# Ai-Based Healthcare Monitoring System Using Raspberry -Pi

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***Abstract:*** Diabetes is a chronic condition. Traditional invasive techniques like the finger-prick test, though commonly used, often lead to discomfort and reduced patient compliance. To overcome these limitations, this project presents a Non-invasive monitoring system. The proposed system utilizes a Near-infrared (NIR) sensor by analyzing how light is absorbed and scattered through skin tissue instead of directly connecting the NIR sensor to the Raspberry Pi 4B. An ESP8266 Wi-Fi Module is used. The sensor data is sent to the Raspberry Pi 4B via serial communication. This setup ensures smooth data acquisition while maintaining modularity and flexibility in hardware design. The received data is processed using a Python-based long short-term memory (LSTM) neural network algorithm. The LSTM model is known for its ability to analyze time-series data and predict results accurately. In addition to glucose estimation, the system is also designed to predict other health parameters such as blood group, blood level, cholesterol level, skin temperature, hydration level and blood pressure using AI-based analysis.

***Index Terms*** - **AI-based algorithms, Diabetes management, ESP8266 module, NIR sensor, Raspberry pi 4B, health parameters.**

## I. INTRODUCTION

Millions of people worldwide suffer from diabetes mellitus, a condition that is becoming a major global health concern. To effectively control diabetes and prevent major consequences including neuropathy, cardiovascular disease, and kidney failure, blood glucose levels must be continuously and accurately monitored. Invasive techniques like finger-prick tests, which have historically used for glucose monitoring, can be uncomfortable, and inconvenient, and eventually result in lower patient compliance even though they are accurate. These restrictions have prompted research into more patient-friendly alternatives, including non-invasive monitoring devices. The Raspberry Pi 4B and artificial intelligence (AI), more especially the LSTM neural network technique, are used in this research to propose a non-invasive blood glucose monitoring device. This system's main concept is to use a Near-Infrared (NIR) sensor, which emits light that penetrates skin tissues, to do away with the requirement for blood samples. The interstitial fluid's glucose molecules interact with the light, and the patterns of reflected or absorbed signals change according to the concentration of glucose. Blood glucose levels are estimated by capturing and processing these signal fluctuations. The Raspberry Pi 4B receives the data collected by the NIR sensor and uses an LSTM model based on Python to analyze it. A particular kind of recurrent neural network (RNN) called LSTM works well with time-series data because it can identify minute variations in the sensor output over time and generate precise predictions.

Through sophisticated AI analysis of the optical data acquired via the NIR sensor, this system seeks to deliver not only blood glucose estimations but also other health indicators like blood group, blood level, cholesterol level, hydration level, skin temperature, and blood pressure. This method's main benefit is its non-

invasiveness, which spares patients from having to use test strips or needles and makes it a painless and convenient option. The technology is very accessible and practical for both patients and healthcare professionals because the Raspberry Pi 4B platform also enables wireless data transfer and remote health monitoring. Using machine learning, the Internet of Things, and optical sensor technologies, this study shows how to control diabetes in a novel way by developing a portable, intelligent, and real-time health monitoring system. The suggested approach offers a major advancement in healthcare technology by fusing AI with embedded technologies.

## II. LITERATURE REVIEW

This section explains how to use artificial intelligence and a Raspberry Pi to track blood sugar in a non-invasive manner. Without taking blood, an NIR sensor measures the amount of light that passes through the skin to determine blood sugar levels. The data is processed by a short-term memory neural network, which provides prompt feedback to aid with diabetes management.

The authors of [1] talked about a novel non-invasive technique that uses radiofrequency transmission between two antennas to assess blood glucose. They examined tissue dielectric characteristics while designing a patch antenna and a SIW slot antenna.

The authors in [2] used modified Beer-Lambert's law and smartphone-based optical spectroscopy to create a non-invasive glucose monitoring technique. Their method allows for real-time, cost-effective glucose tracking without pricking by measuring fingertip transmission using near-infrared light.

The effects of elevated glucose concentrations on human erythrocytes were examined by the authors in [3]. They discovered decreased antioxidant capability, membrane damage, and elevated oxidative stress. According to the study, extended exposure to glucose may change the shape of red blood cells, which could lead to issues from diabetes.

Researchers used NIR light, which detects how light is absorbed and scattered by the skin, to create a painless blood sugar testing procedure in [4]. Despite providing a non-invasive substitute for conventional techniques, it has drawbacks such as variations in skin tone and background noise that may compromise precision.

In [5], the authors created a non-invasive blood glucose measurement tool that uses red laser light. In both laboratory and real-world tests, the device demonstrated excellent accuracy and performance. It provides a straightforward and painless substitute for conventional finger-prick techniques.

The authors of [6] used an improved convolutional neural network (CNN) to create a real-time, non-invasive diabetes screening system. The model's ability to identify diabetes produced encouraging results.

The authors of [7] investigated a needleless technique for measuring blood sugar that makes use of infrared light and a smartphone camera. The Deep Neural Network produced the best results when they used machine learning models to analyze finger videos.

Using several sensors and measuring various health factors, researchers created an Internet of Things-based health monitoring system for diabetes patients in a study report [8].

The CNN approach of diabetes classification by warnings was described by the authors in [9].

A machine learning-based diabetes classification system was created by the authors [10] for patients living in remote areas as well.

The authors of [11] created an Internet of Things (IoT)-based health monitoring system that allows patients in remote areas to measure their health metrics and share the results with both their doctor and themselves.

## III. RESEARCH METHODOLOGY

Current blood glucose monitoring systems mostly involve invasive techniques, such the widely used finger-prick method. With this method, a lancet is used to extract a small drop of blood from the fingertip, and a glucose meter is used to measure the drop. Despite being accurate and commonly used, this method frequently results in pain, discomfort, and skin irritation, especially when used frequently. Because many users avoid routine testing out of discomfort or fear of pain, these intrusive procedures may also result in decreased patient compliance. The long-term expense of these systems is further increased by their reliance on consumables like test strips and lancets. Furthermore, conventional glucometers often operate independently without smart features like cloud integration, wireless networking, or real-time data sharing with medical professionals. Invasive finger-prick testing, which involves drawing blood with a lancet and analyzing it with a glucose meter, is the mainstay of the current blood glucose monitoring system. However, this procedure can be painful, uncomfortable, and irritate the skin, which lowers patient compliance.

The Non-invasive, AI-powered approach shown in this study greatly increases user comfort and monitoring effectiveness. It detects changes in light absorption in skin tissue associated with glucose levels using a Near-Infrared (NIR) sensor. Rather than connecting the NIR sensor directly to the Raspberry Pi 4B, the system uses an ESP8266 Wi-Fi module to act as a wireless microcontroller-based NIR sensor driver. The ESP8266 records the sensor readings and transmits them to the Raspberry Pi 4B serially. A Python-based Long Short-Term Memory (LSTM) model, a kind of neural network ideal for time-series data analysis, is used to process the data as it arrives at the Raspberry Pi 4B. Without taking blood, this model calculates blood glucose levels as well as other critical health measures like blood pressure, skin temperature, blood group, blood level, cholesterol, and hydration state. The system is a painless, economical, and clever way to track general and diabetic health because it offers fast, accurate data and supports wireless connectivity and remote health monitoring.
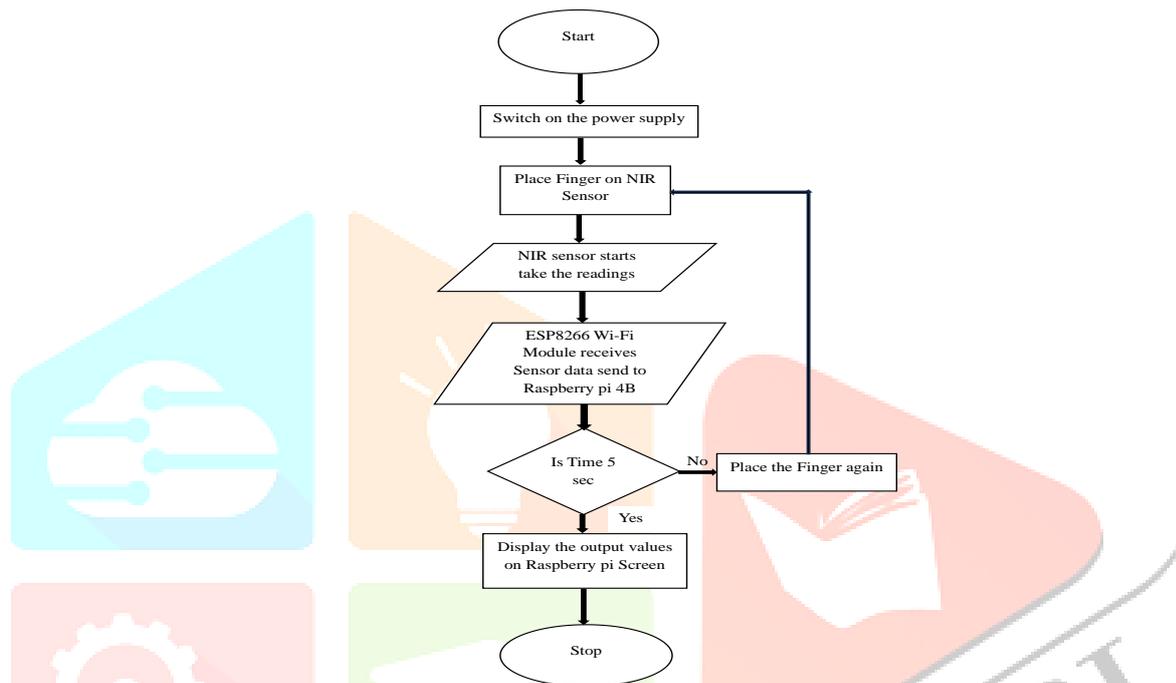


**Fig 1: Flow chart of Non-invasive blood glucose monitoring system**

**Working Principle**

The above flow chart in Figure 1 shows how a Raspberry Pi 4B-based non-invasive blood glucose monitoring device operates. The Raspberry Pi and other linked components receive the electrical energy they require from the power supply at the start of the system. Data is gathered using a Near-Infrared (NIR) sensor to identify changes in light absorption via the skin that are correlated with blood glucose levels.

The sensor data is sent wirelessly to the Raspberry Pi 4B through the ESP8266 Wi-Fi module, which acts as a communication bridge. The operating system, Python scripts, machine learning models, and sensor data are stored on a 32GB SD card that is attached to the Raspberry Pi 4B. To estimate glucose levels, the Raspberry Pi uses AI-based algorithms to analyze the received data. Users may then monitor their glucose readings and other critical health data in real time by viewing the final output on the Raspberry Pi screen. A mobile app for convenient access, alarms, and sharing with physicians, as well as cloud storage for Thing Speak data for long-term health tracking.

Non-invasive blood glucose monitoring system includes hardware and software components:
**Hardware components**
*NIR sensor*

Variations in light absorption in skin tissue are detected by an NIR sensor and are associated with physiological indicators such as glucose levels. One material that absorbs NIR light after it travels through the skin is glucose (fig. 2).
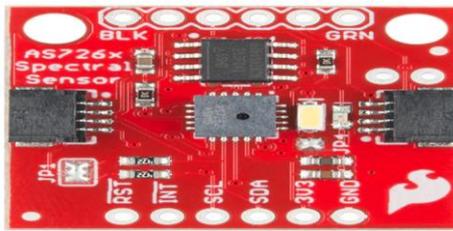
**Fig 2: NIR sensor**

*ESP8266 Wi-Fi module*

The NIR sensor is driven by a wireless microcontroller-based ESP8266 Wi-Fi module, as seen in Fig. 3. The module records sensor values and wirelessly sends them to the Raspberry Pi 4B over serial connection. A low-cost, low-power microcontroller with Wi-Fi capabilities, the ESP8266 module can communicate with the NIR sensor and provide data wirelessly.



**Fig 3: ESP8266 Wi-Fi module**

*Raspberry pi 4B*

The Raspberry Pi 4B takes data from the ESP8266 Wi-Fi module, processes it using an LSTM model based on Python, and may display the findings or send them to a remote destination, as seen in Fig. 4 below. A tiny, reasonably priced computer, the Raspberry Pi 4B is capable of running software programs and operating systems, including machine learning models. The Raspberry Pi 4B cannot function without a 32GB SD card to store its operating system. Important files like sensor interfaces, Python code, and AI models are also saved. It also saves sensor data, including NIR signals that are used to predict blood sugar levels in real time.



**Fig 4: Raspberry pi 4B**

**Software Description**

*Long Short-Term Memory (LSTM)*

A specific kind of recurrent neural network called the Long Short-Term Memory, or LSTM, is made to analyze time-series data, which makes it perfect for monitoring health indicators over time. Near infrared sensors continuously gather physiological signals from the body without taking blood samples as part of a non-invasive blood glucose monitoring system. The LSTM model receives these raw signals and uses previously labeled data to identify patterns and trends related to glucose changes. In order to preserve significant features from previous inputs while eliminating unnecessary data, the model uses its memory cells to process the input in a sequential manner. Based on real-time sensor data, the LSTM eventually gains the ability to forecast blood glucose levels and other critical health metrics with accuracy. This eliminates the need for conventional blood sample, permits painless, real-time monitoring, and aids in the early detection of abnormal glucose levels.

## IV. RESULTS AND DISCUSSION

The Results and Discussions of the Non-invasive blood Glucose Monitoring system using Raspberry pi as shows in the below figures. The Raspberry Pi 4B-based system's essential parts and connections are depicted in below Fig. 5. Raspberry Pi 4B-based non-invasive blood glucose monitoring system. A Near-Infrared (NIR) sensor is used to collect data and detect changes in light absorption via the skin, which correlates with glucose levels. The system is powered by a power supply. The Raspberry Pi 4B receives data from the sensor through an ESP8266 Wi-Fi module. The OS, Python code, ML models, and data are stored on a 32GB SD card.
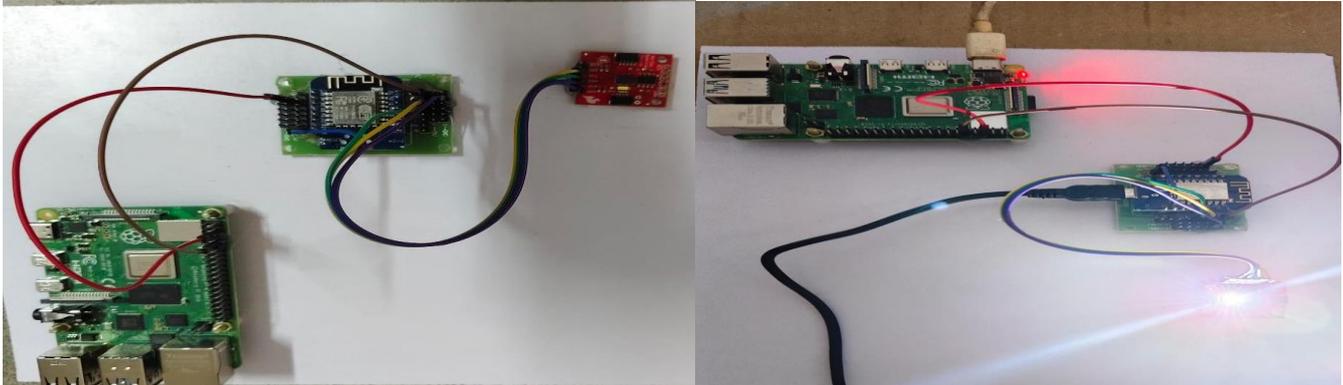


**Fig 5: Circuit connections of Non-invasive blood glucose monitoring system**

The below Table1 shows a Python-based LSTM algorithm integrated on the Raspberry Pi 4B allows for precise, real-time prediction of blood glucose levels as well as other critical health parameters like blood group, blood level, cholesterol, skin temperature, hydration level, and blood pressure.

### Table 1: Details of Output measured parameters

| S.No. | Name of Person | Measured/Prediction Values | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Blood Glucose | Diabetic Stage | Blood Level | Blood Cholesterol | Skin Temperature | Hydration Level | Blood Pressure | Blood Group |
| 1. | k. Sravanthi | 111.47 | Stage 1 | 4.50 | 162.26 | 98.28 | 57.16 | 123.13 | O+ |
| 2. | L. Anitha | 113.24 | Stage 1 | 4.23 | 158.30 | 97.12 | 55.18 | 122.33 | A+ |
| 3. | M. Aswitha | 109.38 | Stage 1 | 3.91 | 140.11 | 99.32 | 53.22 | 120.36 | A- |
| 4. | Y. Priyanka | 130.22 | Stage 2 | 4.68 | 150.13 | 85.96 | 54.08 | 121.12 | B+ |
| 5. | N. Sirisha | 108.66 | Stage 1 | 4.71 | 163.18 | 96.68 | 48.35 | 119.01 | A+ |
| 6. | M. Geetha | 120.23 | Stage 1 | 5.29 | 153.83 | 89.98 | 55.34 | 122.43 | B- |
| 7. | K. Sravani | 112.55 | Stage 1 | 4.30 | 141.23 | 90.88 | 50.19 | 109.22 | AB+ |
| 8. | B. Manisha | 110.29 | Stage 1 | 3.98 | 145.49 | 77.98 | 49.08 | 110.76 | O+ |
| 9. | M.Srilekha | 101.99 | Stage 1 | 5.31 | 166.59 | 100.01 | 38.98 | 115.10 | A- |
| 10. | R. Lakshmi | 127.92 | Stage 2 | 5.23 | 149.64 | 82.32 | 60.18 | 125.80 | AB- |

## V. CONCLUSION AND FUTURE SCOPE

This project's Non-Invasive Blood Glucose Monitoring System effectively illustrates a cutting-edge, patient-friendly substitute for conventional invasive glucose testing techniques. It gathers data using an ESP8266 module and an NIR sensor, then transfers it to a Raspberry Pi for processing. Without requiring blood samples, a Python-based LSTM algorithm on the Raspberry Pi reliably predicts blood glucose levels as well as other health metrics like blood group, cholesterol, hydration, and blood pressure. The system is perfect for both professional and personal usage, encouraging regular and pleasant health monitoring with its wireless

communication, remote tracking, and quick results. For various skin kinds and situations, advanced AI models can increase prediction accuracy.

## VI. ACKNOWLEDGMENT

## REFERENCES

[1] Hofmann, M., Fersch, T., Weigel, R., Fischer, G., & Kissinger, D. (2011, May). A novel approach to non-invasive blood glucose measurement based on RF transmission. In 2011 IEEE International Symposium on Medical Measurements and Applications (pp. 39-42). IEEE.

[2] Vishnu Dantu, Jagannadh Vempati, and Srinivasan Srivilliputhur "Non-Invasive Blood Glucose Monitor Based on Spectroscopy Using a Smartphone". 978-1-4244-7929-0/14 IEEE-2014.

[3] Viskupicova, J., Blaskovic, D., Horakova, L., et al., Effect of High Glucose Concentrations on human erythrocytes in vitro, Redox Biology, Vol. 5, 2015 Aug:381-387.

[4] Narkhede, P., Dhlwar, S.Karthikeyan B., NIR Based Non-Invasive Blood Glucose Measurement. Indian Journal of Science and Technology, Vol 9, 2016 November:41. 2016.

[5] Ali, H., Bensaali, F., & Jaber, F. (2017). A novel approach to non-invasive blood glucose monitoring based on transmittance and refraction of visible laser light. IEEE Access, 5, 9163-9174.

[6] Lekha S, M S. Real-time non-invasive detection and classification of diabetes using modified convolution neural network. IEEE J Biomed Health Inform 2018 Sep;22(5):1630-1636. [doi: 10.1109/JBHI.2017.2757510] [Medline: 28961131]2018.

[7] Sumaiya J, Hasan MR, Hossain E. Non-invasive blood glucose measurement using live video by smartphone. 2020. Presented at: 2020 IEEE 8th R10 Humanitarian Technology Conference (R10-HTC); December 01, 2020; Kuching, Malaysia. [doi:10.1109/r10-htc49770.2020.9357018].

[8] MahaLakshmi B, Lavanya M, Rajeswari Haripriya G, Sushmasri K, Teja M, Jayasri M," Design and Implementation of IoT Based Smart Health Monitoring System for Diabetic Patients Using Wireless Sensor Networks", International Journal of Information Technology (IJIT) – Volume 8 Issue 3, ISSN: 2454-5414, May – Jun 2022, PP16-19.

[9] MahaLakshmi B, Dr. G. SrinivasaRao, Bhavya Sree Ch, Lakshmi Durga P, Naga Niharika P, Chaitanya Lakshmi A," IoT Based System for Classification of Diabetes Using Convolutional Neural Network Algorithm", International Journal of Scientific Development and Research (IJSDR), Volume 8 Issue 4, ISSN: 2455-2631 April 2023, PP 1285-1290.

[10] MahaLakshmi.B, Srinivasa Rao.G, Tejaswini.R, Supraja.K, Ramya.A, Sumythri.V," Machine Learning-based Diabetes Classification using Raspberry-Pi", International Journal for MultidisciplinaryResearch (IJFMR)- Volume 5, Issue 2, E-ISSN: 2582-2160 March-April 2023,PP1-6.

[11] MahaLakshmi Bollimuntha, Kalpana Murugan," Design and Implementation of An Interoperable IoT Based Health Monitoring System for Diabetes, IEEE 5$^{TH}$ international conference at ICSSIT-2023, January 2023, Francis Xavier Engineering College, Tirunelveli, India.