A

Project Report

on

"ESP32 Microcontroller Based Voice Assistant using ChatGPT"

Submitted in partial fulfilment for the award of the degree of

Bachelor of Technology

in

Robotics and Artificial Intelligence

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YMCA, FARIDABAD

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DECLARATION

I hereby declare that the work, being presented in the project report entitled "ESP32 Microcontroller Based Voice Assistant using ChatGPT" in partial fulfilment of the requirement for the award of the Degree in Bachelor of Technology in Robotics and Artificial Engineering and submitted to the Department of Mechanical Engineering of J.C. Bose University of Science and Technology, YMCA, Faridabad is an authentic record of my own work carried out during a period from Aug 2023 to Dec 2023 under the supervision of Dr O.P. Mishra (Assistant Professor), Department of Mechanical Engineering. No part of the matter embodied in the project has been submitted to any other University / Institute for the award of any Degree or Diploma.

Signature of Student(s)

Sumit Bhardwaj (21001020024)

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CERTIFICATE

This is to certify that the project entitled, "ESP32 Microcontroller Based Voice Assistant using ChatGPT" submitted in partial fulfillment of the requirements for the degree in Bachelors of Technology in Robotics and Artificial Intelligence is an authentic work carried out under my supervision and guidance.

Dr O.P. Mishra

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ACKNOWLEDGEMENT

This opportunity was taken to express our deep sense of gratitude and respect towards our supervisor Dr O.P. Mishra, Assistant Professor, Department of Mechanical Engineering, J.C. Bose University of Science & Technology, YMCA, Faridabad.

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ABSTRACT

In the development of our project, the "ESP32 Microcontroller Based Voice Assistant using ChatGPT," the primary goal was to create a versatile and user-friendly device that leverages the ChatGPT model for a seamless conversational experience. The project centers on integrating ChatGPT into a portable speaker, allowing users to interact with the language model in a convenient and accessible manner.

The software backbone of our portable speaker relies on the ChatGPT API, enabling users to engage in dynamic question-answer interactions. By harnessing the power of ChatGPT, the speaker transforms into a responsive conversational agent, providing users with information, assistance, and friendly exchanges.

To facilitate user input, we've incorporated Google's Speech-to-Text (STT) technology. This feature enables users to interact with the portable speaker not only through text-based queries but also through spoken commands. The combination of ChatGPT, TTS, and STT enriches the versatility of the portable speaker, offering users multiple modes of interaction.

The hardware components include an ESP32 microcontroller, chosen for its compatibility and versatility. The system utilizes a quality INMP441 I2S microphone to capture spoken queries, and a MAX98537 I2S amplifier ensures that ChatGPT's responses are delivered in clear and audible tones through a portable 4-ohm speaker.

By focusing on the simplicity and portability of the speaker, users can enjoy the benefits of ChatGPT in a variety of environments. The project's emphasis on a user-friendly interface aims to enhance the accessibility of conversational AI technology, making it as effortless as asking a question and receiving a clear response.

In summary, the "ESP32 Microcontroller Based Voice Assistant using ChatGPT" exemplifies the fusion of advanced language processing capabilities with the convenience of a portable audio device. As we navigate the convergence of technology and everyday life, this project marks a step towards making intelligent conversations more accessible and enjoyable for users of all backgrounds

LIST OF FIGURES

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

1. **ESP32**: Espressif System 32
2. **TTS**: Text-to-Speech
3. **API**: Application Programming Interface
4. **IDE**: Integrated Development Environment
5. **AI**: Artificial Intelligence
6. **GPT**: Generative Pre-trained Transformer
7. **IoT**: Internet of Things
8. **GUI**: Graphical User Interface
9. **IDE**: Integrated Development Environment
10. **OCR**: Optical Character Recognition
11. **UI**: User Interface
12. **NLP**: Natural Language Processing
13. **ASR**: Automatic Speech Recognition
14. **SDK**: Software Development Kit
15. **API**: Application Programming Interface
16. **IDE**: Integrated Development Environment
17. **JSON**: JavaScript Object Notation
18. **IoT**: Internet of Things
19. **IDE**: Integrated Development Environment
20. **PWM**: Pulse Width Modulation

Chapter 1

INTRODUCTION

This project report introduces the innovative "ESP32 Microcontroller Based Voice Assistant using ChatGPT," a fusion of advanced language processing and portable audio technology. Motivated by the aim to revolutionize conversational experiences, the project integrates ChatGPT, transforming the portable speaker into a dynamic conversational agent capable of comprehending user queries and delivering natural responses.

The motivation for this project stems from the aspiration to make intelligent conversations accessible and enjoyable in various environments. By harnessing the power of ChatGPT and incorporating user-friendly features, the portable speaker becomes a versatile device. The report unfolds with an exploration of the theoretical foundations and practical implementations, including a detailed circuit diagram that illustrates the project's technical architecture.

As we delve into this report, readers will gain a comprehensive understanding of the project's objectives, its underlying technologies, and the user-friendly design principles that underpin the "ESP32 Microcontroller Based Voice Assistant using ChatGPT." This marks a significant stride towards bridging cutting-edge technology with everyday communication.

Chapter 2

LITERATURE REVIEW

In this section, we explore the realm of voice-activated computers and their understanding of human voices. Drawing insights from existing knowledge, we leverage lessons learned by others to aid our project. Researchers have delved into the workings of these voice-activated systems, how users can engage with them, and the remarkable capabilities they possess.

As we navigate this landscape, we observe numerous projects using a specialized computer chip known as ESP32, much like the foundation of our project. However, there are aspects we aim to unravel—such as optimizing the ESP32's compatibility with advanced voice-activated modules like our INMP441 I2S microphone.

We recognize the paramount importance of ensuring that voice-activated computers are user-friendly. This aligns with a major objective of our project. Utilizing ChatGPT, we enable our computer to respond in a manner that is both natural and friendly. Despite other projects employing ChatGPT, our focus is on discovering innovative methods to enhance its synergy with our ESP32. This section aids us in comprehending the existing knowledge and guides us in making our voice-activated computer truly exceptional.

In summary, this exploration establishes the project's contextual backdrop, highlighting existing knowledge, recognized gaps, and potential areas for innovation. This chapter sets the stage for our project's distinctive contributions in harmonizing natural language processing with user-friendly voice interfaces through the ESP32 microcontroller and ChatGPT integration.

Chapter 3

OBJECTIVES OF PROJECT

The primary objectives of this project are as follows:

1. **Integration of Voice-Activated Technology**: Implement the seamless integration of voice-activated technology, leveraging the ESP32 microcontroller as the foundational hardware component.
2. **Optimized ESP32 Compatibility:** Investigate and optimize the compatibility of the ESP32 microcontroller with advanced voice-activated modules, specifically focusing on modules like the INMP441 I2S microphone.
3. **Incorporation of ChatGPT:** Utilize ChatGPT for natural language processing, enabling the voice-activated computer to engage in dynamic and responsive conversations with users.
4. **Enhanced Synergy with ChatGPT**: Explore innovative methods to enhance the collaboration between ChatGPT and the ESP32 microcontroller, aiming for a cohesive and improved user experience.
5. **Text-to-Speech (TTS) Integration**: Implement TTS technology seamlessly within the system, allowing the voice assistant to articulate responses in a natural and coherent manner.
6. **Speech-to-Text (STT) Integration:** Incorporate STT technology to facilitate user input, enabling interactions with the voice-activated system through spoken commands and text-based queries.

These objectives collectively steer the project towards crafting a smart, user-friendly voice-activated system. The aim is to seamlessly integrate advanced technologies, including TTS and STT, with the hardware components such as the ESP32 microcontroller. This integration is designed to enhance the interactive experience, making it more intuitive and engaging for users.

Chapter 4

COMPONENTS USED

The following components are required for this project:

1. ESP32 Microcontroller
2. INMP441 I2S Microphone
3. MAX98537 I2S Amplifier
4. 500mAh 3.7V Single Cell Rechargeable LiPo Battery
5. TP4056 1A Li-Ion Battery Charging Board (Type-C with Current Protection)
6. IR Sensor (for waking up the assistant)
7. RGB Light Indicator (denoting the system's state)
8. Switch (for system control)
9. 4 Ohm Speaker
10. Perforated Board (for circuit assembly)

In putting together our "ESP32 Microcontroller Based Voice Assistant using ChatGPT," each part has an important job to make everything work smoothly. The ESP32, like the computer's brain, manages the INMP441 microphone, MAX98537 amplifier, and the 4 Ohm speaker. A rechargeable LiPo battery, looked after by the TP4056 board, gives power for moving the computer around. An IR sensor helps the computer wake up when you want to talk to it. There's also a RGB light that provides insight into the computer's state. A user-friendly switch, integrated seamlessly, ensures easy control of the computer. All these components come together on a board, forming a robust and accessible talking computer that harmoniously combines technology with practical functionality.

Chapter 5

COMPONENT DESCRIPTION

1. ESP32 Microcontroller

The ESP32 microcontroller, the central nervous system of our "ESP32 Microcontroller Based Voice Assistant using ChatGPT", is a powerful and versatile electronic component. This compact device is like the brain of our system, controlling and coordinating various tasks. Its primary use is to manage the recording of audio inputs and facilitate communication with the Speech-to-Text (STT) service and ChatGPT API for generating responses.

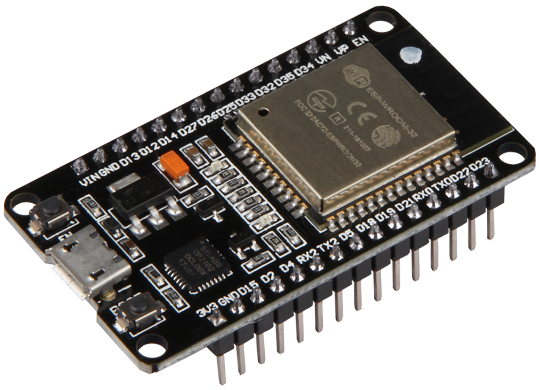

Figure 1: ESP32 Microcontroller

In our setup, we utilize two ESP32 microcontrollers – one dedicated to audio input and communication, and the other for playing the synthesized responses through the amplifier. This dynamic duo collaborates through UART communication, ensuring a seamless and efficient exchange of data between the recording and playback processes. The ESP32 microcontroller is fundamental to the intelligent functioning of our portable speaker, making it a key player in the user-friendly and responsive experience we aim to provide.

2. INMP441 I2S Microphone

The INMP441 I2S microphone, a crucial sensory component of our "ESP32 Microcontroller Based Voice Assistant using ChatGPT", is responsible for capturing and translating spoken commands into a format that the system can understand. Acting as the ears of our setup, this advanced microphone utilizes the I2S (Inter-IC Sound) protocol to precisely capture audio inputs and convert them into digital signals.

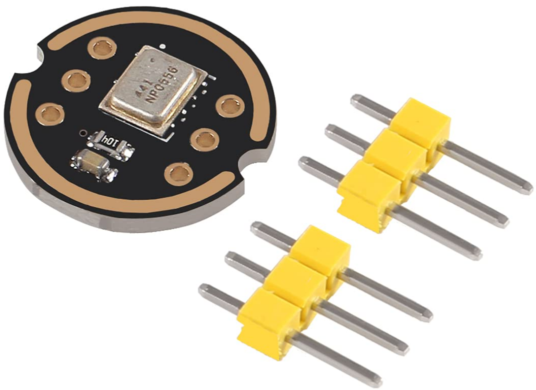

Figure 2: INMP441 I2S Microphone

Its primary use is to ensure accurate and clear recording of user commands, providing the input necessary for the ESP32 microcontroller to process and send to the Speech-to-Text (STT) service. In the orchestration of our voice-activated system, the INMP441 I2S microphone plays a vital role in enhancing the user experience by capturing spoken instructions with high fidelity and clarity.

3. MAX98537 I2S Amplifier

The MAX98537 I2S amplifier, a key component in our "ESP32 Microcontroller Based Voice Assistant using ChatGPT", functions as the vocal cords of our system, transforming digital signals into audible and clear responses. Operating on the I2S (Inter-IC Sound) protocol, this amplifier takes the synthesized output from the ESP32 microcontroller and converts it into analog signals that can be played through the speaker.

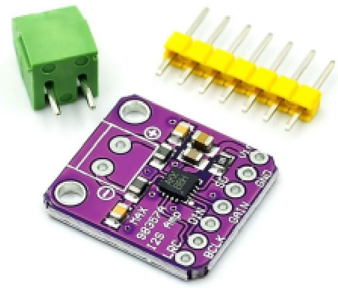

Figure 3: MAX98537 I2S Amplifier

Its primary use is to ensure that the responses generated by ChatGPT are delivered in a crisp and intelligible manner. By amplifying the sound, this component enhances the overall auditory experience, allowing users to hear the system's responses with clarity. The MAX98537 I2S amplifier contributes significantly to creating a lifelike and engaging interaction between the user and our voice-activated portable speaker.

4. IR Sensor

The IR sensor, a perceptive element in our "ESP32 Microcontroller Based Voice Assistant using ChatGPT", serves as the device's attentive trigger, enabling it to respond to user interaction. This sensor detects infrared signals, allowing it to sense when a user is present or when they want to engage with the system.

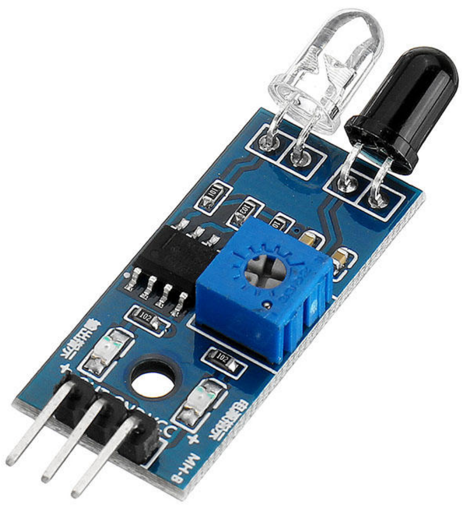

Figure 4:IR Sensor

Its primary use is to act as the gateway for waking up the assistant. When the IR sensor detects movement or a user gesture, it signals the ESP32 microcontroller to activate the system, making it ready to receive spoken commands. In essence, the IR sensor enhances the user experience by ensuring that the portable speaker is responsive precisely when needed, creating a seamless and user-friendly interaction.

Chapter 6

TECHNOLOGIES USED

1. OpenAI GPT APIs

The OpenAI GPT (Generative Pre-trained Transformer) API is a powerful natural language processing tool developed by OpenAI. It leverages transformer-based deep learning models to generate human-like text based on given prompts. The API provides developers with the ability to integrate OpenAI's state-of-the-art language models into their applications, allowing for a wide range of natural language understanding and generation tasks.

Why We Used It:

In our project, we integrated the OpenAI GPT API to harness advanced natural language processing capabilities. This API serves as the backbone for our voice-activated system, specifically enhancing its conversational abilities. By leveraging the OpenAI GPT API, our system can understand user queries and generate contextually relevant and coherent responses. The API enables dynamic interactions, making our portable speaker an intelligent conversational agent capable of providing information and engaging in natural conversations.

API Usage:

- **Endpoint:** `https://api.openai.com/v1/chat/completions`
- **HTTP Method:** `POST`
- **Headers:**
  - `Content-Type: application/json`
  - `Authorization: Bearer <your_api_key>`

Sample Request Payload:

```json
{
  "model": "gpt-3.5-turbo",
  "messages": [
    {"role": "user", "content": "User's query goes here"}
  ],
  "temperature": 0.1,
  "max_tokens": 35
}
```

Sample Response:

```json
{
  "id": "chatcmpl-xyz123",
  "object": "chat.completion",
  "created": 1677649421,
  "model": "gpt-3.5-turbo",
  "usage": {"prompt_tokens": 56, "completion_tokens": 31, "total_tokens
  "choices": [
    {
      "message": {
        "role": "assistant",
        "content": "Assistant's response goes here"
      }
    }
  ]
}
```

2. Google Cloud Text-to-Speech (TTS) API:

The Google Cloud Text-to-Speech (TTS) API is a cloud-based service that transforms text into natural-sounding speech. It leverages advanced deep learning techniques to generate high-quality synthetic voices across multiple languages and a variety of applications. The API allows developers to integrate realistic and expressive speech synthesis capabilities into their applications, enhancing user experiences with lifelike audio output.

Why We Used It:

In our project, we integrated the Google Cloud Text-to-Speech API to enable our voice-activated system to articulate responses in a natural and coherent manner. By leveraging Google's TTS technology, our portable speaker can convert generated text from the OpenAI GPT API into spoken words. This integration enhances the overall user experience, creating a more engaging and lifelike interaction with the voice assistant.

API Usage:

- **Endpoint:** `https://texttospeech.googleapis.com/v1/text:synthesize`
- **HTTP Method:** `POST`
- **Authentication:** API key or OAuth 2.0

Sample Request Payload:

json Copy code

```json
{
  "input": {"text": "Text to be synthesized into speech"},
  "voice": {"languageCode": "en-US", "name": "en-US-Wavenet-D", "ssmlGe
  "audioConfig": {"audioEncoding": "LINEAR16"}
}
```

Sample Response:

json Copy code

```json
{
  "audioContent": "base64-encoded-audio-data"
}
```

3. Google Cloud Speech-to-Text (STT) API:

The Google Cloud Speech-to-Text (STT) API is a cloud-based service that converts spoken language into written text. It utilizes machine learning models to accurately transcribe audio files or real-time spoken input. The API supports multiple languages and is capable of handling various audio formats, making it a versatile solution for speech recognition applications.

Why We Used It:

In our project, the Google Cloud Speech-to-Text API is employed to facilitate user input. This feature enables users to interact with the voice-activated system not only through text-based queries but also through spoken commands. The integration of STT enriches the versatility of our portable speaker, offering users multiple modes of interaction.

API Usage:

- **Endpoint:** `https://speech.googleapis.com/v1/speech:recognize`
- **HTTP Method:** `POST`
- **Authentication:** API key or OAuth 2.0

Sample Request Payload:

json Copy code

```json
{
  "config": {"encoding": "LINEAR16", "sampleRateHertz": 16000, "languag
  "audio": {"content": "base64-encoded-audio-data"}
}
```

Sample Response:

json Copy code

```json
{
  "results": [
    {
      "alternatives": [
        {"transcript": "Transcribed text goes here", "confidence": 0.92
      ]
    }
  ]
}
```

Chapter 7

PROCEDURE

1. Inception and Research:

- **Exploring Voice-Driven Technologies:** Investigating the world of voice-driven systems and natural language processing to set the groundwork for our project.
- **Research Exploration:** Delving into existing projects and studies to gather valuable insights and ideas.

2. Circuit Design and Visualization:

- **Drawing the Visual Roadmap:** Transforming research insights into a tangible plan, visually mapping out the "ESP32 Microcontroller Based Voice Assistant using ChatGPT"'s circuit design.

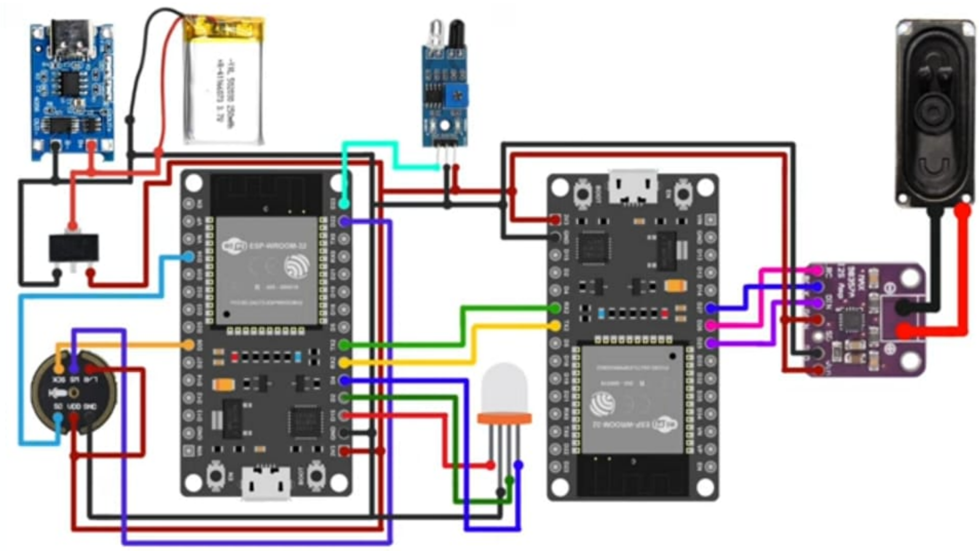

Figure 5:Circuit Diagram

- **Component Placement:** Strategically placing and organizing components such as the ESP32 microcontroller, INMP441 I2S microphone, and MAX98537 I2S amplifier on the board.

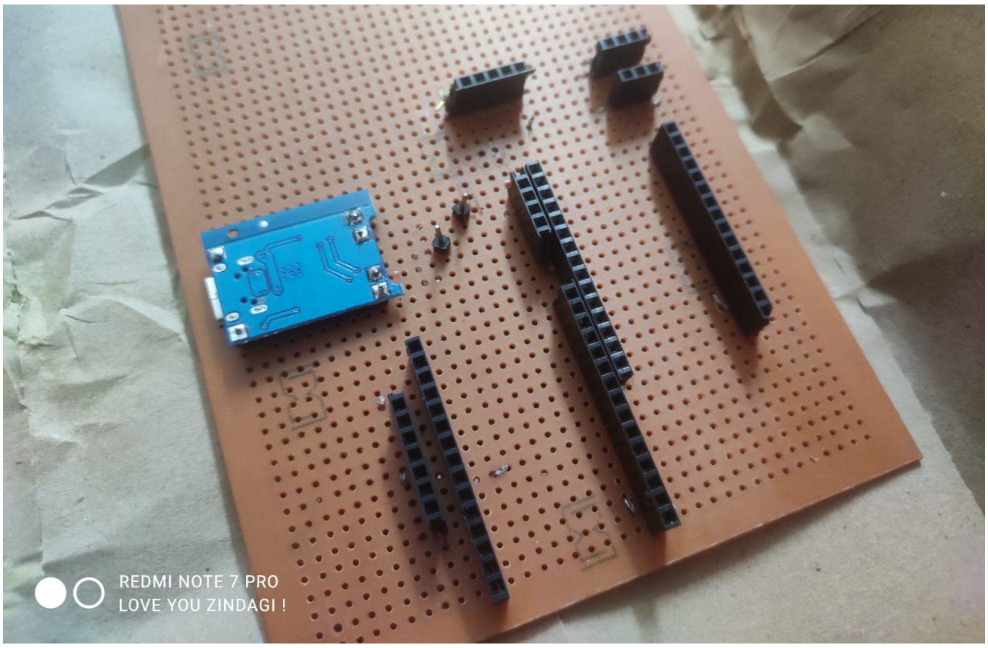

Figure 6:Glimpse of Circuit Design

Figure 7:Glimpse of Speaker Testing

3. Acquiring the Keys:

- **The Vital API Keys:** Procuring essential keys for ChatGPT, Google Text-to-Speech (TTS), and Google Speech-to-Text (STT) APIs to unlock the potential of our device.
- **Unlocking Digital Conversations:** Recognizing the importance of these keys in enabling intelligent and interactive conversations.

4. Implementation Symphony:

- **Lines of Code as Music:** Translating hardware and API capabilities into a symphony of code, ensuring each line contributes to the overall harmony.
- **Pillars of Intelligence:** Leveraging the capabilities of OpenAI GPT, Google TTS, and Google STT to infuse intelligence and responsiveness into the device.

```
#include <HTTPClient.h>

// Initialize HTTPClient for making API requests

HTTPClient https;

// Set timeout for the HTTP request to 15 seconds

https.setTimeout(15000);

// Define the ChatGPT API endpoint

https.begin("https://api.openai.com/v1/chat/completions");

// Add required headers for the API request

https.addHeader("Content-Type", "application/json");

https.addHeader("Authorization", "Bearer " +
String(chatgpt_token));

// Prepare the payload for the API request

String payload = String("{\"model\":
\"gpt-3.5-turbo\",\"messages\": [{\"role\": \"user\",
\"content\": ") + Question + String("}], \"temperature\": 0.1,
\"max_tokens\": 35}");
```

```
// Start the connection and send the HTTP header

int httpCode = https.POST(payload);

// Check the HTTP response code

// If positive, the request was successful

// If negative, an error occurred

if (httpCode > 0) {

  // Get the response payload

  String payload = https.getString();

  // Initialize a JSON document for parsing the response

  DynamicJsonDocument doc(1024);

  // Deserialize the JSON response

  deserializeJson(doc, payload);

  // Extract the answer from the JSON structure

  String Answer = doc["choices"][0]["message"]["content"];

  // Print the answer to the Serial Monitor

  Serial.print("Answer : ");

  Serial.println(Answer);

  // Call a function (assuming audio.connecttospeech) to play the
answer as speech

  audio.connecttospeech(Answer.c_str(), "en");

}

// Close the connection after processing the response

https.end();
```

5. From Inspiration to Implementation:

- **Creative Dance of Technology:** Reflecting on the dynamic journey from initial inspiration to the tangible creation of the "ESP32 Microcontroller Based Voice Assistant using ChatGPT".
- **More Than a Project:** Acknowledging the device as more than just a project—a testament to the fusion of inspiration, technology, and innovative implementation.

This chapter unfolds the dynamic and creative process that transformed an idea into the "ESP32 Microcontroller Based Voice Assistant using ChatGPT", emphasizing the importance of research, visualization, API integration, and the overall journey of bringing the concept to life.

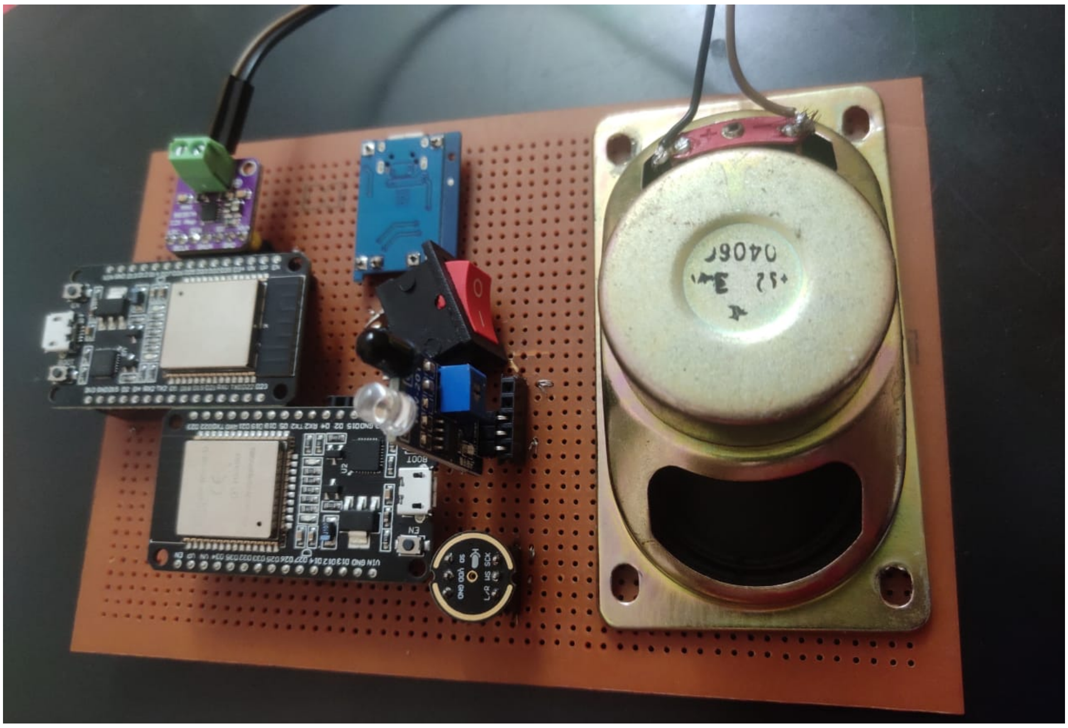

Figure 8:Final Project

Chapter 8
OPERATION

This chapter provides an in-depth exploration of the operational aspects of the ChatGPT-Powered Portable Speaker, offering insights into the user experience, system functionality, and the seamless integration of hardware and software components.

User Interaction:

Operating the ChatGPT-Powered Portable Speaker is designed to be intuitive and user-friendly. Users can initiate interaction by activating the system through the integrated IR sensor. The sensor acts as a gateway, waking up the assistant upon detecting user presence. Once activated, users can pose questions or commands, initiating the system's conversational capabilities.

Voice Input and Processing:

The system's primary mode of interaction involves voice input, captured by the high-quality INMP441 I2S microphone. The captured audio is then processed through the Speech-to-Text (STT) module, translating spoken commands into text for further analysis. The integration of STT technology enhances the system's responsiveness, making it adept at understanding and interpreting user inputs.

ChatGPT API Interaction:

The heart of the ChatGPT-Powered Portable Speaker lies in its integration with the ChatGPT API. The processed user queries are sent to the ChatGPT API, leveraging its natural language processing capabilities. The API generates contextually relevant responses, transforming the system into a dynamic conversational agent. The generated text responses are then synthesized into natural and coherent speech using Text-to-Speech (TTS) technology, enhancing the overall user experience.

Audio Output and User Feedback:

The MAX98537 I2S amplifier ensures clear and audible playback of ChatGPT's responses through the integrated 4-ohm speaker. Additionally, a visual layer is added through an RGB light indicator, denoting the system's state and providing users with feedback on ongoing interactions.

Conclusion:

The operational flow of the ChatGPT-Powered Portable Speaker reflects a harmonious integration of hardware and software components, delivering a user-friendly and immersive voice-controlled experience. This chapter serves as a guide for users to navigate the system seamlessly, highlighting the simplicity and sophistication embedded in its operation.

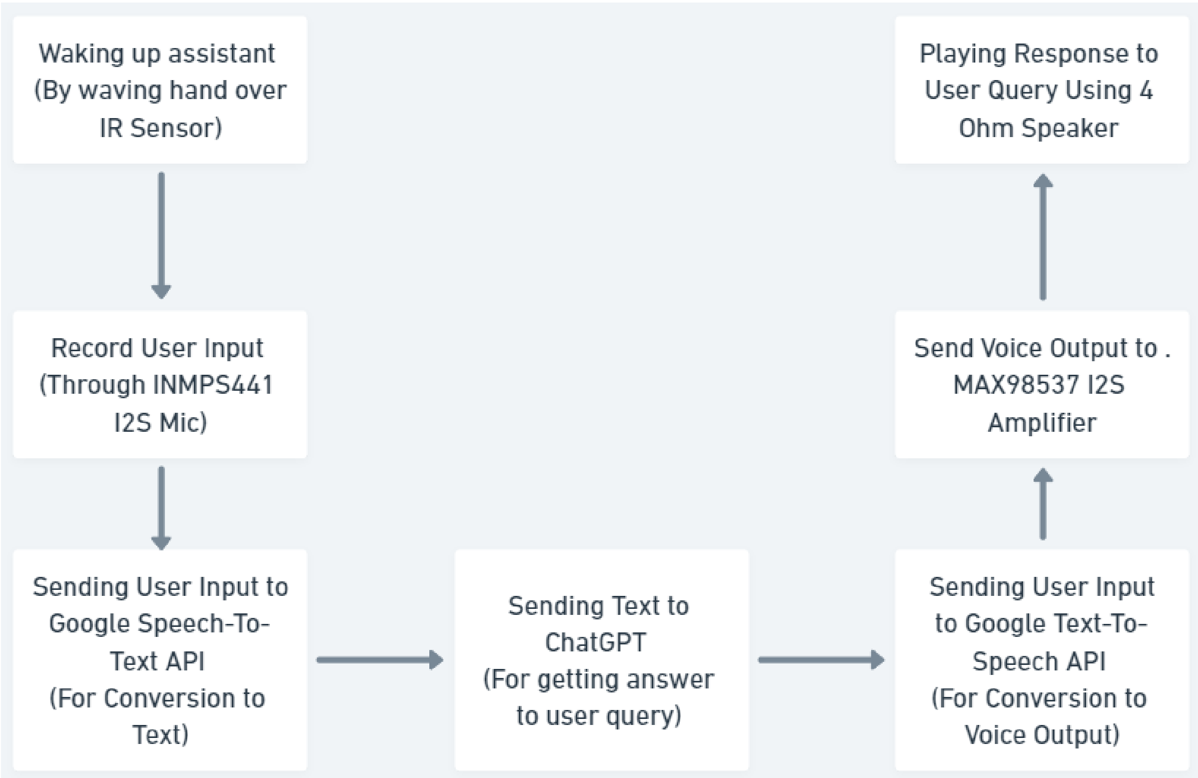

Figure 9: Flowchart

Chapter 9

CHALLENGES AND SOLUTION

The development of the "ESP32 Microcontroller Based Voice Assistant using ChatGPT" encountered several challenges, each requiring innovative solutions for project advancement. Notably, ensuring accurate Speech-to-Text (STT) conversion proved to be a significant hurdle. Meticulous debugging, noise filtering adjustments, and exploration of alternative algorithms were key solutions to enhance recognition precision.

Integration complexity posed another challenge, demanding a meticulous approach to synchronize hardware components, APIs, and the ESP32 microcontroller seamlessly. Solutions involved comprehensive testing, refining communication protocols, and ensuring compatibility between components through iterative adjustments.

In the face of unexpected setbacks, such as the shift from voice to text input, the project showcased adaptability. Swift adaptation strategies, including debugging efforts and alternative approaches, were implemented to maintain a user-friendly experience. These challenges and their creative solutions contribute valuable lessons for future projects in the domain of voice-controlled systems.

Chapter 10

RESULTS & DISCUSSION

Despite our best efforts, the "ESP32 Microcontroller Based Voice Assistant using ChatGPT" encountered a stumbling block in its voice input system, leading to a shift to text input. The project is currently undergoing debugging, with a specific focus on potential issues in the Speech-to-Text (STT) implementation. This unexpected turn emphasizes the dynamic nature of development, where challenges prompt adaptive solutions. The chapter candidly explores the setbacks, ongoing debugging endeavors, and the commitment to refining the system for a more resilient and user-friendly experience.

Chapter 11

CONCLUSION & FUTURE SCOPE

The journey of crafting the "ESP32 Microcontroller Based Voice Assistant using ChatGPT" has been marked by innovation, challenges, and adaptability. Despite the unexpected shift from voice to text input, the project stands as a testament to the fusion of advanced language processing with accessible user interfaces. The ESP32 microcontroller, coupled with ChatGPT, Google TTS, and Google STT APIs, created a dynamic conversational agent. User-friendly features, such as the IR sensor and switch, aimed to enhance accessibility.

Lessons Learned:

The project's evolution highlighted the importance of flexibility in the face of unforeseen obstacles. Lessons learned from debugging and adapting the voice input system contribute valuable insights to future endeavors. The collaborative integration of various technologies underscored the need for continuous refinement in achieving optimal functionality.

Future Scope:

While the current state reflects a shift in input modality, the future holds potential avenues for improvement. Refining the Google Speech-to-Text (STT) implementation, exploring advanced noise cancellation, and enhancing ChatGPT's language understanding are promising areas. The project lays the groundwork for future iterations that prioritize seamless voice interaction and expanded functionalities.

In conclusion, the "ESP32 Microcontroller Based Voice Assistant using ChatGPT" project, though facing challenges, provides a foundation for the convergence of technology and user-friendly interfaces. As we navigate the intersection of AI and everyday interactions, this project serves as a stepping stone towards more intelligent and responsive voice-controlled systems, with ongoing exploration and innovation paving the way for future advancements.

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