Design and implementation of blood glucose monitoring using 450 nm wavelength by NIR spectroscopy

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Abstract
This paper presents the implementation of a simple, compact, and cost-efficient non-invasive device for Blood Glucose Monitoring (BGM), addressing the drawbacks of invasive techniques. Current BGM methods require a finger-prick blood sample, which is painful and carries the risk of infection. However, this new technique, known as Red Laser Blood Glucose Monitoring (RL-BGM), utilizes visible red optical laser light with a wavelength of 650 nm, offering the superior potential for accurate BGM. Existing BGM techniques based on Near-infrared (NIR) have limitations, including light absorption in human tissue, a higher signal-to-noise ratio (SNR), and reduced Consequently, NIR methods have not been widely adopted for commercial BGM applications. The proposed RL-BGM device is developed to overcome these challenges, eliminating the need for invasive procedures and enhancing accuracy. This non-invasive device offers several advantages by utilizing visible red optical laser light. It is simple to use, requiring no finger pricking, and provides a compact design for convenient handling.Additionally, it is cost-efficient, making it accessible to a broader range of users. In conclusion, this paper introduces a novel approach to BGM, the RL-BGM technique, demonstrating promising potential. Implementing a non-invasive device utilizing visible red optical laser light at 650 nm wavelength opens up new possibilities for accurate and convenient blood glucose monitoring, overcoming the limitations of invasive techniques and existing NIR-based methods

Keywords— Diabetes Mellitus, Blood Glucose Level, Blood pricking, Laser 650nm, Photodiode, Arduino UNO,Arduino IDE, LCD

I. INTRODUCTION

Diabetes has emerged as a significant challenge in the current decade, characterized as a non-communicable disease. Individuals with diabetes must regularly monitor their blood glucose levels, typically multiple times daily, which can be inconvenient and burdensome. Furthermore, the conventional method of pricking the finger for blood samples poses a risk of infection, and the expenses associated with test strips and lancets add up due to the requirement of a new one for each test. Diabetes is recognized as one of the leading causes of death among non-communicable diseases [1]. Though effective, the prevailing self-monitoring glucose meter approach is invasive as it involves extracting blood from the body for analysis. This process induces pain and discomfort through frequent finger pricks and incurs financial and psychological burdens. Non-invasive techniques offer a more user-friendly alternative, reducing costs and alleviating the mental and physical distress associated with invasive glucose monitoring methods Maintaining social distancing, improving surveillance, and strengthening health systems were key measures to control the pandemic. Recent research from the University of Edinburgh revealed that wearing face masks significantly reduces the risk of COVID-19 transmission by more than 90%. Furthermore, a study by Steffen et al. demonstrated that widespread adoption of even moderately effective masks could prevent a substantial number of projected deaths [2]. As countries reopen following lockdowns, governments and public health agencies now recommend using face masks as an essential measure to protect individuals in public spaces. However, ensuring mask compliance requires effective techniques for face mask detection and its Challenges: Face mask detection involves determining whether a person is wearing a mask. Face detection algorithms have traditionally been developed for security, authentication, and surveillance purposes. Extensive research in Computer Vision and Pattern Recognition has contributed sophisticated algorithms for face detection, primarily using handcrafted features and traditional machine learning techniques. However, these approaches suffer from high complexity in feature design and low detection accuracy. In recent years, deep convolutional neural networks (CNN) have emerged as a powerful tool for face detection, improving performance significantly, Differentiating "Detection of the Face Under Mask" and "Detection of Mask Over Face": While considerable research has focused on face detection and recognition, there remains a notable difference between detecting a face under a mask and detecting the mask itself. The literature indicates limited research in the area of detecting masks over faces. Therefore, this work aims to develop a technique that accurately detects masks over faces in public areas such as airports, railway stations, crowded markets, and bus stops, to curb the spread of Coronavirus and contribute to public healthcare. The scarcity of available datasets for detecting masks on human faces makes model training difficult [3].

RELATED WORK

To comprehensively understand the current research on non-invasive blood glucose monitoring using visible laser light. The findings presented here contribute to advancing the development of accurate, user-friendly, and cost-effective methods for blood glucose monitoring, ultimately benefiting individuals living with diabetes. to provide a comprehensive understanding of the characteristic features of cancer cells mediated by HIF-1 that contribute to tumour radioresistance. The findings from this survey will contribute to the ongoing efforts to develop innovative therapeutic approaches and combination strategies to enhance the efficacy of radiation therapy and improve patient outcomes in cancer treatment. Non-invasive glucose monitoring has been a longstanding goal in diabetes management, offering a pain-free and convenient alternative to traditional invasive methods. This literature review focuses on developing and evaluating an optical-based non-invasive glucose monitoring sensor prototype. the identification of type 2 diabetes risk factors using machine learning-based phenotypes of anthropometry and triglycerides. The findings from this survey contribute to the ongoing efforts to develop personalized and effective strategies for diabetes prevention and management.[4] Continuous glucose monitoring is vital in managing diabetes, enabling timely interventions and improved glycemic control. This literature review focuses on utilizing a long-term implanted sensor/telemetry system and model for glucose monitoring in individuals with diabetes [5] Closed-loop insulin delivery systems, also known as artificial pancreas systems, offer a promising approach to improving glycemic control in individuals with Understanding the day-to-day variability of glucose-insulin regulation during long-term home use of these systems is crucial for their effective implementation. Model predictive control (MPC) has emerged as a promising approach for managing blood glucose levels in individuals with diabetes. This literature review focuses on applying robust physiologically-based pharmacokinetic/pharmacodynamic (PBPK/PD) models in the MPC of blood glucose.[6] Optical coherence tomography (OCT) is a non-invasive imaging technique that has shown great potential for studying the optical properties of human skin.

METHODOLOGY

Current non-invasive sensors for blood glucose monitoring primarily rely on near-infrared (NIR) technology. However, these NIR sensors have several drawbacks, including high cost, interference from biological chromophores and the stratum corneum, reduced accuracy, signal-to-noise ratio (SNR) issues, and sensitivity to the surrounding environment. Despite its potential advantages as a non-invasive technique, these limitations have hindered the widespread medical and commercial adoption of NIR-based blood glucose monitoring (BGM). Regular blood glucose monitoring is crucial for diabetes management and healthcare, as there is currently no cure for diabetes. However, the current method of BGM often involves invasive techniques such as pricking the skin to obtain a blood sample. This method relies on costly test strip consumables and can result in skin puncture-related issues and generated medical waste. These factors increase the overall costs and decrease the frequency of testing among patients. The development of an accurate and non-invasive BGM device would be a significant breakthrough for diabetic patients who are currently reliant on invasive techniques. This proposed work utilizes a non-invasive approach using visible laser light. Specifically, a laser with a wavelength of 650 nm is chosen as it is suitable for measuring blood glucose concentration. The sensing unit consists of a laser transmitter and an optical receiver (photodetector) positioned on opposite sides of the measurement site (such as a finger pad). When the laser light is transmitted through the measurement site, which could be a finger pad, it interacts with glucose molecules in the blood. A portion of the laser light is absorbed based on the glucose concentration, while the remaining light is transmitted through the measurement site (finger pad, for example). The amount of laser light passing through the measurement site depends on the blood glucose concentration. The figure 1 shows flowchart of proposed system.

BLOCK DIAGRAM

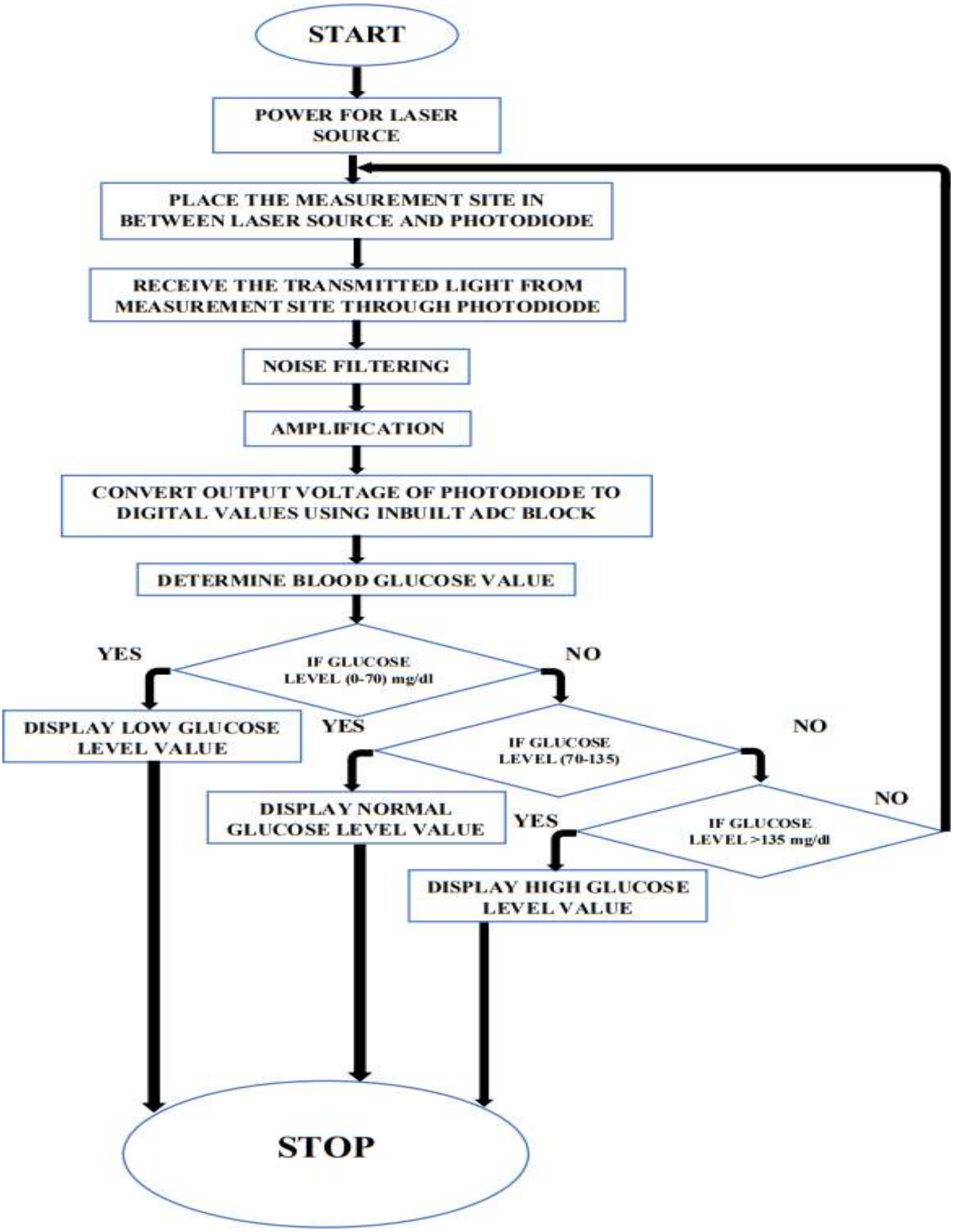

Figure 1: Flowchart of proposed system

Optical measurements for glucose monitoring are influenced by concentration changes in various body compartments and changes in the ratio of tissue fluids. These fluid ratios can be altered by factors such as activity level, diet, hormone fluctuations, blood circulation, body temperature shifts, metabolic activity, medication, and other physiological factors. These variations can affect the accuracy of glucose measurements. Challenges arise due to changes in the tissue composition over time, which can deviate from the original calibration. Additionally, calibration transferability between different parts of the body is limited. Tissue changes include alterations in the source of body fluid supply, medications impacting fluid ratios, day-to-day changes in vasculature, ageing, diseases, and individual metabolic activity. These factors can influence the optical parameters and, consequently, impact the accuracy of blood glucose measurements.

Furthermore, day-to-day changes in vasculature, tissue texture, and the ageing process can affect the long-term stability of glucose monitoring. Considering these factors and their potential impact on the reliability and consistency of optical-based glucose measurements is essential. Addressing these challenges and accounting for the various influencing factors is crucial for improving glucose monitoring technologies' accuracy and long-term stability.

WEIGHTED AVERAGE

The F1 Scores area unit is calculated for every label, and then their average is weighted bysupport - that is, the range of true instances for every label. It may result in AN F1Score that's not between exactitude and recall. The circuit diagram is shown in figure 2.

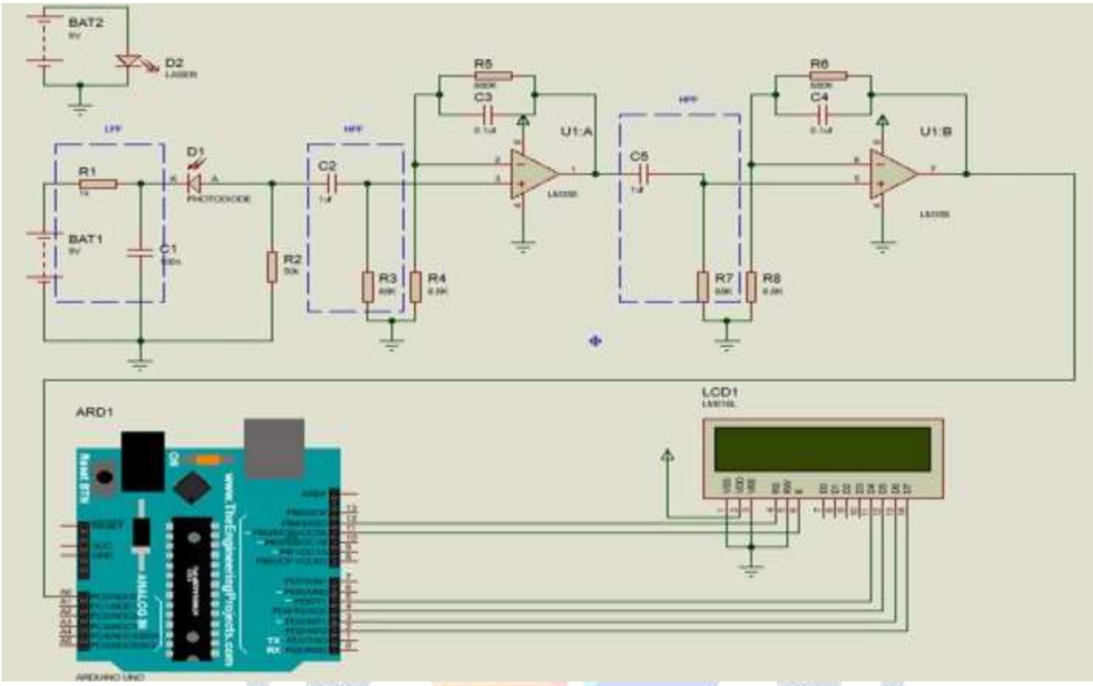

Fig 2: Circuit diagram of the Blood glucose monitoring system.

RESULT

Glucose concentration in patients can be measured using sensors and compared to typical glucometers. A non-invasive blood glucose meter offers painless glucose measurements without needing a blood sample or finger pricks. This non-invasive glucometer can be used for self-monitoring of blood glucose levels, as well as for hospital symptom screening and hypodermic insulin dosing. It finds applications in both medical and home settings. The non-invasive glucometer significantly reduces discomfort and the risk of infection or tissue damage, which are major disadvantages of invasive blood glucose monitoring systems. Unlike invasive glucometers, it does not require glucose test strips, making it more efficient. Continuous monitoring of blood glucose levels can be achieved by making further improvements to the system. Overall, the non-invasive glucometer offers a more convenient and safer approach to blood glucose monitoring, providing accurate measurements without the need for invasive procedures or consumables like test strips. Continued advancements in this technology will further enhance its capabilities for continuous and efficient monitoring of blood glucose levels. The hardware implementation is shown in figure 3.

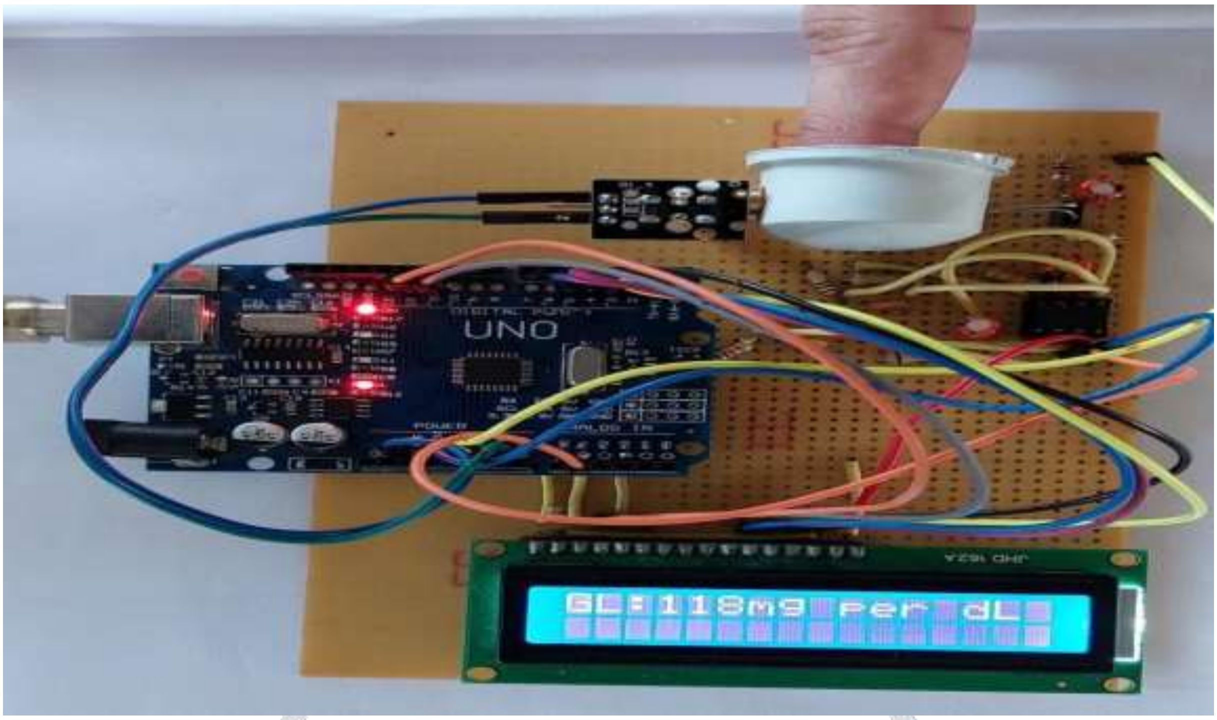

Figure 3 : Hardware implementation of blood glucose monitoring system.

CONCLUSION

This paper introduces a potential device for blood glucose monitoring called RL-BGM (Red Laser Blood Glucose Monitoring). The handheld RL-BGM device operates on a +5V power supply, providing accurate blood sugar concentration readings. The design of the blood glucose monitor has been successfully implemented and tested. In the development of the device, a detection sensor utilizing a 650 nm wavelength laser light and a photodetector were used to measure the glucose concentration in patients. An Arduino microcontroller controls the operation of the device. The measured glucose level is then displayed in units of mg/dL. Experimental results demonstrated that using red light with a wavelength of 650 nm is suitable for non-invasive blood glucose monitoring. Compared to NIR (Near-Infrared) laser light, visible light at 650 nm has a significantly higher transmission coefficient through the human finger, making it more effective for glucose measurements. Overall, the implemented RL-BGM device shows promise as a non-invasive blood glucose monitoring solution. By utilizing red light at 650 nm and incorporating an Arduino microcontroller, the device accurately measures and displays blood sugar concentrations, providing a potential alternative to invasive methods.

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