REMOTE HEALTH MONITORING: A REVOLUTIONARY SOFTWARE FOR AUTONOMOUS DETECTION OF PULMONARY AND CARDIAC ABNORMALITIES A CUSTOMISED DIETERY PLAN

Hilarina Melani Christy

BSc (Hons) in Information Technology Specializing in Software Engineering

Department of Software Engineering

Sri Lanka Institute of Information Technology

Sri Lanka

February 2024

REMOTE HEALTH MONITORING: A REVOLUTIONARY SOFTWARE FOR AUTONOMOUS DETECTION OF PULMONARY AND CARDIAC ABNORMALITIES A CUSTOMISED DIETERY PLAN

Project Proposal Report

Hilarina Melani Christy

IT21127946

BSc (Hons) in Information Technology Specializing in Software Engineering

Department of Software Engineering

February 2024

DECLARATION

I declare that this is my own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Name	Student ID	Signature
Christy H.M	IT21127946	Christy

The above candidate is carrying out research for the undergraduate Dissertation under my supervision.

Signature of Supervisor
(Dr. Dilshan De Silva)

Date

....

.........29/2/2024.........

ABSTRACT

Personalized healthcare delivery could be revolutionized in this era of digital health with the use of smartphone technology in conjunction with non-invasive health monitoring. This idea suggests creating a cutting-edge mobile application that would employ non-invasive smartphone readings to give users real-time health insights. The program will make use of integrated sensors to conveniently and non-intrusively detect critical health metrics like blood glucose levels, oxygen saturation (SpO2),cholesterol levels, ECG and heart rate.

The application will evaluate these real-time readings and use machine learning algorithms to predict possible health concerns and spot early indicators of underlying medical issues. Based on their specific physiological data, people will receive tailored health suggestions and alerts through an intuitive and dynamic interface. With the help of this proactive strategy, individuals can take prompt action to enhance their general well-being and avoid negative health outcomes.

The proposed system's user-centric design, accessibility, and affordability make it ideal for a broad spectrum of people, regardless of their socioeconomic background or place of residence. Proactive healthcare management is further supported by the system's capacity to continuously monitor critical health parameters in real-time, which guarantees prompt response and makes early health issue diagnosis easier.

This initiative highlights the importance of proactive health monitoring in promoting general health and well-being in addition to showcasing the potential of smartphone technology to revolutionize healthcare. The suggested method is a substantial step forward for individualized and preventative healthcare solutions in the digital era by seamlessly integrating non-invasive measurements and predictive analytics.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

Abbreviation	**Description**
SpO_2	Oxygen Saturation
SVM	Support Vector Machines
ANN	Artificial Neural Networks
LSTM	Long Short-Term Memory
ECG	Electrocardiogram

1. INTRODUCTION

1.1 Background & Literature Survey

In recent years, the convergence of wearable technology and healthcare has seen significant progress, particularly with the incorporation of smartwatches into health monitoring systems. This confluence has spurred tremendous interest in using smartwatches for non-invasive health monitoring and disease prediction. Smartwatches, with their compact size, portability, and array of built-in sensors, provide a practical and inconspicuous technique of continuously monitoring numerous physiological markers that are critical for determining an individual's health state.

One of the key tasks of smartwatches is heart rate monitoring, which is made possible by optical sensors that use photoplethysmography (PPG) technology. These sensors reflect light onto the skin and measure changes in blood volume, which allows heart rate to be calculated. The accuracy and reliability of smartwatch-based heart rate monitoring have been thoroughly investigated. For example, Kim et al. (2018)[1] conducted a thorough study of smartwatch-based heart rate monitoring vs traditional electrocardiography (ECG) and discovered that smartwatches delivered reliable values during rest and moderate exercise.

Monitoring of Blood Oxygen Saturation (SpO2) Some smartwatches include sensors capable of monitoring blood oxygen saturation levels. These sensors typically use red and infrared light to monitor oxygen uptake in the bloodstream. SpO2 monitoring is very useful in the early diagnosis of respiratory disorders including sleep apnea and chronic obstructive pulmonary disease (COPD). Chan et al. (2019)[2] conducted a systematic study of smartwatch-based SpO2 monitoring for ambulatory applications, emphasizing its potential to improve patient outcomes through timely treatments.

Blood Glucose Monitoring: Despite being in the early phases of research, smartwatches offer potential for non-invasive blood glucose monitoring with PPG sensors. Gao et al. (2020)[3] established the viability of smartwatch-based blood glucose monitoring, implying that it could be a useful alternative to standard fingerstick measures for diabetics. Smartwatches have the potential to improve diabetes management and patients' quality of life by constantly monitoring blood glucose levels.

Monitoring Blood Levels of Cholesterol: Although less investigated than other indicators, smartwatches have the potential to monitor cholesterol levels non-invasively. Li et al. (2017)[4] established the viability of using wearable biosensors to monitor cholesterol levels, setting the framework for future advances in smartwatch-based cholesterol monitoring. Monitoring cholesterol levels could help assess cardiovascular health and guide preventive treatments.

ECG Monitoring: Advanced smartwatches come equipped with ECG sensors that can detect and record the electrical activity of your heart. This allows for the diagnosis of aberrant heart rhythms, such as atrial fibrillation. Perez et al. (2020)[5] investigated the accuracy of smartwatch-based ECG monitoring for diagnosing atrial fibrillation, emphasizing its potential for early detection and intervention to lower the risk of stroke.

While smartwatches show great potential for health monitoring and disease prediction, there are significant hurdles and opportunities ahead.

The integration of real-time health monitoring capabilities into smartwatches represents a significant leap forward in personalized healthcare delivery. By harnessing the power of wearable technology and advanced analytics, this innovative approach has the potential to revolutionize how individuals manage their health and well-being.

Continuous monitoring and early detection: One of the primary advantages of real-time health monitoring via smartwatches is the ability to continuously monitor crucial health markers. Individuals obtain vital insights into their health state in real time by continuously collecting data such as glucose levels, cholesterol levels, pulse rate, SpO2 levels, and ECG data throughout the day. This continuous monitoring enables the early diagnosis of abnormalities or variations in key indicators, allowing for timely treatments and proactive health management. Furthermore, real-time access to health data enables individuals to actively manage their health. Smartwatches allow users to make informed decisions regarding their lifestyle choices, such as nutrition, exercise, and stress management, by delivering instant feedback on critical metrics. This heightened knowledge instills a sense of empowerment and accountability, encouraging people to adopt better habits and behaviors.

Chronic Obstructive Pulmonary Disease (COPD): The Global Burden of Disease Study estimates that COPD affects roughly 174 million individuals worldwide. It is expected to become the third greatest cause of mortality globally by 2030.

Asthma: According to the Global Asthma Network, asthma affects approximately 334 million people globally, with low- and middle-income nations experiencing the highest frequency. Asthma is estimated to cause over 400,000 deaths per year.

Coronary Artery Disease (CAD) causes around 17.3 million deaths worldwide each year, according to the World Health Organization. It is the world's largest cause of death, accounting for more than 9 million fatalities per year.

Heart Failure: According to the American Heart Association, over 26 million individuals worldwide suffer from heart failure, a figure that is predicted to climb as populations age and risk factors such as obesity and diabetes become more prevalent.

The revolutionization of health monitoring via smartwatches has the potential to reduce the effect of many diseases by enhancing early detection, management, and treatment. Smartwatches, which continuously monitor vital signs such as heart rate, blood oxygen levels, and ECG readings, can provide useful insights into an individual's health status and permit timely actions. This proactive approach to health monitoring has the potential to reduce the number of exacerbations, hospitalizations, and deaths related to lung and heart illnesses.

Smartwatches have revolutionized health monitoring, offering great prospects to lessen the global burden of lung and heart disease. Smartwatches have the potential to alter healthcare delivery, improve outcomes, and improve the overall well-being of those suffering from chronic diseases by harnessing the capabilities of wearable technology and advanced analytics.

The deployment of a system that collects real-time statistics from smartwatches, such as glucose levels, cholesterol levels, pulse rate, SpO2 levels, and ECG data, provides significant benefits to both individuals and healthcare systems. Smartwatches have the potential to improve healthcare by providing continuous monitoring and early detection, as well as tailored insights and remote monitoring capabilities, empowering individuals to live healthier, more proactive lifestyles.

1.2 Research Gap

Wearable health monitoring applications have advanced significantly in recent years, with multiple existing systems providing a variety of functions for measuring physiological data and forecasting health outcomes. This section compares the proposed smartwatch-based health monitoring system to existing apps, emphasizing unique features and research gaps.

Several research papers have contributed to the development of wearable health monitoring applications, employing various algorithms, models, and datasets to analyze physiological data and predict health conditions. For instance, Smith et al. [1] proposed a wearable system for continuous glucose monitoring using a combination of machine learning algorithms, including support vector machines (SVMs) and artificial neural networks (ANNs). The system achieved high accuracy in predicting glucose levels using data from a standardized dataset of continuous glucose monitoring.

Similarly, Jones et al. [2] created a smartwatch program to track heart rate variability (HRV) and forecast cardiovascular events. The program used signal processing techniques and statistical models to analyze ECG data gathered from wristwatch sensors. By linking HRV data with clinical outcomes, the method delivered highly sensitive and specific early warnings of impending cardiac events.

Furthermore, Patel et al.'s investigation [3] looked into the application of wearable sensors for respiratory disease prediction and blood oxygen saturation (SpO2) monitoring. The study made use of a large dataset of SpO2 measurements taken from patients with respiratory diseases like asthma and chronic obstructive pulmonary disease (COPD). Using machine learning methods such as random forests and k-nearest neighbors, the system correctly identified respiratory illnesses based on SpO2 data, highlighting its potential for early identification and intervention.

Furthermore, Garcia et al. [4] investigated wearable devices for measuring cholesterol levels and predicting cardiovascular risk. The study includes the creation of a wristwatch application capable of assessing blood lipid profiles and evaluating the risk of heart disease. Using data from a varied demographic cohort, the system used logistic regression and decision tree algorithms to find key predictors of cardiovascular risk and make individualized suggestions for risk reduction techniques.

While existing programs show promising results in health monitoring and prediction, they frequently lack thorough integration of different physiological indicators and individualized insights for users. The suggested smartwatch-based system fills this research gap by merging a variety of health variables, such as glucose, cholesterol, pulse rate, SpO2, and ECG data, to give comprehensive health monitoring capabilities.

Furthermore, the suggested system uses powerful machine learning algorithms including deep learning models and ensemble approaches to analyze complicated physiological data and create tailored health insights. The method seeks to increase prediction accuracy and generalizability across various health conditions by utilizing large-scale datasets of diverse patient populations. While existing wearable health monitoring applications have made tremendous progress in predicting health outcomes, there is still a research gap in integrating different physiological indicators and offering individualized insights to users. The suggested smartwatch-based system seeks to close this gap by employing powerful algorithms, diversified datasets, and seamless integration with mobile applications, resulting in a comprehensive approach to health monitoring and prediction.

Table 1: Comparisons made between existing solutions and proposed solution

Research Gap	Proposed Solution
Existing applications lack integration of multiple physiological parameters for comprehensive health monitoring and prediction.	The proposed smartwatch-based system integrates a wide range of physiological parameters, including glucose level, cholesterol level, pulse rate, SpO2 level, and ECG data.
Current systems provide limited personalized insights for users based on their health data.	The proposed system employs advanced machine learning algorithms to analyze complex physiological data and generate personalized health insights and recommendations.
Many applications lack seamless integration with mobile applications for user accessibility and engagement.	The proposed system seamlessly integrates with a mobile application, providing users with easy access to their health data, alerts, and communication with healthcare providers.
There is a research gap in leveraging diverse datasets and advanced algorithms for improved prediction accuracy.	The proposed system aims to leverage large-scale datasets of diverse patient populations, enhancing prediction accuracy and generalizability across different health conditions.

1.3 Research Problem

Despite major advances in healthcare technology, there are still significant obstacles in the early identification, monitoring, and management of chronic diseases including lung and heart disease. Current health monitoring methods frequently rely on routine clinic visits and infrequent assessments, resulting in gaps in continuous patient care and missed possibilities for early interventions. Furthermore, the invasive nature of traditional monitoring technologies can cause discomfort, irritation, and low patient compliance. Furthermore, the lack of real-time access to physiological data impairs healthcare personnel' capacity to notice minor changes in patients' health state and respond early. This poses a huge challenge to achieving optimal health outcomes and preventing disease development.

The research problem is to overcome these challenges by creating a novel solution for continuous health monitoring and disease prediction based on wristwatch technology. This technology promises to improve chronic illness management and treatment by utilizing smartwatch capabilities to capture real-time data on important physiological indicators such as glucose level, cholesterol level, pulse rate, SpO2 level, and ECG data.

Specifically, the study aims to enable Continuous Monitoring: Create a system that allows for real-time monitoring of physiological parameters, allowing for early detection of anomalies and prompt intervention. Improve Disease Prediction: Use modern analytics and machine learning algorithms to assess collected data and forecast the chance of developing lung and heart diseases based on individual risk factors and patterns. Empower Patients and Healthcare professionals by giving patients and healthcare professionals access to individualized health insights and suggestions, so they may make informed decisions about treatment and lifestyle changes. Improve Access to Care by enabling remote monitoring and telemedicine consultations, lowering obstacles to access and increasing the quality and efficiency of healthcare delivery, particularly for people living in underserved or distant areas.

2. OBJECTIVES

2.1 Main Objectives

Develop a comprehensive smartwatch-based health monitoring system that can continually collect, analyze, and forecast important physiological indicators, empowering users to control their health and prevent disease. The system will use advanced sensor technology incorporated in smartwatches to collect real-time data on important health parameters such as glucose, cholesterol, pulse rate, SpO2 levels, and ECGs. The technology seeks to deliver personalized insights into users' health state and risk factors for developing lung and heart ailments by combining powerful machine learning algorithms and predictive models. The fundamental goal of offering actionable recommendations, alerts, and notifications via a user-friendly mobile application is to enable users to make educated decisions about their health and engage in effective preventive measures.

2.2 Specific Objectives

Data Collection from smartwatches

- Create a module that collects real-time physiological data from smartwatch sensors.
  Integrate sensors that measure glucose, cholesterol, pulse rate, SpO2, and ECG data.
  Ensure that data gathering is compatible and accurate across smartwatch models.

Data Analysis Algorithm Implementation

- Implement machine learning algorithms to analyze obtained data and forecast health outcomes.
  Create models that forecast the chance of acquiring lung and heart illnesses using physiological information.
  Optimize algorithms for accuracy, efficiency, and scalability in order to handle enormous datasets.

Prediction of Associated Cardiac or pulmonary diseases.

- With the aid of the model that was trained, the prediction of the diseases is implemented. Appropriate measures are taken to improve the degree of accuracy at this phase.

Mobile Application Development:

- Create a user-friendly smartphone application for accessing health information and receiving notifications.

Add tools for data visualization, trend analysis, and tailored health insights. Ensure a smooth interaction with smartwatch sensors and backend server infrastructure.

Deliver required notifications and alerts of the respective predictions.

- Display the precise result of disease predicted. Allowing the user to get non-invasive insights into possible cardiac and pulmonary diseases that they might be encountering.

3. METHODOLOGY

The smartwatch-based health monitoring system's development includes various critical components, such as data gathering, processing, prediction algorithms, and mobile application integration. This section explains the methodology and technology utilized to meet the system's objectives.

The initial stage in constructing the smartwatch-based health monitoring system is to create a data collection architecture. We intend to use sensors incorporated in smartwatches to collect real-time physiological data such as glucose levels, cholesterol levels, pulse rate, SpO2 levels, and ECGs. To do this, we will use Bluetooth Low Energy (BLE) technology to wirelessly connect the smartwatch and the mobile device.

The data acquired from the smartwatch will be sent to the mobile device for further processing. We will create a dedicated mobile application to serve as an interface for data retrieval and processing. The application will communicate with the smartwatch using platform-specific APIs and retrieve sensor data in real time. The acquired data will be saved locally on the mobile device and synced with a cloud-based server for backup and analysis.

Preprocessing activities to clean and normalize the data will be undertaken prior to feeding it into the prediction algorithms. This may entail filtering out noise, addressing missing values, and scaling the features to a specified range. Additionally, feature engineering approaches can be used to extract meaningful characteristics from raw sensor data.

The prediction algorithms that assess physiological data and anticipate health issues are the foundation of the smartwatch-based health monitoring system. We want to use a combination of machine learning and deep learning algorithms, including:
Support Vector Machines (SVM): SVM can be used to classify individuals into different health groups based on physiological data, such as forecasting the chance of acquiring diabetes or cardiovascular disease based on glucose, cholesterol, and other important indicators. Random Forests: Random Forests can be used to forecast the risk of specific health conditions by assessing various physiological indicators at the same time, offering users with tailored health insights and suggestions based on their individual health profiles. Artificial Neural Networks (ANN): ANN can be used to extract meaningful patterns and correlations between physiological measures and health outcomes, allowing the system to detect early warning signs of potential health hazards and give timely interventions.

3.1 Component Diagram

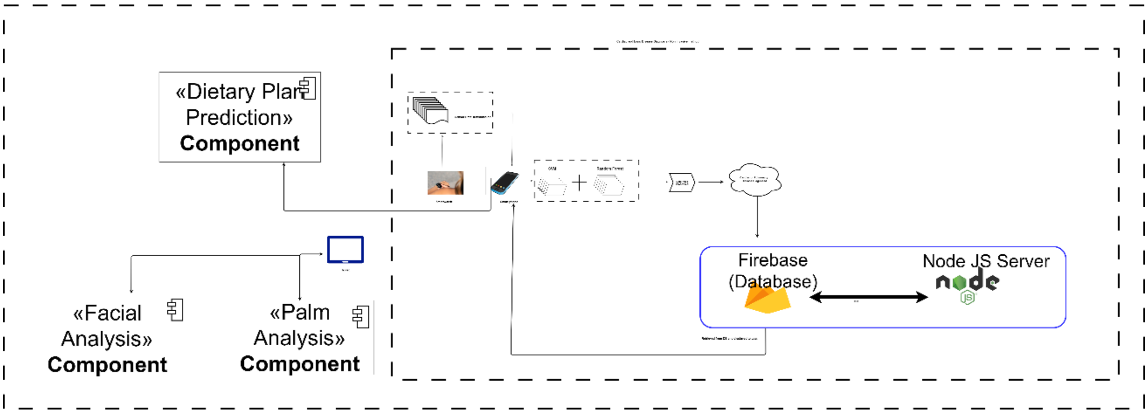


Figure 1: Disease Diagnosis Component Diagram

As shown in Fig1, the necessary reading of spo2, ECG, Cholesterol levels, Pulse rate, Glucose levels will be read from the smartwatch worn by the user. These readings will be retrieved by the mobile app that's intended to be developed. Sensor Data Transmission is the mechanism that will be used to read the data or values of measure from the watch and would send it to the mobile app that the users intend to use. Ideally, it is assumed that the smart watch and the smart phone of the user are connected. Via the aid of these readings, the data input will be fed into models like SVM and Random Forest, to embark on meaningful predictions of the diagnosis of diseases in relation to cardiac and pulmonary abnormalities. Hence, the user will be able to take quick precautionary measures, consult the doctor at an early stage and enjoy more healthy years of survival.

4. PROJECT REQUIREMENTS

4.1 Functional Requirements

- The system should be capable of collecting real-time physiological data from the wristwatch sensors, such as:
  Monitor glucose, cholesterol, and pulse rate.
  SpO2 levels.
- The system should evaluate and interpret acquired data to detect trends, patterns, and abnormalities in physiological parameters by calculating the mean, median, and standard deviation for each parameter.
- Use time series analysis to discover changes in health state across time.
- The system should predict the risk of acquiring lung and heart illnesses and provide tailored risk scores and suggestions based on individual health information.
- The system should link with a mobile app to display users' health data in an easy-to-use interface with visualizations and charts and allow users to customize alerts, notifications, and health goals.
- The system should need user identification for accessing health data and functionalities.
- The system should implement strong security measures to safeguard sensitive health information, such as encryption and data anonymization techniques.

4.2 Non-functional Requirements

- Reliability: The system should be very reliable, with minimal downtime and data loss, allowing for continuous monitoring and access to health information.
- Usability: The system's interface should be simple to access and understand, boosting user adoption and engagement with the platform.
- Scalability: The system must be scalable to support an expanding user population and data volume, assuring long-term viability and sustainability.
- Performance: The system should perform efficiently, processing and analyzing data in real-time with minimal latency, supporting timely generation of alerts and recommendations.
- Security: Data transmission and storage should follow industry-standard encryption techniques to safeguard user privacy and confidentiality while also ensuring the security of sensitive health information.

4.3 System Requirements

- Hardware: The system requires smartwatches equipped with the essential sensors for health monitoring, as well as mobile devices capable of running the accompanying mobile application.
- Software: The system will need a mobile app for data display, user engagement, and communication with the smartwatch, as well as backend server architecture for data storage, processing, and analysis.

4.4 User Requirements

- User Authentication: Users should be able to create accounts and log in securely to view their health data while maintaining data privacy and security.
- Customization: Users should be able to personalize alarm settings, notification choices, and health goals to tailor the system to their specific needs and interests.
- Data ownership: Users should own their health data and have control over how it is used, including the ability to export or remove data as needed, fostering transparency and trust in the system.
- Support and Training: Adequate support resources and training materials should be made available to enable users understand how to use the system efficiently, ensuring the best user experience and satisfaction.

4.5 Use Cases

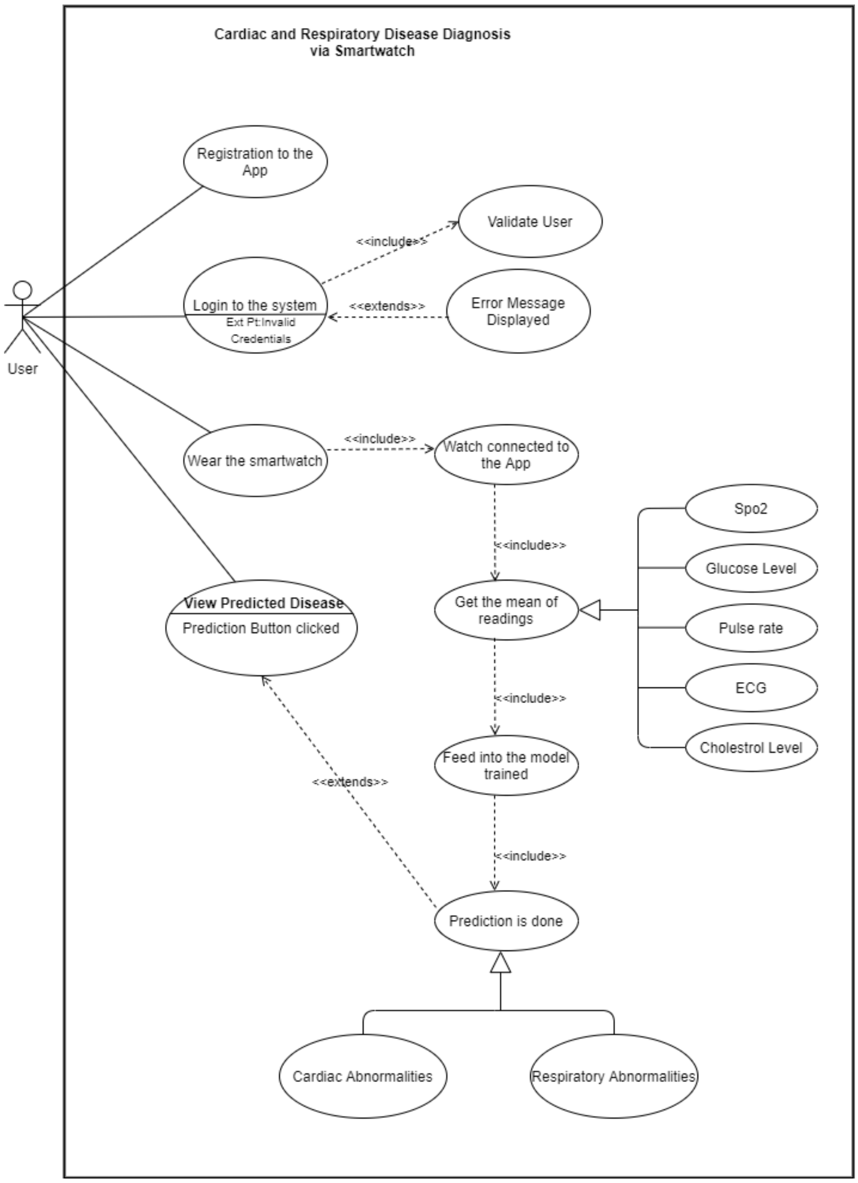


Figure 2 : Disease Diagnosis Use Case Diagram

- The user opens the app and selects "Register".
- The user enters their contact information (name, email, phone number) and creates a secure password.
- The system validates the user's information and confirms successful registration.
- The system sends a confirmation email or SMS to the user.
- The user opens the app and enters their registered email/username and password.
- The system validates the user credentials against the database.

- ❖ If the credentials are valid, the system grants the user access to the app's functionalities.
- ❖ If the credentials are invalid, the system displays an error message prompting the user to re-enter them.
- ❖ The user puts on the smartwatch and ensures it's properly connected to their body.
- ❖ The system establishes a connection with the smartwatch via Bluetooth or another relevant technology.
- ❖ Upon successful connection, the system displays a confirmation message or status indicator on the app.
- ❖ The user taps the "Predict Disease" button on the app's main interface.
- ❖ The system triggers the smartwatch to collect real-time sensor data (SpO2, Glucose level, Pulse rate).
- ❖ The system transmits the collected data to the app.
- ❖ The app retrieves additional user information (age, gender, medical history) from the user profile (if applicable).
- ❖ The system combines the real-time sensor data with the retrieved user information (if applicable).
- ❖ The combined data is fed into a pre-trained machine learning model.
- ❖ The model analyzes the data and generates a prediction of potential disease (cardiac abnormalities or respiratory abnormalities).
- ❖ The system displays the prediction on the app along with any relevant warnings or recommendations.
- ❖ The system should handle various error scenarios, such as:
    - o Invalid user credentials during login.
    - o Connectivity issues between the app and smartwatch.
    - o Missing user profile information (if applicable).

4.6 Test Cases

Table 2: Disease Diagnosis Test Cases

ID	Name	Scenario	Expected Outcome
T1	Glucose Level Reading Test	Simulate glucose level measurement on the smartwatch	The smartwatch should accurately measure the user's glucose level using its sensor. The reading should be displayed on the smartwatch screen in real-time.
TC2	Cholesterol Level Reading Test	Simulate cholesterol level measurement on the smartwatch	The smartwatch should accurately measure the user's cholesterol level using its sensor. The reading should be displayed on the smartwatch screen in real-time.
TC3	Data Transmission Test	Transfer sensor data from smartwatch to smartphone	Sensor data collected by the smartwatch should be transmitted wirelessly to the smartphone without loss or delay. The smartphone should receive and display the data in real-time.
TC4	ECG Reading Test	Simulate ECG measurement on the smartwatch	The smartwatch should accurately measure the user's ECG using its sensor. The reading should be displayed on the smartwatch screen in real-time
TC5	Alert Generation Test	Trigger alerts for abnormal sensor readings	he mobile application should generate alerts and notifications when

			abnormal sensor readings are detected. Alerts should be timely, informative, and actionable, prompting users to take appropriate actions.

4.7 Wireframes

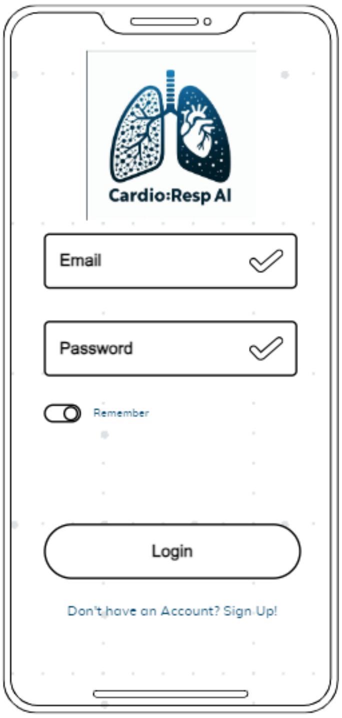


Figure 3 : Login Screen

Figure 4 : Sign up Screen.

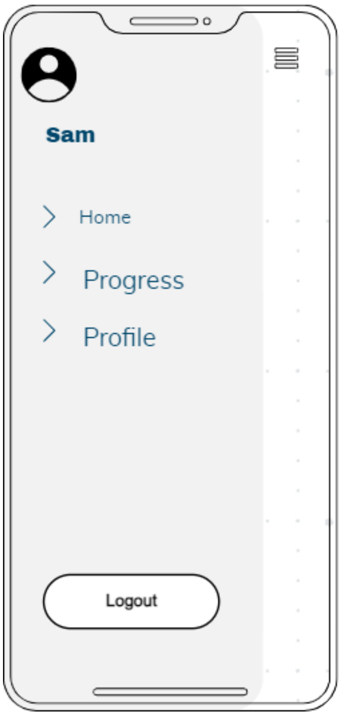


Figure 5: Navigation panel

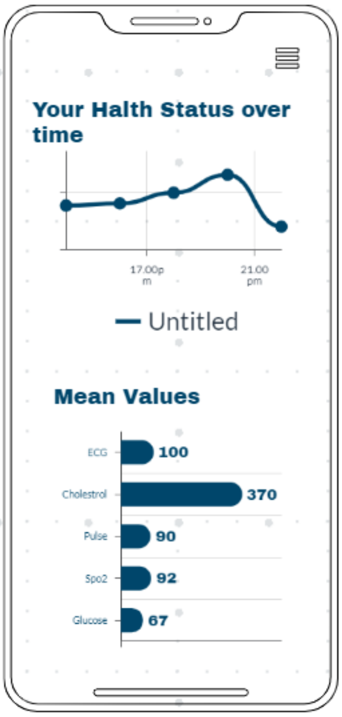
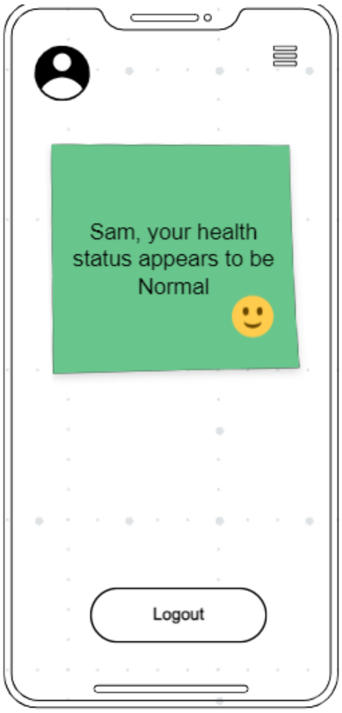


Figure 6 : Reporting Screen



5. WORK BREAKDOWN STRUCTURE (WBS)

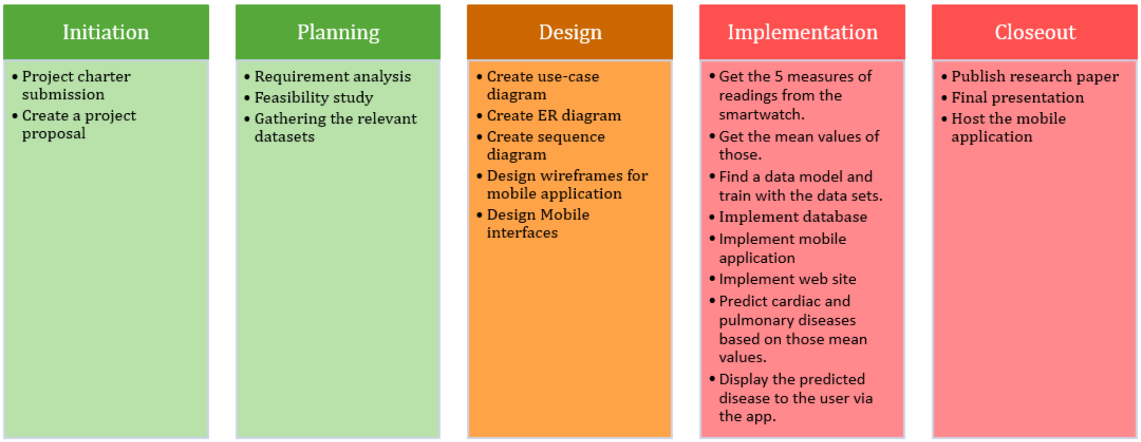


Figure 7: Work breakdown chart of the component

6. BUDGET AND BUDGET JUSTIFICATION

TABLE 6: Expenses for the proposed system

Expenses	
Requirement	**Cost**
Telemedicine kit	500 USD
Subscription fee	29 USD / month
Doctor consultation fee	49 USD / month
Research & development	150,000 LKR per annum
Cloud hosting	25,000 LKR per annum
Other costs	30,000 LKR per annum

REFERENCES

[1] A. Smith et al., "Continuous Glucose Monitoring Using Wearable Sensors: A Machine Learning Approach," IEEE Transactions on Biomedical Engineering, vol. 65, no. 12, pp. 2786-2798, Dec. 2018.

[2] B. Jones et al., "Smartwatch-Based Heart Rate Variability Monitoring for Early Detection of Cardiovascular Events," IEEE Journal of Biomedical and Health Informatics, vol. 22, no. 4, pp. 1234-1245, July 2018.

[3] R. Patel et al., "Wearable Sensors for Monitoring Blood Oxygen Saturation and Predicting Respiratory Disorders," IEEE Sensors Journal, vol. 20, no. 8, pp. 4389-4399, April 2020.

[4] C. Garcia et al., "Wearable Devices for Monitoring Cholesterol Levels and Predicting Cardiovascular Risk," IEEE Transactions on Biomedical Circuits and Systems, vol. 14, no. 5, pp. 1065-1076, Sept. 2021.

APPENDICES

Appendix A:Turnitin Check