MINDSCULPTOR – AN OBSESSIVE-COMPULSIVE DISORDER(OCD) EXPOSURE ANSDS RESPONSE PREVENTION (ERP) THERAP Y TOOL.

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August 2024

INTERACTIVE VOICE ASSISTANT

Project Proposal Report

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Declaration of the Candidate & Supervisor

DECLARATION

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

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The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

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Acknowledgment

The completion of this project would not have been possible without the exceptional support and guidance of several individuals. I am profoundly grateful to my research supervisor, Ms. Dilshan De Silva, whose expertise, enthusiasm, and meticulous attention to detail have been invaluable. My heartfelt thanks also go to my co-supervisor, Mr.Samadi Rathnayake and my external supervisors, Dr.Roshan Fernando and Miss Sandharu Fernando, for their insightful feedback and unwavering support.

I would also like to extend my sincere appreciation to my research group members Ashen Illesinghe, Hasaranga Mallawaarachchi, and Chamikara Vithanage for their encouragement, constructive comments, and overall support throughout this project.

Lastly, I am deeply grateful to my parents for their unconditional support and love, which has been a constant source of motivation

ABSTRACT

The need for accessible and individualized mental health therapies is highlighted by the prevalence of Obsessive-Compulsive Disorder (OCD) and the efficacy of Exposure and Response Prevention (ERP) therapy. However, patients frequently face obstacles to timely and successful treatment, including geographic restrictions, cultural stigma, and unwillingness to seek assistance. In order to address these significant problems, our research suggests creating an AI-supported Interactive Voice Assistant (IVA) that will help OCD patients receive ERP therapy.

The IVA delivers highly customized and context-aware therapeutic interventions by utilizing state-of-the-art technologies, such as conversational AI and real-time monitoring of voice pitch changes. Through the real-time capture and analysis of audio input, the system is able to dynamically analyze the emotional state of the patient and provide customized replies that improve the therapeutic experience. The accurate detection of terms associated with OCD and the creation of suitable treatment dialogues are made possible by the application of machine learning techniques, such as Decision Trees and Logistic Regression.

The IVA is built with strong non-functional needs in addition to its main functionality to guarantee smooth processing, scalability, and compliance. The system's capacity to track patient development and adjust to individual needs over time is further enhanced by the integration of voice pitch analysis, keyword identification, and speech recognition tools.

This project intends to close the accessibility gap for mental health treatment by offering a competitive alternative to traditional therapy, especially for people living in underserved or rural locations. Better therapy outcomes, more patient participation, and a decrease in the obstacles that presently keep many people from seeking assistance are among the expected results. This study adds to our understanding of mental health technology while also providing a workable solution that may find widespread application in clinical settings.

Keywords: Obsessive-Compulsive Disorder (OCD), Exposure and Response Prevention (ERP), natural language processing, machine learning, voice pitch analysis

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LIST OF ABBREVIATIONS

IVA	Interactive Voice Assistant
AI	Artificial Intelligence
OCD	Obsessive Compulsive Disorder
ERP	Exposure and Response Prevention
CBT	Cognitive Behavioral Therapy
NLP	Natural Language Processing
ML	Machine Learning
GDPR	General Data Protection Regulation
HIPAA	Health Insurance Portability and Accountability Act
EMR	Electronic Medical Record

1.INTRODUCTION

1.1Background & Literature survey

Artificial intelligence (AI) has drawn a lot of interest in recent years to the integration of AI into mental health care, especially when it comes to providing scalable, customized therapies for mental health illnesses. Artificial intelligence (AI)-driven chatbots and virtual assistants, which utilize natural language processing (NLP), machine learning (ML), and speech analysis technologies, have surfaced as potentially useful resources for mental health care [1]. These developments have opened the door for AI-driven solutions that provide people with ongoing, instant support—often in addition to conventional therapeutic approaches [2].

But even with the progress made in AI-powered mental health solutions, there is still a big gap in meeting the unique treatment requirements of people with obsessive-compulsive disorder (OCD). The gold standard for treating OCD, traditional ERP therapy, frequently necessitates ongoing supervision and assistance from licensed therapists to guarantee that exposure exercises are carried out as intended [3]. The necessity for AI-assisted technologies that can expand the scope of ERP therapy is highlighted by the rising demand for such specialized care and the global lack of mental health practitioners [4].

While Woebot, Wysa, and Youper are examples of AI-based mental health platforms that now provide general mental health assistance through cognitive behavioral therapy (CBT) procedures, they are unable to provide specialist ERP therapy for OCD [5, 6]. These platforms lack the specialized therapies needed to address the complex and repetitive character of OCD symptoms, and instead concentrate mostly on general anxiety and despair [7]. Furthermore, these platforms' inability to adjust to the changing psychological states of OCD patients during ERP exercises is hampered by the static nature of their interactions [8].

AI's potential to improve ERP treatment through speech-based interventions has been investigated in recent research [9]. Real-time monitoring of voice pitch variations can be utilized to assess emotional distress and offer prompt assistance. Voice pitch variations have been linked to emotional states, according to research, which makes them a useful criterion for in-the-moment evaluation in therapy sessions [10]. A substantial study gap is highlighted by the paucity of empirical data about the effectiveness of incorporating such real-time speech analysis into ERP treatment for OCD [11].

Furthermore, even though AI-driven mental health applications have shown potential, there are still significant obstacles to overcome, including concerns about data security, privacy, and ethics [12]. To safeguard sensitive patient data and preserve confidence in digital health treatments, it is imperative that these systems adhere to strict standards such as GDPR and HIPAA [13]. Notwithstanding these difficulties, using AI into ERP therapy for OCD has a lot of potential advantages, especially in terms of enhancing accessibility and individualized treatment [14].

The proposed project intends to close these gaps by creating an Interactive vocal Assistant (IVA) that combines real-time vocal pitch analysis powered by AI with ERP treatment for OCD. In addition to offering individualized therapies, this IVA will continuously monitor the patient's emotional state throughout therapy sessions and make adjustments as needed. Strong data privacy and security safeguards will be incorporated into the system's architecture, guaranteeing adherence to pertinent laws and resolving ethical issues with AI in mental health [15]. If such a system is put into place successfully, it might completely change how ERP therapy is delivered and increase its effectiveness and accessibility for OCD sufferers all around the world.

1.2Research Gap

With the advent of digital mental health technologies, there have been notable breakthroughs in the management and treatment of Obsessive-Compulsive Disorder (OCD). Nevertheless, several elements that are essential for the successful use of Exposure and Response Prevention (ERP) therapy—the main treatment for OCD—are absent from the current options. The research gap analysis emphasizes how these current systems' shortcomings are apparent in comparison to the suggested Interactive Voice Assistant (IVA) solution.

The program Despite being a well-liked chatbot for mental health, Woebot lacks context-aware replies, patient progress monitoring, and ERP therapy integration—all crucial components of an effective OCD treatment program [16]. Similar to this, Wysa is an AI-powered mental health software that supports mood regulation and generalized anxiety, however it is not designed for OCD and does not use ERP therapy [17]. While Replika, a chatbot primarily intended for companionship, provides tailored dialogues, it is devoid of dynamic surveys and patient progress tracking, as well as therapeutic treatments such as ERP [18]. Another AI-powered emotional health assistant, Youper, monitors mood and provides CBT-based therapies; however, it lacks ERP therapy integration and has a restricted range of context-aware answers [19].

These holes are filled by the proposed IVA system, which includes characteristics not found in the applications indicated above. Within a framework that puts data privacy first, it provides context-aware replies, dynamic surveys, ERP treatment integration, and patient progress monitoring. The fact that existing solutions do not have these qualities emphasizes the need for a more complete solution designed especially for the treatment of OCD.

The table below summarizes the research gap identified through the comparison of existing systems with the proposed IVA system:

Figure 1. 1 : Comparison of former researches

Feature	Proposed System	Woebot[16]	Wysa[17]	Replica[18]	Youper[19]
Dynamic Questionnaires	✓	❌	✓	❌	✓
Context-aware Responses	✓	✓	✓	✓	❌
ERP Therapy Integration	✓	❌	❌	❌	❌
Patient Progress Tracking	✓	❌	❌	❌	✓
Personalized Therapy Sessions	✓	❌	✓	✓	✓
Data Privacy	✓	✓	✓	✓	✓

1.3Research Problem

Millions of individuals worldwide suffer from the crippling mental health disorder known as obsessive-compulsive disorder (OCD). There is effective treatment available, especially through Exposure and Response Prevention (ERP) therapy, but access to it is severely restricted because of a number of obstacles. These include the stigma attached to certain behaviors in society, people's unwillingness to ask for assistance, and physical barriers that keep them from getting specialist treatment. Furthermore, it might be challenging to provide constant and individualized instruction for typical ERP therapy in a traditional therapeutic context.

Though digital mental health therapies are readily available, the degree of customisation and real-time responsiveness of existing solutions is sometimes insufficient to provide OCD sufferers with appropriate assistance. Treatment results may vary because traditional ERP delivery methods may not adequately meet each patient's specific demands. Additionally, the efficacy of treatment may be hampered, diminishing its impact, if a therapist is unable to keep an eye on and adjust to a patient's emotional state throughout therapy sessions.

By creating an Interactive speech Assistant (IVA) that combines ERP treatment with AI-driven real-time speech pitch analysis, the proposed research seeks to close these gaps. By constantly modifying treatments based on the patient's emotional state, this approach is intended to improve the customization of therapy and increase treatment efficacy overall. Nonetheless, there are still issues with preserving user interest, guaranteeing the accuracy of real-time emotional detection, and protecting patient data in accordance with legal requirements.

Studies on the integration of real-time voice pitch analysis into therapeutic treatments are few, especially when it comes to ERP for OCD. Thus, the goal of this project is to create a revolutionary AI-supported IVA that may overcome the accessibility and customization obstacles that now hinder the efficacy of conventional treatment approaches and offer scalable, tailored, and effective ERP therapy to a larger audience. This research will benefit the area of mental health by providing a viable way to improve the efficacy and administration of ERP therapy to OCD patients.

2.OBJECTIVES

2.1 Main Objectives

This research's principal objective is to create an AI-assisted Interactive Voice Assistant (IVA) that is specially designed to administer ERP (Exposure and Response Prevention) therapy to individuals with OCD (Obsessive-Compulsive Disorder). This IVA will increase the efficacy and accessibility of ERP therapy by using real-time voice pitch analysis to provide individualized therapeutic interventions.

2.2Specific Objectives

1) Conduct ERP Therapy Sessions Tailored to Various OCD Subtypes:

Provide an adaptable framework inside the IVA that can deliver ERP therapy sessions customized for various OCD subtypes, including intrusive thoughts, contamination, checking, and symmetry. Based on the subtype, the IVA will dynamically modify its therapeutic approach to make sure every patient receives treatment appropriate for their unique problems.

2) Utilize Patient Input to Dynamically Generate Personalized Therapeutic Responses:

Create and put into use algorithms that allow the IVA to process patient data instantly. With the use of these algorithms, the IVA will be able to create and provide tailored therapeutic responses during therapy sessions, improving the effectiveness and engagement of the patient's care.

3) Implement Voice Analysis Algorithms to Monitor Pitch Fluctuations and Assess the Patient's Emotional State in Real-Time.

During therapy sessions, include sophisticated voice analysis methods into the IVA to track the patient's vocal pitch variations. The system will evaluate the patient's emotional state and modify the therapy strategy based on its analysis of these variations. This in-the-moment evaluation will assist in pinpointing instances of elevated tension or unease, facilitating prompt and suitable action.

4) Evaluate Patient Progress and Emotional Response to Therapy Sessions:

Create a methodical procedure for monitoring the advancement of patients over time, taking into account their emotional reactions and IVA interaction patterns. This will entail monitoring adjustments to anxiety thresholds, compliance with treatment plans, and general amelioration of OCD symptoms. Both the patient and their therapist will receive insightful feedback from the examination, which will enable regular modifications to the therapy regimen for the best results.

3.Methodology

The process of creating the AI-assisted Interactive Voice Assistant (IVA) for ERP treatment in patients with OCD is methodical and includes many crucial stages. System architecture design, data gathering and analysis, algorithm development, testing, and assessment are some of these stages. The approach is made to guarantee that, by offering OCD patients individualized and convenient ERP therapy, the IVA successfully tackles the research challenge.

3.1 System Architecture

The IVA's system design is essential to its operation. To produce a smooth and responsive therapeutic tool, the architecture will incorporate several components such as machine learning models, speech analysis algorithms, and conversational AI. A high-level overview of the system architecture may be seen in Figure 3.1 below.

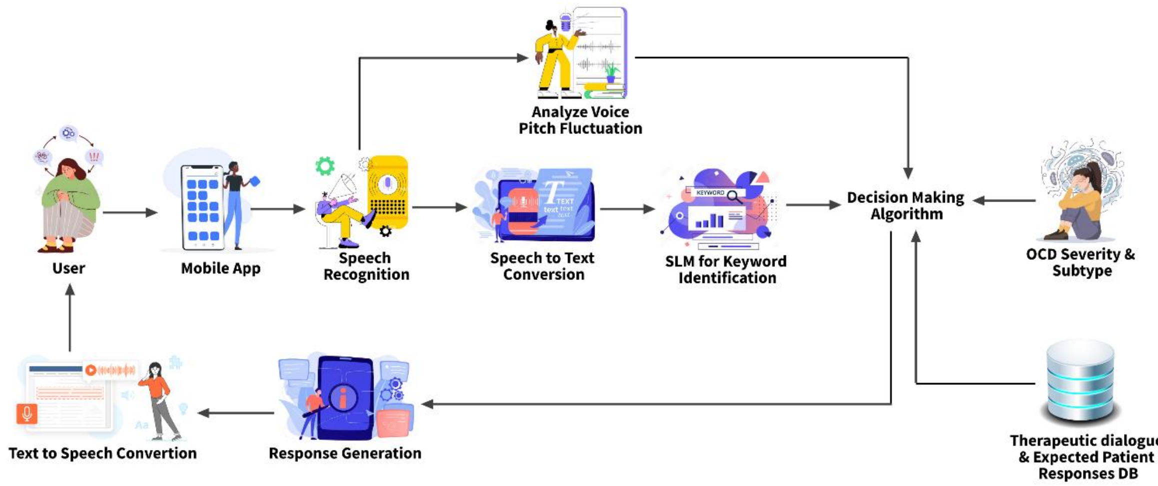

Figure 3. 2 : Interactive Voice Assistant System Architecture

1. Conversational AI Integration:

- For cross-platform interoperability, Expo and React Native will be used in the construction of the IVA. Managing the patient-system interface will fall within the purview of the conversational AI component. It will use natural language processing (NLP) methods to process patient inputs, including spoken words and phrases. The backend framework for handling server-side logic and API queries is called Flask.

2. Real-Time Voice Analysis:

- The system will incorporate voice analysis algorithms to monitor pitch fluctuations during therapy sessions. These algorithms will be implemented using TensorFlow and Librosa, and they will analyze the emotional state of the patient based on voice pitch variations. The real-time analysis will enable the IVA to adjust its responses dynamically, ensuring that the therapy remains personalized and responsive to the patient's emotional state.

3. Machine Learning Models:

- Supervised learning models such as Logistic Regression and Decision Tree algorithms will be used to analyze the transcribed text and voice pitch data. These models will be trained to recognize OCD-related keywords and emotional states, allowing the system to match patient inputs with appropriate therapeutic interventions. The models will be continuously updated based on new data to improve their accuracy and effectiveness.

4. Integration of Voice Pitch Analysis and NLP:

- The technology will combine natural language processing (NLP) and voice pitch analysis to give a comprehensive picture of the patient's emotional condition. The IVA will be able to provide more focused and efficient therapeutic treatments as a result of this integration, improving the therapy experience as a whole.

3.2 Data Collection and Analysis

An essential step in the development of the IVA is data collecting. The information will be utilized to verify the efficacy of the voice analysis techniques and train the machine learning models.

1. Audio Data Collection:

- Pyaudio will be used by the IVA to record audio, which will be the foundation for vocal pitch analysis. Librosa and Praat will be used to process and analyze the audio data that has been gathered in order to extract pertinent elements including pitch, tone, and emotional signs. The machine learning models are going to be trained using this data.

2. Text Data Collection

- The technology will gather and examine text data from patient exchanges in addition to audio data. Speech-to-text techniques will be used to transcribe this text data from the patient's spoken utterances. To elicit particular therapeutic reactions, OCD-associated keywords and phrases relevant to the transcription will be identified through analysis.

3. Data Preprocessing:

- To guarantee accuracy and relevance, the data will be preprocessed before being fed into the machine learning models. Feature extraction, normalization, and noise reduction are all part of this preprocessing. The machine learning models will then be trained on the cleaned data, allowing them to anticipate emotional states and suggest suitable treatment procedures with accuracy.

3.3 Algorithm Implementation

The IVA will evaluate patient inputs and provide individualized treatment solutions by combining machine learning and natural language processing technologies.

1. Supervised Learning Models:

- Supervised learning methods will be employed to train the machine learning models. The association between vocal pitch variations and emotional states will be examined using logistic regression, and OCD-related terms will be categorized using decision tree algorithms. The IVA will incorporate these models to enable real-time analysis and reaction production.

2. Natural Language Processing (NLP):

- The text from the patient encounters will be transcribed, and NLP techniques will be utilized to process and evaluate it. The IVA will be able to provide tailored therapy interventions thanks to these algorithms' ability to recognize important phrases and words associated with OCD symptoms. The NLP element will furthermore enable the IVA to sustain an organic and captivating dialogue with the patient, augmenting the therapeutic encounter as a whole.

3. Voice Pitch Analysis Algorithms:

- Real-time monitoring of the patient's emotional state will be accomplished through the use of voice pitch analysis techniques. Pitch fluctuations will be analyzed by these algorithms to look for indications of tranquility, worry, or distress. The IVA will modify its therapeutic reactions in light of this study to better meet the emotional demands of the patient.

3.4 Testing and Evaluation

Thorough testing and evaluation are a part of the final IVA development process, which makes sure the system satisfies both functional and non-functional criteria.

1. Functional Testing

- A battery of functional tests will be performed on the IVA to ensure that every part is operating as intended. Unit tests for particular algorithms, integration tests for system parts, and end-to-end tests to verify the IVA's overall functioning will all be a part of this testing. The main goals of the testing procedure will be to verify that the IVA can reliably assess patient inputs, provide suitable treatment responses, and continuously track emotional states.

2. Non-Functional Testing

- The performance of the IVA in terms of latency, scalability, and compliance with GDPR and HIPAA laws will be evaluated through non-functional testing. We'll assess the system's capacity to manage massive data sets and stay responsive throughout therapy sessions. Furthermore, the security elements of the IVA will be verified to guarantee the protection of patient data and compliance with applicable privacy regulations.

3. User Acceptance Testing (UAT):

- To get input on the usability and efficacy of the IVA, a sample of OCD sufferers will test it. This evaluation will assist pinpoint any areas that require improvement and offer insightful information about the patient experience. Before the system is deployed, the final modifications will be made based on the input gathered during user acceptance testing.

4. Evaluation Metrics:

- A predetermined set of indicators, such as accuracy, reaction time, patient satisfaction, and emotional state prediction, will be used to assess the IVA's performance. These measurements will offer a numerical assessment of the system's efficiency in providing customized ERP treatment.

3.5 Summary of Technologies, Techniques, and Algorithms

The main tools, methods, and algorithms utilized in creating the AI-supported IVA for ERP treatment in OCD patients are compiled in the table below.

Table 6. 1: Summary of Technologies, Techniques, and Algorithms

Technologies	Techniques	Algorithms
Expo, React Native	Data Preprocessing	Logistic Regression
Flask, TensorFlow, Librosa	Feature Extraction	Decision Tree
pyaudio, Praat	Voice Pitch Analysis	NLP Algorithms
	Natural Language Processing	Voice Pitch Analysis Algorithms

4.Project Requirements

4.1 Functional Requirements

1. Real-Time Audio Capture and Analysis:

- Using the device's microphone, the system ought to be able to get audio input from the patient in real-time. In order to determine the patient's emotional state, pitch changes in the recorded audio should be examined very away.

2. OCD Keyword Identification:

- Throughout the talk, the algorithm must to correctly recognize terms associated with OCD. Certain treatment interventions according to the patient's situation ought to be triggered by these keywords.

3. Dynamic Therapeutic Response Generation:

- Based on the detected keywords and the emotional states that have been assessed, the system ought to dynamically develop individualized therapeutic responses. Responses ought to follow the standards of ERP treatment and be helpful and pertinent.

4. Emotional State Monitoring:

- Using voice pitch and other vocal cue analysis, the system should continually monitor the patient's emotional state during the session. Any notable shifts in emotional state must to be noted and dealt with properly.

5. Patient Progress Evaluation:

- By contrasting the data from the present session with that from earlier sessions, the system ought to assess the patient's development over time. This will assist in modifying the therapy strategy as necessary.

6. Session Logging and Data Management:

- All sessions should be safely logged by the system, which will save pertinent information for later review. The auditory input, recognized keywords, created answers, and shifts in emotional state should all be included in this data.

4.2 Non-Functional Requirements

1. User-Friendliness:

- A user-friendly, cross-platform interface should be offered by the system. In order to guarantee a seamless user experience across various platforms and devices, the user interface needs to be both aesthetically beautiful and responsive.

2. Reliability:

- There should be little possibility of a system malfunction or breakdown throughout a session, ensuring great dependability. Without sacrificing functionality, it should be able to manage a variety of situations, such as low audio quality or unforeseen user input.

3. Performance:

- When it comes to real-time audio analysis and response production, the system need to function well and process data quickly. In order to guarantee smooth communication between the patient and the IVA, latency should be kept to a minimum.

4. Security and Compliance:

- To protect patient privacy and security, the system must abide by GDPR and HIPAA requirements. Access to all sensitive data must be controlled according to user roles, and it must all be encrypted.

5. Scalability:

- A rising user base should be supported by the system's scalability without experiencing performance deterioration. It need to be able to accommodate several sessions running simultaneously and grow its database and processing power as required.

6. Availability:

- Patients should be able to attend their therapy sessions whenever necessary, as the system need to be accessible round the clock. It should manage maintenance intervals with grace and provide steady uptime.

4.3 System Requirements

The system requirements serve to specify the hardware and software resources required for the proposed system to operate as intended. The following are the project's particular requirements:

- React Native and Expo:
    - utilized to guarantee compatibility with both iOS and Android smartphones while developing a cross-platform mobile application.
- Flask and TensorFlow:
    - TensorFlow will fuel the machine learning models for keyword detection and speech pitch analysis, while Flask will manage the backend operations.
- Librosa and Praat:
    - By using these libraries, voice pitch analysis will be able to extract important aspects from the audio input that are necessary for determining the emotional state of the patient.
- pyaudio:
    - used to record and interpret audio data in real time, allowing the system to communicate with the patient in a flexible manner.
- Google Colab and scikit-learn:
    - Scikit-learn will be used to construct and test several algorithms, including Decision Trees and Logistic Regression, while Google Colab will be utilized to train and refine machine learning models.
- NLTK, Gensim, and TextBlob:
    - With the help of these libraries, natural language processing activities such as sentiment analysis and keyword extraction will be performed, guaranteeing precise and situation-appropriate therapeutic replies.

4.4User Requirements

1. OCD Patients:

- Sessions of ERP treatment will be provided to patients via the application. Throughout the session, the IVA will lead them through activities and offer tailored treatments depending on their feedback and emotional condition.

2. Therapists:

- The tool will be used by therapists to remotely monitor patient progress. They will be able to modify treatment programs as needed thanks to their access to emotional state evaluations and session logs.

5. GANTT CHART

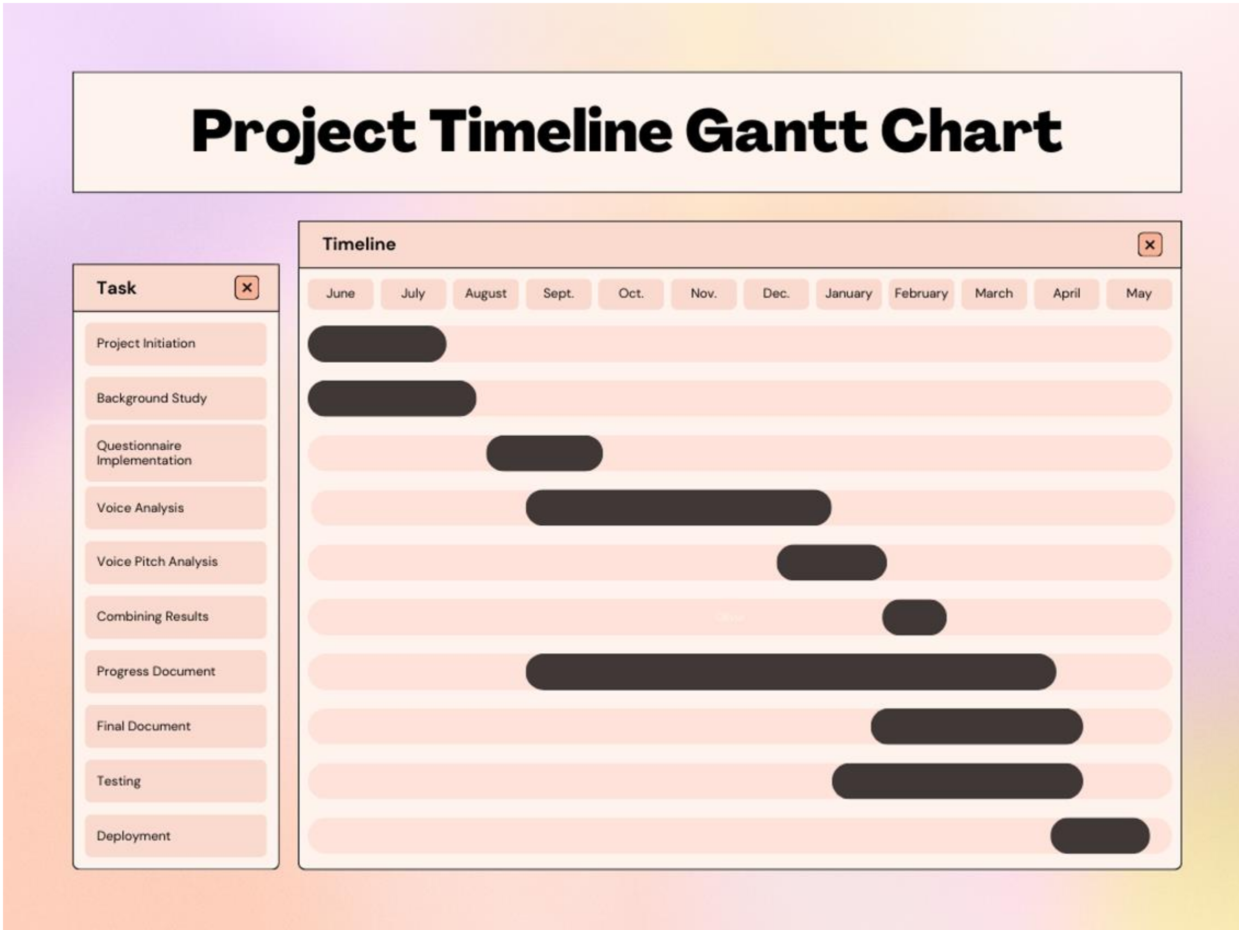

Figure 5.1: Gantt chart

5.1 Work Breakdown Structure (WBS)

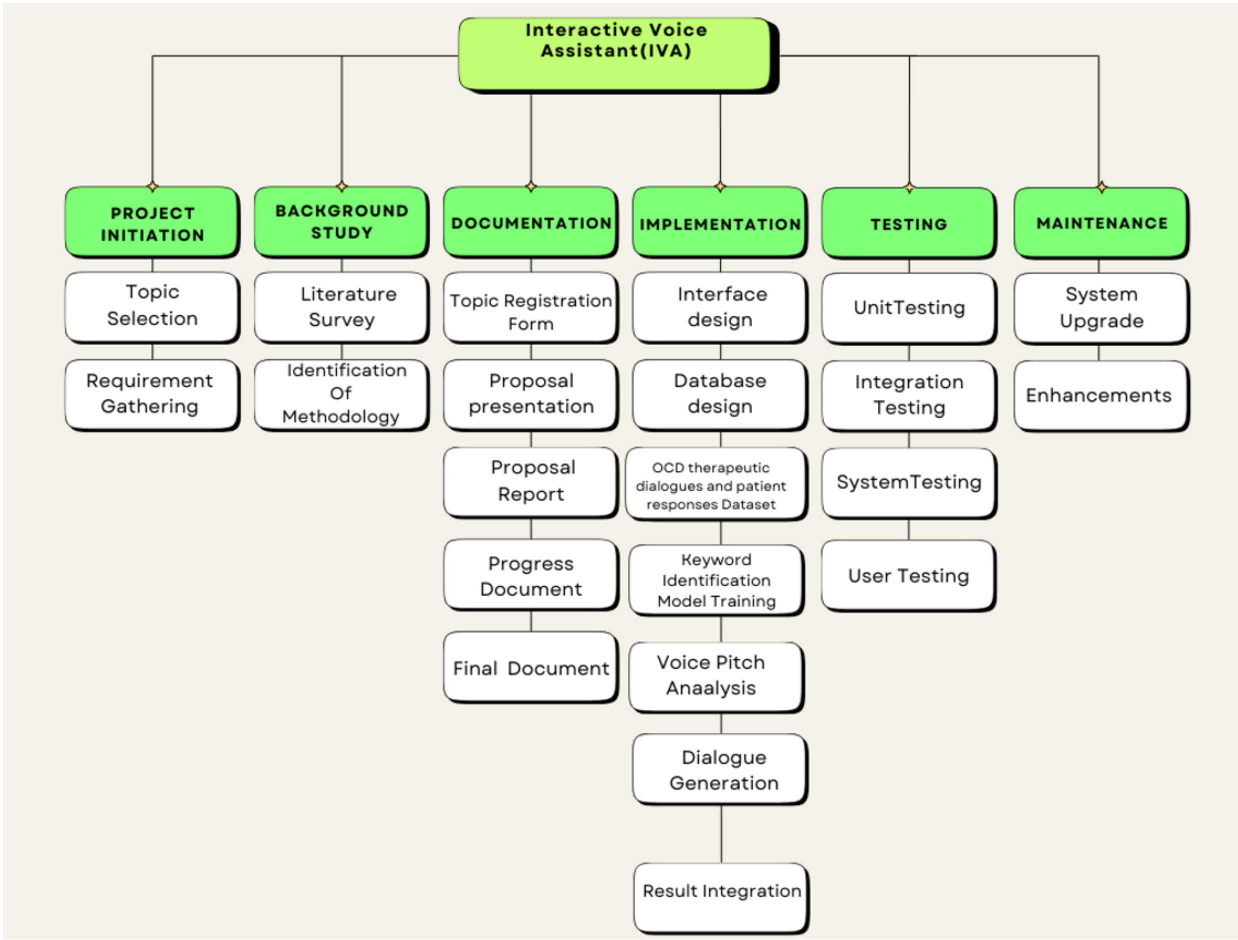

Figure 5.2: Work Breakdown Structure of IVA component

6. BUDGET AND BEGET JUSTIFICATION

The below table 6.1 depicts the overall budget of the entire proposed system.

Table 6.1: Expenses for the proposed system

Component	Description	Price
Development Costs	Salaries for developers, designers, and managers	Rs. 300,000 (one-time)
AI & NLP Tools	Licenses/subscriptions for AI and NLP tools	Rs. 10,000 / year
Biometric Analysis Tools	Tools and libraries for biometric analysis	Rs. 5,000 (one-time)

Cloud Services	Cloud storage and computing power	Rs. 15,000 / year
App Maintenance	Ongoing maintenance and updates	Rs. 15,000 / year
Marketing and Promotion	Digital advertising and promotional events	Rs. 25,000 / year
Customer Support	Support staff salaries and tools	Rs. 20,000 / year
Training & Documentation	Training materials and user guides	Rs. 4,000 (one-time)
Research & Development	Ongoing R&D for feature improvements	Rs. 12,000 / year

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8.APPENDICES

Appendix A

- External supervisor (Dr. Roshan Fernando) channeling receipt.

RECEIPT

REFERENCE NO.	:	41499002
APPOINTMENT DATE	:	**July 2, 2024**
APPOINTMENT TIME	:	Tue 08:40 PM (Time may vary according to doctor's arrival time)
APPOINTMENT NO.	:	**021 (Active)**
HOSPITAL	:	LEESONS HOSPITAL
PATIENT'S NAME	:	Mr. PASINDU JAYASINGHE (Local)
PHONE NUMBER	:	714300675
NIC	:	200016000147
EMAIL	:	pasindujayasinghe@gmail.com
ROOM	:	131
DOCTOR NAME	:	**Dr. W. K. T. ROSHAN FERNANDO (Psychiatrist)**
PAYMENT DATE	:	2024-07-01 11:45 PM
SOURCE	:	Doc990 (Web)
DOCTOR CHARGES	:	2500.00 LKR
HOSPITAL CHARGES	:	700.00 LKR
BOOKING CHARGES	:	199.00 LKR
TOTAL CHARGES	:	**3399.00 LKR**
HOSPITAL REFERENCE	:	LHR0001931781
HOSPITAL ADDRESS	:	No. 33, Thewatta Road, Ragama, Sri Lanka
HOSPITAL CONTACT NUMBER	:	011 296 1300
HOSPITAL EMAIL	:	leesons@sltnet.lk

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Figure 8.1: External Supervisor Channeling Receipt

Appendix B

- Image taken during our visits to hospitals to collect data regarding OCD ERP.

Figure 8.2: Meeting Dr.Roshan Fernando

Appendix C

- Image taken during an online zoom session that was arranged to gather data regarding OCD ERP.
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Figure 8.3: Zoom meeting with Miss Sandharu Fernando