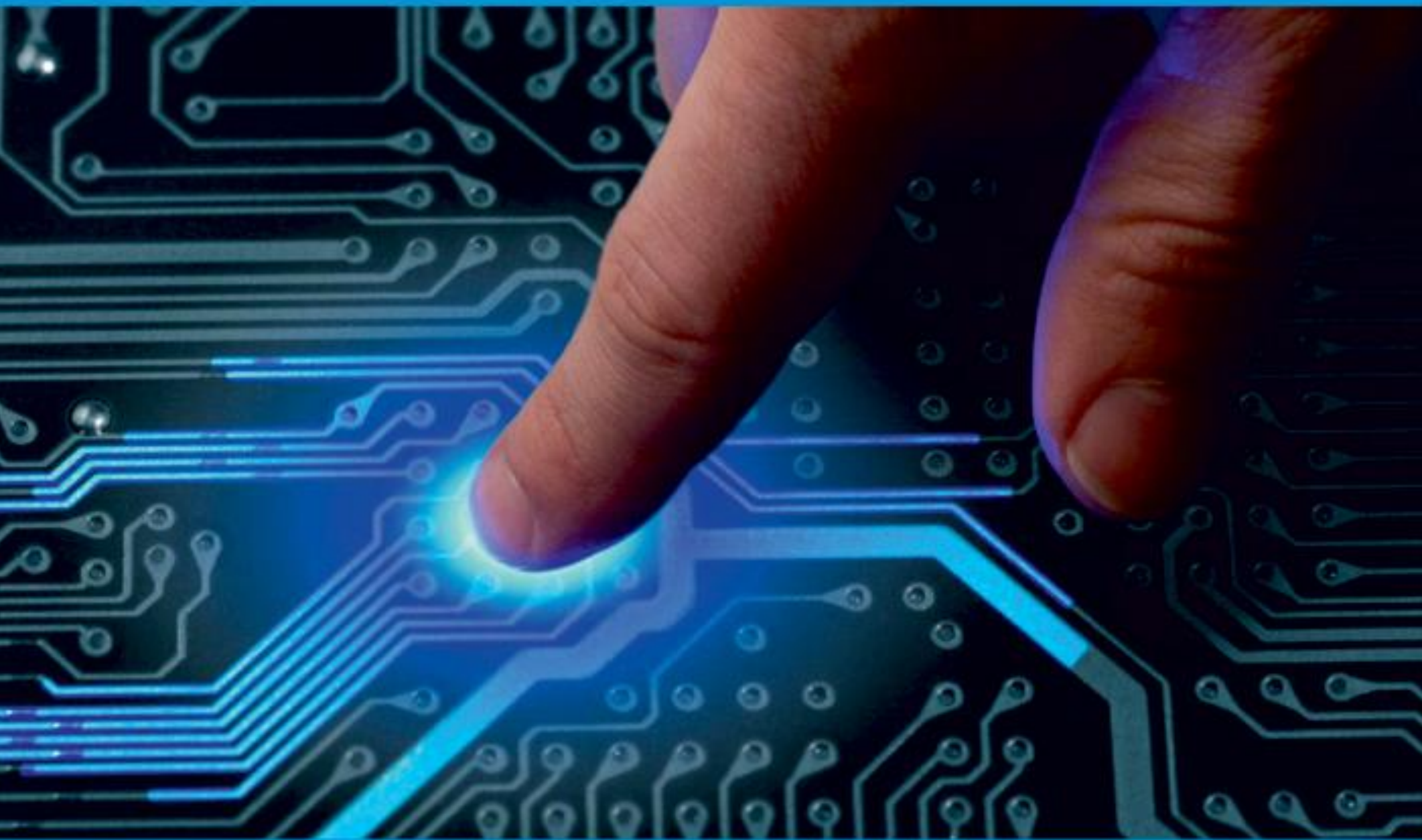
IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 11, Issue 5, May 2023

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.379

International Journal of Innovative Research in Computer and Communication Engineering
| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 |
|| Volume 11, Issue 5, May 2023 ||
| DOI: 10.15680/IJIRCCE.2023.1105153 |

Non-Invasive Smart Glucose Monitoring System

Mr. Narendra U P[1], Vijay G H[2], Fawwaz Hameed[3], Mohammed Sheik Sauban[4], Prathiksha Prabhakaran[5], Rakshitha Roshini DCosta[6]

[1]Associate Professor, Department of Information Science & Engineering, MITE, Moodabidri, India

[2]DLithe Consultancy Services, Bengaluru, India

[3,4,5,6]Student, Department of Information Science & Engineering, MITE, Moodabidri, India

ABSTRACT: Along with major health risks, diabetes and its complications have a significant negative economic impact on people, families, health systems, and nations. Research has clearly demonstrated that better glucose regulation lessens the long-term effects of diabetes. Diabetes patients must be continuously monitored, but doing so is costly for both the government and the typical household. An additional way of measuring blood glucose levels is required for patients with serious diseases or diabetes mellitus who frequently cannot draw blood samples. The term "non-invasive method" is used to describe this process. It is a technology that offers a quick, painless approach to check glucose levels without using intrusive procedures like finger-prick tests. The blood glucose level in a person's body can be measured by a non-invasive blood glucose monitoring system without the need for a blood sample. It is customary to use a lancet to puncture the skin and extract a small sample of blood to measure blood glucose levels.

KEYWORDS: Non-invasive, NIR sensors.

I.INTRODUCTION

Diabetes is a chronic condition brought on by either insufficient insulin production by the pancreas (Type 1 Diabetes) or ineffective insulin usage by the body (Type 2 Diabetes). Insulin is a hormone that controls blood sugar levels. Uncontrolled diabetes frequently causes hyperglycaemia, or elevated blood sugar, which can eventually cause serious harm to the body's organs, nerves, and blood vessels. The World Health Organisation (WHO) reports that diabetes is a significant contributor to kidney failure, heart attacks, strokes, blindness, and lower limb amputation. Blood glucose metres are the most common tools used today to measure blood glucose levels. These techniques need invasive procedures, like pricking a finger, to show the outcome on the LED screen.
The International Diabetes Federation (IDF) estimates that 425 million persons (aged 20 to 79) worldwide had diabetes in 2017. It might be claimed that a big number of invasive procedures will be performed on a huge number of individuals. For instance, people with Type 1 diabetes might be required to check their blood sugar four to eight times each day, which would be unpleasant for the patients.

A non-invasive blood glucose monitoring smart system is therefore required. The GlucoMon device, which is presented in this paper is described in length, along with the components utilised, how they were implemented, and how they perform.

The various methods for measuring blood sugar are presented. The system architecture of the suggested device GlucoMon is covered. Section IV then presents some preliminary findings. Section V delivers a quick conclusion at the end.

Overview of diabetes
One of the most prevalent chronic diseases that affect people their entire lives is diabetes. It is mostly brought on by immunological issues, genetics, and other variables that affect the human body, which result in islet function loss and insulin resistance, among other things. This imbalance of glucose levels in the body causes failure of glucose metabolism and hyperglycemia. Type 1 and type 2 diabetes are the two subtypes. Diabetes type 1 is brought on by insufficient insulin production in the pancreas. Contrarily, type 2 is mostly brought on by patients' deteriorating insulin sensitivity and increasing insulin resistance.Diabetes is a severe health risk to people due to its high incidence rate,

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 |
|| Volume 11, Issue 5, May 2023 ||
| DOI: 10.15680/IJIRCCE.2023.1105153 |

numerous complications, wide range of pathogenic factors, difficulties in treatment, and otherconsiderations. As a result, research into diabetes has received significant attention from several relevant sectors.

The International Diabetes Federation predicts that the percentage of the global population affected by diabetes would climb substantially and that the number of diabetics will continue to rise, with type 2 diabetes accounting for more than 90% of cases. The World Health Organization (WHO) estimates that there are currently about 450 million cases of diabetes worldwide, with a potential increase to 700 million cases by 2045, 39.7 million cases by 2030, and 60.6 million cases in the United States alone by 2060.A sizable section of the population is undiagnosed for a variety of reasons or at potentially high risk in addition to the vast number of people who have been diagnosed. As a result, the prevention of diabetes has received increased attention globally, especially in industrialized nations, and the diagnosis and treatment of diabetes have grown in importance in terms of both their practical use and their potential economic benefits.

Glucose fuels cellular metabolism in the human body. In addition to blood, glucose is present in a variety of bodily fluids, including tears, saliva, urine, and interstitial fluids (ISF). Currently, the primary factor used to diagnose diabetes is the level of blood glucose. The WHO established the guideline in 2009, recommending that normal individuals' fasting blood glucose (FBG) be between 3.9 and 6.1 mM and their blood sugar be 7.8 mM or less two hours after a meal. Patients with polyuria, polydipsia, and unexplained weight loss who have arbitrary blood glucose levels of 11.1 mM or higher, fasting blood glucose levels of 7.0 mM, or blood glucose levels of 11.1 mM two hours after eating can be diagnosed with diabetes.

II. METHODS FOR MONITORING BLOOD GLUCOSE CONCENTRATION

Simple distinctions between invasive and non-invasive blood glucose monitoring can be made based on whether the test has damaged human skin.

Invasive Blood Glucose Monitoring

Hospitals and home glucometers both use the technique of first drawing blood and then analysing it in a laboratory for blood glucose measurement since invasive blood glucose detection technology is currently mainstream, practical, and convenient. In hospitals, subjects have their blood drawn in the morning on an empty stomach, and an automatic biochemical analyser correctly measures the blood glucose content. Despite the fact that the results of this approach are accurate and can serve as a crucial foundation for the diagnosis of diabetes, they are inappropriate for the continuous monitoring of diabetics due to their laborious process, extended detection time, and substantial venous blood extraction.

Self-monitoring of blood glucose (SMBG) is the process of checking one's own blood glucose levels at a given time, typically using a home glucose metre. However, home blood glucose monitors often employ glucose oxidase biosensors, that collect blood from the fingertip using a disposable paper strip, and then calculate the blood glucose concentration using the chemical reaction current of the strip.

(a) (b)

Fig-2.1: Invasive techniques: (a) Finger-pricking, (b) Forearm blood collection.

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 |

|| Volume 11, Issue 5, May 2023 ||

| DOI: 10.15680/IJIRCCE.2023.1105153 |

The results from the portable glucose metres can be produced quickly and with high precision. Both methods can be viewed as costly, particularly for people who check their blood sugar two to three times day. Additionally, as shownin Fig.1., both procedures require a small amount of blood to be drawn from the patient's body by puncturing either a finger or the forearm.
The outer layer of the skin will be thoroughly penetrated since a particular amount of blood must be drawn from the fingertips prior to each test. With the increase in the frequency of blood collection, it is difficult for patients' fingertip wounds to heal in time. Along with the increased risk of environmental infection, the patient will also experience significant discomfort and worry prior to the daily blood draw. The test paper and the blood needle, are consumables that must be thrown away. If they are used regularly, it will cost a lot for households in underdeveloped nations and areas and will incur high costs. Additionally, the strip has a short shelf life, and poor storage will affect the accuracy of the blood glucose detection measurement.

Non-Invasive Blood Glucose Monitoring
As the name suggests, non-invasive blood glucose monitoring relates to the detection of human blood glucose without endangering human tissues. There are numerous non-invasive techniques for detecting blood sugar levels, which can be broadly categorised into optical, microwave, and electrochemical techniques. Near-infrared reflectance spectroscopy (NIRS), polarised optical rotation (POR), Raman spectroscopy, fluorescence, optical coherence tomography (OCT), and other optical techniques are examples of optical technologies. Fig.2. demonstrates that, in addition to being present in significant levels in human blood, glucose is also present in various biofluids, including saliva, tears, perspiration, and ISF.

The electrochemical approach typically measures the glucose content in bodily fluids first and indirectly obtains the blood glucose value after the calibration of the algorithm or data model by using the coherent correlation between biofluids and blood glucose value. The creation of an ISF glucose sensor has a theoretical foundation since the glucose range in ISF is the one that is most similar to the glucose range in blood in both healthy and diabetic individuals.

Recent studies have shown that near-infrared (NIR) light with various wavelengths has the potential to be used for non-invasive glucose measurements. Near infrared spectroscopy (NIRS) uses light in the 750-2500 nm region, which exposes the tissue to some low energy radiation. Since near-infrared light penetrates deeply into the skin and the tissues beneath it, it is also one of the optical techniques that has received the most research.

III.NIR SPECTROSCOPY

The wavelength of light has a direct impact on how well it is absorbed by human tissues. Proteins and DNA may be easily penetrated by ultraviolet light, haemoglobin by visible light, and water by infrared. It is challenging to infer information about the human body from spectral data since none of these wavelengths can pierce the human body in significant quantities. However, the detection spectra for the near-infrared (NIR, 680-2500 nm) range from good to excellent. Near-infrared light may be sensed and measured by both transmission and reflection, scatters less than ultraviolet (UV) or visible light, and has a reasonably strong ability to permeate biofluids and soft tissues (>0.5 mm). The mathematical description of the procedure that enables the determination of absorbance of a sample from the concentration and thickness is the Beer-Lambert law: $I = I_0 10^{(-l.\varepsilon.c)} = I_0 e^{(-l.\mu a)}$
where I is the light intensity at any depth within the absorption medium (W/cm2), I0 is the initial light intensity (W/cm2), l is the absorption depth within the medium (cm), ε is the molar extinction coefficient or molar attenuation coefficient in L/(mmol cm), which depends on the wavelength of incident light and the structure of the absorbing molecules, c is the concentration of absorbing molecules (mmol/L).The product of ε and c is proportional to the absorption coefficient (μa).

The model displays the reflected/transmitted light intensity as a function of sample thickness, concentration, and absorption coefficient, where the effect of scattered light is ignored. Absorbance is defined as log(I0/I). In aqueous glucose solutions, NIR/MIR absorption spectroscopy is able to measure the wavelength dependence of the absorbance of glucose. Water is the most abundant substance in biofluids, so the absorption of incident light by water must be taken into consideration. In the NIR range, there are two absorption peaks for water: (1) ranges from 1350nm to 1520nm (2) ranges from 1790nm to 2000 nm. Therefore, the general NIR wavelength windows are 700–1100 nm, 1500–1850 nm and 2000–2400 nm. These can be used to measure glucose.

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 |

|| Volume 11, Issue 5, May 2023 ||

| DOI: 10.15680/IJIRCCE.2023.1105153 |

Typically, the lips, oral mucosa, earlobes, forearms, fingers, and other body parts will be chosen as the NIR reading site. However, measurements on the fingers are less precise than on the inside of the lips, where blood glucose levels and optical density are correlated. Additionally, only 0.07–0.1% of plasma is made up of glucose, and other elements of tissues or blood, such as water, pigments, proteins, etc., can affect how much light is absorbed and obstruct the measurement of blood glucose. Therefore, the light source's wavelength must be selected so that it is as specifically absorbed by glucose as possible.Although there are examples of non-invasive NIR spectroscopic glucose sensors that have been successfully used in the marketplace, more work needs to be done to enhance the sensors' sensitivity and selectivity, as well as the correlation between measurement results and actual values.

IV. SCOPE AND METHODOLOGY

Aim of the project

The aim of this project is to eliminate the drawbacks of invasive method and build a convenient method for frequent glucose monitoring. For that we have used Near Infrared based method which is non-invasive, portable, cost efficient, reliable and accurate up to a considerable extent and also to improve the analysis diagnosis of diabetic patients. Therefore, with the proposed system diabetic patients can keep update of their current glucose levels.

Methodology

The system consists of three components: A wearable device, data acquisition module and a processing unit. The wearable devise is composed of a sensor module and is controlled by a microcontroller that is connected to the application. The body sensors collect information about the glucose levels and is sent to the application. Data acquisition module is composed of the application and a database server. The database server collects the data from the sensors. The processing unit is composed of a patient's wearable device and a monitoring system. The wearable device sends information to a processing unit via a Bluetooth/4G network. The monitoring system analyses the data gathered from the sensor. When the system detects an abnormal situation, a notification is sent to the patient's wearable device and notify the patient.

Existing system

Numerous non-invasive smart blood glucose monitoring devices are currently on the market. Some of the common systems include:

- **Glucowise:**
  Glucowise monitors body glucose levels using a tiny sensor. The glucose levels are measured by this device, which is applied to the earlobe and combines electromagnetic and thermal technologies. The gadget can give precise readings in a matter of seconds and can be connected to a smartphone application for tracking.
- **K'Watch:**
  K'Watch is a smartwatch that measures blood sugar levels using optical sensors and algorithms. The device can integrate with a smartphone app for easy tracking and can deliver real-time glucose readings in just a few seconds.
- **Dexcom G6:**
  The Dexcom G6, continuous glucose monitoring (CGM) system measures blood glucose levels using a tiny sensor that is inserted under the skin. Every five minutes, the device may deliver real-time glucose readings and notify the user if their blood sugar levels are too high or too low. A smartphone application is coupled with this gadget for simple tracking and supervision.
- **Freestyle Libre:**
  Freestyle Libre is a glucose monitoring device that measures blood sugar levels using a tiny sensor that is attached to the back of the upper arm. The device measures the glucose levels in the interstitial fluid by penetrating the skin with a tiny filament. Every minute, the device may deliver real-time glucose levels and can be easily tracked by scanning it with an application for smartphones or reader.

Proposed system

The proposed system helps diabetic patients to monitor their glucose level data from glucose monitoring sensors. Additionally, it helps diabetic patients to keep track of their blood glucose levels.

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 |

|| Volume 11, Issue 5, May 2023 ||

| DOI: 10.15680/IJIRCCE.2023.1105153 |

V. DESIGN AND IMPLEMENTATION

It is important to understand how the Design phase forms an essential stage within the procedure of software development. That is an innovative method where in system organization is hooked up that satisfies both functional and non-functional system requirements. Big systems are decomposed into sub-systems and those sub-systems offer a related set of services. The output of this design process is a description of the software structure. Although there are examples of non-invasive NIR spectroscopic glucose sensors that have been successfully used in the marketplace, more work needs to be done to enhance the sensors' sensitivity and selectivity, as well as the correlation between measurement results and actual values.

The following components make up most for non-invasive smart blood glucose monitoring systems:

- **Sensor:**
  The system that measures the body's glucose levels primarily consists of a sensor. There are several technologies for non-invasive glucose monitoring. For this system we've used Near InfraRed sensor for non-invasive glucose monitoring. The sensor does not irritate or bother the skin andis discrete and pleasant to wear.
- **The Data Processing Unit:**
  In order to provide correct glucose measurements, the data processing unit must analyze sensor data. The device is able to process sensor data in real-time and is quick, effective, and accurate.
- **Display Unit:**
  The user can view the glucose readings on the display unit. It offers real-time glucose readings and is simple to read and comprehend.
- **Communication Unit:**
  For additional analysis and tracking, the communication unit sends the glucose measurements to the web application. The device securely and wirelessly transfers the data.
- **User Interface:**
  The area of the system with which the user interacts is known as the user interface. The user receives clear instructions and feedback via the user-friendly, intuitive interface.

The non-invasive smart blood glucose monitoring system is made to be comfortable, practical and simple to use in addition to these features. The technology helps the person with diabetes to better control their illness by providing accurate glucose readings in real-time.

VI. SYSTEM ARCHITECTURE AND OPERATION

System Components

GlucoMon consists of two major components.

1. To process the supplied input and transform it into a meaningful output, an integrated ESP32 (microcontroller) and NIR sensor is used.
2. The patient logs in to the online application to calibrate the system and take the glucose readings.

System Operation

Bluetooth is used to connect the microcontroller and web application. In the followingfigure, a brief system architecture is displayed**.**

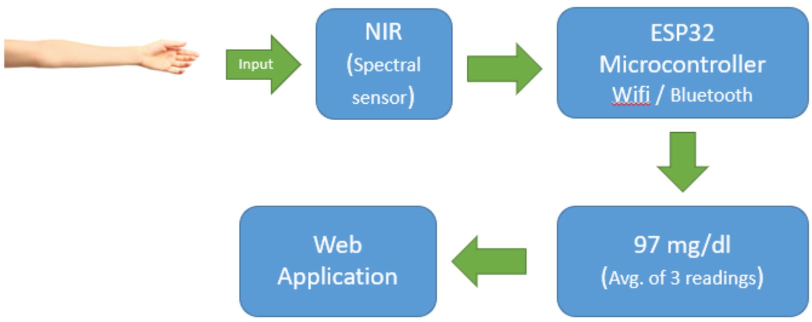


Fig.6.1- System operation

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 |

|| Volume 11, Issue 5, May 2023 ||

| DOI: 10.15680/IJIRCCE.2023.1105153 |

VII. RESULT

The result page displays the level of glucose in blood, humidity and pressure in the patient's body.

Fig.7.1- Result

VIII. CONCLUSION

We have discussed GlucoMon in this paper as it is a simple, dependable, and long-lasting device that can benefit everyone with diabetes. It serves as an alternative to the invasive technologies of today.
The user can check and keep the measured readings on their account using the application that controls the device.
The actual device is based on NIR technology, has a relatively straightforward but efficient implementation, and in a compact and portable case.

REFERENCES

1. Villena Gonzales, W.; Mobashsher, A.T.; Abbosh, A. The Progress of Glucose Monitoring-A Review of Invasive to Minimally and Non-Invasive Techniques, Devices and Sensors. Sensors 2019.
2. International Diabetes Federation Guideline Development Group. Global guideline for type 2 diabetes. Diabetes Res. Clin. Pract. 2014..
3. Alberti, K.G.; Zimmet, P.; Shaw, J. International Diabetes Federation: A consensus on Type 2 diabetes prevention. Diabet. Med. 2007.
4. Lin, M.J.; Wu, C.C.; Chang, K.S. Effect of Poly-l-Lysine Polycation on the Glucose Oxidase/Ferricyanide Composite-Based Second-Generation Blood Glucose Sensors. Sensors 2019.
5. Barathi, P.; Thirumalraj, B.; Chen, S.-M.; Angaiah, S. A simple and flexible enzymatic glucose biosensor using chitosan entrapped mesoporous carbon nanocomposite. Microchem. J. 2019.
6. Zhao, L.; Wen, Z.; Jiang, F.; Zheng, Z.; Lu, S. Silk/polyols/GOD microneedle based electrochemical biosensor for continuous glucose monitoring. RSC Adv. 2020.
7. Kim, K.B.; Lee, W.-C.; Cho, C.-H.; Park, D.-S.; Cho, S.J.; Shim, Y.-B. Continuous glucose monitoring using a microneedle array sensor coupled with a wireless signal transmitter. Sens. Actuators B Chem. 2019.
8. Bollella, P.; Sharma, S.; Cass, A.E.G.; Antiochia, R. Minimally-invasive Microneedle-based Biosensor Array for