

**Nile University**

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**Program of Computer Science**

Health monitoring system using IoT.

**CSCI495 Senior Project I**

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**Project Summary**

The development of information and communication technology has resulted in the development of the Internet of Things (IoT). Today, a wide range of industries, including engineering, healthcare, and smart cities, rely on the Internet of Things for monitoring, recording, storing, presenting, and communicating. An Internet of Things-based monitoring system keeps an eye on the crucial indications of health, sending data over a network. The aim of getting access to the data is to enhance the current condition of the patient. The remote monitoring of heart rate, SPO2 (MAX30100), and body temperature (DS18B20) was the focus of this investigation. The position of the patient could also be retrieved on demand by the SIM7600E GSM and GNSS HAT (hardware mounted on top) modules. Sensor data is collected using a Raspberry Pi 4B microcontroller to measure health parameters. Sensor data is transmitted across a network and saved in the cloud. The recommended system uses the most recent version of the IoT microcontroller, and the devices used significantly affected the overall speed and accuracy of the system. A cross-platform mobile GUI application was made with the intention of providing real-time data access to doctors and patients. Synchronous patient health status monitoring is a beneficial application of technology that helps doctors make the right decisions at the right time.

Keywords: SPO2 ( MAX30100), (DS18B20), SIM7600E GSM and GNSS HAT, Raspberry Pi 4B

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# **Chapter 1**

# **Introduction**

## **Background:**

The Internet of Things (IoT) and its revolutionary implications for information and communication technologies constitute the core of the research's contextual base. The Internet of Things has become a major force in several sectors, including engineering, healthcare, and smart cities. Its ability to simplify data tracking, recording, storing, displaying, and transferring between networked devices accounts for much of its strength. IoT is crucial to the healthcare sector because it makes it possible to remotely monitor and continuously track important health data in real time. The study focuses on the requirement of a remote monitoring system for patients requiring longer follow-up and continual medical professional supervision. It focuses on tracking vital health indicators, including blood oxygen saturation (SPO2), heart rate, and body temperature, using Internet of Things (IoT) technologies. The system makes use of advanced sensors, such as the (SIM7600E GSM and GNSS HAT) Module for patient location, the (DS18B20) for temperature, and the (MAX30100) for heart rate and (SPO2). The microcontroller for data processing and collecting has been chosen to be the well-liked and versatile Raspberry Pi 4B single-board computer. The sensor data is sent across a network to cloud storage via the (Cloud SQL for MySQL) database. Through the provision of real-time health parameter data to patients and physicians, the system aims to enable synchronous monitoring of the patient's state of health. A cross-platform mobile graphical user interface (GUI) application made with Flutter and Dart is also presented in the research. This program can deliver real-time data and alerts to patients and healthcare practitioners. The intended system is designed to provide a comprehensive remote healthcare monitoring solution, allowing medical practitioners to make timely decisions without the need for physical presence. The backdrop also includes a study of relevant research that looks at IoT-based healthcare monitoring systems. These papers highlight the growing interest in and advancements in IoT applications in healthcare, addressing issues like remote military monitoring, intelligent healthcare system creation, and monitoring of elderly adults.

## **Motivation:**

The study was carried out due to a need for practical and creative healthcare solutions, particularly in the field of remote patient monitoring. The following are some of the reasons behind this investigation are as follows:

* Growing challenges in the medical industry:

The healthcare industry faces several difficulties, such as an aging population, a rise in chronic illnesses, and the need for in progress, customized care. To address these issues, we want creative solutions that make use of cutting-edge technologies.

* Innovation in technology and the effects of the Internet of Things:

The Internet of Things (IoT) and other quickly evolving ICTs are creating previously unimaginable opportunities to enhance healthcare services. The seamless integration of smart devices and sensors becomes possible by the Internet of Things allowing for real-time data monitoring.

* The significance of observation from a distance:

Most people are starting to recognize the benefits of remote patient monitoring, especially people who require continuous care due to chronic conditions. Remote monitoring can lead to better patient outcomes, fewer hospital admissions, and an all-around more efficient delivery of healthcare.

* Timely medical actions:

It is crucial to have timely access to health information to make medical decisions. Critical health indicators that can be remotely monitored to give doctors essential data about their patients' situations include body temperature, heart rate, and blood oxygen saturation.

* The need for telehealth services is growing:

Global telehealth and telemedicine trends highlight the need for comprehensive remote monitoring solutions, especially in situations where physical presence poses challenges. These technologies ensure that patients receive fast consultations and interventions by overcoming the communication gap between patients and healthcare providers.

* The potential of IoT in healthcare:

There are several uses for IoT in healthcare, wearables devices for instance smart sensors in watches. Smart sensors are used more efficiently providing better patient care when IoT is employed for remote monitoring.

* Empowerment of patients and healthcare professionals:

When people can actively participate in their care and when physicians can remotely monitor their patients. patients can save more time and money yet the process of remotely monitoring can go more smoothly. This empowerment may lead to increased treatment program adherence and improved health outcomes.

* Research gap and contribution:

While other studies have addressed IoT-based healthcare monitoring, this work aims to close the gap by focusing on a comprehensive system that integrates state-of-the-art sensors, a powerful microcontroller, and an intuitive mobile application. The goal is to close gaps in remote monitoring systems.

* Ability to make life-saving judgements:

With the aid of the proposed system, medical personnel may find it simpler to make life-saving decisions in an emergency. Patient outcomes can be significantly impacted by timely alerts and notifications, together with accurate health data.

## **Objectives:**

* Implementation of IoT-Based Health Monitoring System:
* Utilize Raspberry Pi 4B as the Microcontroller:

Integration:

* Raspberry Pi 4B serves as the central hub for the entire system.
* Connect sensors and the GSM/GPRS/GNSS HAT module to the Raspberry Pi GPIO pins.
* Write Python scripts to read data from the DS18B20 and MAX30100 sensors.
* Real-Time Monitoring of Critical Health Parameters:

Implement Sensors:

* DS18B20 for Body Temperature:

Integration:

* Connect DS18B20 to a patient's body to measure body temperature.
* Raspberry Pi reads temperature data from DS18B20 in real-time.
* MAX30100 for Heart Rate and SPO2:

Integration:

* Place MAX30100 on a patient's fingertip to measure heart rate and SPO2.
* Raspberry Pi reads pulse and blood oxygen saturation data in real-time.
* Incorporation of GSM/GPRS/GNSS HAT Module:
* Integrate Hardware Attached on Top (HAT) Module:

Integration:

* Raspberry Pi communicates with the GSM/GPRS module for efficient data transmission.
* Utilize GNSS for patient location tracking.
* Implement functionality to send SMS notifications in case of abnormal health parameters.
* Cross-Platform Mobile Application Development:

Develop User-Friendly Mobile Application:

* Use Flutter and Dart:

Integration:

* Develop a mobile application using Flutter and Dart.
* The application communicates with the Raspberry Pi over a network.
* Display real-time health parameter data on the mobile application interface.
* Cloud Storage Integration:

Transmit Processed Health Data to MySQL Cloud Storage:

* Use MySQL Database:

Integration:

* Set up a MySQL database to store health data.
* Raspberry Pi sends processed health data to the MySQL database for storage.
* Ensure secure communication between the Raspberry Pi and MySQL server.
* How it Works:
* Data Collection:
* Raspberry Pi gathers real-time heal data from DS18B20 and MAX30100 sensors.
* Patient location is tracked using the GNSS module.
* Processing:
* The gathered data is processed on the Raspberry Pi.
* Abnormalities in health parameters trigger SMS notifications.
* Communication:
* Processed health data is transmitted to the MySQL cloud storage for remote accessibility.
* GSM/GPRS ensures efficient communication between the Raspberry Pi and the cloud.
* User Interface:
* The Flutter and Dart-based mobile application provides a user-friendly interface.
* Displays real-time health parameters and historical data retrieved from the MySQL database.
* Alerts and Notifications:
* In case of abnormal health parameters, SMS notifications are sent to doctors/paramedics and patients' relatives.
* Alerts allow for timely medical interventions.
* Historical Tracking:
* Data stored in the MySQL database enables historical tracking of health parameters.
* Facilitates a comprehensive overview of the patient's health status over time.

By integrating these components, the system ensures a seamless flow of data from sensors to the Raspberry Pi, through communication modules, and finally to cloud storage and mobile application. This integrated approach facilitates real-time health monitoring, timely alerts, and remote accessibility for both healthcare providers and patients.

## **scope:**

Scope Definition:

To establish a robust framework for this project, a meticulous definition of its scope is imperative. This involves setting clear boundaries and limitations, encompassing a comprehensive understanding of both inclusions and exclusions. The project's scope is designed to be expansive yet clearly defined, fostering an environment of precision and purpose.

* Inclusions:
* Holistic Health Monitoring: The central objective of this project is the remote monitoring of critical health parameters, including body temperature (DS18B20), heart rate, and SPO2 (MAX30100). This monitoring aims to provide a real-time insight into the patient's physiological well-being.
* IoT Integration: Embracing the Internet of Things (IoT) concept, the project integrates cutting-edge technologies to facilitate seamless communication between health sensors and the central monitoring system. This connectivity enhances the overall efficiency of data collection and transmission.
* Raspberry Pi 4B Microcontroller: At the core of the project lies the Raspberry Pi 4B microcontroller, chosen for its versatility and computing capabilities. This device serves as the nexus, gathering data from health sensors and acting as the conduit for transmitting information to cloud storage.
* Cloud Storage Utilization: The project employs MySQL database as the designated cloud storage solution. This integration ensures secure and scalable storage of processed health data, enabling healthcare providers and patients to access historical records and real-time information.
* Cross-Platform Mobile Application: To provide a user-friendly interface for both healthcare professionals and patients, a mobile application is developed using Flutter and Dart. This cross-platform application visualizes real-time health data, making it easily comprehensible and accessible.
* GSM/GPRS/GNSS HAT Module: Enhancing communication and enabling geolocation services, the SIM7600E GSM and GNSS HAT module is incorporated. This module not only contributes to real-time tracking of the patient's position but also serves as a conduit for emergency SMS notifications.
* Exclusions:
* Additional Health Parameters: While the project focuses on the triad of body temperature, heart rate, and SPO2, other health parameters such as ECG, blood pressure, respiratory rate, and urine output are deliberately excluded from the present scope to maintain focus and feasibility.
* Advanced Decision-Making Algorithms: The scope does not extend to the incorporation of advanced decision-making algorithms for healthcare professionals. The emphasis is on providing real-time data, leaving complex medical decision-making to the discretion of the attending healthcare providers.
* Extensive Hardware Customization: The project confines itself to a well-defined set of hardware components, specifically the Raspberry Pi 4B, DS18B20, MAX30100, and the GSM/GPRS/GNSS HAT module. Extensive hardware customization beyond these components is excluded from the current scope.

By explicitly delineating these inclusions and exclusions, the project endeavors to strike a balance between comprehensiveness and achievability. This clear definition serves as a guiding principle for all stakeholders, ensuring a shared understanding of the project's boundaries and objectives.

## **Significance of the Study:**

The proposed project creates a fabric of relevance throughout the larger landscape of healthcare and technology integration. Its potential benefits and contributions not only revolutionize patient care, but also pave the way for improvements in research and the use of the Internet of Things (IoT) in the healthcare industry.

* Empowering Patient-Centric Healthcare:
* By enabling remote monitoring, the project shifts the focus from episodic healthcare to continuous, patient-centric care.
* Patients gain agency over their health, fostering a sense of empowerment and proactive engagement in their well-being.
* Data-Driven Healthcare Insights:
* The real-time collection and transmission of health parameters generate a wealth of data.
* Healthcare providers can harness this data to derive valuable insights into patient health trends, contributing to evidence-based decision-making.
* Facilitating Preventive Healthcare:
* The continuous monitoring of health parameters offers a preventive healthcare approach.
* Identifying subtle changes in vital signs allows for early intervention, potentially averting the escalation of health issues.
* Holistic Healthcare Accessibility:
* The project extends healthcare beyond the confines of traditional settings, reaching patients in remote or underserved areas.
* It bridges geographical gaps, promoting inclusivity and equitable access to quality healthcare services.
* Potential for Chronic Disease Management:
* For individuals with chronic conditions, the project provides an unobtrusive and continuous monitoring solution.
* It aids in disease management, offering a proactive approach to addressing the unique needs of patients with prolonged health concerns.
* Technological Innovation in Wearable Healthcare:
* The wearable model of the system represents an innovative stride in healthcare technology.
* It sets the stage for the integration of wearable devices in healthcare, with implications for personalized, on-the-go health management.
* Intersection of IoT and Emergency Medicine:
* The inclusion of emergency SMS notifications and precise geolocation services demonstrates the project's potential impact on emergency medicine.
* Rapid responses to critical health events can be orchestrated, potentially reducing response times, and enhancing emergency medical services.
* Educational Implications for Healthcare Providers:
* Healthcare professionals can benefit from the project's implementation by gaining insights into remote monitoring methodologies.
* It provides a learning opportunity for medical practitioners to adapt and integrate technological solutions into their practice.
* Societal and Economic Impacts:
* By reducing the need for frequent hospital visits and enabling early intervention, the project has the potential to alleviate healthcare costs.
* Societal benefits include improved patient outcomes, enhanced quality of life, and a potential reduction in the burden on healthcare infrastructure.
* Global Implications for Public Health:
* The scalable nature of the project makes it adaptable to diverse healthcare settings globally.
* It has the potential to contribute to global health initiatives by providing scalable, technology-driven solutions for healthcare monitoring.

# **Chapter 2**

# **Related Work**

## **2.1 Introduction to Literature Review:**

Constraints with traditional healthcare services are becoming more apparent as the number of older persons and patients with chronic illnesses rises quickly. Firstly, healthcare services are restricted to hospitals, which makes them difficult for the elderly or crippled and unable to meet emergency medical needs. As a result, a novel idea known as "pervasive healthcare" was put up to solve the problem and provide healthcare services to everyone, wherever, and whenever needed. Recent years have seen many ubiquitous healthcare applications proposed. Many research projects and prototypes have been developed with different aims, dealing with various diseases, users, or different geographical scopes, Additionally, systems utilized in confined spaces like hospitals15 were taken into consideration by the researchers in addition to those used in large areas. Their varying objectives have led to a diversity of their structures and means of monitoring. Heart disorders also draw a lot of study interest because they are a major cause of mortality16. Despite addressing the same condition, these studies differ in several ways. Initially, the physical indicators that need to be observed are essentially distinct. Some focus primarily on one indicator, like blood pressure, heart rate, or ECG 17. Others, however, keep an eye on a variety of factors, not only physiological ones. These non-physiological factors are taken into consideration since they can give patients' contextual knowledge, which could help with remote analysis or assist in providing context-based services. Multiple monitoring systems can provide distant experts with more and more accurate information than single-parameter ones.

## **2.2 Historical Perspective:**

* Early Developments:
  + Temperature Measurement:
    - Traditional mercury thermometers, which needed to be read by hand, were used in early temperature measurement techniques. With the advent of digital thermometers, which provide quicker and more precise temperature readings, there was a noticeable change over time. The effectiveness of health monitoring was greatly improved by these developments, particularly in situations involving fever or other temperature-related ailments.
  + Heartbeat Measurement:
    - Counting the number of pulses per minute by hand was the primary method used by healthcare professionals to monitor heartbeats in the past. Even with the development of stethoscopes in the early 1800s, accurate evaluation of cardiac sounds still required a qualified medical professional. These techniques were essential to comprehending fundamental heart function.
* Technological Advancements:
  + Introduction of Wearable Devices:
    - Wearable health monitoring gadgets have become revolutionary in the last few years. A paradigm shift was brought about by the incorporation of temperature sensors and heart rate monitors into small wearable devices. These gadgets made it possible for people to keep an eye on their vital signs all the time, giving consumers and medical professionals access to real-time data.
  + Wireless Health Monitoring Systems:
    - A major turning point was the switch from wired to wireless health monitoring systems. The advent of early wireless devices opened the door to greater mobility and less restrictions on patient movement. This advancement made it possible to continuously monitor vital signs, such as temperature and heart rate, without requiring direct physical connections to monitoring apparatus.
* Integration with IoT:
  + Internet of Things (IoT) Integration:
    - Health monitoring systems have grown increasingly complex and networked because of the Internet of Things. Devices with Internet of Things capabilities may easily gather, send, and analyze data. IoT integration enables real-time data exchange and remote monitoring in the context of temperature and heartbeat monitoring kits, facilitating prompt interventions and individualized healthcare.
  + Smart Health Wearables:
    - Modern wearables have further revolutionized health monitoring with their powerful sensors and IoT connectivity. In addition to continuously monitoring body temperature and heartbeat, smartwatches and other wearable technology can now analyze trends, spot anomalies, and give users and healthcare professionals useful information.
* Ongoing Research and Future Prospects:
  + Advancements in Sensor Technology:
    - The goal of ongoing research is to improve sensor technology to enable more precise and non-invasive assessments. For instance, advances in photoplethysmography (PPG) sensors have increased the precision of heartbeat measures, while non-contact infrared thermometers provide accurate temperature readings.
  + Integration of AI and Machine Learning:
    - The integration of artificial intelligence (AI) and machine learning algorithms is a contemporary development, enabling more complex analysis of heartbeat and temperature data. By improving predictive capacities, these technologies enable early anomaly identification and offer individualized health advice.

## **2.3 Theoretical Framework:**

* + Pervasive Healthcare Model: The main idea behind this model is that healthcare needs to be made available to everyone, everywhere, by going beyond traditional settings. The concept of continuous and widespread healthcare is promoted by this paradigm, which serves as the project's base.
  + Multi-parameter Monitoring Model: This is the exciting part. We're not only evaluating health indicators like heart rate. To get a complete picture of your health, we're taking consideration a lot of factors, including non-physical ones. It's similar like reading the entire book rather than just a chapter.
  + integration of Technology Model telehealth of patient being monitored by a lot of smart devices and programming language like, smartphones, sensors, and even cloud computing. They are integrated together to make sure we're keeping an eye on your health in real-time IoT application.
  + Machine Learning and Models: The include machine learning models Like neural networks, random forest, and support vector machines all this predictive modeling. These models help to understand how algorithms can help in accurate prediction and diagnosis of cardiac diseases.
  + The Internet of Things (IoT) paradigm: The use of IoT focuses on a paradigm in which interconnected devices enable effective data sharing and monitoring. This model emphasizes how important it is for medical devices to be in a networked environment since it facilitates easy communication and data accessibility.

How These Theories Contribute to the Understanding of the Project:

* + - Comprehensive Healthcare Approach: The widespread healthcare model helps clarify the project's goals by focusing on the importance of a complete approach. It emphasizes the importance of regular checks and healthcare services over regular borders, resulting in a broader and more flexible system.
    - Enhanced Accessibility: Pervasive healthcare theory is like your health buddy, always by your side. With the help of advanced tech, it ensures that healthcare is easy to reach, especially for those who might find it hard to move around a lot of need for this.
    - Flexibility and Responsiveness: The use of cloud computing and Internet of Things allows for real-time data transfer and analysis. This enhances the flexibility and responsiveness of healthcare systems, enabling healthcare professionals to monitor patients remotely and make informed decisions promptly.

## **2.4 Previous Research and Studies:**

* The development of remote patient monitoring devices, including kits that measure temperature and heartbeat, is a result of the Internet of Things incorporation into the healthcare industry. These instruments offer vital physiological information, facilitating proactive health care and early problem diagnosis. Several research works have investigated these integrations, presenting a range of techniques and creative strategies.
* Heartbeat Measurement Kits:
* Neural Network-based Heart Disease Prediction:
* (Niti Guru) used a neural network to predict blood pressure, sugar levels, and heart disease. IoT-enabled heartbeat monitoring kits were used in the study to collect data in real-time for precise forecasting.
* Wearable Technology for Continuous Monitoring:
* (Lee, Y.D. and Chung, W.Y.) created a real-time mobile healthcare system that combined cellphones and bio-signal sensors with wearable cardiac measuring kits. Using the GPRS/UMTS network, this novel technique allowed for the ongoing indoor and outdoor surveillance of elderly patients, providing information on their vital signs and mobility.
* Three-Tier Architecture for Large Data Handling:
* A three-tier design was put up by Umar and Gandhi to handle and store massive volumes of data from wearable sensors, such as cardiac monitors. The system makes use of cloud computing for storage, IoT devices for data collection, and logistic regression-based cardiac disease prediction algorithms.
* Hybrid Machine Learning for Cardiovascular Prediction:
* Mohan introduced a hybrid machine learning approach, using the hybrid random forest with a linear model (HRFLM) to predict cardiovascular illnesses. This study explored integrating heartbeat data into machine learning algorithms for accurate predictions.
* Temperature Measurement Kits:
* Cloud-based Intelligent Health Care Monitoring System:
* MedlinePlus magazine has recently issued an article about integrating cloud computing into a healthcare system, suggesting a cloud-based intelligent healthcare monitoring system (CIHMS). Through the cloud, the system provides patients with medical input using temperature measurement kits that are enabled by the Internet of Things.
* Blockchain-based Secure Healthcare Architecture:
* A blockchain-based safe healthcare architecture that guarantees patient information confidentiality and transparency was proposed by Rathee et al. This study investigates how temperature monitoring kits and blockchain technology can work together to manage patient data securely.
* Population Variability in Identifying Cardiac Illness:
* Vijayashree and Sultana highlighted the need of population-specific factors in temperature measurement for categorizing cardiac diseases by presenting a system that employs tuning functions and population variability to select optimal weights.
* IoT Framework for Real-time Bio Signal Monitoring:
* To increase the evaluation accuracy of cardiac sickness, Zouka and Hosni established a system for safe, lightweight authentication utilizing an IoT framework and modified deep convolutional neural network (MDCNN). The integration of temperature sensors for real-time bio signal monitoring is highlighted in this paper.
* Combined Heartbeat and Temperature Measurement:
* Internet of Things for Heart Failure Monitoring:
* A framework for monitoring individuals with heart failure by combining information from several sources, such as temperature and heartbeat monitoring kits, was presented by Abdel-Basset et al. To effectively monitor and treat heart failure, this study combined computer-supported diagnostics with Internet of Things technology.

## **2.5 Current State of the Field:**

* + The present status of health monitoring systems, especially those that use Internet of Things (IoT) to combine temperature and heartbeat measuring kits, illustrates a changing environment with notable breakthroughs, new trends, and enduring difficulties.
* Recent Advancements and Trends:
  + Advanced Wearable Technologies:
    - Wearable technology with advanced heartbeat and temperature tracking capabilities have advanced significantly in recent years. More precise sensors are being included into wearable health monitoring devices, fitness trackers, and smartwatches to provide consistent and trustworthy monitoring. These gadgets use Internet of Things (IoT) connectivity to send data to centralized systems smoothly.
  + Integration of AI and Machine Learning:
    - In the field of health monitoring, combining artificial intelligence (AI) and machine learning (ML) has grown popular. This involves using sophisticated algorithms to analyze temperature and heartbeat data in real time. AI-driven insights improve the overall efficacy of health monitoring systems by enabling more precise forecasts, early anomaly identification, and personalized health recommendations.
  + Cloud-based Health Monitoring Solutions:
    - These days, cloud computing is still very important to the state of health monitoring systems. Massive volumes of data produced by temperature and heartbeat monitoring kits may be stored, analyzed, and retrieved more easily with the use of centralized cloud-based platforms. This strategy makes collaborative healthcare initiatives, scalability, and accessibility possible.
  + Expansion of Remote Monitoring:
    - Health monitoring systems are developing to offer more complete and up-to-date data, as telehealth and remote patient monitoring become increasingly important. With the use of IoT-enabled kits, medical personnel can keep an eye on patients' vital indicators, like their temperature and heartbeat, from a distance. This facilitates prompt interventions and lessens the need for in-person hospital visits.
  + Interconnected Ecosystems:
    - The current tendency in health monitoring is towards the creation of linked ecosystems. This entails the smooth integration of several IoT-enabled gadgets with other health-related technology, such temperature and heartbeat monitoring kits. The goal of this integrated strategy is to enhance the overall efficacy of healthcare interventions by offering a comprehensive picture of a person's health status.
* Challenges and Unresolved Issues:
  + Data Security and Privacy Concerns:
    - Data security and privacy are growingly complicated issues as health monitoring systems become more networked. Sensitive health data, such as temperature and heartbeat readings, are transmitted and stored, which raises the possibility of breaches and illegal access. Taking care of these issues is essential to winning over the public and guaranteeing the moral use of health data.
  + Standardization and Consistency:
    - One of the challenges is the absence of standard operating procedures and Consistency across various health monitoring devices. Devices from different manufacturers have disparate data formats and communication protocols, which makes it difficult for them to integrate easily into a single ecosystem for health monitoring. To guarantee platform compatibility and data consistency, standardization activities are crucial.
  + Reliability and Accuracy of Measurements:
    - Ensuring the accuracy and dependability of readings from temperature and heartbeat measuring kits is still a major challenge, even with advances in technology. The quality of data can be affected by variables such sensor calibration, ambient circumstances, and user compliance with device usage recommendations. To improve the accuracy of these metrics and provide more trustworthy health assessments, more study is required.
  + User Adoption and Engagement:
    - It's still difficult to get people to consistently accept and interact with health monitoring technology. Wearable technology may be uncomfortable for certain people, or they may have trouble understanding the data they offer. To increase user adoption and engagement, it is essential to design user-friendly interfaces, offer clear insights, and attend to user issues.
  + Regulatory Compliance:
    - Health monitoring systems are always faced with the issue of navigating the complicated regulatory environment. Constant effort is needed to ensure adherence to ethical norms, data protection legislation, and healthcare regulations. For IoT-based health monitoring technologies to be widely adopted, it is imperative to strike a balance between innovation and regulatory compliance.

# **Chapter 3**

# **Materials and Methods**

## **System Description:**

* Context and Boundaries:

The Heartbeat Rate Monitoring System, a sophisticated fusion of Python, MySQL, and Raspberry Pi technologies, is primarily intended for use in hospitals. Under the auspices of hospital-based patient care, the system exclusively offers services to patients who are closely supervised by physicians. The integration of DS18B20 for body temperature, MAX30100 for heart rate and SPO2, and SIM7600E GSM and GNSS HAT modules for on-demand patient position retrieval creates a comprehensive and varied platform for real-time health monitoring and management.

* Objectives and Requirements:

The main goals go beyond only tracking heart rate, body temperature, and SPO2 in real time. By seamlessly integrating features like medication reminders and promoting discreet contact between patients and healthcare providers, the system hopes to go beyond traditional boundaries. Beyond these primary goals, the system is intended to function as a holding facility for extensive medical information, including thorough sickness histories, detailed X-ray pictures, and holistic health statuses. The goal of this all-encompassing strategy is to improve the general standard and effectiveness of patient care and healthcare delivery.

## **System Requirements:**

* Use Cases Diagrams:
  + **use cases of patient:**
    - **Sign in:**

**Diagram:**

A long black line on a white background

Description automatically generated

**Brief description**

The patient shall create an account to be able to use our application.

**Step-by-step description**

1- Patient should enter his information.

2-System shall check all patient information if it is valid.

3-If the information is valid the system will register the account.

4-If information is not valid the system will display information that is not correct.

* + - * **Profile:**

**Diagram:**

A diagram of a person's profile

Description automatically generated

**Brief description**

The patient must follow his condition and treatment plans through his profile.

**Step by step**

1-The patient can see his profile.

2-The system displays all the patient’s reports and data on his profile.

3-The system should allow the patient to modify his data.

* + - **Chat:**

**Diagram:**

A black line on a white background

Description automatically generated

**Brief description**

The patient must know the answer to any question related to Heart problems.

**Step-by-step description**

1- The patient must ask questions and be aware of any information he needs for Heart problems.

2-The doctor must help the patient answer any question related to him via the chat.

3-The patient must enter the chat, submit a question, and get an answer.

* + - **Show description:**

**Diagram**

A long black line on a white background

Description automatically generated

**Brief description**

The patient could be able to review his weekly prescription written by the doctor.

**Step-by-step description**

1- The patient presses the prescription button.

2- The prescription weekly window pops out.

3- The patient can see the daily intake of the medication he needs.

4-The patient can also see the previous prescription.

* + - **Temperature sensor:**

**Diagram**

A blue and black object with a long black line

Description automatically generated

**Brief description**

The patient can measure and show his temperature.

**Step-by-step description**

1-The patient should wear the kit.

2- once the kit senses the patient’s temperature.

3- the kit will automatically operate.

4-The patient’s Temperature will appear on application.

* + - * **Heart rate sensor**

**Diagram**

A blue oval with black text

Description automatically generated

**Brief description**

The patient can measure and show his heart rate.

**Step by step**

1. The patient should wear the kit.

2. The kit senses the patient’s heart rate.

3. The kit will automatically operate.

4.The patient’s Heart rate will appear on application.

* + - * **oxygen rate sensor:**

**Diagram**

A blue oval with black text

Description automatically generated

**Brief description**

The patient can measure and show his Oxygen rate.

**Step by step:**

1. The patient should wear the kit.

2. the kit senses the patient’s Oxygen rate.

3. the kit will automatically operate.

4.The patient’s Oxygen rate will appear on application

* + - * **Make report:**

**Diagram**

A diagram of a diagram

Description automatically generated

**Brief description**

After assembling those sensors then it will be formed into reports.

**Step by step:**

1-The reading of all sensors will collect

2-It will be formed into reports to be visible to the doctors.

* + - * **Detect the location of patient:**

**Diagram**

A long black line on a white background

Description automatically generated

**Brief description**

The system has permission to locate the patient.

**Step by step:**

1. The patient could wear the kit.

2. The kit will locate the patient’s location.

3.The system should be acquired at the patient’s location in case of emergency.

* + - * **Send Alarm**

**Diagram**

A long black line on a white background

Description automatically generated

**Brief description**

The Application will send a notification alert to the patient.

**Step by step:**

1. The patient suffering from health issue

2. The system will be aware that the patient will be in danger.

3. The system will send an alarm to the patient.

4. If the patient didn’t respond to the alarm.

5. The system will automatically localize his location.

6.The system will automatically send information to the emergency unit near the patient.

* + **use cases of doctor**
    - **Sign in:**

**Diagram**

A blue oval with black line

Description automatically generated

**Brief description**

The doctor shall create an account to be able to use our application.

**Step-by-step description**

1- doctor should enter his information.

2-System shall check all doctor information if it is valid.

3-If the information is valid the system will register the account.

4-If information is not valid the system will display information that is not correct.

* + - **Profile:**

**Diagram**

A diagram of a person's profile

Description automatically generated

**Brief description**

The doctors have access to edit and show his profile.

**Step by step:**

1- The doctors have access to show their profile by pressing on profile button.

2- The system will display his profile.

3- The doctors can modify their profile.

4-The doctors have access to show the profile of the patient to follow up on his case.

* + - **Write prescriptions:**

**Diagram**

A blue oval with black text

Description automatically generated

**Brief description**

The doctor has access to write prescriptions to the patient.

**Step by step:**

**1-**Doctors have access to write prescription to the patient by pressing on the write button.

2-He has access to edit at any time.

* + - **Chat**

**Diagram**

A blue oval with a black line

Description automatically generated

**Brief description**

The doctor must know the answer to any question related to Heart problems.

**Step-by-step description**

1- The doctor must answer questions and be aware of any information he needs for Heart problems.

2-The doctor must help the patient answer any question related to him via the chat.

3-The doctor must enter the chat, submit a question, and send an answer.

**A diagram of a network

Description automatically generated**

**A simple photo of the use case**

* **hardware devices:**
* Raspberry Pi 4B:

The heartbeat rate monitoring system relies heavily on the Raspberry Pi 4B, which serves as the local processing unit. In addition to gathering data, it processes information in real time, combining important health metrics and facilitating easy connectivity with the MySQL database and AWS EC2 cloud server. Patients and healthcare providers can easily navigate the interface thanks to its interaction with the mobile application. The Raspberry Pi's built-in scalability and flexibility set the system up for future growth and technical innovations, enhancing the healthcare solution's overall flexibility and efficiency.

A green circuit board with many different ports

Description automatically generated

* DS18B20 (Body Temperature Sensor)

An essential component of the Heartbeat Rate Monitoring System is the DS18B20 sensor, which was selected for its remarkable accuracy and patient-friendly, non-intrusive design. It offers continuous, comfortable monitoring by giving healthcare providers accurate information about a patient's body temperature in real time. When combined with other sensor outputs, such as the heart rate and SPO2 data from the MAX30100, the DS18B20 improves the overall effectiveness and quality of patient care by facilitating a comprehensive health evaluation in the hospital setting.

A close-up of a transistor

Description automatically generated

* MAX30100 (Heart Rate and SPO2 Sensor)

Strictly selected for its precision, the MAX30100 sensor is an essential part of the Heartbeat Rate Monitoring System. With unmatched accuracy, it records the patient's heart rate and blood oxygen saturation levels in real time, giving vital information about their respiratory and cardiovascular health. The sensor's dual functionality includes detecting SPO2 levels, which is very important for assessing respiratory health. Its superior PPG technology also guarantees continuous and precise heart rate monitoring. Healthcare practitioners are empowered with actionable information for quick decision-making and individualized patient treatment thanks to the MAX30100's exceptional accuracy and dependability. When combined with other system elements, this sensor enhances the overall quality of healthcare delivery in a hospital setting by supporting a comprehensive approach to patient assessment.

A green circuit board with black and white text

Description automatically generated

* SIM7600E GSM and GNSS HAT Modules:

The Heartbeat Rate Monitoring System is made more sophisticated by the combination of the GNSS HAT and SIM7600E GSM modules. These modules' flexible communication features guarantee strong connectivity, enabling smooth communication and real-time updates. Accurate on-demand patient position retrieval is made possible by the GNSS feature, giving medical practitioners contextual information. Through this integration, a deeper contextual awareness of patient dynamics is facilitated, transforming the system into a dynamic solution that improves the effectiveness and customization of healthcare delivery in a hospital setting.

A blue circuit board with a white label

Description automatically generated

* MySQL Database

MySQL, the reliable relational database management system (RDBMS) in the Heartbeat Rate Monitoring System's center, is essential to the safe archiving and retrieval of data. It guarantees a smooth connection with the backend components of the system and effectively maintains the structured health data produced by the sensors. Patient records, including previous health data, pertinent medical documents, and real-time vital sign data, are centrally stored in the MySQL database. It plays a critical role in preserving data integrity by giving medical personnel safe, authorized access to complete medical records. MySQL is implemented with strict privacy safeguards, including strong encryption and access restrictions, to guarantee the responsible and moral management of patient data in the healthcare system.

* AWS EC2 Cloud-Based Server:

The Heartbeat Rate Monitoring System's patient data is centralized and dynamically stored on an AWS EC2 cloud server. It guarantees that patient records are kept safe, easily accessible, and updated in real time. The server enables smooth connections between the MySQL database and the Raspberry Pi local processing unit, enabling effective data synchronization and transmission. Healthcare providers now have the freedom to access critical patient data from any location in the healthcare ecosystem, thanks to this innovative solution. Scalability is improved by the AWS EC2 server, which allows the system to adjust to changing workloads and maintain steady performance even when demand spikes. Its integration is consistent with the system's dedication to real-time responsiveness, accessibility, and security in the administration of patient health records.

* Flutter and Dart-based Mobile Application:

The Heartbeat Rate Monitoring System's user-friendly interface for patients and medical professionals is provided by a mobile application built using Flutter and Dart. Its user-centric design allows for easy access to critical health information, such as complete health records, prescription reminders, and cardiac rate monitoring. By using the capabilities of Flutter and Dart, the application guarantees cross-platform interoperability and offers a dependable and adaptable user experience on many devices. The app provides users with a simple and convenient way to view their medical information, get medication reminders, and keep an eye on their health in real time. An intuitive user interface helps medical staff evaluate patient data, make wise decisions, and provide individualized treatment. The Flutter-powered application functions as a bridge to improve patient-provider interaction and communication.

* Sensor Selection

A selection of carefully chosen hardware components, such as the Raspberry Pi 4B CPU, DS18B20, and MAX30100, show how committed the system is to accuracy and reliability in monitoring vital health metrics.

* Network Interfaces:

The system's ability to connect with the Raspberry Pi unit, AWS EC2 cloud server, MySQL database, and Flutter mobile application is dependent on dependable internet access. Using secure data transmission techniques ensures the integrity and security of patient data while it is in transit.

* Application Programming Interface (API):

A technical mainstay, the Python backend offers APIs that allow the Raspberry Pi, database, and mobile application to communicate with each other in an easy-to-use manner. These APIs enhance the system's overall performance and interconnectivity by supporting essential services including prescription reminders, cardiac rate tracking, and health record storage.

* Non-functional Attributes:

The concepts of security, dependability, maintainability, portability, and extensibility are not only catchphrases; they serve as a framework for the system's careful design. Strict privacy controls, including strong encryption methods and access limits, have been put in place to protect patient data. The AWS EC2 cloud-based server and MySQL database work in harmony to provide quick, authorized access to health records that are kept in a safe manner.

## **Design Constraints:**

* Standards Compliance:

The system's steadfast adherence to pertinent healthcare technology standards creates a strong basis for interoperability and conformity with industry standards. This promise opens the door for smooth integration into the current healthcare ecosystems.

* Hardware Limitations:

All hardware components, including the Raspberry Pi, MAX30100, and DS18B20, are carefully selected to ensure they closely match the needs of the system. This careful selection guarantees unmatched precision in monitoring critical health parameters, in addition to compatibility.

* Other Constraints:

The system considers important aspects that go beyond technology, such as cybersecurity precautions, privacy protection, and strict adherence to healthcare laws. Adherence to regulatory regulations, strong cybersecurity protections, and strict privacy measures all work together to guarantee the moral and responsible use of healthcare technology. Essentially, the Heartbeat Rate Monitoring System—a fitting moniker for this extensive system design—represents a significant advancement in hospital-based patient care. Modern technology has made it possible to monitor health in real time.

## **Research Design:**

* Project Planning:
  + Define scope, objectives, and requirements.
  + Identify target audience and user personas.
  + Create project timeline and milestones.
  + Set a budget and allocate resources.
  + Choose a technology stack for the application.
* Research and Analysis:
  + Research existing Heart rate and temperature, blood pressure health care systems.
  + Analyze user needs and pain points.
  + Define key features and functionalities.
* Design, Home Page, and Login Page:
  + Create a home page and login page.
  + Design user interface.
  + Implement data validation and security.
  + Develop wireframes and prototypes.
  + Obtain user feedback and iterate designs.
* Front-end and Backend Development:
  + Develop web pages with responsive design.
  + Set up a server for data storage.
  + deploy reading of sensors function.
  + Ensure the health status of the patient.
  + Ensure user authentication and data security.
* Notification alarm integration & location with Data Extraction and Validation:
  + Integrate. alarm & location with reading sensor.
  + Implement numerical measurement with alarm.
  + Verify the accuracy of extracted data.
  + Test usability and optimize performance.
* Data Integration:
  + Integrate with readings databases.
  + Develop APIs for secure data retrieval.
  + Ensure data accuracy and confidentiality.
* Data Entry Page:
  + Create a secondary page for data entry.
  + Develop a form for manual data entry.
  + Ensure data validation and error handling.
* Report Presentation:
  + Design UI for displaying medical reports by doctors.

Implement interactive charts and graphs.

* + Develop features for sorting, filtering, and searching reports.
  + Assure responsiveness and accessibility.
* User Profile Management:
  + Create a user profile page for viewing and editing information.
  + Implement options for updating contact details and preferences.
  + Ensure data validation and security for user profile changes.
* Content Research and Collection - Content Organization and Structure- Content Creation:
  + Gather accurate information about heart rate management.
  + Create a clear and logical structure for presenting instructions.
  + Develop high-quality written content.
  + Ensure content is easily comprehensible for varying health literacy levels.
* Design an easy-to-use health advice page:
* Design a user-friendly web page layout.
* Use responsive design for accessibility.
* Implement a navigation system for easy information retrieval.
* Content Creation - User-Friendly Design:
* Develop high-quality written content.
* Create or source images for visual aid.
* Ensure content is clear, concise, and user-friendly.
* Design user-friendly webpage layout.
* Use responsive design for content accessibility.
* Chat:
* Design a user-friendly chat interface.
* Implement responsive design.
* Implement chat interface.
* Deployment:
* Prepare the system for production deployment.
* Deploy system on an application server.
* Configure domain and hosting settings.
* Perform final testing.
* Post-launch Maintenance and Support
* Provide ongoing support and updates.
* Monitor system performance and security.
* Plan regular feature updates based on user feedback.
* Marketing and User Acquisition
* Develop marketing strategy.
* Implement digital marketing campaigns.
* Gather user feedback for continuous improvement.

The research concept presented in the documents suggests an intricate and difficult technique for developing an Internet of Things (IoT) enabled heart rate tracking device optimized for hospital situations. The overarching scheme seeks to strategically combine the Python programming language, MySQL database software, and Raspberry Pi microcomputers to create an integrated solution capable of continuously monitoring critical physiological indicators while also facilitating interaction between individuals receiving care and medical practitioners providing that care. The strategy specifically calls for the use of Python to create sensors capable of detecting and recording cardiovascular data from patients. Concurrently, the collected biometric statistics would be stored in a MySQL database for ease of retrieval and analysis furthermore, Raspberry Pi minicomputers would act as a hub for integrating the different components, delivering real-time cardiac data from the bedside to centralized screens around the hospital via an IoT network. This complex combination of technologies has the potential to provide healthcare staff with constant insight into patients' heart activity while also assisting in the rapid response to any deviations from normal values. When completely implemented, the suggested system has the potential to optimize monitoring capabilities and communication procedures in clinical contexts.

## **Architectural Design:**

The architectural design relies heavily on using a Raspberry Pi 4B as the local processing core. This device works seamlessly with both the MySQL database, which saves information, and a cloud SQL for MySQL server, which aids in data analysis and synchronization. The Raspberry Pi 4B serves as the center hub, receiving input from a variety of sensitive yet precise sensors. The DS18B20 sensor detects body temperature non-invasively, whereas the MAX30100 sensor monitors both heart rate and blood oxygen saturation levels in a contactless way. Real-time monitoring of diverse health indicators becomes smooth when these specialized instruments are combined through a single centralized process. The design forms an integrated network in which diverse components work seamlessly together to achieve the joint aim of enabling constant health oversight.

Each component of the system has been carefully selected and professionally assembled to ensure precision and dependability in component design. The SIM7600E GSM and GNSS HAT modules enhance the system's capabilities by providing communication capabilities and geo-tracking functions upon request, hence adding a level of situational awareness. Maintaining the integrity and safety of information is critical, with MySQL serving as the basis for information storage and cloud SQL for MySQL ensuring flexibility and availability to access data as needs change over time.

It is critical to ensure that data design considerations are handled with great attention and precision. These sensors capture data, which is subsequently stored in a MySQL database under tight privacy procedures such as encryption and access limits to protect critical patient information. The system's cloud-based server enables real-time access to medical information from any place, allowing healthcare practitioners to make educated, timely decisions that benefit individuals in need of care. However, several elements must be addressed to further improve this setup, since new technologies emerge regularly with fresh capabilities, and security remains a major problem. Overall, such digital solutions hold the potential of simplifying processes while protecting secrecy.

Our objective is to improve patient care; thus, every design decision is driven by this. The technical basis was chosen not only for its current tasks but also for future expansion and integration with other systems. We focused on infrastructure that can grow and connect with new apps to continue to benefit the people we serve as their needs evolve. Our goal is to create a flexible framework for incrementally improving services inside current healthcare ecosystems. This approach shows a thorough grasp of the convergence of healthcare demands and technology capabilities, intending to improve patient care quality and effectiveness.

Each component of the system has been carefully selected and professionally assembled to ensure precision and dependability in component design. The SIM7600E GSM and GNSS HAT modules enhance the system's capabilities by providing communication capabilities and geo-tracking functions upon request, hence adding a level of situational awareness. Maintaining the integrity and safety of information is critical, with MySQL serving as the basis for information storage and cloud SQL for MySQL ensuring flexibility and availability to access data as needs change over time.

A screenshot of a phone

Description automatically generated

* **Login Screen:**

At the center of the screen, you'll find a clean and modern login interface designed for a seamless user experience.

* Header:

A subtle logo or application name positioned at the top, creating a sense of identity.

* Username Field:

A designated area where users can input their unique usernames. Placeholder text or a subtle hint may guide users on the expected format.

* Password Field:

Below the username field, a secure password entry area awaits. Hidden characters ensure the confidentiality of the entered information.

* Show/Hide Password Toggle:

An eye icon or a checkbox allowing users to reveal or hide their password, providing flexibility and security.

* Forgot Password Link:

A discreet "Forgot Password?" hyperlink leading to a password recovery or reset page, ensuring users can regain access if needed.

* Remember Me Checkbox:

An optional checkbox allowing users to choose whether they want the system to remember their login credentials for future sessions.

* Login Button:

A prominent and inviting button labeled "Login," encouraging users to proceed once their credentials are entered.

* Registration Link:

A clear and accessible link to the registration or sign-up page for new users who haven't created an account yet.

A screenshot of a phone login form

Description automatically generated

* Registration Page:

Welcoming and user-centric, the registration page invites new users to join the community with a straightforward and secure process.

* Registration Icon:

A distinctive register icon or graphic element at the top, creating a visual cue that aligns with the purpose of the page.

* Username Field:

A designated space for users to choose a unique username. Real-time availability checks may assist users in selecting an unused username.

* First Name and Last Name Fields:

Separate fields prompting users to enter their first and last names, promoting a personal and tailored experience.

* Email Field:

A field where users input their email address, with validation checks to ensure the correct format.

* Phone Number Field:

An optional field for users to provide their phone number, enhancing account security or enabling communication features.

* Password Field:

A secure password entry area with guidelines for creating a strong and unique password. Visual indicators may show password strength.

* Confirm Password Field:

A field for users to re-enter their chosen password, ensuring accuracy and minimizing errors during the registration process.

* Register Button:

A prominent and enticing "Register" button, signaling users to complete the registration process and join the platform.

* Already Have an Account? Login Link:

A clear and visible link, often in smaller text, offering users who already have accounts a quick path to the login screen.

* Terms of Service and Privacy Policy:

Links to the terms of service and privacy policy, emphasizing transparency and compliance with legal requirements.

A screenshot of a device

Description automatically generated

* Heart Rate Monitor Page:

Focused on user well-being, the Heart Rate Monitor Page provides real-time insights and access to essential features for a comprehensive health tracking experience.

* Measurement in Progress Icon:

A dynamic icon, such as a pulsating heart or a progress wheel, indicates that a heart rate measurement is currently in progress. This assures users that their data is actively being recorded.

* Heart Rate Monitor Display:

A prominent section showcasing the real-time heart rate, presented in a visually appealing and easily understandable format. Graphical elements may accompany the numerical data for a quick glance.

* Heart Rate Signal Indicator:

A visual indicator, such as a signal strength bar or color-coded feedback, represents the quality and reliability of the heart rate signal being received.

* History Button:

A button labeled "History," providing users with quick access to a comprehensive log of their past heart rate measurements and trends.

* Measure Button:

A central and inviting button labeled "Measure," prompting users to initiate a new heart rate measurement.

* Settings Button:

A gear or settings icon leading to a menu where users can customize preferences, set notification thresholds, or adjust measurement intervals.

* Direct Messages Button:

An envelope or chat icon leading to a section where users can engage in direct messages, consultations, or support with health professionals or friends.

A screenshot of a medical application

Description automatically generated

* Medicine Page:

Designed with patient care in mind, the Medicine Page serves as a central hub for doctors to manage patient information, track medical history, and prescribe medications.

* Patient Information Box:

A dedicated section with fields for the patient's name, gender, age, blood group, and appointment date. This information serves as a quick reference for the doctor.

* Patient Overview:

A section displaying a summarized overview of the patient's medical history, providing a snapshot of essential information to guide the doctor's decisions.

Medical History:

A tab or section where doctors can access a detailed medical history of the patient, including past illnesses, treatments, and procedures.

* Diagnosis Section:

An area where doctors can input and review current and past diagnoses, facilitating a comprehensive understanding of the patient's health status.

* Medicine Icon Button:

An icon button, possibly resembling a pill or prescription bottle, that doctors can click to add or update medication information for the patient.

* Prescription List:

A dynamic list that displays prescribed medications, including dosage, frequency, and duration. Each entry may have an option for the doctor to edit or remove a prescription.

* Add Medicine Button:

A clearly labeled button, such as "Add Medicine," enabling doctors to input new prescriptions. This opens a pop-up or a dedicated section with fields for medicine name, dosage, instructions, etc.

A screenshot of a calendar

Description automatically generated

* Pill Schedule Page:

Efficiently managing medication is crucial for patient well-being. The Pill Schedule Page offers a straightforward interface for users to track their pill-taking schedule.

* Calendar or Date Picker:

A section where users can select the date for which they want to view or manage their pill schedule. This could be represented by a calendar icon or a date picker for ease of use.

* Pill Schedule Display:

A visual representation of the daily pill schedule, organized by time slots or specific hours. Each scheduled pill is displayed with relevant information, including the pill name, dosage, and any special instructions.

* Schedule Button:

A button labeled "Schedule” allows users to add a new pill-taking event to their schedule. Clicking this button opens a form or pop-up where users can input details such as the pill name, dosage, time, and any additional notes.

* Cancel Button:

A button labeled "Cancel" that users can click to cancel or remove a scheduled pill-taking event. This helps users adjust their schedule when necessary.

A screenshot of a phone

Description automatically generated

* + Pill Reminder Page:

Prioritizing medication adherence, the Pill Reminder Page offers a comprehensive overview of scheduled pills and provides easy access to essential information.

* Today's Reminders Header:

A prominent header displaying "Today's Reminders," signaling users that the page focuses on the scheduled pills for the current day.

* Schedule Date and Days:

A section showcasing the current date and possibly a brief overview of the upcoming days in the week. This helps users plan and stay informed about their medication schedule.

* Pill Information Box:

A box displaying details of each scheduled pill, including the time to take the pill, the medication name, and possibly additional instructions or notes. This section may dynamically update as the day progresses.

* Time and Medication Box:

A structured box with columns for time slots and rows for each medication, making it easy for users to see when each pill is scheduled and which medication it corresponds to.

* Calendar Icon:

An icon resembling a calendar that users can click to access a broader view of their pill schedule, allowing them to navigate and manage upcoming doses.

* Pills Reminder Icon:

An icon resembling a pill bottle or medication capsule that users can click to set up or manage reminders for their pills. This could include configuring notification preferences or adjusting reminder settings.

* Profile Icon:

An icon representing a user profile that users can click to access their personal profile information. This may include details such as their name, age, and any relevant health information.

* Quick Actions:

Buttons or shortcuts for quick actions, such as marking a pill as taken, rescheduling, or acknowledging a reminder.

* Today's Overview:

A summary or overview section indicating the total number of pills scheduled for the day and any special considerations or notes.

## **Data Design:**

**Gathering Data for the Project:**

We collected data from various medical sources like hospitals and research databases or websites that focus on heart rate and blood pressure health.

**Sources of Data, Sampling Methods, and Collection Tools:**

* **Where Data Came From:** Our data mainly came from medical records and research studies about heart conditions.
* **How We Picked Data:** We chose data randomly and specifically targeted certain groups to ensure our data covered a wide range of people and conditions.
* **Tools Used:** Doctors and researchers likely used electronic systems to record patient information during check-ups or research studies. They might have also used surveys or devices to collect data.

**Transformation of Information Domain into Data Structures:**

We took all the different kinds of information about heart health, like age, sex, blood pressure, and cholesterol levels, and organized them neatly into a table format. Each piece of information has its own spot in the table.

**Storage, Processing, and Organization of Major Data Entities:**

* **Storage:** We kept our data in a system that makes it easy to find and work with, like a big spreadsheet or a database.
* **Processing:** We cleaned up the data and looked for important patterns or trends in it.
* **Organization:** Our data is arranged in rows and columns. Each row is about one person, and each column is a different piece of information about them.

**Description of the Dataset:**

Our dataset has a bunch of details related to heart health, such as age, sex, chest pain type, blood pressure, cholesterol levels, and more. It also tells us whether each person has heart disease or not.

**Collection, Storage, and Organization of the Dataset:**

* **How We Got the Data:** We gathered data from hospitals, clinics, and research studies.
* **Where We Put It:** We stored all this information in a way that makes it easy to use, like in a spreadsheet or a special database.
* **How It's Arranged:** Each row in our dataset represents one person's information, and each column is a different detail about them. This setup helps us quickly understand and analyze the data.

# **Chapter 4**

# **Implementation and Preliminary Results**

## **Programming Languages and Tools:**

* Flutter:

Flutter is an open-source UI software development toolkit created by Google. It is used for building natively compiled applications for mobile, web, and desktop from a single codebase. Flutter uses the Dart programming language and provides a rich set of pre-designed widgets for creating modern and responsive user interfaces.

* Dart:

Dart is an open-source, general-purpose programming language developed by Google. It is designed for building mobile, desktop, server, and web applications. Dart is known for its focus on performance, productivity, and ease of use.

* Python:

Python is a high-level, interpreted programming language known for its simplicity, readability, and versatility. It was created by Guido van Rossum and first released in 1991. Python supports multiple programming paradigms, including procedural, object-oriented, and functional programming, making it suitable for a wide range of applications.

* NumPy:

NumPy is a powerful numerical library in Python that provides support for large, multi-dimensional arrays and matrices, along with a collection of mathematical functions to operate on these arrays. It is a fundamental package for scientific computing in Python.

* Pandas:

Pandas is a popular open-source data manipulation and analysis library for Python. It provides data structures for efficiently storing and manipulating large datasets, along with tools for reading and writing data in various formats. Pandas is widely used in data science, machine learning, and other fields for tasks such as data cleaning, exploration, and analysis.

* Seaborn:

Seaborn is a data visualization library for Python that is built on top of Matplotlib. It provides a high-level interface for creating attractive and informative statistical graphics. Seaborn comes with several built-in themes and color palettes to make it easy to create visually appealing visualizations. It also simplifies the process of creating complex statistical plots by providing functions for common tasks.

* Matplotlib:

Matplotlib is a popular Python library for creating static, animated, and interactive visualizations in a wide variety of formats. It provides a flexible and powerful interface for producing high-quality charts, plots, and figures. Matplotlib is often used for tasks such as data exploration, data analysis, and presentation of results.

* Scikit-learn:

Scikit-learn is a popular machine learning library in Python that provides simple and efficient tools for data analysis and modeling. It is built on top of other scientific computing libraries like NumPy, SciPy, and Matplotlib.

* SciPy:

SciPy is an open-source library in Python used for scientific and technical computing. It builds on the capabilities of NumPy and provides additional modules for optimization, signal and image processing, statistics, linear algebra, integration, interpolation, and more.

* Logistic Regression:

Logistic Regression is a statistical method used for binary classification, which means it is employed when the outcome variable is binary, taking on two possible classes such as 0 and 1, or "positive" and "negative." Despite its name, logistic regression is used for classification, not regression.

* MySQL

MySQL is an open-source relational database management system (RDBMS) that is widely used for managing and organizing data. It is a crucial component in the development of many web-based applications and is known for its reliability, performance, and ease of use.

Cloud SQL for MySQL

Cloud SQL for MySQL is a fully managed relational database service offered by Google Cloud Platform (GCP). It allows you to set up, manage, and scale MySQL databases in the cloud without having to worry about the underlying infrastructure. This service is designed to simplify database administration tasks, enhance scalability, and improve the overall reliability of MySQL databases.

## **Code Structure:**

Technology is growing with machine learning providing helpful predictions. This project looks at a Python code designed to predict heart problems by using a health dataset.

The coding starts by importing necessary libraries - numpy, pandas, seaborn, and scikit-learn. These libraries enable data handling, visualization, and creating machine learning models.

* Gathering And preprocessing Data:

A large dataset with heart health attributes gets loaded via pandas. The code then checks and fixes the data, tests its shape, data types, and any missing pieces. The script organizes categorical variables for further review.

* Statistical Measures about Data:

Descriptive statistics are computed to understand the dataset's distribution, including count, mean, minimum, and maximum values. Missing data visualization is conducted using the missingno library, and box plots and histograms are generated to visualize the distribution of numeric variables.

* Data Visualization:

Seaborn and Matplotlib are utilized to create visualizations, providing insights into the distribution of various features within the dataset. These visualizations help identify patterns and potential correlations between variables.

* Splitting Features and Target:

The dataset is divided into features (X) and the target variable (Y). Features contain all columns except the 'target' column, while the target variable contains only the 'target' column.

* Splitting Data into Training and Test Sets:

Using the train\_test\_split function from scikit-learn, the dataset is split into training and test sets. This step ensures that the model is trained on a subset of the data and evaluated on unseen data.

* Model Training:

A logistic regression model is trained on the training data using the fit method. Logistic regression is a popular choice for binary classification tasks like predicting heart disease.

* Model Evaluation:

The model's performance is evaluated using the accuracy score computed for both the training and test sets. This step assesses how well the model generalizes to unseen data.

Building a Predictive System: Finally, a predictive system is built where a sample input is provided, and the model predicts whether the individual has a risk of heart disease or not. This practical application demonstrates the model's potential use in real-world scenarios.

## **Data Structures and Databases:**

We will use Cloud SQL for MySQL for data Structures and databases.

In the context of Cloud SQL for MySQL, data structures and databases refer to the way data is organized and stored within the MySQL instance.

* Tables:

Tables are fundamental components of a relational database. They define the structure of the data by specifying columns, each with a data type, and rows containing the actual data. In Cloud SQL for MySQL, you create and manage tables using SQL statements.

* Indexes:

Indexes are used to optimize query performance by providing a fast access path to the data. In Cloud SQL for MySQL, you can create indexes on one or more columns of a table. This can significantly improve the speed of data retrieval operations.

* Constraints:

Constraints enforce rules on the data stored in tables. Common constraints include primary keys (to uniquely identify rows), foreign keys (to establish relationships between tables), and unique constraints. These constraints help maintain data integrity.

* Stored Procedures and Functions:

Cloud SQL for MySQL supports the creation of stored procedures and functions. These are sets of SQL statements that can be executed as a single unit, providing a way to encapsulate logic and reuse it within the database.

* Triggers:

Triggers are SQL statements that are automatically executed in response to specific events, such as data modifications (insert, update, delete). Cloud SQL for MySQL allows you to define triggers to automate certain actions based on changes in the data.

* Views:

Views are virtual tables derived from the result of a SELECT query. They provide a way to simplify complex queries, encapsulate business logic, and restrict access to certain columns or rows of a table. Cloud SQL for MySQL supports the creation and use of views.

* Partitions:

MySQL supports table partitioning, which involves dividing large tables into smaller, more manageable pieces. Each partition can be stored and managed independently, improving query performance. This feature can be useful for handling large datasets efficiently.

* Data Types:

Cloud SQL for MySQL supports a variety of data types, including numeric, string, date and time, and spatial types. Choosing appropriate data types for columns is crucial for optimizing storage and ensuring data accuracy.

* Backups and Recovery:

While not directly a data structure, the ability to perform backups and recovery is crucial for data management. Cloud SQL for MySQL provides automated backup options, and you can restore data to a specific point in time using these backups.

* High Availability and Replication:

Cloud SQL for MySQL offers features like high availability and replication. This involves maintaining multiple copies of your data across different locations to ensure reliability and fault tolerance.

Understanding and optimizing these aspects of data structures and databases in Cloud SQL for MySQL is essential for designing efficient, scalable, and reliable database systems in the cloud. It also contributes to achieving better performance and ensuring the integrity of your data.

## **Quantitative Results:**

We will use the pandas profiling report, and this is the explanation of how to use it.

Basic information about the dataset, including the number of variables and observations.

Summary statistics like mean, median, minimum, maximum, and quantiles for numerical columns.

Information about the presence of missing values in each column.

Variables:

A detailed list of all the variables in the dataset, along with their data types.

For numerical variables, statistics such as mean, median, standard deviation, and percentiles.

For categorical variables, the count and frequency of each category.

Information about the cardinality of categorical variables (the number of unique values).

Correlations:

A correlation matrix showing the relationships between numerical variables.

Visualizations such as heatmaps to highlight strong positive or negative correlations.

Missing Values:

A matrix or bar chart depicting the presence of missing values in the dataset.

Insights into the percentage of missing values for each variable.

Distributions:

Histograms for numerical variables to visualize their distributions.

Bar charts or pie charts for categorical variables to show the distribution of categories.

Kernel density plots for a smooth representation of the data distribution.

Descriptive Statistics:

Additional statistics like skewness, kurtosis, and various quantiles to understand the shape of the distributions.

Interactions:

Scatter plots and other visualizations to explore relationships between pairs of variables.

Cross-tabulations and pivot tables to identify patterns and trends.

Warnings and Suggestions:

Flags potential issues or areas that may require attention, such as high cardinality in categorical variables or high correlation between two features.

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## **Quantitative Results:**

The key of this project is to gather as much information as possible by publishing surveys from our colleges and other universities, a statistical chart will be conducted from the surveys that will be published.

# **Chapter 5**

# **Discussion and Conclusion**

## **Future Work:**

As we look ahead, there are several promising areas for future research and improvements in the realm of health monitoring systems utilizing IoT, specifically focusing on heartbeat and temperature measurement kits. This section outlines potential directions for extending and advancing the project.

* Enhanced Sensor Technologies:

Future research could focus on the development and integration of advanced sensor technologies for heartbeat and temperature measurements. Exploring innovative sensors, such as those based on nanotechnology or advanced materials, could improve the accuracy, sensitivity, and reliability of data. Additionally, research efforts might be directed towards the miniaturization of sensors to enhance user comfort without compromising measurement precision.

* Machine Learning Optimization:

Further refinement of machine learning algorithms could significantly contribute to the predictive capabilities of health monitoring systems. Exploring deep learning models, ensemble methods, and continuous model training could enhance the system's ability to adapt to individual health variations. Additionally, incorporating explainable AI techniques could provide more transparent insights into the decision-making process, fostering user trust and understanding.

* Privacy-Preserving Solutions:

Given the increasing concerns about data security and privacy, future work could focus on developing robust privacy-preserving solutions. This may involve the implementation of advanced encryption techniques, decentralized identity management, or blockchain-based approaches to ensure secure and confidential storage and transmission of sensitive health data.

* User-Centric Design:

Improvements in user adoption and engagement can be achieved through user-centric design principles. Future research may explore ways to enhance the user interface, provide personalized insights, and incorporate user feedback mechanisms. User studies and feedback collection could guide the iterative design of health monitoring systems to better meet the needs and preferences of diverse user groups.

* Interoperability Standards:

Addressing the challenges related to interoperability and standardization is crucial for creating a seamless and integrated health monitoring ecosystem. Future work could involve collaborative efforts within the healthcare and technology industries to establish and adopt standardized communication protocols, ensuring compatibility among different devices and platforms.

* Integration with Emerging Technologies:

Exploring the integration of health monitoring systems with emerging technologies holds significant potential. This may include synergies with augmented reality (AR) for immersive user experiences, edge computing for real-time data processing, or the integration of 5G connectivity for faster and more reliable data transmission.

* Longitudinal Health Monitoring:

Extending health monitoring beyond episodic measurements to continuous, longitudinal monitoring is an area ripe for exploration. Developing systems that can provide insights into trends, variations, and long-term health trajectories could significantly contribute to preventive healthcare and early intervention strategies.

* Community-Based Health Monitoring:

Exploring community-based health monitoring initiatives could be a novel avenue for future research. Implementing collaborative health monitoring within communities could foster a supportive environment for individuals, encourage healthy behaviors, and contribute to a collective understanding of community health patterns.

In conclusion, the future work in health monitoring systems using IoT, particularly focused on heartbeat and temperature measurement kits, should strive to advance sensor technologies, optimize machine learning algorithms, prioritize user-centric design, address privacy concerns, establish interoperability standards, explore emerging technologies, enable longitudinal monitoring, and promote community-based health initiatives. Continuous innovation in these areas will contribute to the evolution of effective, user-friendly, and privacy-aware health monitoring systems.

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