DESIGN AND DEVELOPMENT OF AN INTERACTIVE CHATBOT FOR DIABETES PATIENT PRE-SCREENING

SACHITRA HALDER
MUHAMMAD RIFAT ISLAM
Md. TAUSIFUL HAQUE

B.Sc. ENGINEERING THESIS

DEPARTMENT OF COMPUTER SCENCE AND ENGINEERING
MILITARY INSTITUTE OF SCIENCE AND TECHNOLOGY
DHAKA, BANGLAGESH

MARCH 2024

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B.Sc. Engineering Thesis

By

SACHITRA HALDER (201914060)
MUHAMMAD RIFAT ISLAM (202014034)
Md. TAUSIFUL HAQUE (202014036)

Approved as to style and content by the Examiners in March 2024:

____________________________________ Chairman
Asst. Prof Dr. Md Akhtaruzzaman (Supervisor)
Department of CSE
MIST, Dhaka

_______________________________________ Head of the Department
Brig Gen Mohammad Sajjad Hossain
Department of CSE

MIST, Dhaka.

Department of Computer Science and Engineering, MIST, Dhaka

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DECLARATION

We hereby declare that the study reported in this thesis, entitled as above, is our original work and has not been submitted anywhere before for any degree or other purposes. Further, we certify that the intellectual content of this thesis is the product of our work and that all the assistance received in preparing this thesis and its sources have been acknowledged and cited in the reference Section.

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Sachitra Halder
Student ID: 201914060

____

Muhammad Rifat Islam
Student ID: 202014034

____

Md. Tausiful Haque
Student ID: 202014036

Department of Computer Science and Engineering, MIST, Dhaka

ABSTRACT

Design and Development of An Interactive Chatbot for Diabetes Patient Pre-screening

Diabetes is now a common problem in the context of Bangladesh and health care, it is the most important disease to solve its issues. The project aims to develop a healthcare system that combines an interactive pre-screening chatbot for diabetes patients with a sensor system for collecting body health data. For diabetes patient treatment, doctors need a lot of information from the patient, such as his/her lifestyle, food habits, medicines, other diseases, etc. Therefore, in a doctor's chamber, this thing takes a lot of time. Therefore, in this system, the sensor system collects vital health information, including temperature, heart rate, and oxygen level, from patients using dedicated sensors. Through a conversational chatbot interface, patients are engaged in a dialogue to provide relevant medical information, such as symptoms and medical history, and the chatbot collects the information. The information is displayed at the end of the conversation on a screen for easy reference. The project is done in 4 main stages. They are requirement analysis, system design, chatbot development, and integration with sensors. The sensor output has a little bit more fluctuation than the medical-grade equipment, but the chatbot's conversation and information extraction have high accuracy (>90%). By integrating vital sign monitoring, and interactive chatbot capabilities, the project aims to reduce wait times, improve the medical checkup system, and enable effective doctor-patient communication in a modern healthcare setting.

সারসংক্ষেপ

Design and Development of An Interactive Chatbot for Diabetes Patient Pre-screening

বাংলাদেশ ও স্বাস্থ্য পরিচর্যার প্রেক্ষাপটে ডায়াবেটিস এখন একটি সাধারণ সমস্যা, এর সমস্যা সমাধানের জন্য এটি সবচেয়ে গুরুত্বপূর্ণ রোগ। এই প্রকল্পের লক্ষ্য একটি স্বাস্থ্যসেবা ব্যবস্থা তৈরি করা যা ডায়াবেটিস রোগীদের জন্য একটি ইন্টারেক্টিভ প্রাক-স্ক্রিনিং চ্যাটবটকে শরীরের স্বাস্থ্যের তথ্য সংগ্রহের জন্য একটি সেন্সর সিস্টেমের সাথে একত্রিত করে। ডায়াবেটিস রোগীর চিকিৎসার জন্য, ডাক্তারদের রোগীর কাছ থেকে অনেক তথ্যের প্রয়োজন হয়, যেমন তার জীবনযাত্রা, খাদ্যাভ্যাস, ওষুধ, অন্যান্য রোগ ইত্যাদি। তাই, একজন ডাক্তারের চেম্বারে এই জিনিসটি অনেক সময় নেয়। অতএব, এই সিস্টেমে, সেন্সর সিস্টেম ডেডিকেটেড সেন্সর ব্যবহার করে রোগীদের থেকে তাপমাত্রা, হৃদস্পন্দন এবং অক্সিজেন স্তর সহ অত্যাবশ্যক স্বাস্থ্য তথ্য সংগ্রহ করে। একটি কথোপকথনমূলক চ্যাটবট ইন্টারফেসের মাধ্যমে, রোগীরা প্রাসঙ্গিক চিকিৎসা তথ্য প্রদানের জন্য একটি সংলাপে নিযুক্ত থাকে, যেমন লক্ষণ এবং চিকিৎসা ইতিহাস, এবং চ্যাটবট তথ্য সংগ্রহ করে। তথ্যটি সহজ রেফারেন্সের জন্য একটি স্ক্রিনে কথোপকথনের শেষে প্রদর্শিত হয়। প্রকল্পটি 4টি প্রধান পর্যায়ে সম্পন্ন হয়। সেগুলি হল প্রয়োজনীয়তা বিশ্লেষণ, সিস্টেম ডিজাইন, চ্যাটবট বিকাশ এবং সেন্সরগুলির সাথে একীকরণ। সেন্সর আউটপুট মেডিকেল-গ্রেড সরঞ্জামের তুলনায় একটু বেশি ওঠানামা করে, কিন্তু চ্যাটবটের কথোপকথন এবং তথ্য নিষ্কাশনের উচ্চ নির্ভুলতা রয়েছে (>90%)। অত্যাবশ্যক সাইন মনিটরিং, এবং ইন্টারেক্টিভ চ্যাটবট ক্ষমতাকে একীভূত করার মাধ্যমে, প্রকল্পটির লক্ষ্য অপেক্ষার সময় কমানো, মেডিকেল চেকআপ সিস্টেম উন্নত করা এবং আধুনিক স্বাস্থ্যসেবা সেটিংয়ে কার্যকর ডাক্তার-রোগী যোগাযোগ সক্ষম করা।

ACKNOWLEDGEMENTS

We are thankful to Almighty Allah for his blessings on the successful completion of our thesis.

Our heartfelt gratitude, profound indebtedness, and deep respect go to our supervisor, Dr. Md. Akhtaruzzaman, PhD, Department of Computer Science and Engineering, Military Institute of Science and Technology, for his constant supervision, affectionate guidance, and great encouragement and motivation. His keen interest in the topic and valuable advice throughout the study were of significant help in completing the thesis.

We are especially grateful to the Department of Computer Science and Engineering (CSE) of the Military Institute of Science and Technology (MIST) for providing all-out support during the thesis work. Also we are grateful to the Quantum Robotics and Automation Research Group (QRARG) and R&D section of AZDREAM Robotics for providing technical support and insightful suggestions.

Finally, we would like to thank our families and coursemates for their appreciable assistance, patience, and suggestions during our thesis.

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CHAPTER 1
INTRODUCTION

In healthcare, the pre-screening process faces challenges such as manual procedures, long wait times, and resource strain. However, emerging technologies offer an opportunity to revolutionize this approach. To address these issues, we propose developing an integrated chatbot-hardware system for patient pre-screening. By combining AI, NLP, and dedicated hardware, our objective is to create a comprehensive solution that optimizes data collection and patient engagement. This research project focuses on designing an interactive chatbot interface and a hardware module for gathering essential physical condition data. The chatbot utilizes advanced NLP techniques to intelligently gather medical information and provide appropriate responses, ensuring effective communication of patients' concerns and healthcare needs. Complemented by sensors in the hardware module, real-time measurements such as temperature, heart rate, and oxygen levels are securely captured. This integration enhances the chatbot's functionality, enabling a holistic approach to patient pre-screening.

By minimizing physical visits and enabling remote engagement, our chatbot-hardware system aims to reduce wait times, optimize resource allocation, and enhance the patient experience. Through seamless integration of technology and healthcare expertise, we can revolutionize patient pre-screening, improving efficiency, accessibility, and patient outcomes. This research contributes to a patient-centric healthcare ecosystem that leverages advanced technologies to optimize pre-screening, leading to improved healthcare delivery and patient experiences.

1.1 Problem Statement

In the healthcare industry, the process of gathering essential patient information and measurements before a doctor's visit often involves manual procedures that can be time-consuming and inefficient. Patients typically need to visit a healthcare facility, wait in lines, and have their vital signs and body measurements taken by healthcare staff. This traditional approach can lead to long wait times, delays in care, and a strain on healthcare resources. Also, taking a patient to a doctor causes a long queue of waiting patients. As a result, sometimes patients can not get proper treatment. Some research and projects are reviewed that chat with the patients to detect his/her diseases or understand his/her symptoms, but they have some limitations. Either it can not be understood or does not have any doctors' involvement and analysis of symptoms (Harikrishnan, and Stephen, 2020) or does not take health measurements via hardware (Stollnberger et al 2016).

1.2 Thesis Objectives

The main objective of the system is to design and develop an interactive chatbot for patient pre-screening and make a sensor module to collect the patient's physical conditions of the patient. The aim can be split into the following :

1. To design & develop a voice-enabled intelligent chatbot with an interactive interface.
2. To develop a sensor module for collecting patients' physical condition.
3. To integrate the overall system and conduct performance evaluation.

1.3 Methodology

The methodology of the system can be defined in 4 stages:

1. **Requirement Analysis:**
    - Identify the specific requirements and goals of the project, considering the functionalities of the chatbot, data collection, and display interface.
    - Conduct interviews or surveys with potential users, including patients and healthcare professionals, to gather their feedback and incorporate their insights into the system design.
2. **System Design:**
    - Design the architecture of the system, including the components such as the chatbot interface, sensor integration, data storage, and display interface.
    - Determine the appropriate technologies, frameworks, and programming languages to be used for each component.
    - Create a comprehensive data model to define the structure of patient information and its relationship with the chatbot conversation history.

3. Chatbot and Display Development:

- Implement the chatbot using natural language processing (NLP) techniques and a suitable programming language or framework.
- Develop conversational flows to engage patients, collect medical information, and provide appropriate responses.
- Integrate the chatbot with the data storage system to store and retrieve patient information.
- Design a user-friendly interface to display the chatbot conversation in real-time, including the questions asked by the chatbot and patient responses.

4. Sensor Integration:

- Connect and calibrate sensors for temperature, heart rate, oxygen levels, and blood pressure to gather real-time data from patients.
- Implement mechanisms to process and interpret sensor data accurately and securely.
- Establish communication channels between the sensors and the data storage system for seamless data transfer.

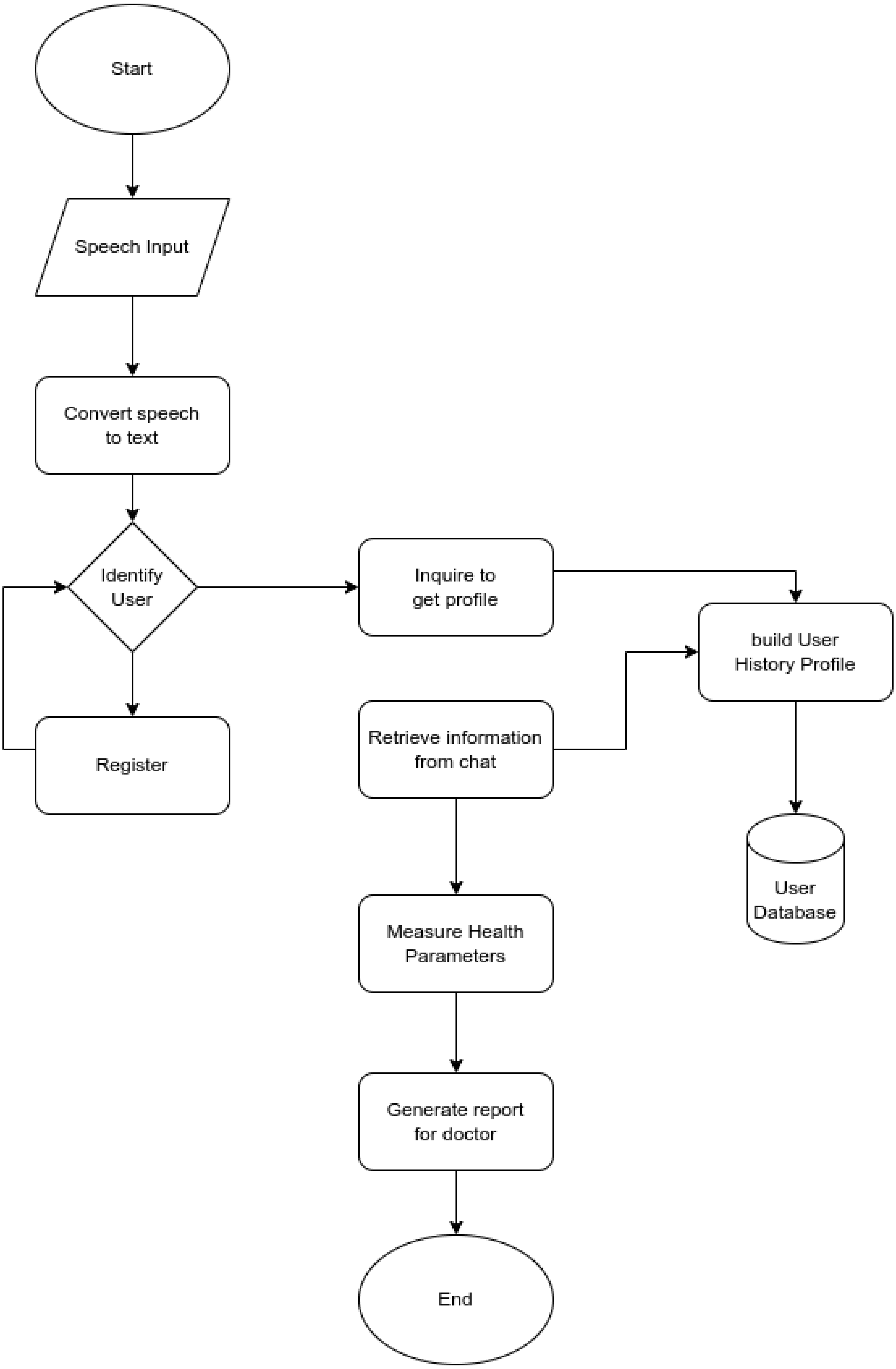


Fig 1.1: Project Work-Flow Diagram

1.4 Potential Applications

a. Developing a system to help patients with diabetes gather information with voice only.

b. It can be used in diabetes doctor's clinics because of its time effectiveness and user-friendly environment.

1.5 Overview of the Project

This project proposes an integrated chatbot-hardware system driven by AI and NLP to revolutionize patient pre-screening. A specialized hardware module simultaneously records vital indications such as temperature, heart rate, and oxygen saturation, and the chatbot's interactive interface facilitates easy information gathering through discussion. With less reliance on in-person visits and wait times, this integrated strategy should maximize data gathering and patient involvement. The initiative envisions a patient-centric ecosystem where effective pre-screening leads to improved healthcare delivery and overall patient experience by seamlessly merging technology with healthcare knowledge. Applications can be anything from simplifying pre-screening procedures in physician offices to helping manage diabetes through voice-activated data collection. This project has the potential to drastically change the healthcare industry by improving pre-screening effectiveness, accessibility, and personalization.

1.6 Organization of the Thesis

This thesis includes six chapters. The rest of the thesis is organized as follows:.

Chapter 1: This chapter gives a detailed introduction to the research and discusses topics like problem statements, thesis objectives, methodology, potential applications.

Chapter 2: A detailed discussion of the literature review and background study is done here. This chapter also gives an overview of some important terminologies in the literature review.

Chapter 3: The design of system architecture that was followed throughout this research is presented in Chapter 3.

Chapter 4: This chapter discusses the environmental setup and implementation.

Chapter 5: This chapter states the testing process for each module and the results.

Chapter 6: Engineering considerations, challenges, and their remedies are focused on in this chapter.

Chapter 7: Finally, the study's conclusion, limitations, and future work are stated in Chapter 7.

CHAPTER 2
LITERATURE REVIEW

Pre-screening chatbot can be used in a section of medical science. It can gather information on a patient's previous health information. The project aims to revolutionize patient pre-screening by creating an integrated chatbot-hardware system using AI and NLP. The chatbot, which engages in natural conversations, gathers medical information and offers personalized responses, while a hardware module collects vital signs like temperature, heart rate, and oxygen levels. This synchronized data collection optimizes efficiency and minimizes in-person visits. The project has potential applications in diabetes management and doctor's office pre-screening procedures. Its goal is to make pre-screening more efficient, accessible, and personalized, leading to better health outcomes.

2.1 Important Concepts

Some important concepts and terminologies that are identified from the literature review are as follows:

2.1.1 Prescreening Chatbot

A pre-screening chatbot acts as a virtual assistant, streamlining the early stages of recruitment. Powered by AI, it gathers basic information and filters candidates based on specific criteria it sets. Think multiple-choice questions about skills, open-ended prompts for motivation, and automated scheduling for qualified applicants. Imagine saving hours sifting resumes by letting the chatbot handle initial interactions, leaving you free to focus on high-potential candidates. Remember, it's not a replacement for personal judgment, but a powerful tool to improve efficiency and candidate experience..

2.1.2 Basic Concept of Diabetes and Diabetes Patients

To make a chatbot for the pre-screening of diabetes patients it is very important to have sound knowledge about diabetes because there is no dataset for questioning to gather information through a conversation. So, a dataset has been made on their knowledge about diabetes which is gathered from their conversation, prescription, and family background knowledge. What information is needed for the doctor to give treatment to the patient in the case of diabetics is very important.

2.2 Relevant Studies

A system is proposed that aims to develop an integrated chatbot-hardware solution for patient pre-screening in hospitals and clinics. The system combines a chatbot interface with sensors to measure the height, weight, heartbeat, oxygen saturation, and body temperature of patients. By streamlining the pre-screening process, our system aims to reduce wait times, optimize resource allocation, and enhance the overall patient experience.

Existing literature highlights several related systems that have addressed aspects of remote healthcare and medical assistance. One study by (Harikrishnan, and Stephen, 2020) describes the development of a hospital/home medical assistant robot, which utilizes surveillance and bystander modes to collect patient data and provide assistance. However, this system may face limitations in terms of its ability to effectively handle complex medical scenarios and communicate critical information to healthcare providers. Another research by (Stollnberger et al., 2016) proposes a three-way teleconference system that enables remote consultations between doctors, patients, and assistants using a medical robot. While this system facilitates communication, it may have limitations in terms of its scalability and ease of use, potentially hindering its widespread adoption. Moreover, the use of chatbots in medical diagnosis has gained attention. (Srivastava, and Singh, 2020, February) present a diagnostic chatbot that engages patients in conveAssistingrsonalized disease diagnosis. However, its limitations may lie in its reliance on textual input, which may not fully capture nuanced symptoms or non-verbal cues from patients. In a similar vein, (Divya et al., 2018) introduced a self-diagnosis medical chatbot driven by Artificial Intelligence. This chatbot engages users in discussions about their health issues, extracts symptoms, and offers personalized disease diagnoses. It aims to improve accessibility to medical knowledge and empower users to understand their health before seeking professional medical advice. Additionally, an AI-IoT-based Healthcare Prognosis Interactive System (Reddy et al., 2020, November) integrates a chatbot and an application interface to provide real-time medical diagnosis and support. However, this system may have limitations in terms of data security and privacy concerns related to the collection and storage of sensitive patient information.

While these existing systems have made significant advancements, our proposed chatbot-hardware system offers a unique integration of AI-powered chatbot technology and physical sensor measurements. By efficiently collecting patient data and enabling effective communication with healthcare providers, our system aims to address the limitations of existing systems and revolutionize the patient pre-screening process, improving efficiency, accessibility, and patient outcomes.

Table 2.1: Literature Review comparison table

Author	**Implementation Approach**	**Findings**	**Limitations**
Harikrishna, and Stephen, 2020	• Uses a Pulse oximeter, temperature, and humidity sensor, and buzzers. • Has a medication reminder system that is built using the RTC module. • Control of the bot in self-sufficient mode, the ultrasonic sensor is used. • To control the system manually android app and Wifi module are used	• Develop a hospital/home medical assistant robot capable of surveillance, and data collection. • Assisting patients. • Operates in surveillance mode, detects obstacles, navigates, and has a bystander mode.	• Needs a high cost to establish the system. • Unable to provide humanlike communicati on with the patients. • No angular movement in the control system.

Table 2.1: Literature Review comparison table (Ctd)

Stollnberger et al. (2016)	● Implemented as a custom-built package. ● GStreamer- 0.10 for video and audio streaming. ● QT4 for the graphical interface. ● The ROS framework for peer-to-peer communication.	● Enables remote consultation and expert advice through a robot divided into two parts. ● Allowing for real-time monitoring and assessment of the patient's condition.	● Requires a doctor's involvement to assess the patient's condition.
Biju, et al. (2021)	● The voice from the user is recorded using a microphone, and the voice is converted to text using Google API. ● The unstructured output of Google API will be taken as input and info is extracted using the Bag of Words method. ● Two types of response systems are developed. ● General Response is created by training the chatbot using the Seq2Seq model. ● Medical Assistant: Apriori algorithm is	● A diagnosis chatbot that engages patients in conversation to understand their medical queries and symptoms. ● Uses a conversational approach and analyzes the input from patients to extract diagnosed symptoms. ● Has a precision of 65% in identifying symptoms and a recall of 65% in	● Doesn't have any hardware system to measure patients' health data.

	used to predict the disease. ● Google text to Speech API converts the response text to speech.	correctly identifying the symptoms. ● Based on the identified symptoms, the chatbot provides an individualized diagnosis to the patients.	
Divya et al. (2018)	● From user interaction, symptoms are extracted using the String Searching algorithm. ● According to the symptoms, the disease is specified.	● Uses artificial intelligence to diagnose diseases. ● Provide basic treatment before consulting a doctor. ● Can diagnose basic diseases by extracting info via human interaction. ● Provide basic treatment.	● It doesn’t have detailed symptom descriptions and doesn’t have the voice conversion feature.
Reddy et al. (2018)	● Utilizes NLP to analyze the user's intent. ● When interacting with the chatbot, it first checks the local database for	● Proposes an AI-based chatbot. ● An application interface that is used for effective means of gathering	● Has low accuracy in providing accurate answers to users.

	information in a primary search. ● If the user has a preexisting medical condition, the chatbot refers to the global database to access medical records and prescription history, providing a suitable response. ● If one doesn't have a preexisting medical condition, the chatbot makes decisions based on its confidence level.	information, and answering general medical queries, providing user assistance specialized for medical purposes, and alerting patients on their medication.	

2.3 Summary

This chapter provides a glossary of key terminology and meanings relevant to the work of our project. To have a deeper understanding of the particular work domain, many papers about the topic were discussed. Overall idea about current and ongoing projects on the research topic was found. The limitations of previous works and how those can be overcome by this project can be summarized.

CHAPTER 3
SYSTEM MODELING AND DESIGN

The system structure has been designed to achieve the overall objective of the project. The system is modeled in multiple stages. This chapter discusses Conceptual Design, Developing machine learning models, Interface Design, External Device integration, and Environment Design. The prototype of the design before implementation has been explained here.

3.1 Conceptual Design

The conceptual design stage presented a flow diagram of different functions. How the system is theoretically designed will be presented in this section. Furthermore, there will also be the dataset collection process, chatbot design, development process, and integration process with the Raspberry Pi.

3.1.1 Dataset Collection

Healthcare professionals and patients who understand the study and provide informed consent are crucial. Clearly explain the study's goals, data collection methods (e.g., anonymized audio recordings), and potential risks and benefits. Prioritize privacy by employing methods like de-identified transcripts and ensuring data security throughout. Finally, meticulous data pre-processing involves de-identification, accurate transcription, relevant annotations (demographics, risk factors, diagnoses), and ethical analysis. Data was collected and preprocessed through responsible data management and participant well-being is essential throughout this process, as shown in Fig 3.1

{} dataset.json > ...

```json
{
    "intents": [
        {
            "tag": "greetings",
            "patterns": [
                "hello",
                "hey",
                "hi",
                "what's up",
                "how is it going"
            ],
            "responses": [
                "Hi. Can you please provide your name"
            ]
        },
        {
            "tag": "name",
            "patterns": [
                "name",
                "my name is"
            ],
            "responses": [
                "Please provide your age"
            ]
        },
        {
            "tag": "inquire_problem",
            "patterns": [
                "age",
                "my age is"
            ],
```

Fig 3.1: Snip of Data Set

3.1.2 Chatbot Design

To make a chatbot, we have to select a programming language (Python). Then the collected data is preprocessed, which means only the necessary conversation form that can be used as a dataset is taken. The preprocessed dataset is trained by ANN(Artificial Neural Network). Then The flowchart of focus position detection and tracking is presented in Fig 3.2.

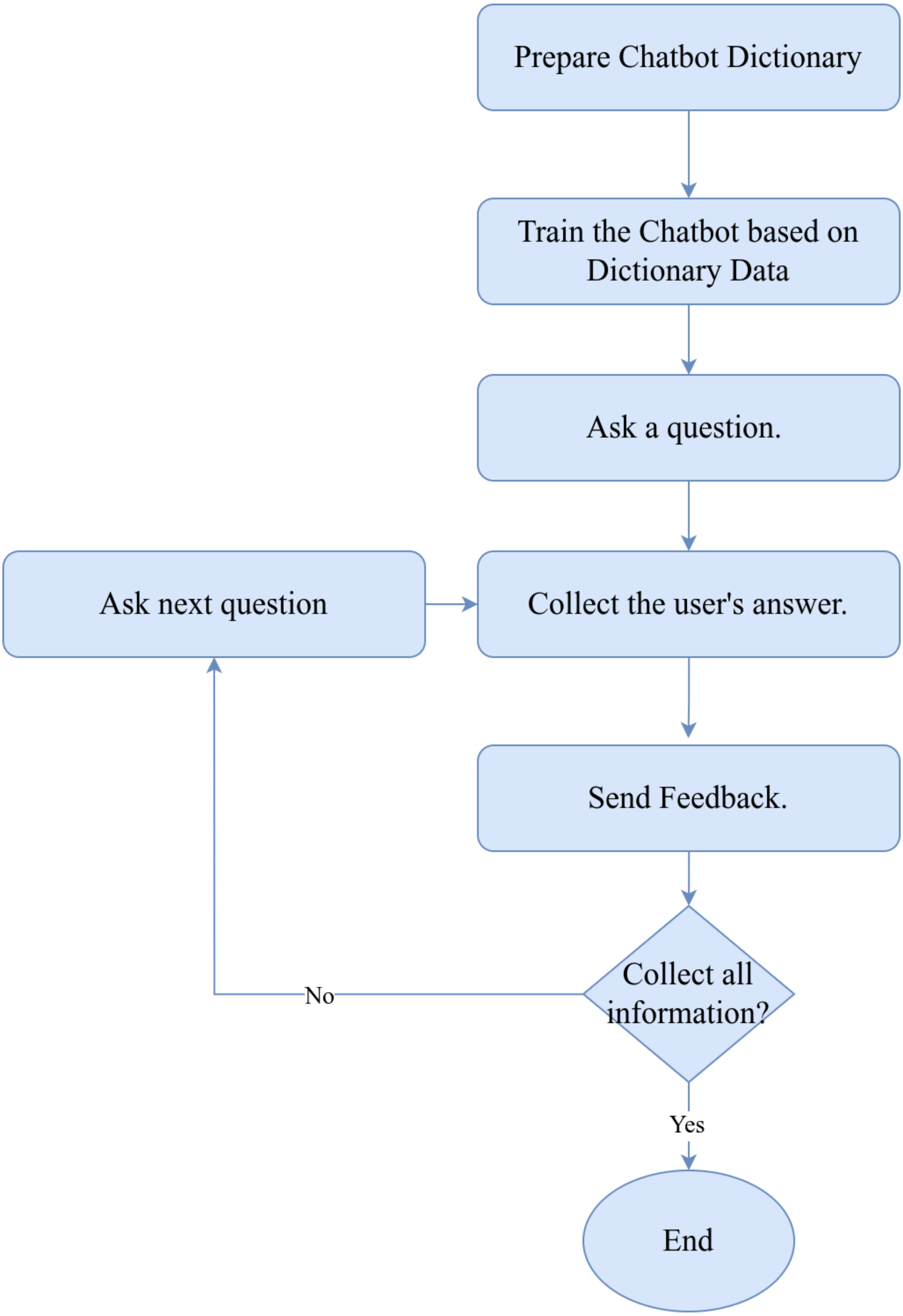


Fig 3.2: Flowchart of The Design of Chatbot

3.1.3 Body Health Measurements Collection

A box has been developed by putting various sensors and circuitry into a PVC-boarded box. The hardware measures three parameters: the user's body temperature, pulse rate, and oxygen level. For processing and uploading the data, Raspberry Pi has been used as a microcontroller. Raspberry Pi is used in CPU cores, which can be individually controlled. A DS18B20 temperature sensor has been used to measure body temperature. DS18B20 has ±0.5°C accuracy from -10°C to +85°C. The MAX30100 Pulse Oximeter Heart Rate Sensor Module has been used for measuring the pulse rate and oxygen level of the user's body. MAX30100 is an optical sensor that derives its readings from emitting two wavelengths of light from two LEDs— a red and an infrared one. It measures the absorbance of pulsing blood through a photodetector. The flow diagram of the hardware system is depicted in Fig 3.3. The circuit diagram of the hardware prototype is illustrated in Fig 3.4.

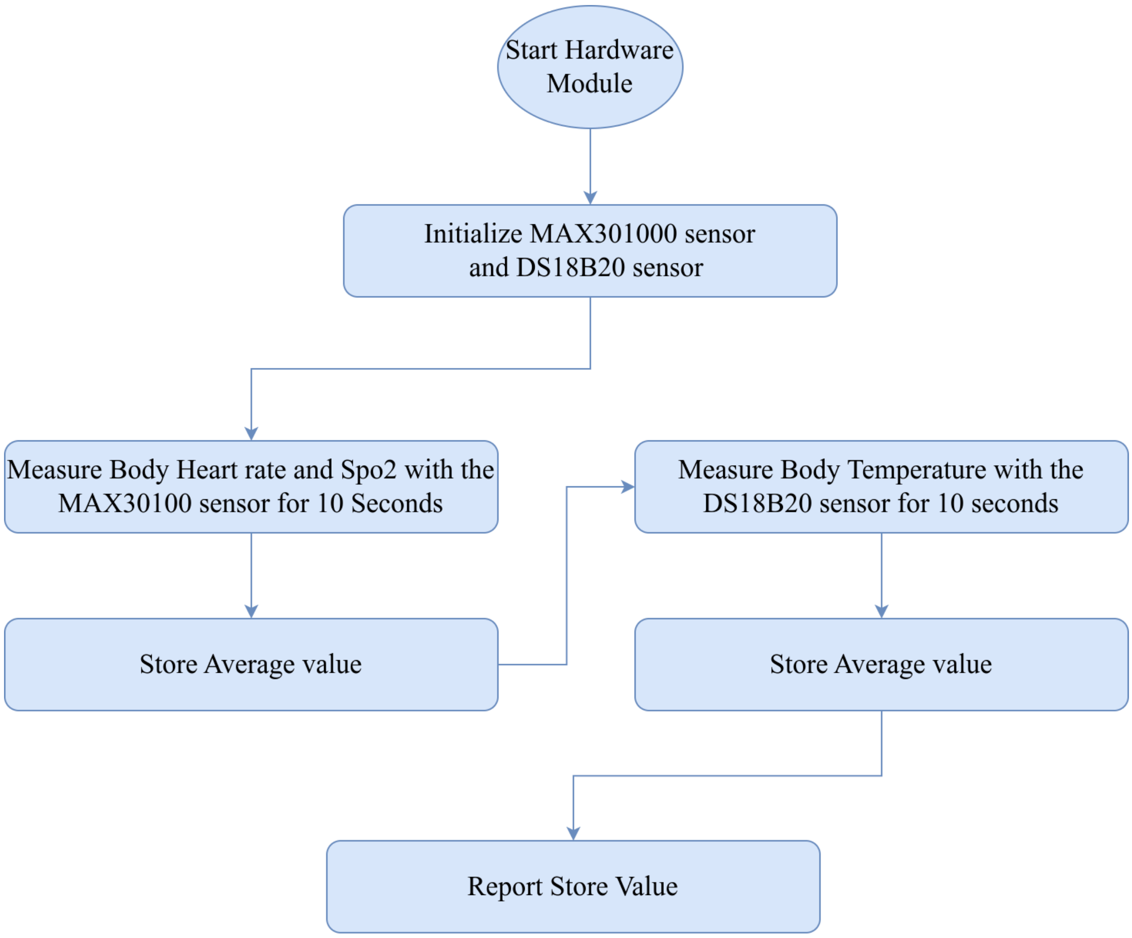


Fig 3.3: Flowchart of Collecting Body Health Measurements

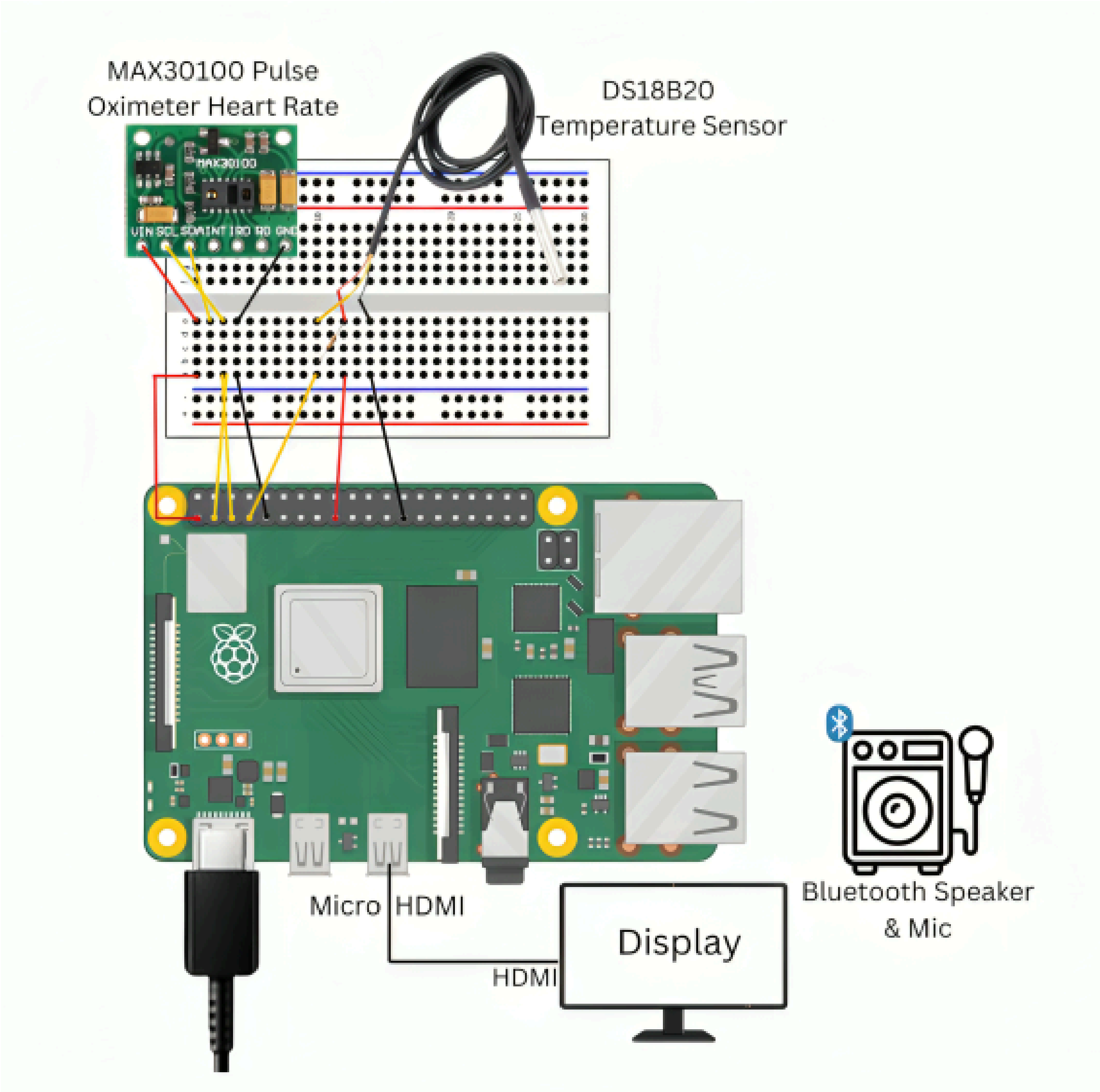


Fig 3.4: Circuit diagram of the Hardware Prototype

3.1.4 Overall Process Diagram

The proposed system starts with a window showing the image of a face simulating the chatbot. If the chatbot speaks, the chatbot speaking window will be shown. Otherwise, the chatbot listening window will be shown. Parallely, the system will wait for engagement with a user. If engagement is detected, the chatbot will speak and ask questions based on the tag. Then the audio response of the user is recorded. The response is then converted into text and inserted into the ANN Sequential model. The ANN Sequential model predicts the tag of the next question based on the user's response. The predicted tag is then used to pick the next question from the chatbot dictionary. After the questions are finished and the responses are recorded, the system will measure the health data of the user. At first, it will measure the pulse and spo2 value of the user and then wait for 10 seconds. then it will measure the body temperature of the user. After the measurement is finished, A new window will appear on the screen showing the report of the user which is generated based on the user's responses and measured sensor data. The overall process of the project is presented in Fig 3.5.

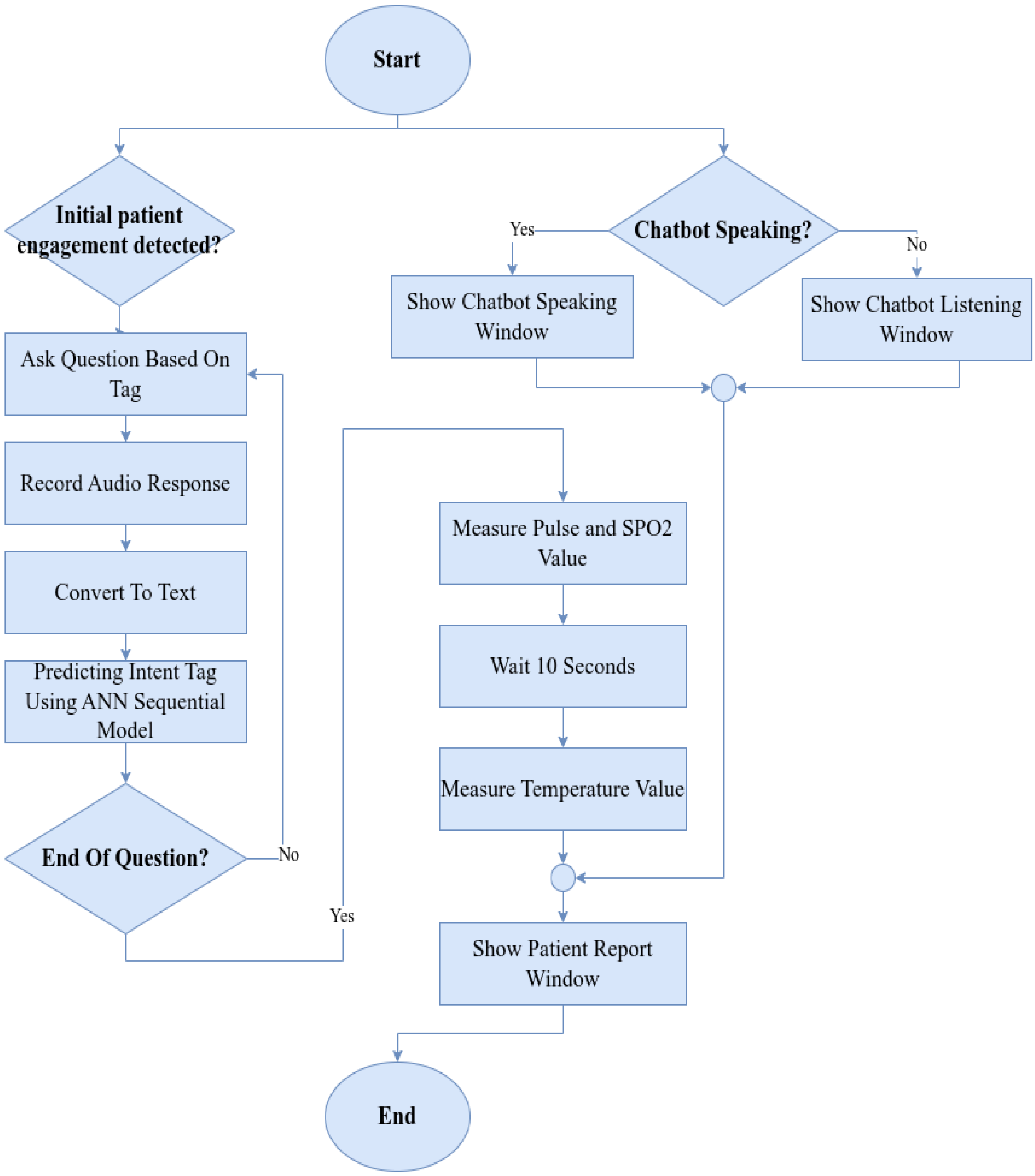


Fig 3.5: Flowchart of Overall Process

3.2 Interface Design

The experiment setup is mainly a software-based interface. The interface is divided into three individual screens having different purposes.

Two screens are for user interaction with the chatbot. The first screen is the speaking screen. When the chatbot is speaking, the speaking screen will be shown which contains an image of a face speaking. The second screen is the listening screen, when the chatbot is done speaking and waiting for the user's response, the listening screen will be shown so that the user can understand that it's his/her turn to talk. The prototype of two testing screens is shown in Fig 3.6 and Fig 3.7

(a): Chatbot Speaking Screen

(b): Chatbot listening screen

Fig 3.6: Chatbot Screen

The third screen is designed for the use of doctors and medical assistants. It will show the patient's report which will contain the necessary medical information required for treatment of the patient, which is collected by the conversation between the chatbot and the patient. The screen will also contain the body temperature, pulse rate, and oxygen saturation level of the patient which is collected by the sensors.

3.3 Machine Learning Model

This project is about the development of an interactive chatbot for diabetes patient pre-screening. The model used in this system is given in Fig 3.8.

In this system, the input is taken as voice. So to insert data into the model, the voice is then converted to text. The text data is preprocessed and the stop words are removed. Bag of words representation of the input text is generated to use in the model. The Sequential neural network model predicts the intent of the next question based on the preprocessed data. The output is returned as a list of probabilities, one for each intent in the data dictionary. Classes with probabilities below the threshold = 0.25 are filtered out. The remaining list of probabilities is then sorted to get the intent with the maximum probability. A return list is generated which contains the name of the intent and its probability which can be used in the system to identify the next question. The dataset used in this model contains 13 intents in total. The number of intents can be increased if new questions are needed to be added to the system.

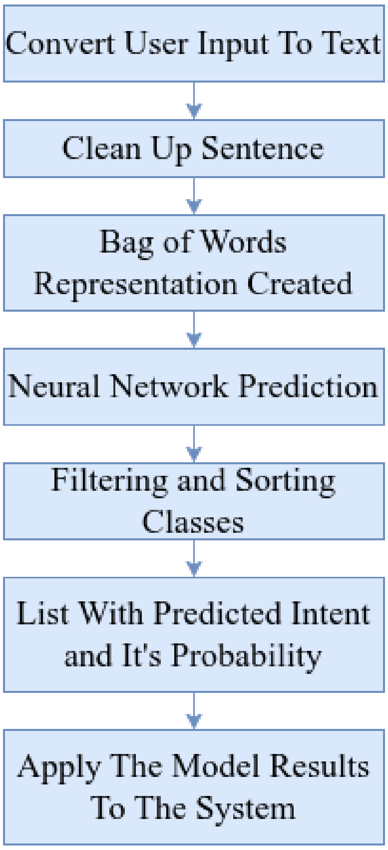


Fig 3.7: Machine Learning Model Choosing Process

3.4 External Device

The system is mainly a software-based system through which a diabetes patient interacts with an assistant(chatbot) to give his information. Still, a PVC box is added as an external device. The purpose of adding the external device is to make an end product and also collect body measurements through external devices. As a prototype, the system includes a simple design of a box system. For controlling the system, Raspberry Pi is used as a processor. The circuit connection of the system is given below in Fig 3.9.

The Raspberry Pi 4, featuring 4GB of RAM and a 64-bit architecture, stands as a versatile and robust single-board computer. With enhanced performance capabilities, smoother multitasking, and compatibility with a wide array of software optimized for 64-bit computing, it serves as an ideal platform for diverse projects ranging from IoT applications to multimedia centers. Equipped with advanced connectivity options, including dual-band Wi-Fi, Gigabit Ethernet, and USB 3.0 ports, alongside support for dual 4K displays, the Raspberry Pi 4 empowers users to explore computing, learn programming, and innovate across various domains with ease.

For interfacing the Max30100 pulse oximeter with the Raspberry Pi, the I2C (Inter-Integrated Circuit) protocol is employed. I2C enables serial communication between the Raspberry Pi and the Max30100 sensor, allowing for the transmission of data such as heart rate and blood oxygen saturation levels.

The DS18B20 temperature sensor is interfaced with the Raspberry Pi using the 1-Wire protocol. This protocol enables communication with the DS18B20 sensor through a single data wire, simplifying the wiring and connection process. With 1-Wire, the Raspberry Pi can accurately measure temperature readings from the DS18B20 sensor.

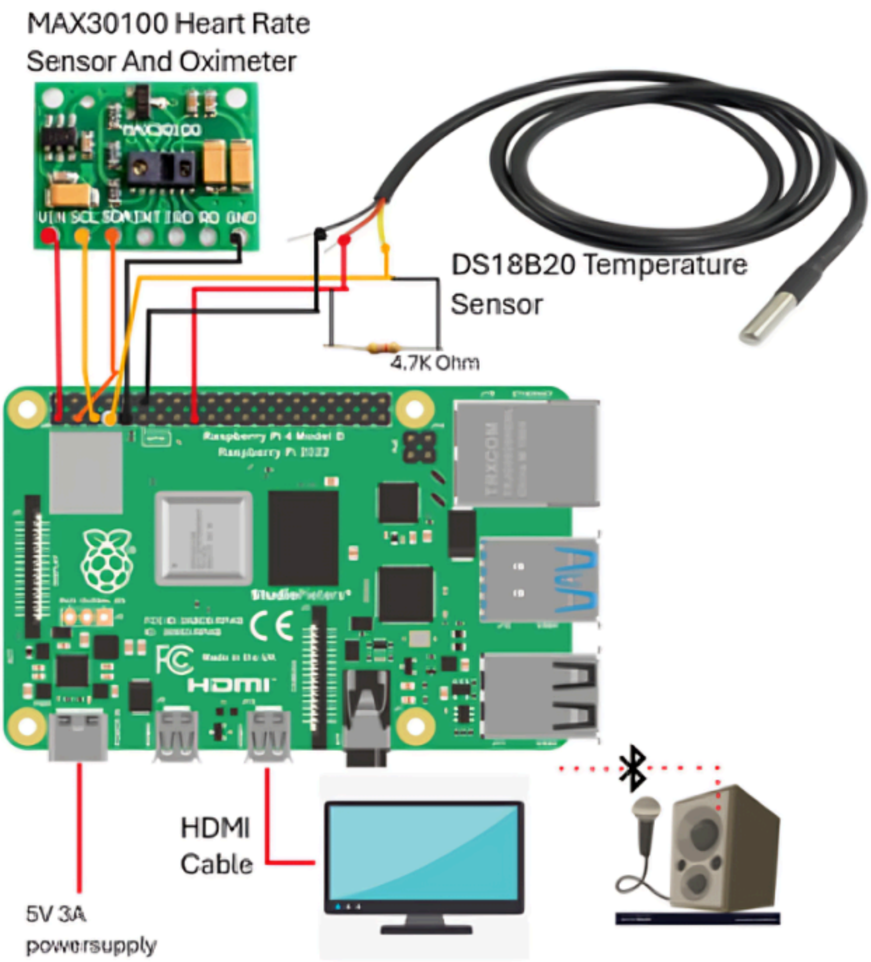


Fig 3.8: Circuit Connection of External Device

3.5 Design of Experimental Setup

The whole system includes a display or monitor in front of the diabetes patient and the box containing the devices and circuits where the display is on the upper part of the box. When the patient comes to the doctor's chamber, he talks with the chatbot and also gives information and body measurements. The proposed overall setup is presented in Fig 3.10.

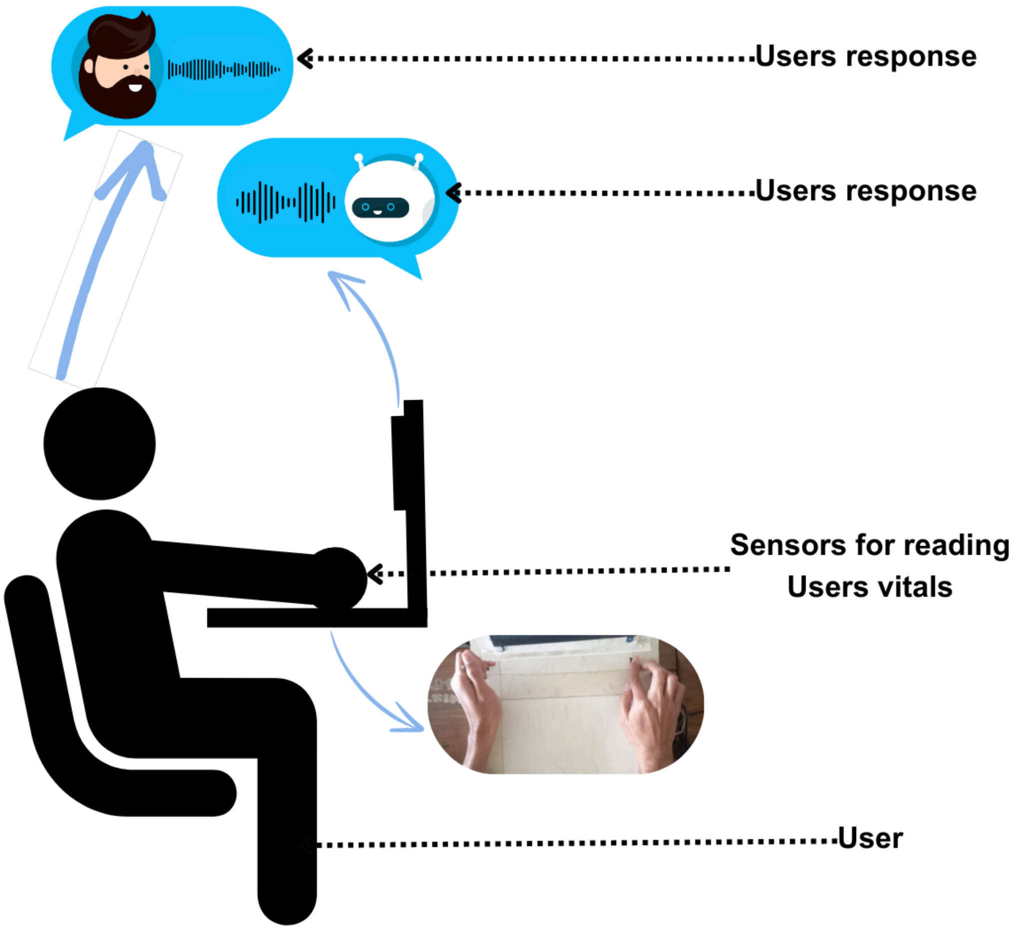


Fig 3.9: Proposed Setup of the System

3.6 Summary

In this chapter, an overall idea about the prototype of the system is given. The chatbot will start when the start button is clicked. An interface will come up which will say whether the bot is talking or listening. Then with guidelines body measurements will be taken. The prototype of the system has been shown in diagrams. Lastly, a detailed discussion on the machine learning model is done. The Artificial Neural Network (ANN) method is used here.

CHAPTER 4
EXPERIMENTAL SETUP AND IMPLEMENTATION

This chapter mainly focused on the system's setup in the real environment. During this phase, the voice-to-text conversion, Sensor data collection, interface screen designs, and external device control mechanisms are discussed. Once the interface has been developed, the integration with the chatbot program has been developed.

4.1 Speech-To-Text Conversion and Sensor Data Gathering

This system is based on voice communication. As a result, a text-to-speech and a speech-to-text conversion is needed to run the system. Here a built-in model of python called “pyttsx3” is used for this conversion. The process of Speech-to-text is presented in Fig 4.1.

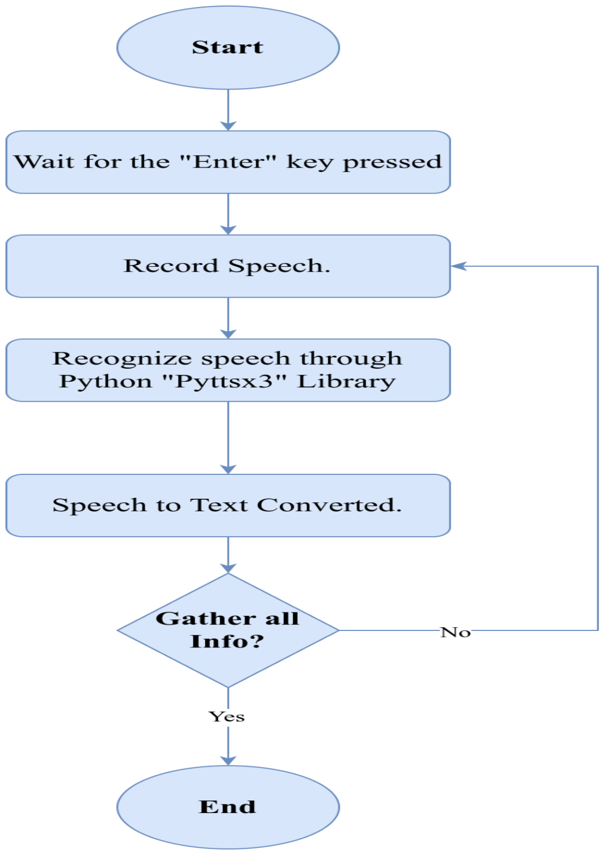


Fig 4.1: Flowchart of Speech-To-Text Conversion process

Algorithm 1 Speech-To-Text Conversion

1: Start: Initialize Mic System.
2: Initialize the file to save the dataset.
3: **while** True **do**
4: **Capture:** Record the user's speech
5: **Understand:** Try to interpret the captured speech (Python "Pyttxs3" model).
6: **Display:** Show what the user said on the screen.
7: **end while**

This Algorithm script utilizes the SpeechRecognition library to convert spoken words into text and the pyttsx3 library to convert text into speech. It defines two main functions: recognize_speech() and text_to_speech(). The recognize_speech() function initializes a recognizer object and uses the microphone as the audio source to capture speech input. It attempts to recognize the speech using Python built-in "Pyttxs3" model, handling potential errors such as unrecognized speech or request errors. The text_to_speech() function initializes a text-to-speech engine and converts the provided text into speech. The main() function orchestrates the overall flow of the script, prompting the user to press Enter to start listening, then recognizing speech input, printing the recognized text, and finally converting it back to speech. The script ensures that the main() function is executed only if the script is run directly as the main module. Overall, this script provides a simple interactive interface for speech recognition and synthesis. The pseudo-code for the body health measurements function that is stored in the database.

Algorithm 2 Collecting Body Health Measurements

```
1: Define function DS18B20:
        Initialize base directory for temperature sensor
        Initialize empty lists sensor_path and sensor_name

2: Define function find_sensors:
        Find all sensor paths matching base directory
        Extract sensor names from paths

3: Define function strip_string:
         Accept temp_str as input
        Find the index of 't=' in temp_str
        If 't=' is found:
                Extract temperature value after 't='
                Convert temperature value to Celsius and Fahrenheit
                Return temperature in Celsius and Fahrenheit
        Else:
                Wait for 0.2 seconds
        Define function read_temp:
        For each sensor and its path:
                Open sensor file and read data
                Check validity of data
                If data is valid:
                        Call strip_string to extract temperature
                        Return temperature
                Else:
                        Wait for 0.2 seconds

4: Define function measure:
        Initialize pulse oximeter sensor
        Enable SpO2 measurement
        Read single sensor data for pulse oximeter
        Extract pulse rate and SpO2 values
        Wait for 10 seconds
        Create instance of DS18B20 class for temperature sensor
        Find connected sensors and store their paths and names
        Read temperature data from sensors
        Extract temperature (°C and °F)
        Return pulse rate, SpO2, temperature (°C and °F)

5: Call measure function
        Extract pulse rate, SpO2, temperature (°C and °F)
        Print pulse rate, SpO2, temperature (°C and °F)
```

This algorithm is designed to collect body health measurements using sensors. It begins by defining functions to interact with a DS18B20 temperature sensor, including finding connected sensors, extracting temperature data, and converting it to Celsius and Fahrenheit. Then, it defines a function to read data from a pulse oximeter sensor, extracting pulse rate and SpO2 values. The main function, measure, and initialize the pulse oximeter sensor, read its data, wait for 10 seconds, initialize the temperature sensor, read its data, and return the collected measurements including pulse rate, SpO2, and temperature in Celsius and Fahrenheit. Finally, it calls the measure function to collect the measurements and print them out. This algorithm thus integrates functionalities for both pulse oximetry and temperature sensing, enabling the monitoring of vital signs and body temperature.

4.2 Software Interface Design:

4.2.1 Software Tool

Two software tools are used in this system. A description of tools is given below.

a. **Tinkercad**

The system has a hardware module that is simulated online first. Therefore, Tinkercad is used which is a user-friendly online platform developed by Autodesk, primarily designed for 3D modeling, electronics, and circuit design. It provides an intuitive interface that allows users, including beginners and students, to create and prototype 3D models and electronic circuits without the need for advanced technical skills or software installations. Tinkercad's drag-and-drop functionality, extensive library of shapes and components, and easy-to-use tools enable users to quickly bring their ideas to life, whether they're designing objects for 3D printing, simulating electronic circuits, or experimenting with robotics projects.

b. **Visual Studio Code**

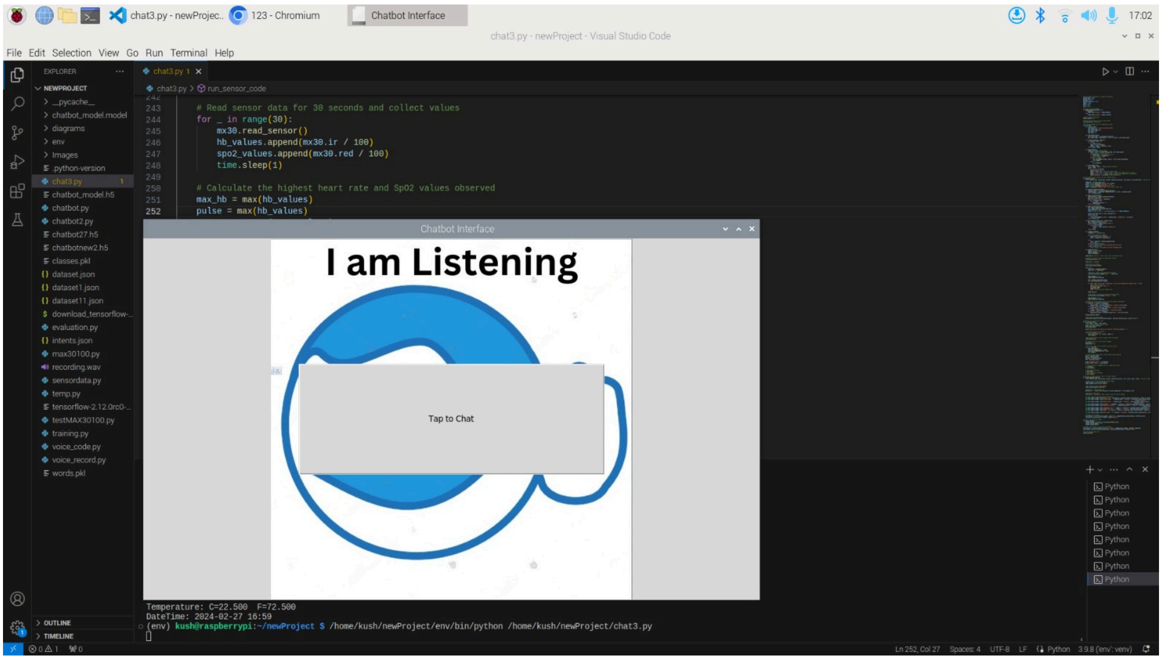
The system is done in Python language. To execute .py files this tool is used. Through this tool both the interface design and raw code execution become flexible. Visual Studio Code (VS Code) is a highly versatile and popular source-code editor developed by Microsoft, widely embraced by Python developers for its seamless integration with the language. With its cross-platform compatibility, and robust features such as code completion, built-in debugging, Git integration, and a customizable user interface, VS Code offers an efficient and productive coding environment tailored to Python development needs.

4.2.2 Interfaces

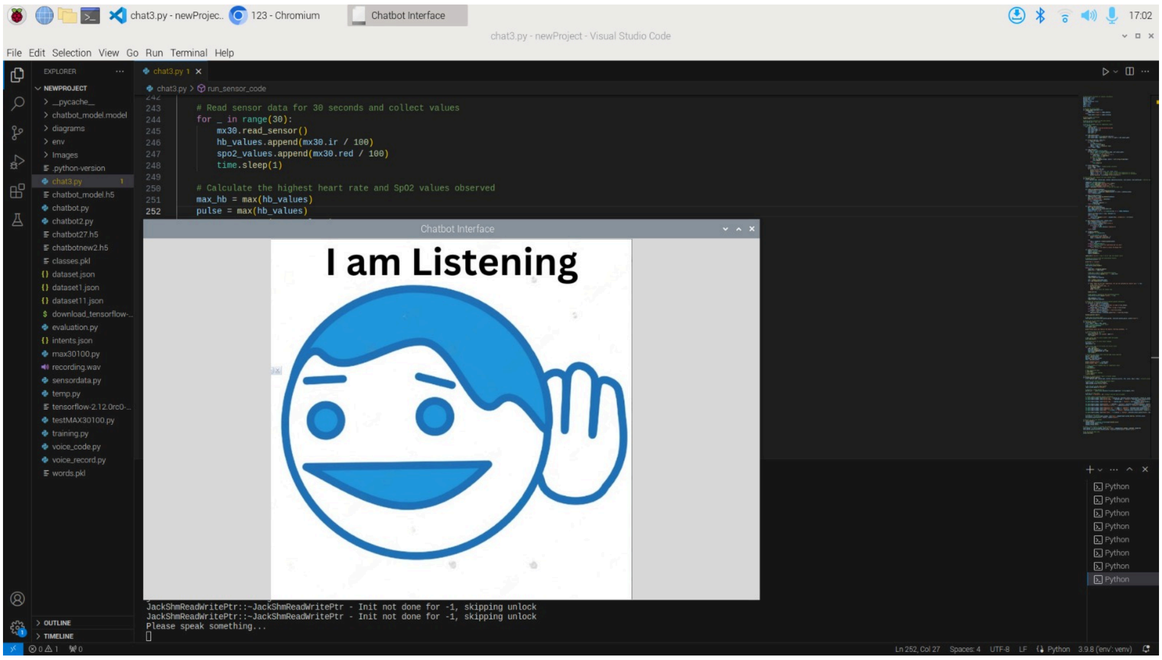
The software-based interface was developed with the screen being divided into three individual segments having specific functions. Two separate screens were developed to speak and listen and another one was for show information.

4.2.2.1 Testing Screen

The test is done in Visual Studio code on a outsider laptop. As the micro-controller (Raspberry-Pi4) is so powerful to train a model, so a outsider laptop is used. So, in testing time, the terminal and also the interface both are observed. When the chatbot system is run, An interface with a button named “Tap to Chat” will come up to the user. When a user taps on that button, the chatbot will be started. It will start the conversation. The following Fig 4.2(a) a snip of the screen where there is a button named “Tap to chat”. After tapping on that button the chatbot will start and wait for the response of the user and the Fig 4.2(b) screen will be opened.



(a) Snip of the Testing Screen 1



(b) Snip of the Testing Screen 2

Fig 4.2: Testing screen

4.2.2.2 Application Screen:

This screen fulfills the goal of the system; which's major objective is to assist a diabetes patient and doctors in their daily clinical activities. Tap the button will start the chatbot. The speaker produces a similar commanding sound to the patient and collects the user's response. The chatbot first takes the user's name and age then it will ask questions to gather medical pieces of information. The design of the application’s opening screen is shown in Fig 4.3.

Fig 4.3: Snip of Initial Interface

4.2.2.3 External Device Controlling Screen:

After gathering enough information chatbot will start a countdown of 30 seconds. In the meantime sensor will collect body measurement data. The design of the external device controlling the screen is shown in Fig 4.4.

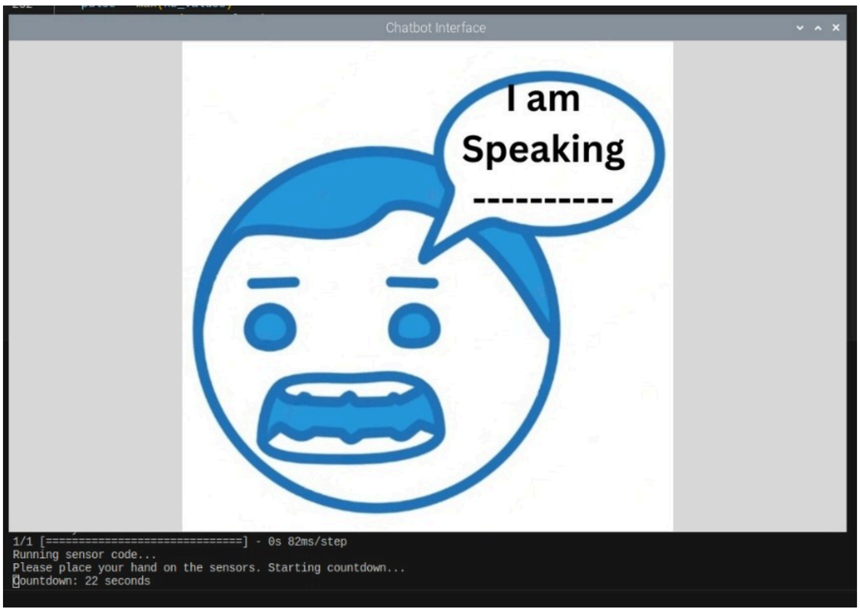


Fig 4.4: External Device Controlling Screen

4.3 Setup with Hardware Device

There is a box where the circuit connection and the microcontroller are situated. The screen is on the top of the box. The following Fig 4.5 is the final system that is ready to use properly.

Fig 4.5: Setup of Hardware Device

4.4 Summary

This chapter presents a detailed description of the implementation according to the designed prototype. It also describes how the experiment is conducted including tools and methods used to collect data.

CHAPTER 5
RESULT AND EVALUATION

The evaluation and results of patient prescreening system surveillance can depend on various factors, including its design, questioning capability, answer prediction in real-world scenarios, controlling power of external devices, etc. The primary purpose of this project is to develop a prescreening system for people having diabetes at their doctor’s chamber. It's important to assess how well the system can perform chatting tasks, including its ability to gather information and store and interpret a document on this information. The accuracy with which the system performs its tasks is an important factor in its evaluation. The system should be able to quickly gather information and interpret that into a document format. The proper execution of external devices through the interface is also a major task.

5.1 Software Interface Evaluation

Focusing on the objectives of the system, interfaces have been designed. Initially, the application screen will show a tap button in front of the patient on the screen. When the patient taps on any screen, the chatbot will start and there will be sound for chatbot response through a Bluetooth-connected speaker and mic system. The application screen is mainly used for assistive purposes.

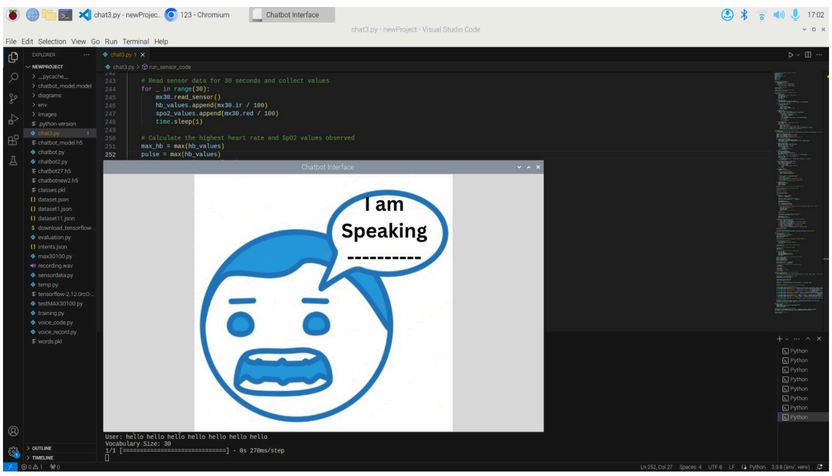
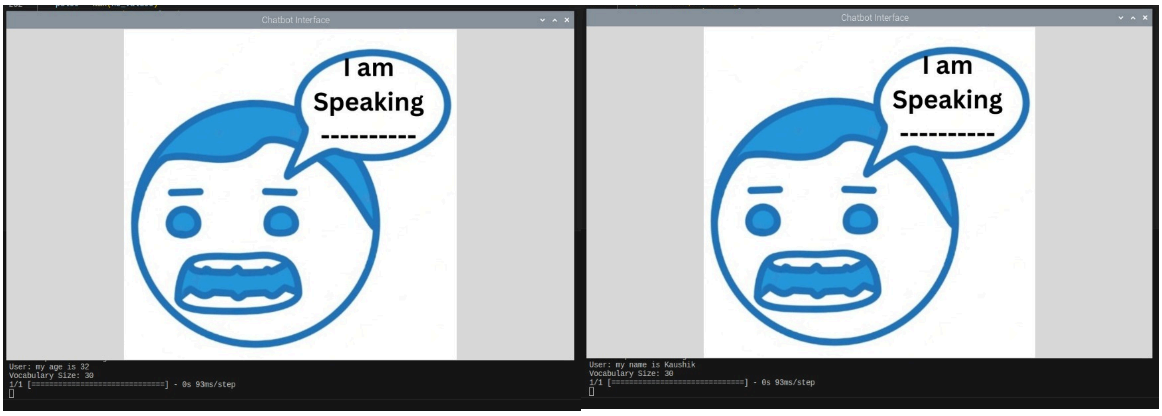
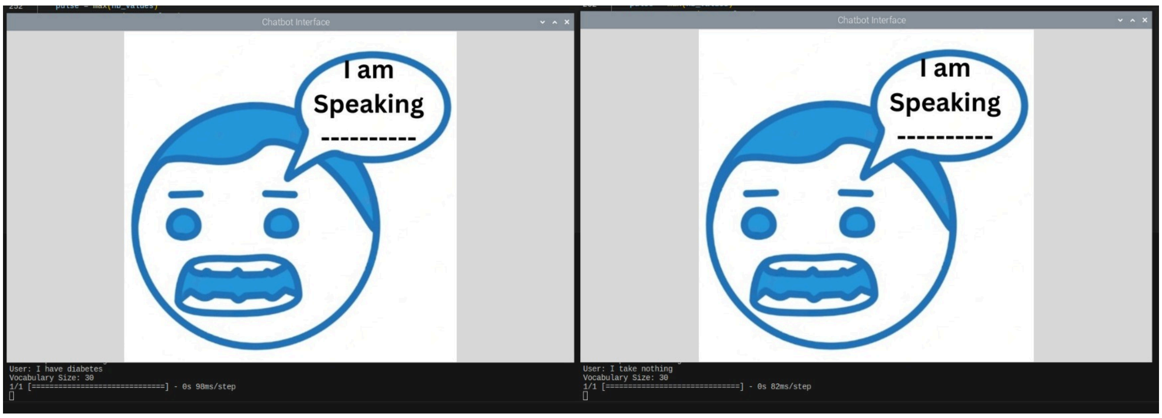


Fig 5.1 : Chatbot has Started

(a) Chatbot listening to the First voice of the User



(b) Gathering Name and Age



(c) Gathering other information

Fig 5.2: User's Different Timeline while using The Chatbot

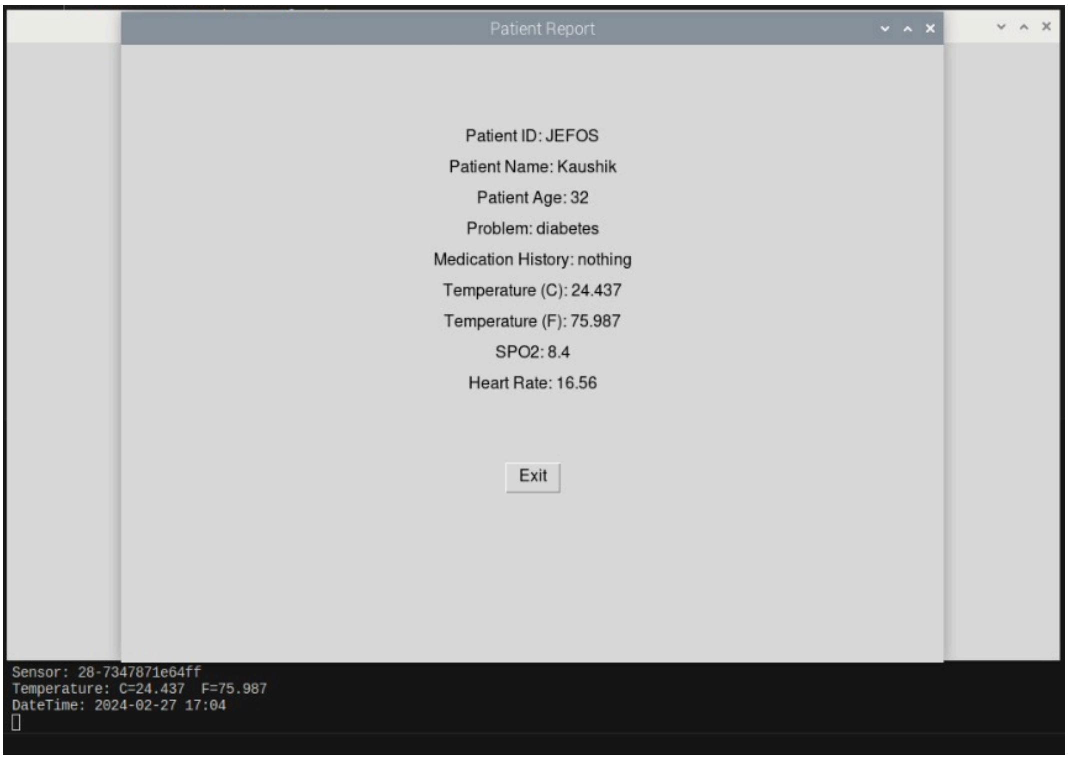


Fig 5.3: User's Different Timeline while using The Chatbot

5.2 Machine Learning Model Evaluation

The system includes machine learning to identify the intent of the next question the chatbot is going to ask from the answer of the current question of the user. The Feedforward Sequential Neural Network model and LSTM are used to perform the task.

5.2.1 Evaluation of Model using test cases

We have used several test cases to evaluate the models. We have used two models here. first one is the Feedforward Sequential Neural Network model and the second one is LSTM.

5.2.1.1 Test Case 1

The following responses are given to the models. The feedforward sequential model was able to predict the intent of the next question correctly with an accuracy of 100% in this case. On the other hand, 50% accuracy was achieved in LSTM.

User: Hello

Chatbot: Hi there! I am happy to chat with you. Could you tell me your name?
User: My name is John.

Chatbot: Nice to meet you. Please provide your age.
User: my age is 23

Chatbot: Can you tell me if you're facing any health concerns?
User: I have high blood sugar.

Chatbot: Do you have any family history of diabetes?
User: My mother has diabetes.

Chatbot: Have you been diagnosed with any other medical conditions except diabetes?
User: No other medical condition.

Chatbot: Are you monitoring your blood sugar levels at home?
User: Yes, I am monitoring my blood sugar levels at home.

Chatbot: What is the recent blood sugar reading?
User: My recent blood sugar reading is 12.

Chatbot: Do you take any medication?
User: No, I don't take any medication.

Chatbot: Put your hand in the marked position for 30 seconds.

For this test case the output of the feed forward neural network model is given in Table 5.1. Here sentences are taken from the conversation and chatbot predict its intention.

Table 5.1: Intent Prediction Table for Feedforward Sequential Neural Network model for Test Data 1

Sentence	Predicted Intent	Probability	Result
Hello	name	1	Correct
My name is John	age	1	Correct
My age is 23	inquire_problem	1	Correct
I have diabetes	family_history	.98	Correct
My mother has diabetes	other_diseases	1	Correct
No other medical condition	sugar_readings	0.96	Correct
My recent blood sugar reading is 12	medication	1	Correct
No I don't take any medication	end	0.86	Correct

Probability vs Intets Graphical representation of the table 5.1for test data 1 of correct and incorrect prediction is in Fig 5.2. The bar for correct predictions is blue and extends all the way to the top of the y-axis, at a probability of 1.00. This means that all of the predictions in test data 1 were correct. The bar for incorrect predictions is gray and is at the bottom of the y-axis, at a probability of 0.00. This means that there were no incorrect predictions in test data 1. Overall, the graph shows that the model performed perfectly on test data 1, with all predictions being correct.

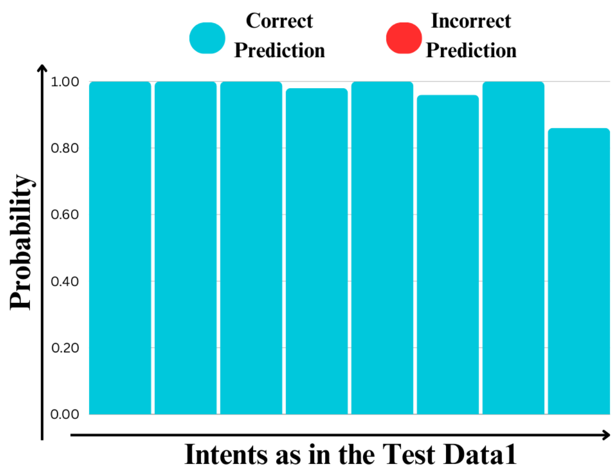


Fig.5.4: Probability vs Intents graph for feedforward Sequential Neural Network model for Test Data 1

For this test case the output of the LSTM model is given in Table 5.2. Here sentences are taken from the conversation and chat bot predicts its intention and probability is for correct intent.

Table 5.2: Intent Prediction Table for LSTM Model for Test Data 1

Sentence	Predicted Intent	Probability	Result
Hello	name	1	Correct
My name is John	age	1	Correct
My age is 23	inquire_problem	1	Correct
I have diabetes	other_diseases	0.97	Incorrect
My mother has diabetes	sugar_readings	0.93	Incorrect
No other medical condition	sugar_readings	1	Correct
My recent blood sugar reading is 12	inquire_problem	0.96	Incorrect
No I don’t take any medication	medication	0.82	Incorrect

Probability vs Intets Graphical representation of table 5.2 for test data 1 of correct and incorrect prediction is in Fig 5.3. The bar for correct predictions is blue and extends all the way to the top of the y-axis, at a probability of 1.00. This means that all of the predictions in test data 1 were correct. The bar for incorrect predictions is gray and is at the bottom of the y-axis, at a probability of 0. Though probability is high, there were four incorrect predictions in test data 2. Overall, the graph shows that the model performed perfectly on test data 1, with four predictions being correct.

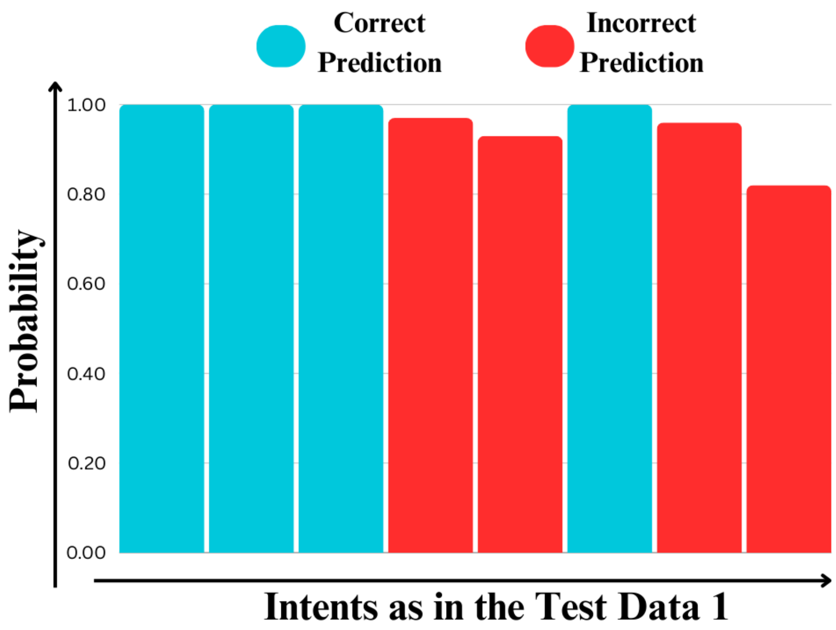


Fig.5.5: Probability vs Intents graph for LSTM for Test Data 1

5.2.1.1 Test Case 2

The following responses are given to the models. The feedforward sequential model was able to predict the intent of the next question correctly with an accuracy of 100% in this case. On the other hand, 87.5% accuracy was achieved in LSTM.

User: Hi

Chatbot: Hi there! I am happy to chat with you. Could you tell me your name?
User: My name is Rifat.

Chatbot: Nice to meet you. Please provide your age.

User: my age is 24.

Chatbot: Can you tell me if you're facing any health concerns?

User: I have diabetes.

Chatbot: Do you have any family history of diabetes?

User: I have no family history of diabetes.

Chatbot: Have you been diagnosed with any other medical conditions except diabetes?

User: No other medical condition.

Chatbot: Are you monitoring your blood sugar levels at home?

User: I do not know my blood sugar reading.

Chatbot: Do you take any medication?

User: Yes, I take paracetamol.

Chatbot: Put your hand in the marked position for 30 seconds.

For this test case the output of the Feed Forward Neural model is given in Table 5.3. Here sentences are taken from the conversation and chat bot predicts its intention and probability is for correct intent.

Table 5.3: Intent Prediction Table for Feedforward Sequential Neural Network model for Test Data 2

Sentence	Predicted Intent	Probability	Result
Hello	name	1	Correct
My name is Rifat	age	0.98	Correct
My age is 24	inquire_problem	1	Correct
I have diabetes	family_history	0.98	Correct
I have no family history of diabetes	other_diseases	1	Correct
No other medical condition	sugar_readings	1	Correct
I do not know my sugar reading	medication	1	Correct
yes I take paracetamol	end	0.99	Correct

Graphical representation of table 5.3 prediction vs intents in Fig 5.4 for correct and incorrect prediction. The bar for correct predictions is blue and extends all the way to the top of the y-axis, at a probability of 1.00. This means that all of the predictions in test data 1 were correct. The bar for incorrect predictions is gray and is at the bottom of the y-axis, at a probability of 0.00. This means that there were no incorrect predictions in test data 1. Overall, the graph shows that the model performed perfectly on test data 2, with all predictions being correct.

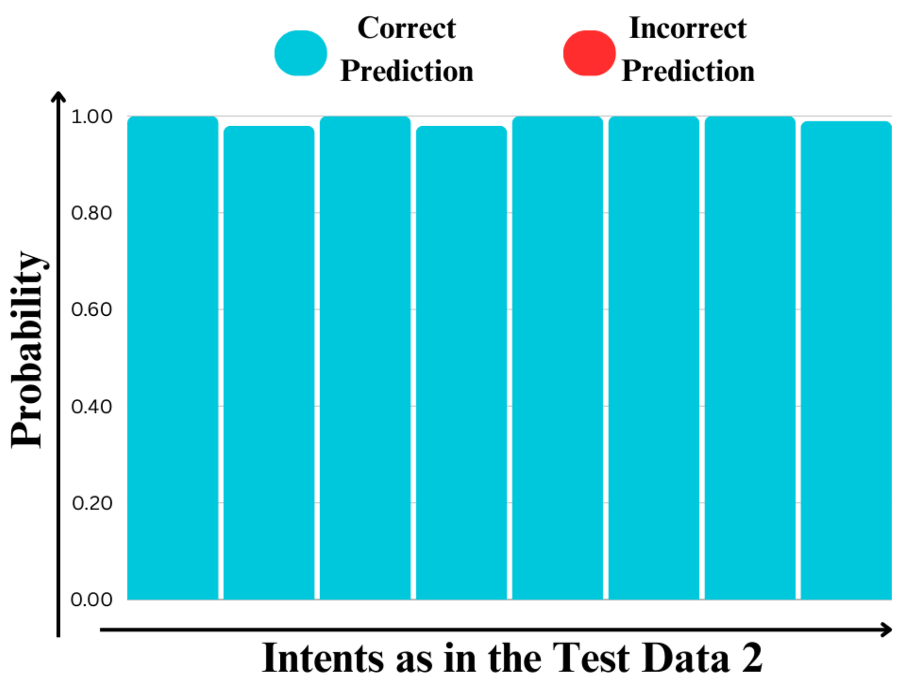


Fig 5.6: Probability vs Intents graph for feedforward Sequential Neural Network Model for Test Data 2

For this test case the output of the LSTM model is given in Table 5.4. Here sentences are taken from the conversation and chat bot predicts its intention and probability is for correct intent.

Table 5.4: Intent Prediction for LSTM Model for Test Data 2.

Sentence	Predicted Intent	Probability	Result
Hello	name	1	Correct
My name is Rifat	age	1	Correct
My age is 24	inquire_problem	1	Correct
I have diabetes	family_history	0.98	Correct
I have no family history of diabetes	other_diseases	0.55	Correct
No other medical condition	inquire_problem	0.91	Incorrect
I do not know my sugar reading	medication	0.68	Correct
yes I take paracetamol	end	1	Correct

Graphical representation of the table 5.4 prediction vs intents in Fig 5.5 for correct and incorrect prediction. The bar for correct predictions is blue and extends all the way to the top of the y-axis, at a probability of 1.00. This means that all of the predictions in test data 1 were correct. The bar for incorrect predictions is gray and is at the bottom of the y-axis, at a probability of 0. Though probability is high, there were one incorrect prediction in test data 2. Overall, the graph shows that the model performed perfectly on test data 1, with all predictions except one being correct.

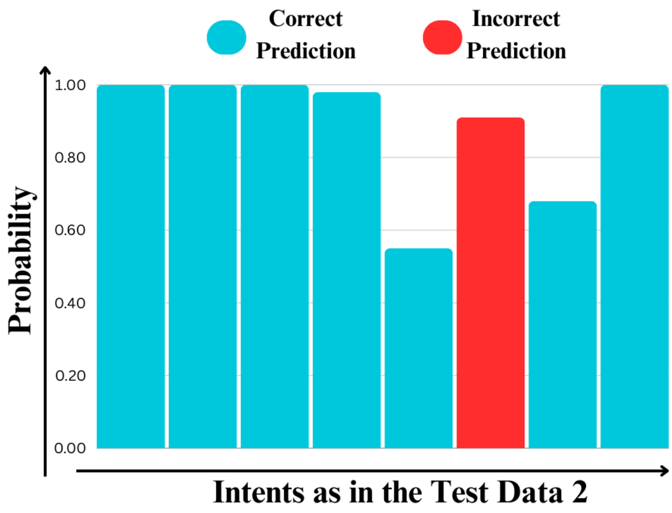


Fig.5.7: Probability vs Intents graph for LSTM for Test Data 2

5.3 Sensor Evaluation

After gathering the patient's verbal information chatbot will start a countdown of 30 seconds to take the sensor-measured values. After this, the system will show a report of the patient. The following graph Fig 5.6 is the value taken in five attempts by a normal patient.

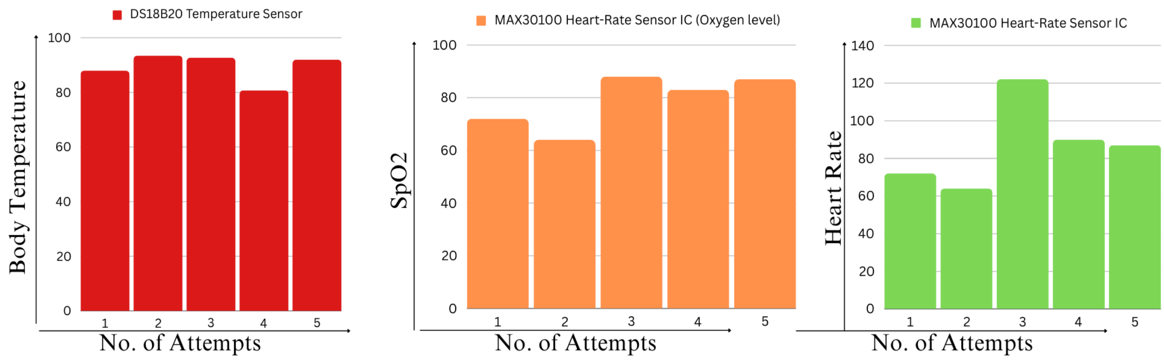


Fig. 5.8: Collected Sensor data in 5 Different times

The comparison between the data value system used sensor and medical grade equipments have been done. In this case, two value have been measured in same time by the sensors. This comparison in given in the following Table 5.5.

Table 5.5: Table of Comparision Between Three Sensor Measurements and Medical Grade Equipments

No of attempts	Sensor Name	1	2	3	4	5
TypesType of Measurements						
Temperature	**DS18B20 Temperature Sensor**	88	94	92.7	80.8	92
	Digital thermometers by Microlife	98	99	98.8	99.3	98
SPO2	**Jumpe Fingertip Pulse Oximeter**	96	99	98	98	96
	MAX30100 Heart-Rate Sensor IC	72	64	88	83	87
Heart rate	**Jumpe Fingertip Pulse Oximeter**	112	100	105	108	110
	MAX30100 Heart-Rate Sensor IC	72	64	122	90	87

By analyzing the result table it is observed that most of the sensors data has a little bit fluctuation form its original value. For a few times, the system gives almost accurate results for the measurements. This data difference is shown below in Fig 5.7 as a line chart for better visualization.

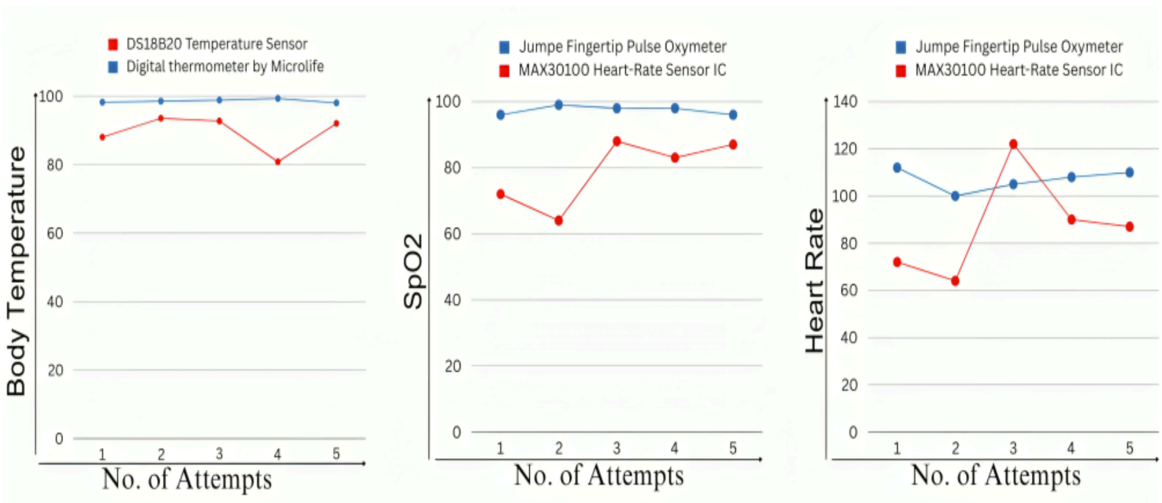


Fig 5.9: Visualization of the Comparison between the Three Sensor Measurements and Medical Grade Equipments

5.4 Summary

This chapter presents the testing process of each model and its results. Machine learning models are tested against different metrics and get better accuracy. Users can interact with the display using the screen. The chatbot system and hardware system work properly.

CHAPTER 6
ENGINEERING CONSIDERATIONS, CHALLENGES, AND REMEDIES

This chapter describes the overall engineering constraints, and problem-solving approach for the thesis by considering ethical, environmental, and social context and their problems and problem-solving approach.

6.1 Design Constraints

6.1.1 Ethical Consideration

Several ethical considerations have been taken when designing a diabetes prescreening chatbot:

I. Informed consent: Users were presented with clear information about the chatbot's purpose, data collection practices, potential risks and benefits, and their right to withdraw consent at any time.

II. Data privacy and security: User data is anonymized and securely stored.

III. Non-judgmental approach: The chatbot should use language that is respectful and inclusive, avoiding any potential for bias or discrimination.

IV. Appropriate guidance: The chatbot should guide users towards appropriate resources based on their risk assessment, such as reliable information sources, self-screening tools, or consultations with healthcare professionals.

6.1.2 Environmental Considerations

The project should consider its environmental impact throughout its lifecycle, from minimizing energy consumption through hardware and software optimization and exploring renewable energy sources to using recycled materials and promoting responsible e-waste disposal. Additionally, the potential positive environmental impacts like reduced paper usage, lower travel emissions, and increased healthcare efficiency should be explored.

6.1.3 Social Constraints

The project's social impact section should delve into potential constraints like accessibility for users with limited digital literacy, cultural sensitivity in language and communication, and potential biases in algorithms. It should emphasize strategies to ensure inclusivity, mitigate bias, and prioritize ethical considerations like data privacy and user consent. This demonstrates a commitment to responsible development that minimizes unintended consequences and fosters positive social outcomes for diverse communities.

6.1.4 Sustainability in Environmental and Societal Context

The project's sustainability is considered both environmental and societal factors. Looking at its long-term ecological impact, it should address resource usage, explore ways to minimize its environmental footprint and acknowledge potential risks while exploring mitigation strategies. Socially, it should evaluate potential benefits like improved healthcare access and drawbacks like job displacement, aiming to ensure equitable access and mitigate biases. By addressing both environmental and societal considerations, the project demonstrates a commitment to sustainable development.

6.2 Complex Engineering Problem

6.2.1 Complex Problem Solving

Complex Engineering Attributes that are addressed:

(P1) Depth of knowledge required: Deep learning knowledge for developing the chatbot, Hardware (Raspberry Pi, Sensors, Display) knowledge.

(P2) Range of Conflicting Requirements: Limited Dataset, more accuracy is required where the dataset is about a conversation between a doctor and a diabetes patient.

(P3) Depth of Analysis Required: N/A

(P4) Familiarity of Issues: Knowledge about different stages of diabetes and diabetic patients.

(P5) Extent of applicable codes: N/A

(P6) Extent of Stake Holder Involvement and Conflicting requirements: N/A

(P7) Interdependence: N/A

6.2.2 Engineering Activities

Complex Engineering Activities that are addressed:

(A1) Range of resources: Hardware equipment and dataset.

(A2) Level of Interaction: N/A

(A3) Innovation: Integration of a chatbot specialized in diabetes and hardware.

(A4) Consequences for Society and Environment: N/A

(A5) Familiarity: The system has developed considering knowledge about diabetes and diabetic patients.

CHAPTER 7
CONCLUSION

This chapter describes the overall thesis by using four subsections to summarize the thesis's outcome, implications and contribution of the research, limitations, and scope for future work.

7.1 Outcome

The main outcome of this thesis is to propose a user-friendly patient-support system to produce necessary documents for a doctor by gathering information from the patients through verbal or measurement systems. An extensive literature review was done to present the model. The limitations of relevant studies were listed. At this point, a conceptual model of the entire system was created. Afterward, the essential tools and the experimental setup were created. After this step, an algorithm was applied in chatting with the patient. Then the refined hardware system is used for the collection of body health measurements. Finally, the result was analyzed and benchmarking was conducted by comparing the results with the existing system found in the literature review.

7.2 Implication and Contribution

The main contribution of this study includes understanding the necessity of a system to support patients with diabetes and their doctors by helping them eliminate wasted time and use time effectively. By reviewing the literature, as well as finding the limitations of existing prescreening chatbot systems, the importance and demand of such systems in the modern world were understood. After exploring the effectiveness of such a system, a prototype was developed using a Deep Learning model to chat through voice with the patient. The system was developed, trained, tested, and evaluated to determine its efficiency and accuracy. There is very little established work done using ML models, the existing ones are mostly focused on question-answering and not on collecting information in real time. The proposed system can contribute to society by effectively using time for patients with diabetes and their doctors and preventing them from getting rid of boring sitting time or wasting time.

7.3 Limitation

The main limitation of the thesis is the lack of conversation datasets. It wasn't possible to test the system on patients, as it requires a lot of formalities. The sensor used in the system has low accuracy. Data could not be fed into the deep learning model due to a lack of user data. All experiments were conducted on healthy human beings in a normal environment; the results of hospital environments were not considered.

7.4 Future Work

The project that we implemented can be extended with multifarious features and applications. This can also be implemented at the industry level to meet the demands of diabetes patients, doctors, and many more. With future research, we can take this project to the next level, where we can start production at the industry level and produce it commercially.

The future work of our project includes:

1. To add measurement of blood pressure.
2. To add better sensors for better results.
3. To add options, only chat or only health metrics.
4. To implement for all diseases.
5. To produce it commercially.
6. To make it widely available in hospitals, clinics, and doctor's chambers.

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APPENDIX A

DATA SAMPLES

The dataset on conversation collected for the machine learning model is given below:

{
"intents": [

{ "tag": "name",
"patterns": ["hello", "hey", "hi", "what's up", "how is it going"],
"responses": ["Hi there! I am happy to chat with you. Could you please tell me your name?"]
},

{"tag": "age",
"patterns": ["name", "my name is", "i am "],
"responses": ["Nice to meet you. Please provide your age"]
},

{ "tag": "inquire_problem",
"patterns": ["age", "my age is"],
"responses": ["Can you tell me if you're facing any health concerns?"]
},

{ "tag": "family_history",
"patterns": ["i have diabetes", "i am facing diabetes", "i have high blood sugar", "i have low blood sugar", "I have been suffering from diabetes"],
"responses": ["Do you have any family history of diabetes?"]
},

{"tag": "other_diseases",
"patterns": ["No family history of diabetes", "No, there's no history in my family", "Yes. I have family history of diabetes", "Yes. My father has diabetes", "Yes. My mother has diabetes"],

```
"responses": [ "Have you been diagnosed with any other medical conditions except diabetes?" ]
},

{"tag": "sugar_readings",
"patterns": ["No other medical condition",  "No other medical condition expect diabetes", "Yes, I have ",  "Yes, I also have", "except diabetes i am suffering from "  ],
 "responses": [ "What is the recent blood sugar reading?" ]
},

{ "tag": "medication",
 "patterns": [ "My recent blood sugar reading is", "recent blood sugar reading is", "My blood sugar reading is", "I do not know my blood sugar reading", "I do not know my reading"  ],
"responses": [ "Do you take any medication?" ]
},

{ "tag": "end",
"patterns": [ "no i don't take any medication", "yes i take" ],
"responses": ["Put your hand on the marked position for 30 seconds" ]
}

]

}
```