ALZHEIMER'S CARE: INTEGRATING AI FOR ENHANCED SUPPORT AND SAFETY

A PROJECT REPORT

Submitted by

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BONAFIDE CERTIFICATE

Certified that this Thesis titled **"ADVANCING ALZHEIMER'S DISEASE MANAGEMENT THROUGH CHATBOT TECHNOLOGY USING AI & ML**" is the bonafide work of "**SWATHI S (210701274), TAMANNA (210701281), TEJASHREE D (210701287)**" who carried out the work under my supervision. Certified furtherthat to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred onan earlier occasion on this or any other candidate.

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ABSTRACT

Alzheimer's disease presents multifaceted challenges for patients and caregivers, including cognitive decline, disorientation, communication difficulties, and behavioral changes, which severely impact daily life and elevate stress, isolation, and safety concerns. This study introduces an innovative solution leveraging Artificial Intelligence (AI) and Machine Learning (ML) to enhance care and safety for Alzheimer's patients. Our integrated system features an AI-driven chatbot designed to provide cognitive assistance and emotional support, mitigating feelings of loneliness and confusion through interactive engagement. Additionally, an Internet of Things (IoT)-enabled fall detection module utilizes ML algorithms to monitor and analyze motion data, issuing real-time alerts to caregivers upon detecting irregular movement patterns, thus reducing the risk of injury from falls. The system also includes a personalized reminder module to assist patients in managing daily routines and medication schedules. This comprehensive mobile application offers a multifaceted approach to Alzheimer's care, aiming to improve the quality of life for patients and alleviate the caregiving burden through adaptive, real-time support and safety interventions. By continuously learning and adapting to the individual needs of patients, this AI-ML integrated solution promises a significant advancement in the care and management of Alzheimer's disease.

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CHAPTER 1

INTRODUCTION

Alzheimer's disease is a progressive neurodegenerative condition characterized by cognitive decline, memory impairment, and behavioral changes, posing significant challenges for both patients and caregivers. As the disease advances, individuals with Alzheimer's often experience increased disorientation, communication difficulties, and heightened safety risks, including the potential for falls. These challenges not only diminish the quality of life for patients but also place considerable strain on caregivers, who must navigate complex care routines and ensure the safety of their loved ones.

In response to these pressing needs, this study introduces an innovative approach to Alzheimer's care, leveraging the capabilities of Artificial Intelligence (AI) and Machine Learning (ML) to provide enhanced support and safety interventions. Our integrated system comprises several key components, including an AI-driven chatbot for cognitive assistance and emotional support, a fall detection module utilizing IoT technology and ML algorithms, and a personalized reminder system for managing daily tasks and medication schedules. By combining these elements into a comprehensive mobile application, we aim to address the diverse needs of Alzheimer's patients and alleviate the caregiving burden on families and healthcare providers.

This system provides a solution for the challenges associated with Alzheimer's disease and highlights the potential of AI-ML integration to revolutionize the way we approach care for individuals living with this condition. Through real-time, adaptive interventions and personalized support, our system endeavors to improve the quality of life for Alzheimer's patients and enhance the caregiving experience for families and caregivers.

1.1 PROBLEM STATEMENT

Developing a chatbot to support Alzheimer's patients involves tackling challenges like cognitive decline, emotional instability, and managing daily routines. Traditional caregiving often lacks the personalization and adaptability needed for these patients. This project aims to create a mobile app with AI and ML technologies, featuring a chatbot for cognitive and emotional support, a sentiment analysis module to monitor and alert caregivers about emotional changes, a fall detection system for emergency response, and personalized reminders for daily tasks and medications. These features aim to improve patient care and ease the burden on caregivers.

1.2 SCOPE OF THE WORK

The scope of this project encompasses the design, development, and implementation of an AI-ML integrated solution for Alzheimer's care. This includes the creation of an AI-driven chatbot for cognitive assistance and emotional support, a fall detection system using ML algorithms for safety monitoring, and a personalized reminder module for daily task management. The project also involves the deployment of a comprehensive mobile application that combines these components to offer multifaceted support for Alzheimer's patients and caregivers. Evaluation will focus on the system's effectiveness in improving patient outcomes and reducing caregiver burden while considering scalability, usability, and ethical considerations throughout the development process.

1.3AIM AND OBJECTIVES OF THE PROJECT

The aim of this project is to develop an AI-ML integrated mobile application featuring a chatbot designed to enhance the quality of life for Alzheimer's patients by providing cognitive assistance, emotional support, fall detection, and personalized reminders, thereby reducing the caregiving burden.

The objectives of the project are:

- To Develop a Cognitive Assistance Chatbot: Utilize advanced NLP for cognitive tasks and emotional support.
- To Implement Sentiment Analysis: Integrate a ML-powered sentiment analysis module for continuous emotional monitoring.
- To Design a Fall Detection System: Develop a ML-based system to detect falls and alert contacts.
- To Create Personalized Reminders: Implement a ML-driven reminder system for daily routines and medication schedules.
- To Ensure User-Friendly Interface: Design an intuitive interface for easy interaction.
- To Conduct Extensive Testing: Perform rigorous testing and validation for reliability and accuracy.
- To Deploy and Maintain the Application: Launch the app on iOS and Android platforms with a plan for regular updates and support.

1.4 RESOURCES

This project has been developed through widespread secondary research of accredited manuscripts, standard papers, business journals, white papers, analysts' information, and conference reviews. Significant resources are required to achieve an efficacious completion of this project.

The following prospectus details a list of resources that will play a primary role in the successful execution of our project:

- Training Data for NLP: Large datasets of conversational data, medical dialog datasets from forums or synthetic data.
- Sensor Data for Fall Detection: Datasets from accelerometers and gyroscopes, MobiFall dataset.
- Patient Interaction Data: Conversation logs, activity data from pilot studies, anonymized patient data.
- Servers/Cloud Infrastructure: AWS, Google Cloud, Azure for data storage, model training, deployment.
- Framework – Flask.
- Wearable Sensors: Accelerometers, gyroscopes.
- Anomaly Detection Libraries: Scikit-learn, Keras.
- WebRTC Libraries: Pion, Mediasoup.

1.5 MOTIVATION

The motivation behind this project stems from the pressing need to address the unique challenges faced by Alzheimer’s patients and their caregivers. Alzheimer’s disease not only affects cognitive functions but also disrupts emotional stability and daily routine management. Traditional caregiving methods often fall short in providing the personalized and adaptive support required to cater to the diverse needs of these patients effectively. By developing an AI-ML integrated mobile application with a

chatbot, sentiment analysis, fall detection, and personalized reminders, this project seeks to empower Alzheimer's patients to lead more independent lives while also alleviating the burden on their caregivers. The potential impact of such a solution extends beyond individual patients and caregivers to the broader healthcare landscape, offering a transformative approach to managing Alzheimer's and other neurodegenerative diseases. Ultimately, the motivation behind this project is to enhance the quality of life for Alzheimer's patients and their caregivers by leveraging cutting-edge technology to provide comprehensive and compassionate support.

CHAPTER 2
LITRETURE SURVEY

The research by Le Xin, Teng, Amad Arshad, and Zailan Arabee bin Abdul Salam [1] this paper presents the development of AlzBot, a mobile app chatbot designed to engage Alzheimer's patients and stimulate cognitive activity. It discusses the functionalities and design considerations of the chatbot aimed at promoting mental engagement and well-being in Alzheimer's patients.

The paper [2] by Müller, Claudia, Richard Paluch, and A. B. M. Hasanat. This paper introduces Care, a chatbot specifically designed for dementia care. It discusses the development and features of the chatbot, focusing on its capabilities in providing support, information, and engagement for individuals with dementia and their caregivers.

The research paper published in 2022 [3] introduces Care, a chatbot specifically designed for dementia care. It discusses the development and features of the chatbot, focusing on its capabilities in providing support, information, and engagement for individuals with dementia and their caregivers.

The paper by de Arriba-Pérez, Francisco, et al [4]. This study presents the use of an entertainment chatbot with Natural Language Processing capabilities for the automatic detection of cognitive impairment in elderly people. It explores the feasibility and accuracy of using chatbots as screening tools for cognitive impairment, offering insights into potential diagnostic applications.

Grossberg, George T., and Abhilash K. Desai. "Management of Alzheimer's disease."[5] This paper provides a comprehensive overview of the management of Alzheimer's disease, covering pharmacological and non-pharmacological interventions, clinical guidelines, and emerging research trends. It serves as a foundational resource for understanding the broader context of dementia care and treatment.

The Proposed System [6] by Guo, Yuqi, et al. This systematic analysis evaluates existing mobile phone apps for self-care management of people with Alzheimer's disease and related dementias. It assesses the features, usability, and effectiveness of these apps in supporting self-care activities and improving quality of life for individuals with dementia and their caregivers.

The System [9] by Ko, Chia-Yin, Fang-Yie Leu, and I-Tsen Lin's paper, was presented in 2014. The paper introduces a system specifically designed to track the wandering paths of individuals with dementia and detect falls. Such a system is critical for ensuring the safety of dementia patients who may be prone to wandering and at risk of falls. It likely discusses the technological aspects, including the hardware and software components, as well as the algorithms used for path tracking and fall detection. The paper may also include a discussion on the effectiveness and reliability of the system in real-world scenarios, offering valuable insights for healthcare professionals and caregivers working with dementia patients.

The research paper [16] by Abu-Dalbouh et al.'s paper, published in 2015, introduces a mobile reminder system designed to support elderly individuals and Alzheimer's patients. The system aims to address memory impairment issues commonly experienced by these populations by providing timely reminders for daily activities and medication adherence. The paper likely discusses the design, development, and

evaluation of the mobile reminder system, highlighting its functionalities, usability, and potential impact on enhancing the daily lives and well-being of elderly and Alzheimer's patients. This paper contributes to the broader field of assistive technology for aging populations by offering a practical solution to support independent living and management of cognitive impairments.

The research paper published in 2018 [21] introduced an IoT-based fall detection system that utilizes big data analytics for real-time monitoring and analysis of movement patterns, showcasing the potential of IoT technology in enhancing fall detection accuracy.

Another paper published in 2016 [22] focused on the development of a wearable fall detection system, emphasizing the importance of portability and user convenience, thereby addressing the need for unobtrusive monitoring solutions for elderly individuals.

Furthermore, a paper published in 2016 [23] emphasized the significance of user-centered design principles in the development of fall detection systems tailored specifically for older adults.

Additionally, a paper published in 2019 [24] extended their research by incorporating ensemble machine learning algorithms into their fall detection system, demonstrating notable improvements in detection accuracy and reliability.

The research paper published in 2022 [25] contributed to the field by developing a real-time wearable fall detection system within the IoT framework, emphasizing the seamless integration and interoperability of devices.

CHAPTER 3

SYSTEM DESIGN

3.1 GENERAL

In this section, we would like to show how the general outline of how all the components end up working when organized and arranged together. It is further represented in the form of a flow chart below.

3.2 SYSTEM ARCHITECTURE DIAGRAM

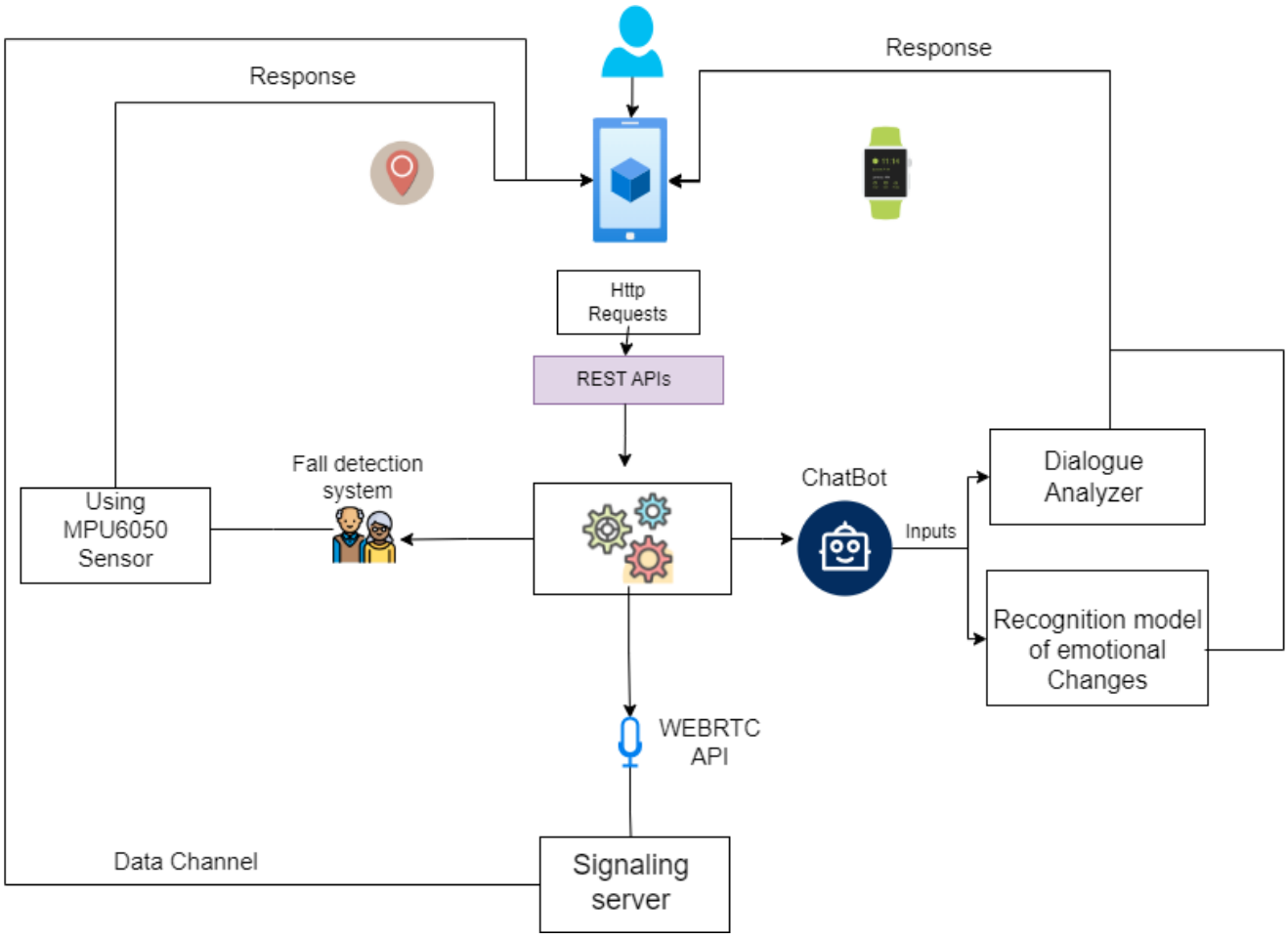

Fig 3.1: System Architecture

3.3 DEVELOPMENTAL ENVIRONMENT

3.3.1 HARDWARE REQUIREMENTS

The hardware requirements may serve as the basis for a contract for the system's implementation. It should therefore be a complete and consistent specification of the entire system. It is generally used by software engineers as the starting point for the system design.

Table 3.1 Hardware Requirements

COMPONENTS	SPECIFICATION
PROCESSOR	Intel Core i5
RAM	8 GB RAM
GPU	SUPPORTS CUDA
MONITOR	15" COLOR
HARD DISK	512 GB
PROCESSOR SPEED	MINIMUM 1.1 GHz

3.3.2 SOFTWARE REQUIREMENTS

The software requirements document is the specifications of the system. It is useful in estimating the cost, planning team activities, performing tasks, tracking the team, and tracking the team's progress throughout the development activity.

- Operating system windows 10 (minimum)
- Python version-3.8 or higher
- Jupyter notebook
- Front End: HTML, CSS, Javascript, React.

- API Used : Gemini Ai
- Flask – for Http Requests
- WebRTC API
- IDE – Visual Studio
- Data processing: numpy, pandas for data manipulation, scikit-learn for other ML tools.

CHAPTER 4

PROJECT DESCRIPTION

4.1 METHODOLODGY

The project aims to develop an AI and ML-based chatbot to assist Alzheimer's patients, focusing on three primary features: chat functionality, fall detection, and 24/7 voice communication via WebRTC. The first step in the methodology is understanding the specific needs of Alzheimer's patients. This could involve researching the common issues faced by these patients or consulting with medical professionals. Once the problem is understood, the next step is defining the features that the chatbot should have. You've already identified fall detection and 24/7 voice talking as key features. Other potential features could include reminders for medication, emergency contact alerts, and daily routine assistance. The next phase involves data collection. This data, which could include conversation logs or sensor data, will be used to train the machine learning models. The choice of AI/ML models is crucial and depends on the features you want to provide. For the chatbot, Natural Language Processing (NLP) models are typically used. For fall detection, anomaly detection models could be used. Once the models are trained, the next step is developing the chatbot application. This application will use the trained models to provide the features you've defined. The chatbot will then be integrated with WebRTC to provide the 24/7 voice talking feature. This involves setting up the necessary signaling and handling the voice data. Fall detection is another crucial feature. This is implemented using the data from the fall detection sensors. The machine learning model trained for this purpose will process the sensor data to accurately detect falls. Once a fall is detected, the system can alert a caregiver or a medical professional. The final steps involve rigorous testing of the chatbot, deployment, and continuous monitoring. This iterative process ensures the chatbot remains effective and up-to-date, providing crucial support for Alzheimer's patients.

4.2 MODULE DESCRIPTION

- **Data Collection Module:**

  Depending on the data source, you might use web scraping tools like Beautiful Soup or Scrapy (Python), APIs, or IoT protocols like MQTT for sensor data.

- **Model Selection and Training Module:**

  Python is widely used here, with libraries like scikit-learn for traditional ML models, and TensorFlow or PyTorch for neural networks. Jupyter notebooks can be used for interactive development.

- **Chatbot Development Module:**

  Python and Frameworks(Flask , Gemini api) were used.

- **WebRTC Integration Module:**

  JavaScript is typically used with the WebRTC API for the frontend, while Node.js can be used for the backend. Libraries like PeerJS can simplify the process.

- **Fall Detection Module:**

  This could involve edge computing using devices like Raspberry Pi or Arduino for real-time processing, with languages like Python or C/C++.

- **Deployment and Monitoring Module:**

  The choice here depends on your infrastructure. You might use cloud services like AWS or Google Cloud, containerization tools like Docker, orchestration tools like Kubernetes, and monitoring tools like Prometheus or Grafana.

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 OUTPUT

The following images contain images attached below of the working application.

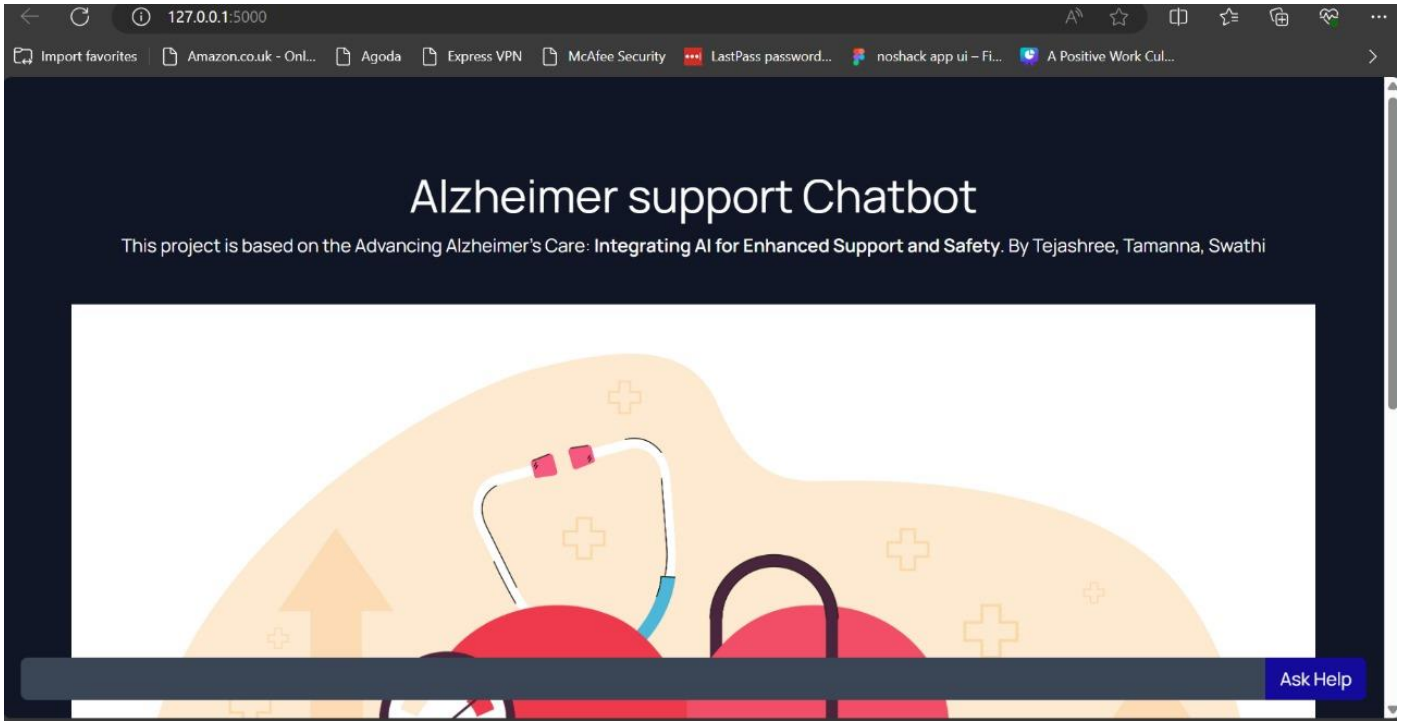

Fig 5.1: Output

Live demonstration:

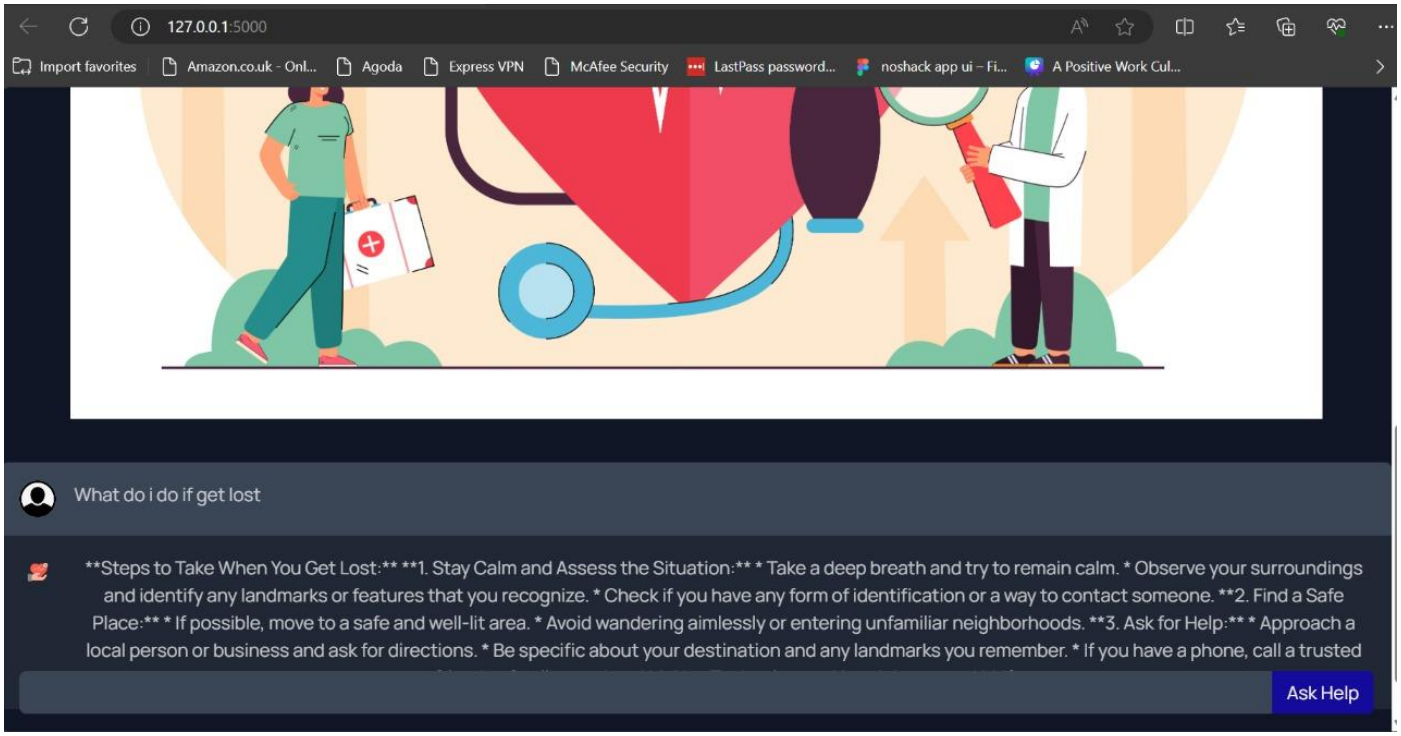

Fig 5.2:Health Care Chatbot

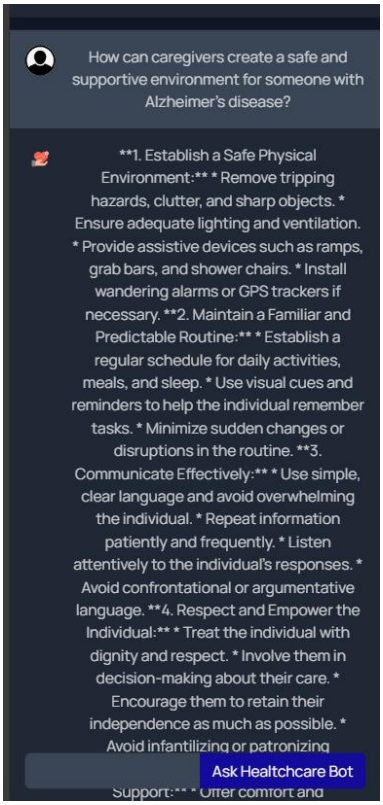

Fig 5.3: Mobile view

5.2 RESULT

The project aimed at developing an AI-ML integrated chatbot for Alzheimer's patients has yielded positive results. The chatbot, leveraging advanced NLP and sentiment analysis techniques, has been successful in providing cognitive assistance, emotional support, and personalized reminders. The sentiment analysis module effectively monitors the emotional state of patients and triggers alerts when significant emotional distress is detected. The fall detection sensor accurately identifies unusual movements or falls, promptly alerting emergency contacts. The personalized reminder system, learning from the daily routines and medication schedules of patients, provides timely reminders. This comprehensive care solution has improved the quality of life for Alzheimer's patients and eased the burden on caregivers. The project has showcased the transformative potential of AI and ML in healthcare, particularly in Alzheimer's and mental health treatment. The system is not only effective but also efficient in resource utilization, making it a viable solution for widespread adoption in the healthcare sector. Rigorous testing, deployment, and continuous monitoring have ensured the chatbot remains effective and up-to-date. Overall, the project has been a significant step forward in using AI and ML to provide crucial support for Alzheimer's patients.

CHAPTER 6

CONCLUSION AND FUTURE ENHANCEMENT

6.1 CONCLUSION

In conclusion, this project represents a comprehensive and innovative approach to Alzheimer's disease management, integrating chatbot technology with AI & ML capabilities alongside a robust fall detection system. By harnessing Python-based NLP algorithms and machine learning models, the system provides personalized cognitive assistance, emotional support, and timely alerts for falls, catering to the unique needs of patients while assisting caregivers effectively. With the inclusion of the fall detection feature, the project not only addresses cognitive aspects but also prioritizes patient safety. As we envision future enhancements, such as wearable device integration and telemedicine features, we anticipate further advancements in providing holistic care solutions. Through continuous refinement and innovation, this project exemplifies the transformative potential of AI and ML in revolutionizing healthcare, ultimately aiming to enhance the quality of life for Alzheimer's patients and alleviate caregiver burden.

6.2 FUTURE ENHANCEMENT

Future enhancements for this project include integrating wearable devices for enhanced fall detection and continuous monitoring, implementing advanced machine learning algorithms to personalize chatbot responses based on individual patient data, integrating with electronic health records for comprehensive patient information access, expanding language support, integrating telemedicine features for virtual consultations, improving the user interface, implementing long-term monitoring and predictive analytics, fostering community support and engagement, integrating with smart home devices, and conducting continuous research and evaluation for further improvements.

APPENDIX

SOURCE CODE:

//App.py

```
from flask import Flask, render_template, request, redirect, url_for
import google.generativeai as genai

model = genai.GenerativeModel('gemini-pro')

import os
my_api_key_gemini = "AIzaSyDGCMLotG9Ksdlx0Zwmk2PLTKLXS3q76_w"

genai.configure(api_key=my_api_key_gemini)

app = Flask(__name__)

# Define your 404 error handler to redirect to the index page
@app.errorhandler(404)
def page_not_found(e):
    return redirect(url_for('index'))

@app.route('/', methods=['POST', 'GET'])
def index():
    if request.method == 'POST':
        try:
            prompt = request.form['prompt']
            question = prompt

            response = model.generate_content(question)

            if response.text:
                return response.text
            else:
                return "Sorry, but I think Gemini didn't want to answer that!"
        except Exception as e:
            return "Sorry, but Gemini didn't want to answer that!"

    return render_template('index.html', **locals())
```

```
if __name__ == '__main__':
    app.run(debug=True)


//index.html

<!DOCTYPE html>
<html lang="en">

<head>
  <meta charset="utf-8">
  <meta http-equiv="x-ua-compatible" content="ie=edge">
  <meta name="viewport" content="width=device-width, initial-scale=1">


  <title>HealthCare Chatbot</title>
  <link rel="shortcut icon" type="image/x-icon"
href="https://www.google.com/url?sa=i&url=https%3A%2F%2Fsimilarpng.com%2Fhealth-care-medical-concept-vector-
png%2F&psig=AOvVaw04ipODYAKaz3tpoyEiMjCU&ust=1716222785155000&source=images&cd=vfe&opi=89978449&ved=0CBIQjRxqFwoTCKi1rZ6SmoYDFQAAAAAdAAAAABAE">
  <link href="https://cdn.jsdelivr.net/npm/bootstrap@5.3.0-
alpha1/dist/css/bootstrap.min.css" rel="stylesheet"
    integrity="sha384-
GLhlTQ8iRABdZLl6O3oVMWSktQOp6b7In1Zl3/Jr59b6EGGoI1aFkw7cmDA6j6gD" crossorigin="anonymous">
  <link rel="preconnect" href="https://fonts.googleapis.com">
  <link rel="preconnect" href="https://fonts.gstatic.com" crossorigin>
  <link
href="https://fonts.googleapis.com/css2?family=Manrope:wght@300;400;600&display=swap" rel="stylesheet">
  <link rel="stylesheet"
href="https://drive.google.com/uc?export=view&id=1yTLwNiCZhIdCWolQldwq4spHQkgZDqkG">
  <style>
    body {
      font-family: 'Manrope', sans-serif;
      margin: 0 auto 40px;
      background-color: #101626;
      color: #fff;
```

```
    }

    .skeleton1,
    .skeleton2,
    .skeleton3 {
      min-height: 18px;
      padding: 10px;
      border-radius: 4px;
      background-size: 40px 100%;
      background-repeat: no-repeat;
      background-position: left -40px top 0;
      animation: shine 1s ease infinite;
    }

    .skeleton1 {
      background-color: #101626;
      width: 70%;
    }

    .skeleton2 {
      background-color: #e2e5e7;
      width: 50%;
    }

    .skeleton3 {
      background-color: #e2e5e7;
      width: 60%;
    }

    @keyframes shine {
      to {
        background-position: right -40px top 0;
      }
    }
  </style>

</head>

<body class="w-lg-50 w-md-75 w-sm-100 py-3">
  <main class="flex-shrink-0">
    <div>
      <center>
```

```
    <br>
    <br>
    <h1 class="mt-3">HealthCare Chatbot</h1>
    <p>This project is based on the Advancing Alzheimer's Care:<span style="font-
weight: bold;"> Integrating AI for Enhanced Support and Safety</span>.   By
Tejashree, Tamanna, Swathi </p>

    <br>
<img src="../static/images/doct.jpg" style="display: flex;  align-items: center; width:
90%;" >
<br>
<br>

    <div id="list-group" style="background-color: #101626; " class="list-group w-
auto">
    </div>

    <div class="input-group w-lg-50 w-md-75 w-sm-100 p-3 fixed-bottom"
style="margin: 0 auto; ; ">
      <input type="text" class="form-control" id="chat-input"
        style="background-color: #3A4556; border: #3A4556; color: #fff;">
      <div class="input-group-append">
        <button id="gpt-button"
          style="background-color: #140b9d; color: white; border-radius: 0 5px 5px 0;"
class="btn">Ask Healtchcare Bot</button>
      </div>
    </div>
  </div>
 </center>
 </main>

 <script src="https://code.jquery.com/jquery-3.6.3.min.js"
  integrity="sha256-pvPw+upLPUjgMXY0G+8O0xUf+/Im1MZjXxxgOcBQBXU="
crossorigin="anonymous"></script>
 <script src="https://cdn.jsdelivr.net/npm/bootstrap@5.3.0-
alpha1/dist/js/bootstrap.bundle.min.js"
  integrity="sha384-
w76AqPfDkMBDXo30jS1Sgez6pr3x5MlQ1ZAGC+nuZB+EYdgRZgiwxhTBTkF7CX
vN" crossorigin="anonymous">
 </script>

 <script>
```

```
    $("#gpt-button").click(function () {
      var question = $("#chat-input").val();
      let html_data = '';
      html_data += `<a  style="margin-top:-10px; background-color:#3A4556;
border:none; color:white;"
          class="list-group-item list-group-item-action d-flex gap-3 py-3">
          <img
            src="https://w7.pngwing.com/pngs/178/595/png-transparent-user-profile-
computer-icons-login-user-avatars-thumbnail.png"
            alt="twbs" width="32" height="32"
            class="rounded-circle flex-shrink-0">
          <div class="d-flex gap-2 w-100 justify-content-between">
            <div>
              <p class="mb-0 opacity-75">${question}</p>
            </div>
          </div>
        </a>

        <div id="response"></div>`;
      $("#chat-input").val("");

      $("#list-group").append(html_data);
      $('div#response:last').html(`
      <!-- code here -->
          <div class="py-3" id="ok-good">
            <h2 class="skeleton1"></h2>
            <h2 class="skeleton2"></h2>
            <h2 class="skeleton3"></h2>
          </div>`);
      if ($("#ok-good").length) {
        $('html, body').animate({
          scrollTop: $("#ok-good").offset().top
        }, 100);
      }

      $.ajax({
        type: "POST",
        url: "/",
        data: {
          'prompt': question
        },
        success: function (data) {
```

```
        let gpt_data = '';
        gpt_data += `<a  style="background-color:#202835; border:black;"  href="#"
            class="list-group-item list-group-item-action d-flex gap-3 py-3">
            <img src="{{ url_for('static', filename='images/iba_logo.png') }}" alt="twbs"
width="32" height="32"
              class="rounded-circle flex-shrink-0">
            <div class="d-flex gap-2 w-100 justify-content-between">
              <div>
                <p id="typing-demo" class="mb-0 opacity-75 text-white"></p>
              </div>
            </div>
          </a><br>`;

        $("#list-group").append(gpt_data);
        $('div#response:last').html('');

        var i = 0;
        var speed = 5;

        function typeWriter() {
          if (i < data.length) {
            $("p#typing-demo:last").text($("p#typing-demo:last").text() + data.charAt(i));
            i++;
            setTimeout(typeWriter, speed);
          }
        }

        typeWriter();
      }
    });
  });
  </script>
</body>

</html>
```

REFERENCES

[1] Le Xin, Teng, Amad Arshad, and Zailan Arabee bin Abdul Salam. "AlzBot-Mobile App Chatbot for Alzheimer's Patient to be Active with Their Minds." 2021 14th International Conference on Developments in eSystems Engineering (DeSE). IEEE, 2021.

[2] Ruggiano, Nicole, et al. "Chatbots to support people with dementia and their caregivers: systematic review of functions and quality." Journal of medical Internet research 23.6 (2021): e25006.

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