasive glucose monitoring system offers several significant advantages over traditional invasive methods:

Pain-Free and Convenient: Non-invasive glucose monitoring eliminates the need for finger pricks and blood samples, providing a pain-free and convenient
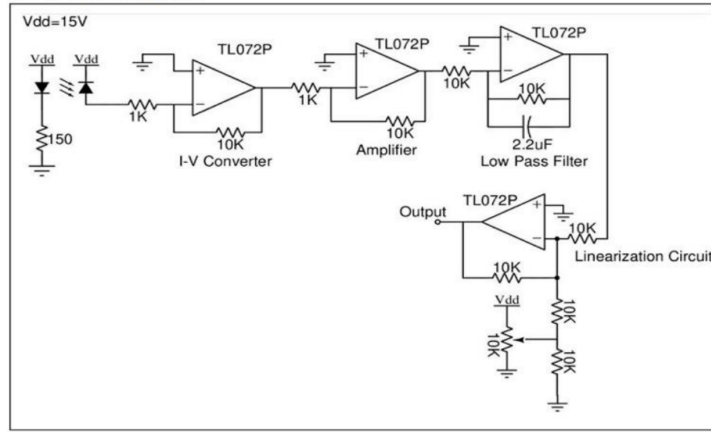
Figure 1: Circuit diagram.

alternative for individuals with diabetes. This feature improves patient compliance with glucose monitoring, leading to better management of the condition.

Reduced Risk of Infections and Complications: Invasive methods carry the risk of infections, tissue damage, and scarring. Non-invasive monitoring eliminates these risks, promoting safer and healthier glucose monitoring practices.

Real-Time Monitoring: The system provides real-time monitoring of glucose levels, enabling individuals to make immediate adjustments to their diet, medication, or physical activity. This real-time feedback empowers users to maintain better control over their glucose levels and prevent potential complications.

Cost-Effective Solution: Compared to traditional glucose monitoring devices, which require continuous purchase of test strips and lancets, a non-invasive system can offer cost savings in the long run. Once the system is set up, the recurring costs are minimal, making it a more affordable option for individuals with diabetes.

Improved Quality of Life: By eliminating the need for frequent blood sampling, non-invasive glucose monitoring systems enhance the overall quality of life for individuals with diabetes. They can carry out their daily activities without the inconvenience and discomfort associated with invasive methods, leading to improved well-being and mental health.

Potential for Continuous Monitoring: Non-invasive monitoring systems have the potential for continuous glucose monitoring, allowing individuals to have a comprehensive understanding of their glucose fluctuations throughout the day. This continuous data can be beneficial for healthcare professionals in making informed treatment decisions and adjusting medication dosages.

Accessibility: The development of a low-cost, non-invasive glucose monitoring system makes it more accessible to a larger population, including individuals in resource-limited settings. This technology has the potential to improve diabetes management globally, regardless of socioeconomic factors.

Overall, the non-invasive glucose monito

6 Commercial Devices

Hitherto, many non-invasive glucose monitors have been developed. Some of these devices have shown promising outcomes and have been successfully introduced to the market. However, due to some issues, including accuracy errors, they were dropped. Nevertheless, manufacturing companies are working on improving their devices. Table 5 lists commercial non-invasive blood glucose monitoring devices that use the optical techniques addressed in this paper. The choice to evaluate the accuracy of the device depends on the manufacturer. Some use Clarke error grid analysis (EGA) while others use consensus error grid (CEG) analysis or the mean absolute relative difference (MARD).

7 Conclusion

Over the past decades, there has been great interest in developing innovative methods of measuring blood glucose levels without the necessity for blood samples. Several non-invasive optical glucose measurement techniques have been introduced. These technologies still need improvement in order to meet the regulations to be released in the market. This paper provided a technical view of some of the prevalent non-invasive optical approaches in glucose sensing currently under study. It also discussed the system configuration of each technique. A summarized comparison was made on the advantages, disadvantages, and other specifications of the non-invasive optical methods discussed. Although these methods show great potential, some challenges are facing them including sensitivity, stability, specificity, biological factors, and calibration issues. Therefore, an enhancement of these non-invasive optical methods is required to surmount their limitations and hopefully replace the conventional methods currently in use.

8 References

A Survey on Non-Invasive Blood Glucose Monitoring Using NIR, International conference on Communication and Signal Processing, April 3-5, (2013)

Near-infrared LED-based Non-invasive Blood Glucose Sensor, 2014 International conference on signal processing and integrated networks (SPIN) (2014)

NIR Based Non-Invasive Blood Glucose Measurement Parag Narkhede, Suraj Dhalwar and B. Karthikeyan Indian Journal of Science and Technology, Vol 9(41), DOI: 10.17485/ijst/2016/v9i41/98996, November (2016)

Non-Invasive Blood Glucometer using NIR Spectroscopy, International Research Journal of Engineering and Technology (2017)

Development of Smart Insulin Device for Non-Invasive Blood Glucose Level Monitoring, IEEE 7th International Advance Computing Conference (2017)

DiabiTech- Non-Invasive Blood Glucose Monitoring System, International Conference on Advancements in Computing (ICAC) (2019)

Development of a discrete spectrometric NIR reflectance glucometer, IFAC PapersOnLine 53-2 15970–15975 (2020)

Portable Non-Invasive Glucometer using NearInfrared Sensor and Raspberry Pi, 4th International Conference on Electrical, Telecommunication and Computer Engineering (ELTICOM) (2020)

Measurement Instrument of Blood Glucose and Oxygen Saturation Non-Invasive by Using Oximeter Sensor, International Conference on Converging Technology in Electrical and Information Engineering (ICCTEIE) (2021)

A Review of Non-Invasive Optical Systems for Continuous Blood Glucose Monitoring Bushra Alsunaidi, Murad Althobaiti, Mahbubunnabi Tamal, Waleed Albaker and Ibraheem Al-Naib (2021)