A

B.TECH. PROJECT

REPORT ON

“REAL TIME PREDICTION OF SUGAR LEVEL USING SWEAT THROUGH BSL BAND”

Submitted in partial fulfillment of the requirements for the award of the degree of

Bachelor of Technology

In

Information Technology

By

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Academic Year 2023 – 24

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CERTIFICATE

This is to certify that the B.TECH. Project Report Entitled

“**Real time Prediction of Sugar level using Sweat through BSL Band**”

Submitted by

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is a record of bonafide work carried out by him, under our guidance, in partial fulfillment of the requirement for the award of Degree of Bachelors of Technology (Information Technology) at Shri Vile Parle Kelawani Mandal's Institute Of Technology, Dhule under the Dr. Babasaheb Ambedkar Technological University, Lonere, Maharashtra. This work is done during semester VIII of Academic year 2023-24.

Date:
Place: SVKM’s IOT, Dhule

Mr. Sachine Kamble	Prof. Rubi Mandal	Dr. Bhushan Chaudhari	Dr. Nilesh Salunke
Project Guide	**Project Coordinator**	**HOD**	**Principal**

Name and Sign with date	Name and Sign with date
Examiner-1	Examiner-2

DECLARATION

We declare that this written submission represents my ideas in our own words and where other's ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

		Signatures
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We have immense pleasure in expressing our interest and deepest sense of gratitude towards our project guide **Mr. Sachin Kamble** for the assistance, valuable guidance and co-operation in carrying out this project successfully. It is a privilege for us to have been associated with **Mr. Sachin Kamble** our Project Guide, during our Project Phase 2 work. We have greatly benefited from his valuable suggestion and ideas. It is with great pleasure that we express our deep sense of gratitude to him for his valuable guidance, constant encouragement and patience throughout this work. We express our gratitude and are thankful to all people who have contributed in their way in making this final year project phase 2 success. Particularly we want to thank **Prof. Rubi Mandal**, Project Coordinator for our department for making this process seamless for us and arranging everything so perfectly. I take this opportunity to thank all the classmates for their company during the course work and for the useful discussion, I had with them. We take this opportunity to express our heartfelt gratitude towards the Department of Information Technology of Shri Vile Parle Kelavani Mandal’s Institute of Technology, Dhule and **Dr. Nilesh Salunke**, Principal of Shri Vile Parle Kelavani Mandal’s Institute of Technology, Dhule, that gave us an opportunity for the presentation of our project phase 2 in the esteemed organization and for providing the required facilities in completing this project. We are greatly thankful to our parents, friends and other faculty members for their motivation, guidance and help whenever needed.

ABSTRACT

Diabetes is a chronic disease or a group of metabolic disease where a person who suffers from a high level of glucose in the body. Diabetes is affected by most of the people nowadays. Diabetes is disease that can be controlled. Diabetes patients need to check the blood daily and take corresponding insulin. Taking blood from the body daily leads to many complications such as cardiovascular and kidney problems, stroke, blindness, and nerve degeneration. Nowadays there is no proper method to check the chance of diabetes. Here the chance of occurrence of diabetes is tested using machine learning, whether there is a chance for diabetes due to food or genetically. So the necessary precaution can be taken. Monitoring blood glucose using sweat helps a person from painful blood-based monitoring. Here Water Drop Sensor is used to find the conductance of skin. From which the glucose level is calculated. The detail of the person's diabetes level is stored in the cloud, so that the previous diabetes level can be known. This way of glucose measurement is said to be painless, costeffective and easy monitoring.

Keywords - Diabetic Patient, Cloud, Glucose mesuremenet, health sensors, Blood Glucose level, IOT Technology.

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LIST OF ABBREVIATIONS

EN	Entropy
GUI	Graphical User Interface
ECG	Electrocardiogram
LCD	Liquid-crystal display
RAM	Random-access memory
SVM	Support Vector Machine
KNN	K-Nearest Neighbor
GSR	Galvanic Skin Response

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Chapter 1: Introduction

1.1 Basic Concept

Human Health is eternal important topic. While the health monitoring hardware and systems are being continuously improved, for the interaction between acquisition module and smartphone developed a health services terminal on the basis of analysing the wifi and windows operating system.

1.2 Motivation of the Project

According to medical survey there one and two patient in every home who is dealing with sugar diabetes and every time they need to check blood for sugar level which is painful to over come this we came up with the idea of BSL Band.

1.3 Project Idea

According to medical survey there one or two patient in every home who is dealing with sugar diabetes and every time they need to check blood for sugar level which is painful to over come this we came up with the idea of BSL Band. We have 2 parts in this project Software and hardware part.In Hardware part we are making sweat sensor for our band which can give the readings of blood glucose level through sweat.And in software part we are building a website which helps keep track of our weekly data through cloud.

1.4 Principle of Blood Glucose Measurement:

When a light ray passes through biological tissues, it is both absorbed and scattered by the tissues. Light scattering occurs in biological tissues due to the mismatch between the refraction index of extracellular fluid and the membranes of the cells. Variation in glucose level in blood affects the intensity of light scattered from the tissue. Beer-Lambert Law plays a major role in absorbance measurement which states that absorbance of light through any solution is in proportion with the concentration of the solution and the length path traveled by the light ray.

Chapter 2: Literature Survey

2.1 Related Work Done

A wearable sensor can gather physiological information, for example, the blood glucose even out and impart into advanced cell through the remote channel [18]. Thusly it conveys the information to the cloud server where it very well may be put away in an Electronics Health Record (EHR) [4]. Trust commendable information administrator screens interfacing calls from various application and confirms them against prerequisites. Wellbeing dev instruments were proposed, which is utilized by an engineer to either create confirmations for dependability of MMAs [6]. The security confirmation is finished utilizing displaying with spatial-fleeting half and half automata (STHA). The body sensor network innovation is one of the center advancements of IoT improvement in medical care framework, where patients can be observed utilizing an assortment of minuscule powdered and light weight sensor hubs. BSN based present day medical care framework gives a few prerequisites like wellbeing, maintainability and security [1]. Any control input structure from MMA is security guaranteed by checking it with half breed automata based model [4]. Discussing sensor with TDM upholds long haul accessibility with feasible plan. Information gathered by the distinctive application are kept in security data set imparted to affirmed applications as it were. Physiology based start to finish security (PEES), gives a safe correspondence channel between the sensor and clinical cloud straightforwardly [4]. The hubs of remote sensor organizations (WSN), give troubleshooting offices and adequately huge networks for sensible investigation might be costly to convey [1]. UPHIAC (Ubiquitous individual wellbeing data access) and PRISM (Platform for remote detecting utilizing PDAs) outline works furnish wellbeing information security with Application program interface (API) to interface with cell phone sensor and cloud for information stockpiling[1]. Unavoidable wellbeing the executives framework (PHSM) gives dynamic changes in the setting instigated by portability of the client [6]. The progressive power the executives engineering for versatile framework (HPM) gives significant degree of consistency by incorporating to extra low power processor. Structure is to improve on interface between assortments of outer sensor customer android gadgets [7]. PDAs can be associated with outside sensors over wired and remote channels. For appropriate gadget collaboration can be troublesome, particularly when a solitary application needs to incorporate with various sensors utilizing diverse correspondence channels and information designs. A structure is to improve on the obstruction between an assortment of outer sensors and customer android gadgets. Subsequently convenientce, effortlessness and arrangement ease [2].Blood glucose measurement is done by using electrical conductivity measurement. Conductivity of a sweat sample is a measure of its ability to conduct the electricity sodium content from sweat is measured in terms of voltage. The sugar level is being correlated by voltage range with the help of interpolation equation. The electrical conductivity of a solution between two plate electrodes separated by a fixed distance. Copper has better strength than silver but offers inferior oxidation resistance. Copper is a common base metal for electrical contact and electrode application it is also used in alloys with graphite, tellurium and tungsten and used to make brass and bronze. Copper electrode is used for conductivity measurement because it has high tensile strength electricity [8].

2.2 Limitation of Existing System

1. Wearing it for whole day might cause inconvenience during working hours.
2. The device is powered by 9v power adapter due to the biosensors, liquid crystal display (LCD), as well as the HC-05 Bluetooth module are in high power consumption.
3. It works when power supply is on.

Chapter 3: Problem Definition and Scope

3.1 Need of Project

- According to the World Health Organization, 422 million people (5diabetes. Predicted to become the seventh leading cause of death, diabetes is dangerous because of its complications: cardiovascular diseases, blindness, risk of amputation, kidney failure, etc. Glucose concentration in blood is the key parameter for diabetic patients: maintaining it at an appropriate level allows these complications to be postponed.
- Noninvasive methods, which exclude not only injury to blood vessels, but also damage to the skin surface, are preferred for diagnostics: such methods are painless and avoid potential infection and trauma to patients. However, despite continuing efforts, the problem of noninvasive evaluation of blood glucose concentration has not yet been solved.

3.2 Problem Statement and Objectives of Project

- In Public health and surveillance there is need for better surveillance methods or tools in public health care to measure and track blood sugar level of patient as they can be unconscious if the blood sugar level is down or up significantly. Sweat contains glucose that can accurately reflect blood glucose. However skin surface glucose can confound these measurements.
- To overcome daily painful blood sugar level measurement.
- To keep track of the patient sugar level and his daily diet.
- Provide accurate information as compared to traditional methods of blood sugar level calculation.

3.3 Scope of the Project

- A suitable and efficient power source need to be revised for the design enhancemnent.
- Besides, the accuracy of the device can be further improved in the future. For instance, some precautions and preparations of ECG and body temperature measurement need to be practiced for optimized vital sign reading.

3.4 Major Constraints

In order to maintain the accuracy, following assumptions are made:

- The user must be sweating during testing.
- User must have PC, Laptop or Mobile as reading will be displayed on it
- User must have contact with sensor during test

3.5 Expected Outcomes

The real time prediction of glucose through BSL band will

- Replace the painful method of blood glucose level testing
- Track daily test records with timeline
- Create simple environment for users

3.6 Applications

- Monitoring blood sugar to make sure it remains in the target range is the cornerstone of diabetes management, but the pain and inconvenience of daily finger pricks can be a deterrent for many.
- The investigational, touch-based test measures blood sugar in sweat and applies a personalized algorithm that correlates it with glucose in blood.
- You place your finger on the sensor for one minute and the hydrogel absorbs tiny amounts of sweat and undergoes a reaction that results in a small electrical current detected by a hand-held device.

Chapter 4: System Requirements Specification

4.1 Hardware Requirement:

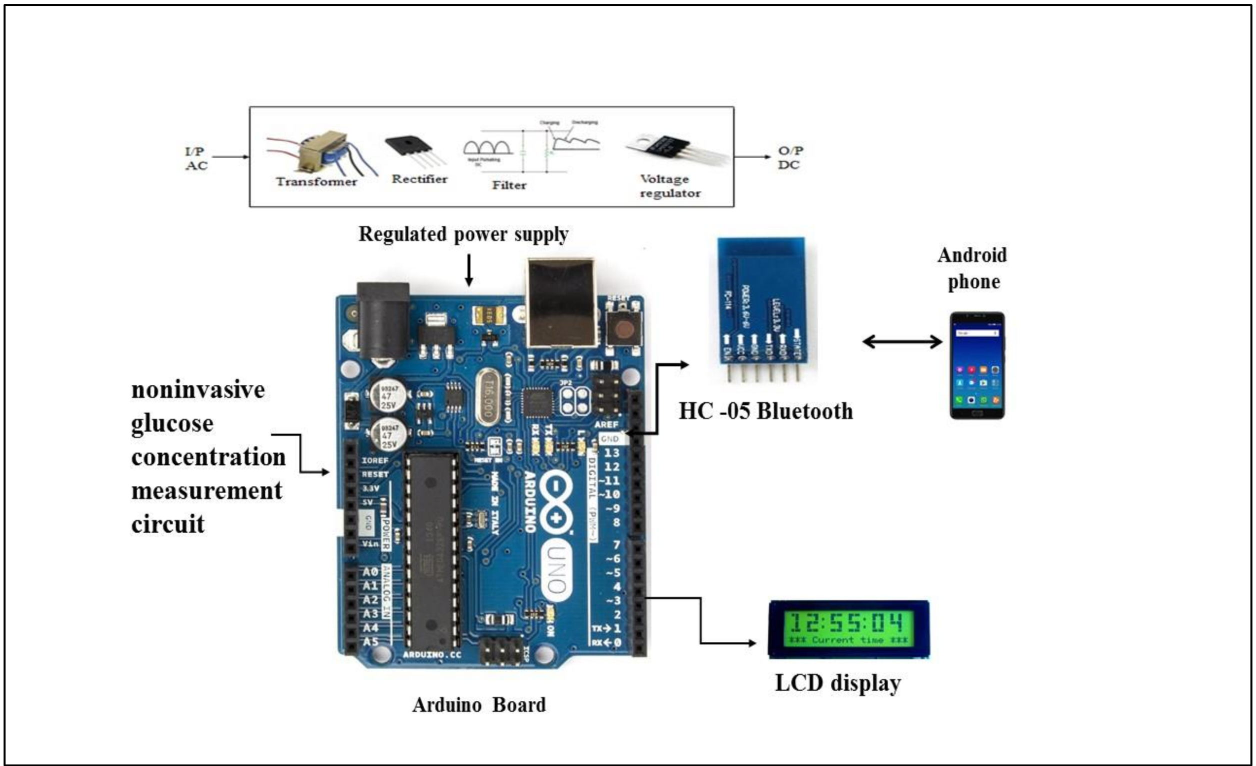

Figure 4.1: Hardware Requirement

- **Arduino UNO:**

  The Arduino Uno is a microcontroller board which has ATmega328 from the AVR family. There are 14 digital input/output pins, 6 Analog pins and 16MHz ceramic resonator. USB connection, power jack and also a reset button is used. Its software is supported by a number of libraries that makes the programming easier.

- **Noninvasive glucose concentration measurement circuit:**

  The proposed work is based on NIR optical technique. NIR light source of 940 nm wavelength is chosen because it is suitable for measuring blood glucose concentration. The sensing unit consists of NIR emitter and NIR receiver (photodetector) positioned on either side of the measurement site (fingertip).When the NIR light is propagated through the fingertip in which it interacts with the glucose molecule, a part of NIR light gets absorbed depending on the glucose concentration of blood and remaining part is passed through the fingertip. The amount of NIR light passing through the fingertip depends on the amount of blood glucose concentration. The transmitted signal is detected by the photodetector. The output current of the photo detector is converted into voltage signal and then it is filtered and amplified. This amplified signal is fed into Arduino microcontroller. This digital signal is processed by using second order regression analysis to predict the blood glucose value and the blood glucose value is displayed on the LCD display also send this blood glucose value to the APP through BLUETOOTH. So user can check this data by using mobile phone.

- **LCD display:**

  One of the most common devices attached to a micro controller is an LCD display. Some of the most common LCD's connected to the many microcontrollers are 16x2 and 20x2 displays. This means 16 characters per line by 2 lines and 20 characters per line by 2 lines, respectively.

- **HC-05 Bluetooth module:**

  HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication. This serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature).

- **Adapter Power Supply:**

  The AC adapter, AC/DC adapter or AC/DC converter is a type of external power supply, often enclosed in a case similar to an AC plug. Other names include plug pack, plug-in adapter, adapter block, domestic mains adapter, line power adapter, wall wart, or power adapter. AC adapters are used with electrical devices that require power but do not contain internal components to derive the required voltage and power from mains power. The internal circuitry of an external power supply is very similar to the design that would be used for a built-in or internal supply.

4.2 Software Requirement:

- Microsoft Windows
- Frontend : HTML, Javascript
- Backend : Firebase, Python, Arduino, Heroku Cloud
- Arduino IDE Studio compiler - for compilation part
- Proteus 7 (Embedded C) – for simulation part

4.3 Functional Requirement

- Accurate glucose measurement: The device should provide accurate readings comparable to traditional invasive glucometers.

- Non-invasive measurement: It should measure glucose levels without puncturing the skin, typically through methods like infrared spectroscopy or electromagnetic sensing.

- User-friendly interface: The device should have a simple and intuitive interface for easy operation by users.

- Quick results: It should provide glucose measurements within a reasonable timeframe to ensure timely monitoring of blood sugar levels.

- Portability: The device should be compact and portable for convenient use at home or on the go.

- Connectivity: Integration with smartphone apps or other devices for data sharing and remote monitoring.

4.4 Non Functional Requirement

- Interface Requirements
  - – Easy Handler
  - – Effective GUI
- Performance Requirements
  - – Response Time
  - – Throughput
  - – Reliability
  - – Security
  - – Data Integrity

Chapter 5: Project Plan

5.1 Project Schedule

Major Tasks in the Project stages are:

- **Task 1: Literature Survey**

  Activities include:

  1. Study of Project Area
  2. Evaluation and Analysis of the Proposed Project
  3. Scope of Proposed Project

- **Task 2: Requirement Hathering and Analysis**

  Activities include:

  1. Gather User Requirement
  2. Analyze Real Time Situation
  3. Decide System Requirements(Consider OS,and other developer's Requirements)

- **Task 3: Design and Modeling**

  Activities include:

  1. Design Structure of Proposed System
  2. Design input and output of the Proposed System
  3. Design Modules required and interfaced between modules
  4. Design User Requirement Diagram
  5. System Diagram

- **Task 4:**

  Activities include:

  1. Developed database and tables needed for system
  2. Developed the GUI for wearable module
  3. Backend connectivity and coding

- **Task 5:**

  Activities include:

  1. Installation of product
  2. Testing of modules
  3. Bug Correction
  4. Re-testing

Chapter 6: System Design

6.1 Use Case Diagram

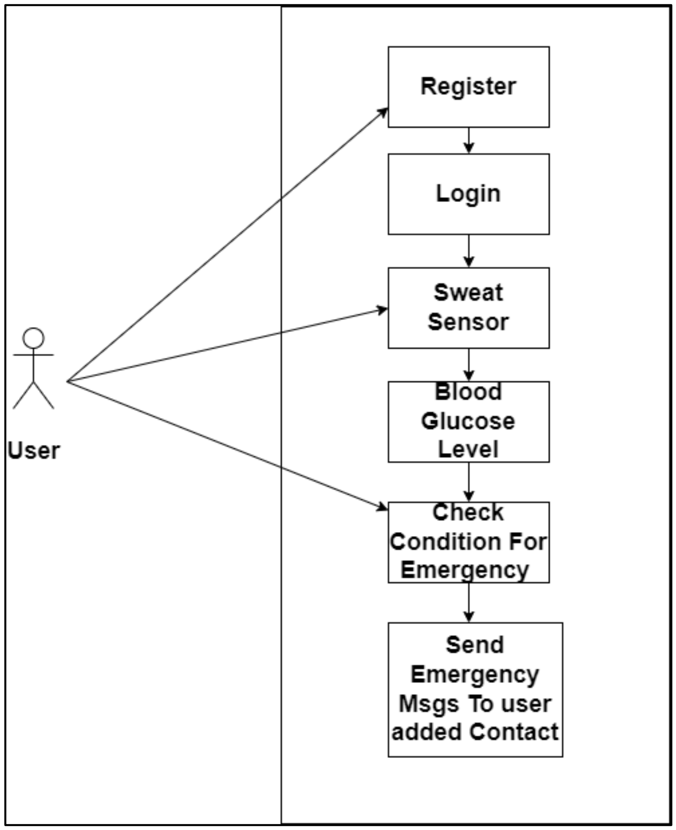

Figure 6.1: Use Case Diagram

UML Diagram we have user who needs to register first and then user can have their login. Sweat sensor send input as blood in this case if user reach lower Count then It sends messages to contact number that user have register

6.2 Data Flow Diagram

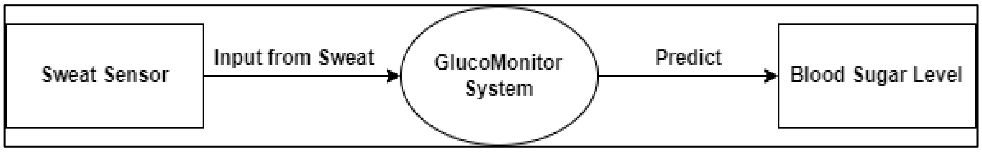

Figure 6.2: Data Flow Diagram

It Shows the Simple architecture of our idea In DFL We have sweat sensor which gives input to glucomonitor and then show it on user login page.

6.3 State Diagram

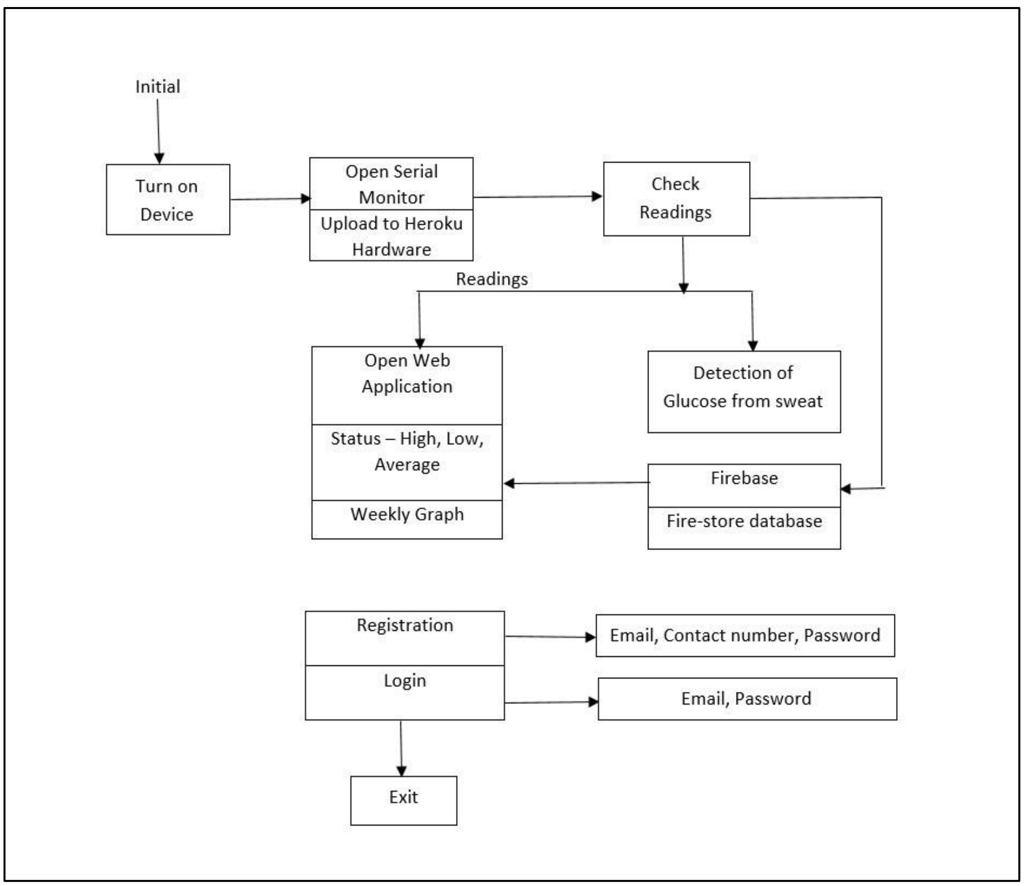

Figure 6.3: State Diagram

6.4 System Architecture

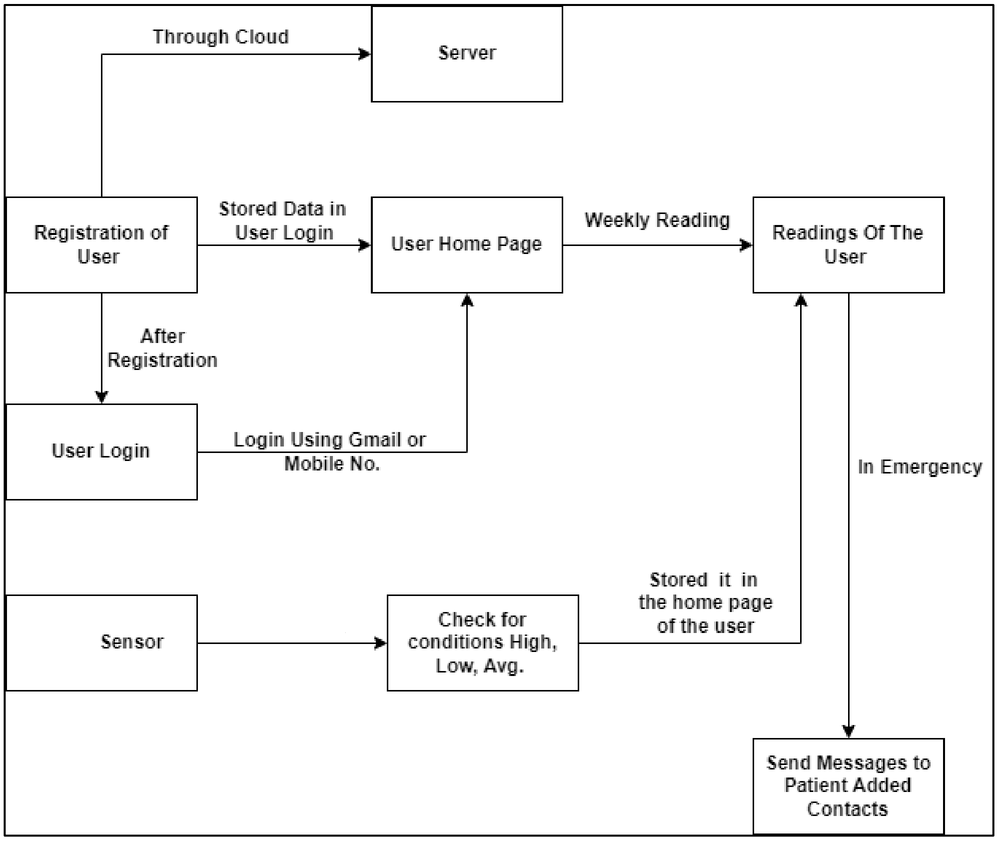

Figure 6.4: System Architecture

- **Registration:** Firstly user will register in our system, for registration user add details like name, username, contact, height, weight, age, email, address and the preferred contact number.

- **Login:** After registration user have to login into the system using Gmail or Mobile number and user will redirect to user home page.

- **Sweat Sensor:** Sweat sensor which gives input to glucomonitor and then show it on user login page.

- **User Readings:** On the user's Home page, user reading are available. These readings are in the form of graph of Blood Sugar Level like Weekly Blood Sugar Level.

- **Conditions:** User readings are stored in the home page of the user these readings are used to check for conditions like High, Low and Average.

- **Messages:** Using the user readings, it check condition such as if Low, High and Average in this case if user reach Lower Count then, it sends messages to contact number that user have register at the time of registration.

6.5 Schematic diagram:

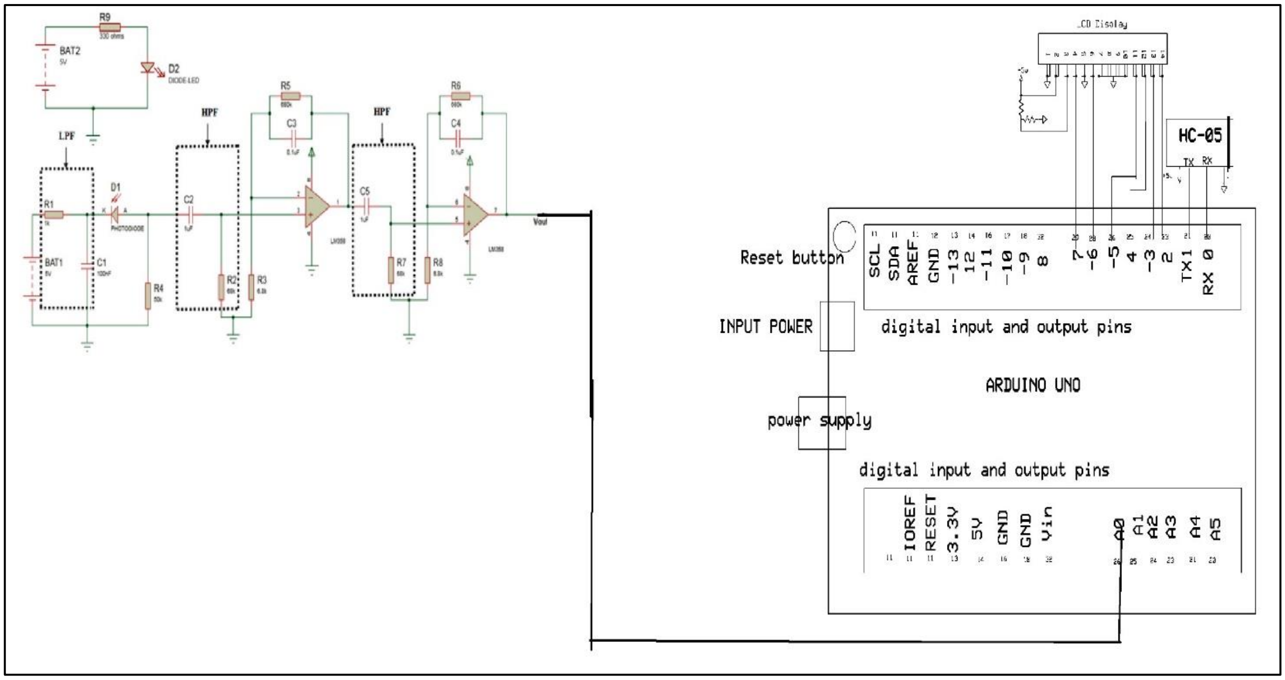

Figure 6.5: Schematic diagram of glucometer

The above schematic diagram of **glucometer** explains the interfacing section of each component with micro controller. The circuit diagram of the designed system consists of filtering stage and amplification stage as shown in figure 3. The electrical current obtained from the photo detector is converted into the voltage by placing the load resistance R4= 50kΩ at the anode side of photodiode. The cut-off frequency of high pass filter and low pass filter are designed as 2.34 Hz and 1.59 kHz respectively. The amplified output voltage is connected to analog pin A0 of Arduino due microcontroller for converting the analog signal into digital values. This digital value corresponds to the glucose level. From this digital value, the actual glucose level is determined using polynomial regression equation. This equation is formed from the glucose levels obtained from the laboratory using invasive measurement. A mobile app is created for displaying and storing the predicted glucose value. Bluetooth module (HC-05) is connected at 0,1 pins of Arduino uno microcontroller in order to communicate with the mobile app via Bluetooth. Once the mobile app is connected to the microcontroller via Bluetooth, the glucose value will be displayed in the mobile app screen. As well as this system monitoring this data on LCD connected at 2 to 7 pins of Arduino respectively.

Chapter 7: Feasibility Study

7.1 Introduction to Feasibility Study:

The feasibility study for the "Real-time Prediction of Sugar Level using Sweat through Blood Sugar Level Band" project evaluates its viability and potential success. This study aims to assess technical, operational, economic, and schedule feasibility, analysing the device's capability to predict blood sugar levels from sweat components. It seeks to determine market demand, technological challenges, financial viability, and user acceptance to gauge the project's potential for development and implementation.

7.2 Economical Feasibility:

The economic feasibility analysis aims to evaluate the financial viability and benefits of implementing the Blood Sugar Level Band project. This assessment explores the project's potential returns on investment, cost-benefit analysis, and overall financial impact.

Development Costs:

Hardware: Estimation of costs related to the acquisition of sensors, microcontrollers, and manufacturing expenses.

7.3 Time Feasibility:

The project aims to create a system capable of predicting sugar levels using a wearable blood sugar level band. The time feasibility study evaluates the project's practicability concerning the anticipated time required for development, testing, and deployment.

Project Phases:

- Research and Planning: Understanding existing technologies, planning system architecture, and feasibility assessment.
- Design and Prototyping: Creating wireframes, algorithms, and initial prototypes for system functionality.
- Development: Building the software and hardware components, integrating algorithms, and refining the system.
- Testing: Thoroughly testing the system for accuracy, reliability, and usability.

- Deployment: Implementing the solution, user training, and ensuring seamless functionality.

Time Estimation:

- Research and Planning: 4 weeks
- Design and Prototyping: 6 weeks
- Development: 16 weeks
- Testing: 4 weeks
- Deployment: 4 weeks

Chapter 8: Project Implementation

8.1 Overview of Implementation

Diabetes is a very common disease affecting individuals worldwide. Diabetes increases the risk of long term complications including heart disease, and kidney failure among others. People might live longer and lead healthier lives if this disease is detected early. Different supervised machine learning models trained with appropriate datasets can aid in diagnosing the diabetes at the primary stage. The goal of this work is to find effective machine learning based classifier models for detecting diabetes in individuals utilizing clinical data. The machine learning algorithms to be trained with several datasets in this article include Decision tree (DT), Naive Bayes (NB), k-nearest neighbor (KNN), Random Forest (RF), Gradient Boosting (GB), Logistic Regression (LR) and Support Vector Machine (SVM).

We have applied efficient pre-processing techniques including labelencoding and nor- malization that improve the accuracy of the models. Further, using various feature selection approaches, we have identified and prioritized a number of risk factors. Extensive experiments have been conducted to analyze the performance of the model using two different datasets. Our model is compared with some recent study and the results show that the proposed model can provide better accuracy of 2.71and the adopted ML algorithm. Finally, a machine learning algorithm showing the highest accuracy is selected for further development. We integrate this model in a web application using python flask web development frame-work. The results of this study suggest that an appropriate preprocessing pipeline on clinical data and applying ML-based classification may predict diabetes accurately and efficiently.

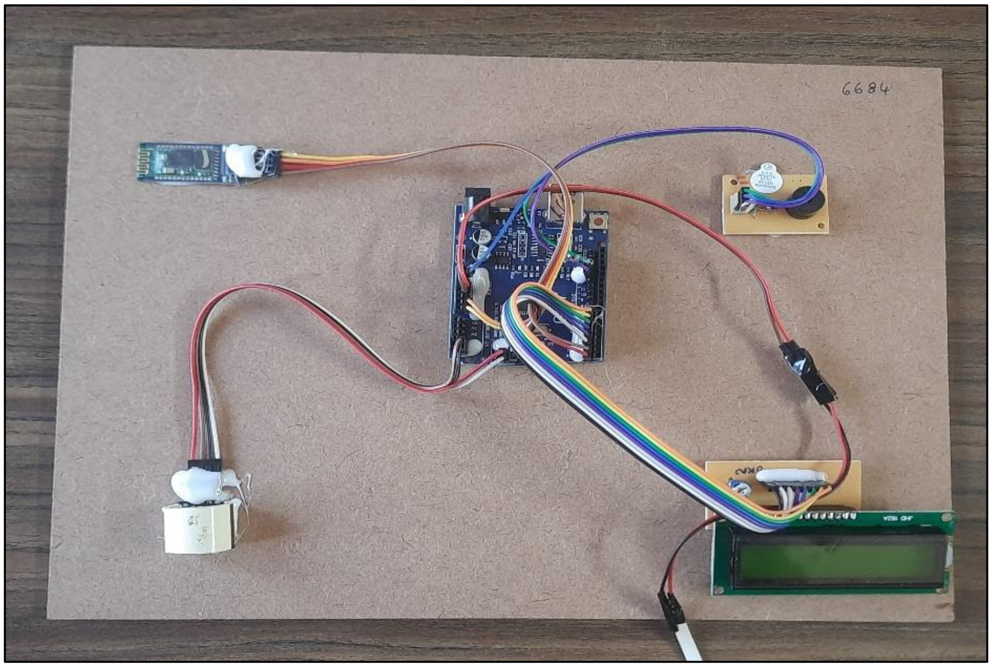

Figure 8.1: Hardware Model

8.2 Tools and Technologies Used

Python

Python is an interpreted, object-oriented, high-level programming language with dynamic semantics. Its high-level built in data structures, combined with dynamic typing and dynamic binding, make it very attractive for Rapid Application Development, as well as for use as a scripting or glue language to connect existing components together. Python's simple, easy to learn syntax emphasizes readability and therefore reduces the cost of program maintenance. Python supports modules and packages, which encourages program modularity and code reuse. The Python interpreter and the extensive standard library are available in source or binary form without charge for all major platforms, and can be freely distributed.

NodeJS

Node (or more formally Node.js) is an open-source, cross-platform runtime environment that allows developers to create all kinds of server-side tools and applications in JavaScript. The runtime is intended for use outside of a browser context (i.e. running directly on a computer or server OS). As such, the environment omits browser-specific JavaScript APIs and adds support for more traditional OS APIs including HTTP and file system libraries.

Heroku

Heroku is a container-based cloud Platform as a Service (PaaS). Developers use Heroku to deploy, manage, and scale modern apps. Our platform is elegant, flexible, and easy to use, offering developers the simplest path to getting their apps to market. Heroku is fully managed, giving developers the freedom to focus on their core product without the distraction of maintaining servers, hardware, or infrastructure. The Heroku experience provides services, tools, workflows, and polyglot support—all designed to enhance developer productivity.

Firebase

Google Firebase is a Google-backed application development software that enables developers to develop iOS, Android and Web apps. Firebase provides tools for tracking analytics, reporting and fixing app crashes, creating marketing and product experiment.

- Authentication : Firebase Authentication makes it easy for developers to build secure authentication systems and enhances the sign-in and onboarding experience for users. This feature offers a complete identity solution, supporting email and password accounts, phone auth, as well as Google, Facebook, GitHub, Twitter login and more.
- Realtime Database : The Firebase Realtime Database is a cloud-hosted NoSQL database that enables data to be stored and synced between users in real time. The data is synced across all clients in real time and is still available when an app goes offline.

JavaScript

JSON is an open standard file format and data interchange format that uses human-readable text to store and transmit data objects consisting of attribute–value pairs and arrays. It is a common data format with diverse uses in electronic data interchange, including that of web applications with servers

JSON files : JSON is a language-independent data format. It was derived from JavaScript, but many modern programming languages include code to generate and parse JSON-format data. JSON filenames use the extension .json.

Noninvasive glucose concentration measurement circuit:

The proposed work is based on NIR optical technique. NIR light source of 940 nm wavelength is chosen because it is suitable for measuring blood glucose concentration. The sensing unit consists of NIR emitter and NIR receiver (photodetector) positioned on either side of the measurement site (fingertip).When the NIR light is propagated through the fingertip in which it interacts with the glucose molecule, a part of NIR light gets absorbed depending on the glucose concentration of blood and remaining part is passed through the fingertip. The amount of NIR light passing through the fingertip depends on the amount of blood glucose concentration. The transmitted signal is detected by the photodetector. The output current of the photo detector is converted into voltage signal and then it is filtered and amplified. This amplified signal is fed into Arduino microcontroller. This digital signal is processed by using second order regression analysis to predict the blood glucose value and the blood glucose value is displayed on the LCD display also send this blood glucose value to the APP through BLUETOOTH. So user can check this data by using mobile phone.

Arduino UNO:

The Arduino Uno is a microcontroller board which has ATmega328 from the AVR family. There are 14 digital input/output pins, 6 Analog pins and 16MHz ceramic resonator. USB connection, power jack and also a reset button is used. Its software is supported by a number of libraries that makes the programming easier.

8.3 Methodology/Algorithm

Block chart of the framework chiefly comprise of two sections, one is for the AI part and other is for the continuous glucose, stress, and hydration checking framework. In the AI part initial a data set is given as the information. Then, at that point, it changes the string over to whole number by the course of Pre-handling. The data set is partitioned as two sections: (testing part and preparing part), later pre-handling.

The preparation part is utilized for ensuring that the machine perceives designs in the information. Information is been cross-approved to guarantee better precision and proficiency of the calculation utilized in the preparation the machine.

Testing part is utilized to guarantee how well the machine can anticipate new responses dependent on its preparation part. Different AI calculations and characterization rules are applied. Exactness of every characterization procedure is determined. Strategy with most noteworthy exactness is utilized for the expectation. This is the principle interaction done in AI. In the continuous checking part GSR sensor is utilized to get the perusing from sweat. A regulator utilized for controlling the framework. Here Arduino Uno is utilized as the regulator. Power supply is given to the regulator. GSR sensor is utilized for observing the perspiration. Result of GSR sensor is the skin conductance. Yield from the sensor is simple, to change it over to computerized and simple to advanced converter (ADC) is utilized From the skin conductance the salt level can be estimated. Skin conductance is contrarily corresponding to the salt substance. Conductance is changed over to voltage perusing. GSR sensor is contrarily corresponding to the worth of glucose level. From the voltage acquired sugar level, feeling of anxiety and hydration level can be observed. Salt level is straightforwardly relative to sugar level. The voltage acquired is changed over to the sugar level by utilizing the condition given underneath. The acquired outcomes are put away in cloud .

The glucose level got from the constant observing part utilizing the above condition are applied to the AI part for forecast. GUI is utilized for enter the glucose worth, age and family background of the individual. Later expectation a spring up message is acquired as the result showing chance of diabetes. Based upon the current dataset forecast of diabetes was made. Precision of various grouping type was determined. Best exactness was picked for the expectation. The ROC bend was likewise plotted. In view of the result from sweat sensor the glucose level is determined. The qualities are given to the AI part through GUI and forecasts are made. Spring up message showed and put away outcome in cloud.

SVM:

SVM will not care about the predictions as long as the error is a lesser amount than certain value. This is well known as Principle Maximal Margin. SVR has been viewed as a convex optimization problem because of this maximal margin idea. The commonly used kernel functions in SVR are as follows; Linear, Polynomial, Sigmoid, Radial Basis Function (RBF). The kernel function transforms data from nonlinear space to linear space. The proposed work applies epsilon insensitive SVM regression. For classification and regression, the standard method in ML is the SVM. Classification problems are most commonly done with SVMs. SVMs locate a hyperplane that best divides the data set into two classes. SVM outfits a learning algorithm for identifying subtle patterns in complex datasets. SVR is different from SVM in the way of predicting real values rather than categorizing as a class. SVR recognizes the occurrence of non-linearity in the data and provides a capable prediction model. This technique does not depend on any parameters. SVR depend on kernel functions rather than depending on spreading of the fundamental reliant and autonomous variables. A nonlinear model would be constructed with the permit of SVR without altering the descriptive values, helping in improved version of the resulting exemplary.

Formula:

$$\textbf{Blood Sugar Level} = \textbf{Glucose Level} \div 18.018$$
$$\textbf{mmol/l} = \textbf{mg/dl} \div 18.018$$

Mmol/l = Blood Sugar Level

Mg/dl = Glucose level

8.3.1 Model Execution Steps:

Step 1 : In user login, the admin can be providing credentials for the login process

Step 2 : In admin, the username and password provided to the user for the login purpose

Step 3 : If the user don’t have credentials then user have to register himself/herself

Step 4 : Accepting the input from the user and storing it into database

Step 5 : Accept the readings from sensor for monitoring diabetes

Step 6 : Classify reading from the sensor between less than 60 must be dangerous 61 to 75 LOW, 76 to 200 AVG and 200 and above must be HIGH

Step 7 : Accept the reading for graph of week in which daily Avg readings must be calculated

Step 8 : Showing the user data along with date, time, readings, status and graph in user dashboard

Chapter 9: System Testing

9.1 Test Result

In recent years, extensive research has been conducted on providing non-invasive, in situ, real-time analysis of sweat analyte concentrations. Advancements in fabrication techniques and material science have allowed multiple sensors to be integrated into a single mechanically flexible multiplexed system with on-site circuitry for signal processing and wireless data transmission. Such devices provide an opportunity to better calibrate analytes that are dependent on other parameters (such as the sweat rate dependence of glucose). Combining tailored materials has proven beneficial for enhancing sensor capabilities with high sensitivity, low LoD and large linear range all shown to improve with the increased surface area and porosity provided by, for example, nanofiber and nanoparticle-modified electrodes. Doping non-conductive but highly selective materials with conductive nanoparticles has proven useful for fabricating non-enzymatic electrochemical sensors with superior LoD, sensitivity and stability than enzymatic sensors due to higher specificity

Person	Glucose Level
1	103.63
2	88.24
3	116.96
4	111.11
5	94.22

Table 9.1: Sugar value using this system

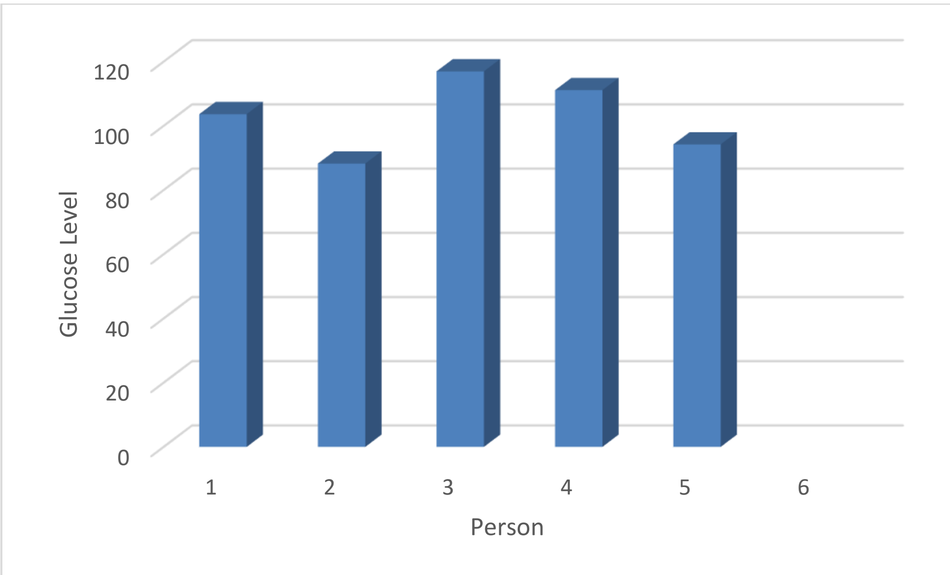

Figure 9.1: Sugar value using this system

Sr. No.	**Existing System**	**Proposed system**
1.	108.45	103.63
2.	95.52	88.24
3.	107.12	116.96
4.	114.63	111.11
5.	104.19	103.45
6.	118.53	120.64
7.	96.53	96.10
8.	130.49	124.3
9.	105.79	108.13

Table 9.2: Comparison of existing and proposed system

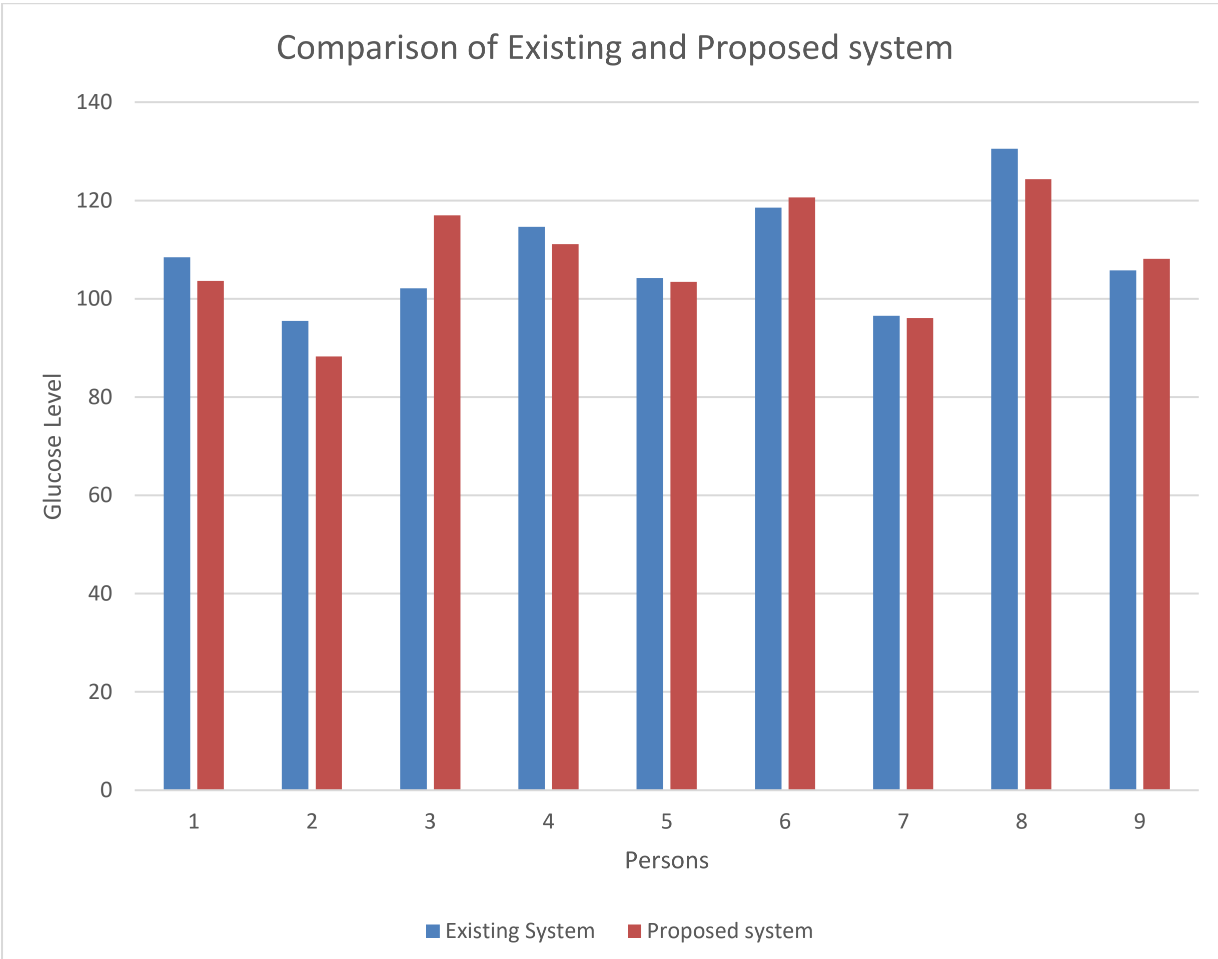

Figure 9.2: Comparison of existing and proposed system

Chapter 10: Results

10.1 Screenshots

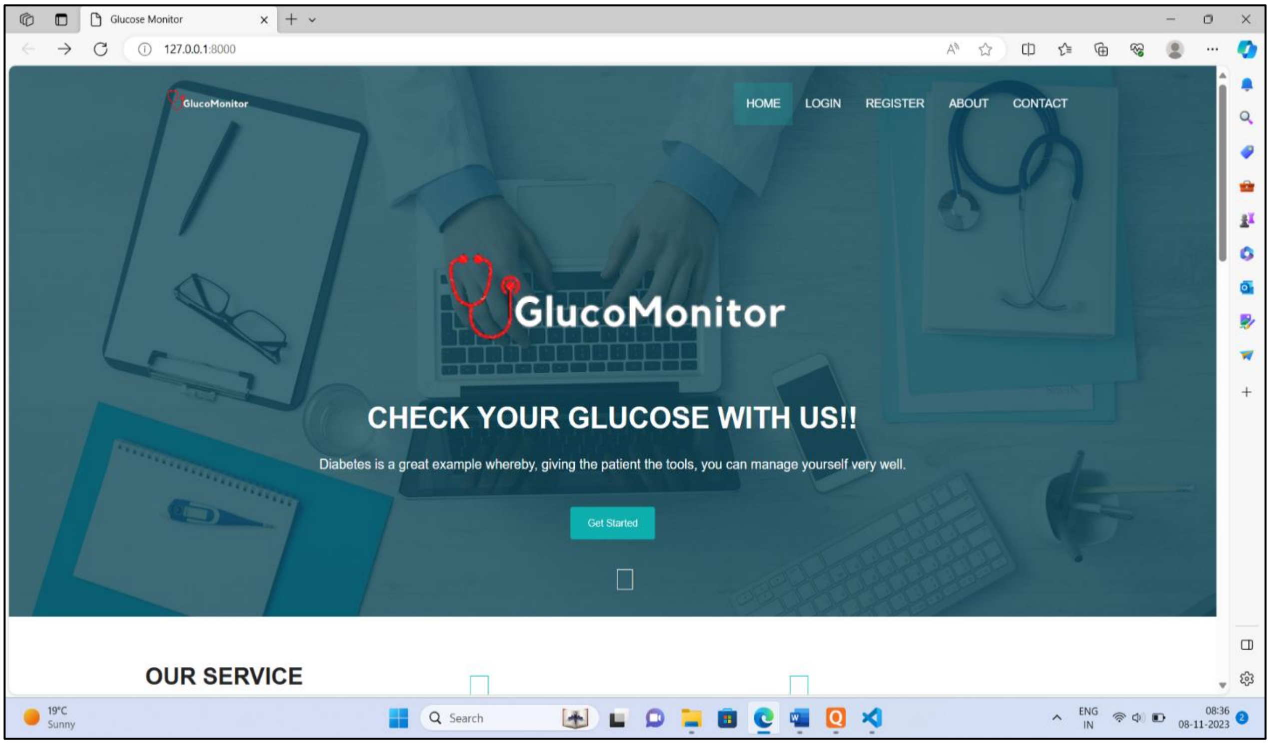

Figure 10.1: Home Page

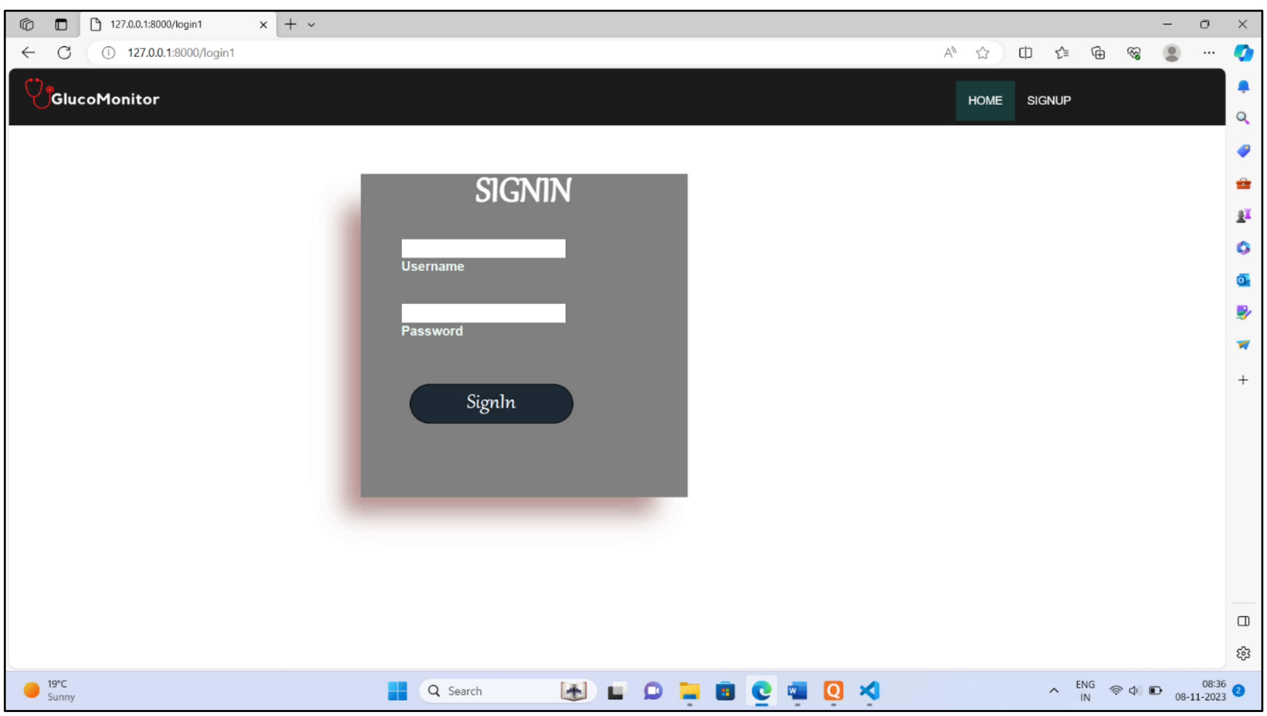

Figure 10.2: SignIn Page

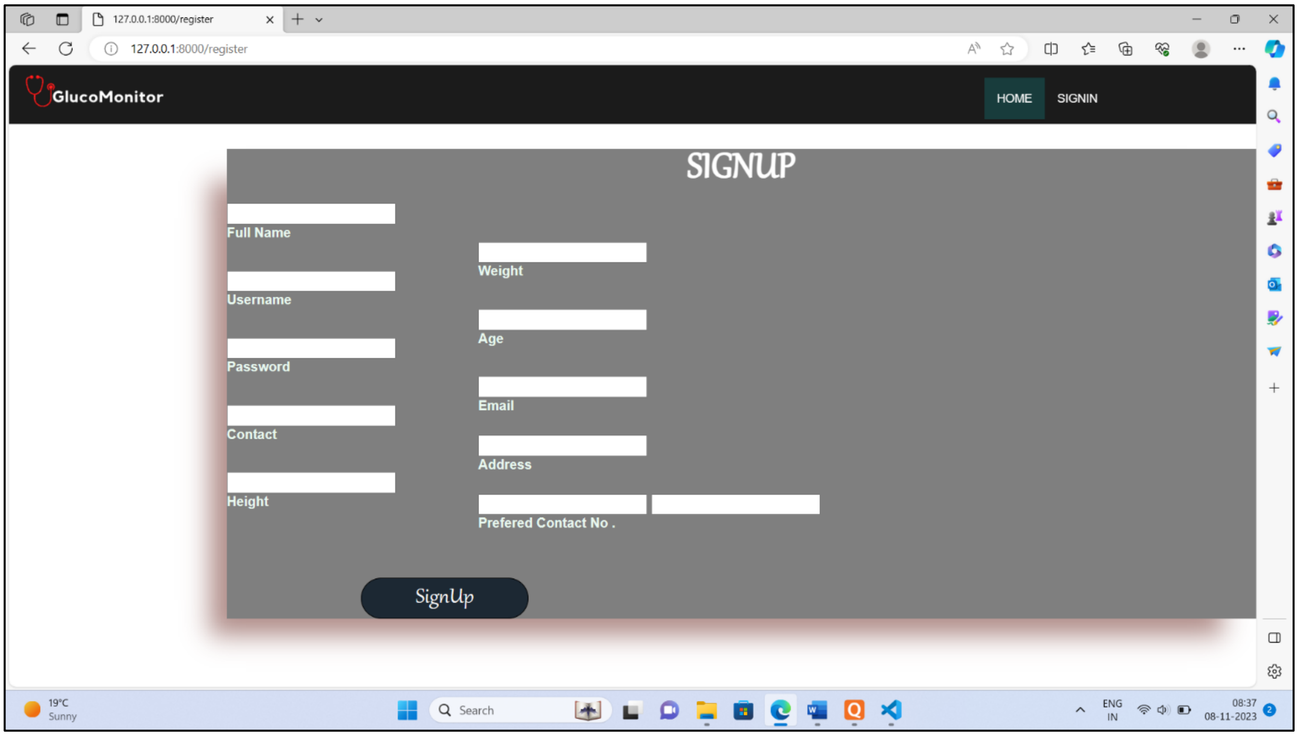

Figure 10.3: SignUp Page

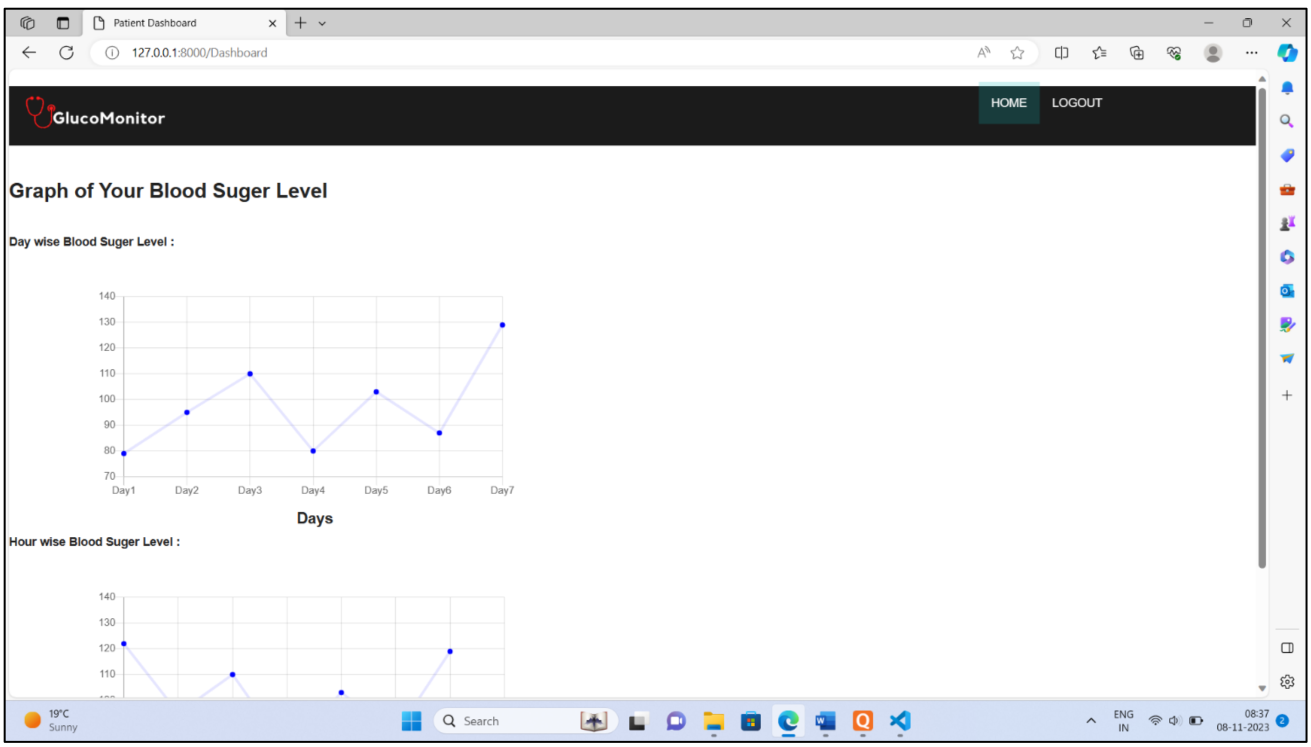

Figure 10.4: Dashboard

10.2 Outputs

Figure 10.5: Serial Monitor

Chapter 11: Conclusion and Future Scope

A Health monitoring network system is presented based on Flutter Apps, which realizes the health monitoring of Multi-Source signals acquired from multi acquisition modules. The experiment shows that the system work effectively and can support multi acquisition devices simultaneously.

Future Scope:

- A suitable and efficient power source need to be revised for the design enhancemnent
- Besides, the accuracy of the device can be further improved in the future. For instance, some precautions and preparations of ECG and body temperature measurement need to be practiced for optimized vital sign reading.

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Appendix B: Actual print of Research Paper

Real time Prediction of Blood Sugar level using Sweat through BSl Band

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Abstract **— We have developed a system which has the capability to provide user feedback through a mobile application by receiving data from the device via Bluetooth. The measurement of proposed physiological parameters was successfully attained with the necessary precision conforming to clinical standards. Diabetic patients have employed glucose monitoring technology for over three decades to monitor their blood glucose levels. This article examines the primary methodologies for detecting blood glucose and implementing intelligent insulin regulation. The most prevalent and extensively used approach involves invasive techniques where users prick their fingers to obtain blood samples. However, recent advancements have introduced numerous innovations for non-invasive blood glucose monitoring, fostering rapid growth in this field. This paper proposes a mobile physical health monitoring system based on the Android smartphone platform. The Android device acquires parameters through Bluetooth communication from each health sensor module and simultaneously presents the monitoring data.**

Keywords— Physical health monitoring system, Bluetooth connectivity, Android app, health sensors, Blood Glucose level, IoT Technology.

I. INTRODUCTION

Advancements in modern technology have facilitated the creation of compact, wireless, and portable health monitoring systems capable of continuous surveillance while remaining power-efficient. These innovations have led to a shift in health monitoring, where wearable body sensors are gaining popularity. Such devices play a vital role in detecting anomalies, unforeseen situations, and even forecasting potential symptoms based on monitoring physiological parameters [1]. Parameters such as heart rate, heart rate variability, and movement data are commonly utilized to gain insights into the physical performance of both professional and amateur athletes [2]. Additionally, the practice of monitoring blood lactate concentration during step ergometer or treadmill tests is prevalent in sports science to gauge the physical capacity of athletes [3].

Diabetes mellitus impacts the body's capacity to regulate blood sugar levels. Individuals managing diabetes routinely track their blood glucose levels (preferably maintaining between 70 to 180 mg/dL, influenced by dietary intake) using medication, exercise, and a balanced diet. Levels below 70 mg/dL suggest potential hypoglycemia, while levels above 180 mg/dL may indicate clinically significant hyperglycemia [1], [3]. Regular monitoring empowers those with diabetes to take necessary actions in adjusting their blood glucose levels, thereby reducing the risks associated with both low and high blood sugar levels. In addition to plasma glucose measurement, finger-prick testing using glucose strips and accompanying meters remains the most dependable method for self-monitoring. A glucose meter consists of a testing strip coated with enzymes (such as glucose oxidase, glucose dehydrogenase, and hexokinase) and a detecting apparatus.
When blood is applied to the strip, the enzymes react with the glucose, initiating an electrochemical reaction that produces a current proportional to the concentration of glucose [4]. There are four primary types of diabetes: Type 1, Type 2, pre-diabetes, and gestational diabetes. Type 1 diabetes occurs due to the immune system's destruction of the pancreas's beta cells responsible for producing insulin. Inadequate insulin leads to elevated blood glucose levels, potentially causing dehydration, weight loss, diabetic ketoacidosis, and adverse effects on various body parts, predominantly affecting teenagers and adults. Type 2 diabetes, more common among adults, involves the loss of sugar regulation in the body, impacting organs like the kidneys, heart, eyes, feet, liver, etc. Blood glucose monitoring is crucial to observe glucose levels in the blood, with various causes leading to diabetes such as bacterial infections, toxins in food, autoimmune responses, unhealthy habits, aging, family history, overweight, pancreatic conditions, PCOS, Cushing's syndrome, glucagonoma, steroid-induced diabetes [5]. Monitoring blood glucose levels involves invasive and non-invasive methods. Invasive methods puncture the skin for blood, while non-invasive methods do not. Diabetic patients often need to monitor their glucose levels regularly, as levels fluctuate. However, the necessity of pricking the skin for blood, especially when insulin intake is required, poses a painful task that many patients avoid, leading to inadequate medication adherence [5].

II. METHODS

A. *Existing Method*

Diabetes risk assessment traditionally relies on familial history and certain diabetes indicators. Professionals estimate the likelihood of diabetes based on genetic predisposition, suggesting a 50 percent chance if one parent has diabetes and a 75 percent chance if both parents are affected. Individuals over 30 are recommended to undergo regular testing to determine the likelihood of diabetes [6]. Blood glucose levels are typically monitored using invasive methods, involving glucometers that require a small amount of blood from a finger prick. This method involves checking glucose levels regularly, which can lead to complications and other health issues due to repeated invasive procedures [7].

B. *Subjects*

Forty individuals in good health (35 males and 5 females) willingly took part in this study, which formed part of a sports clinical assessment. To qualify for participation, athletes needed to be of legal age and free from pre-existing cardiovascular conditions. Their fitness levels ranged from recreational athletes (35 individuals) to professional long-distance runners (5). The participants' ages ranged from 18 to

61, with an average age of 39.9 ± 12.5 years. The mean body height was measured at 180.3 ± 7.9 cm, and the mean body weight was 80.9 ± 12.7 kg. Gender was not distinguished in the lactate diagnostics phase. Prior to data collection, all participants were briefed about the study's objectives and procedures, and written consent was obtained from each individual. The study received approval from the local Ethics Commission at the Friedrich-Alexander University Erlangen-Nuremberg [8].

C. *Exercise Protocol*

Participants arrived at the testing facility well-rested and adequately hydrated. Before commencing the sports clinical assessment, essential metadata such as age, height, weight, and details regarding the participants' fitness levels were documented. They engaged in exercise using an electromagnetically controlled cycle ergometer, gradually increasing the workload until reaching their maximum capacity. Before starting the protocol, participants were equipped with a 12-channel ECG Custo Diagnostic (Custo Med, Ottobrunn, Germany) featuring adhesive electrodes, along with a respiratory gas monitoring system, Cortex Metasoft Studio, which included the Metalyzer 3B-2014 (Cortex, Leipzig, Germany). Continuous measurements of heart rate and respiratory gases were collected during the exercise. Baseline data was collected while participants were at rest. The exercise began with participants cycling at 50 W, and the workload increased by 25 W every two minutes. Participants had the liberty to halt the exercise at any point if they felt they had reached their maximum capacity [9]. The maximum workload achieved by any participant was 375 W. The count of participants reaching each stage of the exercise protocol was recorded.

III. RELATED WORK

A wearable sensor serves to collect various physiological data, such as blood glucose levels, and transmits this information wirelessly to a smartphone. Subsequently, it transfers the data to a cloud server for storage within an Electronic Health Record (EHR) [10]. A reliable data manager oversees incoming calls from different applications, validating them against set criteria. To ensure the reliability of Medical Monitoring Applications (MMAs), Health Device Beta (dev β) tools have been proposed for developer use. Security validation involves spatial-temporal modeling through hybrid automata (STHA). Body Sensor Network (BSN) technology is pivotal in the Internet of Things (IoT) healthcare system, enabling patient monitoring via tiny, lightweight sensor nodes. This modern healthcare system based on BSN meets various requirements including safety, sustainability, and security. Security assurance for any control input from MMAs is attained by verifying it against a hybrid automata-based model. Time-Division Multiplexing (TDM) supported sensors ensure long-term availability with a sustainable design. Data collected by different applications are stored in a secure database accessible only to authorized applications. Physiology-based end-to-end security (PEES) establishes a secure communication channel directly between the sensor and the medical cloud [11]. Wireless Sensor Network (WSN) nodes offer diagnostic capabilities and networks large enough for comprehensive analysis, but they may incur significant deployment costs. Frameworks like UPHIAC (Ubiquitous Personal Health Information Access) and PRISM (Platform for Remote Sensing Using Mobile Devices) ensure health data security through Application Programming Interfaces (APIs) that link smartphone sensors with cloud data storage. The Inevitable Health Management System (IHMS) facilitates dynamic adjustments in user context due to mobility. Hierarchical Power Management (HPM) architecture ensures consistency by integrating ultra-low-power processors. The goal is to streamline the interface between various external sensors and client Android devices. Smartphones can connect to external sensors via wired or wireless channels, simplifying device interaction, which can be complex when a single application needs to integrate with multiple sensors using different communication channels and data formats. A framework aims to streamline this interface between various external sensors and client Android devices, emphasizing usability, simplicity, and ease of deployment [12].Blood glucose measurements utilize electrical conductivity measurement, where the conductivity of a sweat sample indicates its ability to conduct electricity, correlating sodium content from sweat to a voltage measurement. The sugar level correlates with voltage ranges using an interpolation equation. Electrical conductivity between two plate electrodes separated by a fixed distance measures the solution's conductivity. Copper, while offering high tensile strength, is commonly used for electrical contacts and electrodes despite its inferior oxidation resistance. It is alloyed with graphite, tellurium, and tungsten to produce brass and bronze for various applications due to its strength and conductivity.

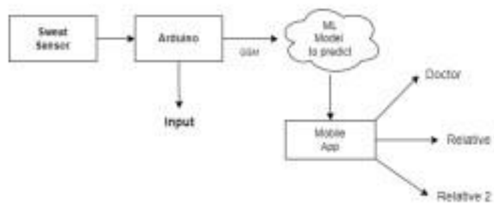

Figure No. 1: Basic Architecture

IV. LITERATURE SURVEY

N. Sneha and Tarun Gangil (Sneha 2019) explored the fundamental aspects of diabetes, focusing on prevalence rates among different populations. Their study discussed causes, impacts, and various testing methodologies including decision trees, Naïve Bayes, support vector machines, random forests, and k-nearest neighbors. To simplify diabetes complexity and enhance people's lives, they gathered a dataset from the UCI machine repository, divided it for training and testing, applied different algorithms, calculated correlation values, and plotted ROC curves. Their findings showed increased accuracy in various algorithms when correlation values were computed. Specifically, Support Vector Machine (SVM) achieved 77.73% accuracy, while Naïve Bayesian reached 73.48%. However, an improved SVM accuracy of 77% and a Naïve Bayesian accuracy of 82.30% proved most effective in identifying diabetic and non-diabetic patients, with SVM indicating a disease prevalence rate of 45.7%.[19]

Hyunjae Lee and Changyeong Song (Hyunjae 2017) developed a non-invasive glucose monitoring system focusing on sweat collection. Their method involved a multi-layered patch design and sensor miniaturization to enhance sweat collection efficiency and sensing accuracy. They emphasized the relationship between pH, temperature, humidity, and accurate sensing, utilizing a wearable patch-based system for non-invasive sweat glucose monitoring. This system incorporated humidity sensors to monitor sweat collection via impedance change and glucose sensors for sweat analysis. The wearable patch remained reliable across different skin temperatures, absorbing sweat before connecting to hardware for analysis.[12]

K. Nivetha, N. Ramya, and R. Thendral (Ramya 2018) proposed a non-invasive blood glucose monitoring technique using sweat, focusing on the dissolved particles between two copper electrodes. They discussed normal glucose levels for diabetic individuals, comparing the invasive and non-invasive glucose monitoring methods. Their hardware setup included copper electrodes, an Arduino UNO, and an LCD display. By measuring conductivity, they estimated salt levels, considering low salt content's correlation to low glucose levels.[18]

Wira Hidayat bin Mohd Saad and Muhd. Shah Jehan Abd (Shah Jehan) introduced a low-power wearable system for continuous blood glucose level monitoring using a GSR (Galvanic Skin Response) sensor. Their study emphasized the relationship between GSR values and blood glucose levels, employing a circuit with resistors, capacitors, and operational amplifiers. They utilized filters to manage skin resistance variations and noise. Their findings suggested an inverse relationship between GSR and blood glucose levels, where increased calories burned and glucose concentration reduced GSR values.[20]

V. PROPOSED METHODOLOGY

The block diagram of the framework consists of two main sections: the AI component and the continuous monitoring system for glucose, stress, and hydration. In the AI segment, a dataset serves as the input, which undergoes preprocessing to convert strings into integers. This dataset is divided into two parts: training and testing. The training segment allows the machine to recognize patterns in the data, cross-validating to enhance accuracy and efficiency of the algorithms used. The testing section assesses the machine's ability to predict new outcomes based on its training. Various AI algorithms and classification rules are applied, and the accuracy of each classification method is evaluated. The most accurate method is employed for prediction, constituting the primary process in AI. In the continuous monitoring segment, a GSR sensor captures sweat readings, with an Arduino Uno acting as the controller and receiving power supply. The GSR sensor monitors sweat, measuring skin conductance as its output. The sensor output is analog, converted into digital using an Analog-to-Digital Converter (ADC) for ease of processing. Skin conductance inversely correlates with salt content, and this conductance is converted into voltage readings. The GSR sensor's output is inversely proportional to the glucose level. The voltage obtained from the sensor aids in monitoring sugar level, stress, and hydration. Salt level directly corresponds to the sugar level. The voltage readings are converted into sugar levels using a provided formula (Equation 1). The collected results are stored in the cloud [17].

$$((Out-a)/(b-a)) * (c-d) + d \quad (1)$$

Out=Acquire from sensor
a=Minimum voltage b=Maximum
voltage c=Maximum sugar
esteem d=Minimum sugar

The glucose levels obtained from continuous monitoring are utilized in the AI segment for prediction. A Graphical User Interface (GUI) enables input of glucose levels, age, and family history. Following the prediction, a pop-up message displays the likelihood of diabetes based on the existing dataset. Various classification methods' accuracy rates were calculated, and the most accurate method was employed for prediction. Additionally, an ROC curve was plotted to assess the model's performance. Using data from the sweat sensor, glucose levels are estimated. Through the GUI, these values are inputted into the AI segment for predictions. A pop-up message displays the prediction outcome, which is then stored in the cloud [18].

Machine Learning:

The AI component was developed using Python programming language. Python installation was completed, and subsequent to the installation, the core program was developed. Predictions were conducted using both a virtual database and real datasets. In the proposed system, a real database was utilized.

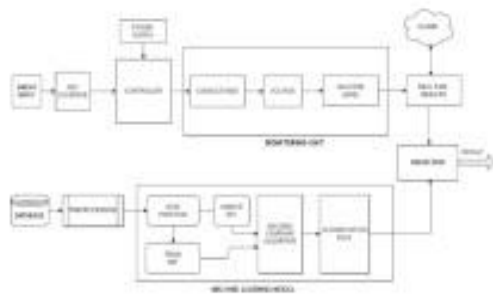

Figure No. 2: Block diagram of proposed system

Virtual database:

The virtual dataset was obtained from the Pima Indians Diabetes Database, containing information such as age, number of pregnancies, glucose levels, blood pressure, skin thickness, insulin, BMI (Body Mass Index), family history of diabetes, and outcomes. This dataset comprises 768 entries across 9 columns. To utilize the entire dataset effectively, it was divided into training and testing subsets.

Real Database:

The real dataset was collected through surveys and collating details from numerous individuals. This database includes information like age, glucose levels, stress levels, sodium intake, weight, height, BMI, family history, and outcomes. The dataset consists of 50 entries spanning 10 columns. To optimize the use of the entire dataset, it was divided into training and testing subsets.

VI. RESULTS AND DISCUSSION

The process begins by detecting and measuring blood glucose levels; initially, a device is responsible for this task and sends the value to a smartphone. The glucose monitoring system connects to the smartphone via Wi-Fi. Following the instructions displayed on the smartphone, a finger is placed inside an NIR sensor equipped with an IR Transmitter and IR Receiver. The sensor detects the pulse rate and determines the blood glucose level, which is then displayed on an LCD and transmitted to the smartphone. Normal human blood glucose levels are typically between 70 mg/dl to 130 mg/dl. The subsequent phase involves administering the required insulin dosage based on the displayed blood glucose value received from the smartphone. The non-invasive measurement estimates the blood glucose level based on the set value from the smartphone. However, it's noted that invasive methods generally offer higher accuracy than non-invasive measurements [19].

This research investigates the presence of ammonium in both blood and sweat during a controlled step ergometer test involving participants with varying fitness levels. This study marks the first attempt, to our knowledge, to directly measure blood and sweat ammonium levels while correlating them with heart rate and blood lactate in a controlled setting, aiming to assess sweat ammonia as an indicator of physical fatigue in wearable devices. Blood lactate concentration rises with physical exertion. As anticipated, professional athletes maintain lower lactate concentrations below the aerobic threshold, indicating a delay in the onset of anaerobic energy pathways compared to untrained individuals. The overall lactate values mirror the subjects' diverse fitness levels, explaining the narrower curves observed in the averaged curve due to earlier exhaustion in subjects with lower fitness levels. Concurrently, blood ammonium concentration also increases with exertion, paralleling the pattern seen in blood lactate. The elevation in blood ammonia during intense exercise is a documented phenomenon linked to the depletion of skeletal muscle ATP during high-intensity workouts. This triggers heightened activity in the Purine-Nucleotide Cycle, leading to increased turnover from AMP to IMP and subsequently higher concentrations of muscle and blood ammonia. Similarly, blood ammonia levels in well-trained subjects rise later and at higher exertion levels compared to untrained individuals, aligning with the patterns observed in lactate concentrations during exhaustive exercise. While lactate, ascertainable only through blood tests, cannot be non-invasively measured in sweat, ammonia, as a weak base, follows the pH gradient from plasma to sweat. The significant loss of ammonia through sweat is a notable pathway. Thus, this study delved into sweat ammonia concentration across different exertion levels as an indicator of physical fatigue.

Although sweat ammonia concentrations display wide variability, an overall decrease in ammonia levels with increased exertion is apparent among most subjects [20]. While the measured values exhibit diversity, the consistent decline in ammonia levels is noticeable. Despite the decrease in sweat ammonia with exertion, there's a notable increase in sweat rate. This increase in sweat rate might augment the overall loss of ammonia through sweat, even amidst declining concentrations. Therefore, a logical step would involve integrating an ammonia sensor with a sweat rate sensor to better understand their relationship.

VII. CONCLUSION

Monitoring blood glucose levels in diabetic patients employs innovative glucose-monitoring technology. A non-invasive approach utilizes NIR sensors based on blood flow rates, eliminating the need for blood draws. These sensors detect glucose levels without invasive measures and transmit the data to a smartphone, enabling control over crucial health devices like infusion pumps. This non-invasive method not only enhances patient compliance but also improves the quality of life and overall health of individuals managing diabetes.

Diabetes, being a chronic condition, lacks a definitive method for prevention or cure. Healthcare professionals rely on family history to predict the likelihood of its occurrence, estimating an average probability rate. Early detection greatly benefits individuals, and the increasing significance of AI plays a pivotal role due to its advantages: reduced reliance on human intervention, increased precision, and efficiency. Our proposed system employs AI algorithms to predict the likelihood of diabetes based on various factors such as age, blood glucose levels, and family history.

Using invasive methods for glucose prediction yields multiple results, prompting the use of non-invasive techniques for monitoring glucose levels. Furthermore, an individual's anxiety and hydration levels can be inferred from sweat. The IoT concept facilitates storing these results in the cloud. As AI and IoT technologies continually advance, these initiatives will garner more attention and support, offering increased value and fostering further development.

VIII. ACKNOWLEDGMENT

We would like to convey our gratitude to Mr. Sachine Kamble for sharing their pearls of wisdom with us during this work.

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We would like to inform you that your paper titled **"Real time Prediction of Blood Sugar level Using Sweat Through BSL Band"** has been accepted for publication in **International Journal of Computer Engineering and Technology (IJCET), Volume 15, Issue 3, (May-June 2024)** issue of the journal based on the Recommendation of the Editorial Board without any major corrections in the content submitted by the researcher.

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