MINDSPACE VR: IMMERSIVE VIRTUAL REALITY THERAPY FOR MENTAL HEALTH ENHANCEMENT

A PROJECT REPORT

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submitted to the faculty of

INFORMATION AND COMMUNICATION TECHNOLOGY

in partial fulfillment

for the award of the degree

of

BACHELOR OF TECHNOLOGY

in

INFORMATION TECHNOLOGY

DEPARTMENT OF INFORMATION SCIENCE AND TECHNOLOGY

COLLEGE OF ENGINEERING GUINDY

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APRIL 2025

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BONAFIDE CERTIFICATE

Certified that this project report titled **"MINDSPACE VR: IMMERSIVE VIRTUAL REALITY THERAPY FOR MENTAL HEALTH ENHANCEMENT"** is the bonafide work of **IBRAHIM NAVAS S (2021115042)**, **MANI@ARUN VENKATESH P (2021115060)**, **THIRUMURUGAN K(2021115117)**, **ADNAN KHAN S (2021115304)** who carried out project work under my supervision. Certified further that to the best of my knowledge and belief, the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or an award was conferred on an earlier occasion on this or any other candidate.

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ABSTRACT

The project presents the development of an immersive Virtual Reality (VR) application designed to support the treatment of mental health disorders such as depression, anxiety, and specific phobias through interactive and gamified therapeutic experiences. The application features a user-friendly interface that allows individuals to access distinct modules, each targeting a particular psychological challenge. A core component is the VR Psychiatrist, an AI-powered virtual counselor that interacts with users via voice input to assess lifestyle factors like sleep, appetite, and routine, offering tailored advice to manage depression, stress, and insomnia. Complementing this is the Fear Simulator, which addresses acrophobia, aquaphobia, and glossophobia using exposure therapy through virtual scenarios-ranging from skydiving challenges and underwater exploration to public speaking in a classroom setting, with performance analysis and feedback. Additionally, the Rage Game module provides a safe, controlled space for stress relief through the virtual destruction of objects, helping users release built-up tension. Another innovative module, Breathing Bird, transforms the user into a virtual bird navigating hazardous environments using real-time breathing patterns. Inhaling elevates the bird while exhaling brings it down, allowing users to practice controlled breathing as a form of stress and anxiety reduction through interactive gameplay. With the integration of AI-driven analysis and immersive VR environments, the project aims to provide an engaging, accessible, and scalable solution for mental health rehabilitation, bridging gaps in traditional therapy with tech driven innovation.

ABSTRACT (TAMIL)

ACKNOWLEDGEMENT

It is our privilege to express our deepest sense of gratitude and sincere thanks to **Dr. P VARALAKSHMI,** Professor, Project Guide, Department of Information Science and Technology, College of Engineering, Guindy, Anna University, for her constant supervision, encouragement, and support in our project work. We greatly appreciate the constructive advice and motivation that was given to help us advance our project in the right direction.

We are grateful to **Dr. S. SWAMYNATHAN,** Professor and Head, Department of Information Science and Technology, College of Engineering Guindy, Anna University for providing us with the opportunity and necessary resources to do this project.

We would also wish to express our deepest sense of gratitude to the Members of the Project Review Committee: **Dr. K. VANI,** Professor, **Dr. K. INDRA GANDHI,** Professor, **Dr. K. VIDYA,** Associate Professor, **Dr. N. ANBARASI,** Teaching Fellow, Department of Information Science and Technology, College of Engineering Guindy, Anna University, for their guidance and useful suggestions that were beneficial in helping us improve our project.

We also thank the faculty member and non teaching staff members of the Department of Information Science and Technology, Anna University, Chennai for their valuable support throughout the course of our project work.

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LIST OF ABBREVIATIONS

ADHD	Attention-Deficit/Hyperactivity Disorder
AI	Artificial Intelligence
API	Application Programming Interface
ASR	Automatic Speech Recognition
AWS	Amazon Web Services
CBT	Cognitive Behavioural Therapy
EEG	Electroencephalogram
LLM	Large Language Model
LLaMA	Large Language Model Meta AI
MCQ	Multiple Choice Questions
MDD	Major Depressive Disorder
MNE	Magnetoencephalography
NER	Named Entity Recognition
PTSD	Post Trauma Stress Disorder
REST API	Representational State Transfer Application Programming Interface
ResNet	Residual Neural Networks
SAD	Seasonal Affective Disorder
UI	User Interface
VIBGYOR	Violet, Indigo, Blue, Green, Yellow, Orange, Red
VR	Virtual Reality

CHAPTER 1

INTRODUCTION

Mental health disorders such as depression, anxiety, and specific phobias are growing global concerns that significantly affect the emotional, cognitive, and physical well-being of individuals. These conditions often go underdiagnosed or untreated due to the stigma associated with mental health, lack of access to professional care, or limited awareness. Traditional therapeutic interventions, although effective, frequently suffer from accessibility and engagement challenges, particularly in underserved populations. Emerging technologies such as Virtual Reality (VR) offer innovative solutions by providing immersive, interactive environments that can simulate real-world therapeutic experiences in a safe and controlled manner.

1.1 OVERVIEW OF MENTAL HEALTH TREATMENT IN VR

Virtual Reality has gained traction in mental health therapy by enabling exposure-based interventions, stress-relief environments, and AI-driven counseling experiences. The proposed VR application introduces a comprehensive and gamified therapeutic platform targeting depression, anxiety, and three specific phobias—acrophobia (fear of heights), aquaphobia (fear of water), and glossophobia (fear of public speaking). The app is structured around interactive modules accessible through a user-friendly main menu. The **VR Psychiatrist** module uses a large language model (LLM) to analyze voice input from users describing lifestyle factors such as sleep, appetite, and daily routine, then provides real-time, personalized counseling. The **Fear Simulator** includes engaging challenges such as skydiving (for acrophobia), surface and underwater exploration (for aquaphobia), and classroom public speaking scenarios (for glossophobia), each offering scoring, feedback, and progressive difficulty. Additionally, the **Rage Game** module allows users to release stress by smashing virtual objects using tools like hammers in a safe environment, enhancing emotional catharsis. Each module is designed not only to simulate realistic experiences but also to promote psychological resilience through interactive, AI-powered feedback and behavioral tracking. This system bridges the gap between clinical therapy and digital self-help tools, offering scalable, cost-effective, and stigma-free mental health interventions.

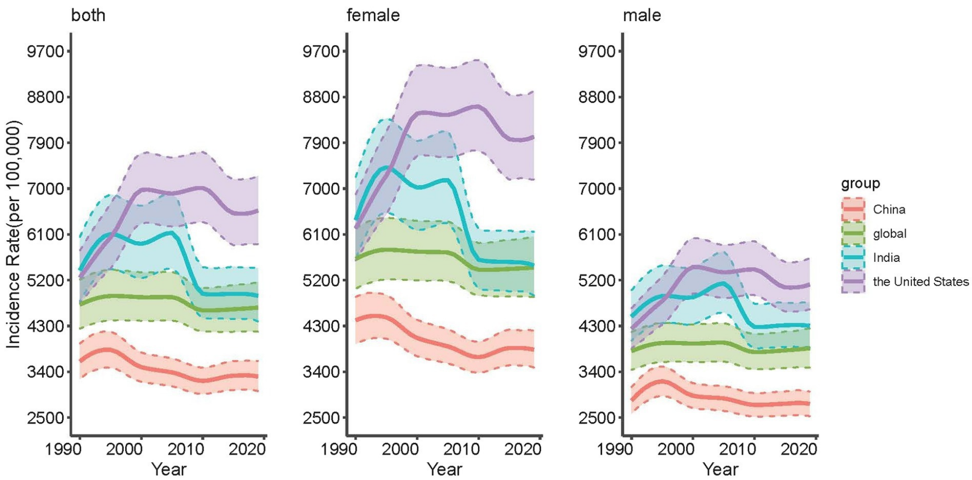

Figure 1.1: Depression Statistics through out the Years

1.2 DOMAIN APPLICATION AREAS

The proposed VR system has wide-ranging applications across healthcare, workplace wellness, education, and digital therapy platforms. In clinical settings, it can supplement traditional therapy with immersive simulations and AI-driven counseling, providing real-time mental health support. In corporate environments, the app can serve as a wellness tool for employees, offering stress relief and early-stage mental health assessments, thus reducing burnout and absenteeism. Educational institutions can use the VR Fear Simulator to help students overcome public speaking anxiety and stress-induced academic pressure. Digital health platforms can integrate the app into wearable and mobile ecosystems to democratize mental health access. Additionally, the VR modules present a valuable tool for researchers and psychologists to study behavioral responses to virtual stimuli and enhance therapeutic interventions.

1.3 CHALLENGES

Realism and User Immersion: Achieving a balance between virtual realism and system performance is crucial to ensure users experience believable environments that effectively trigger and treat their psychological conditions.

Data Privacy and Ethical Considerations: Collecting and analyzing personal audio inputs raises concerns regarding user privacy and data protection. It is essential to maintain strict confidentiality and comply with ethical standards in mental health technologies.

Measuring Psychological Progress: Accurately evaluating a user's emotional and behavioral improvements in a VR setting requires robust data analytics and standardized mental health scoring frameworks.

Content Personalization: Different users experience mental disorders in varying intensities and forms. Designing adaptive gameplay and therapy that caters to diverse user profiles remains a key challenge.

Accessibility and Hardware Dependence: The need for VR headsets and motion controllers may limit access among low-income populations. Ensuring cross-platform compatibility and affordability is vital for widespread adoption.

1.4 MOTIVATION

With millions of individuals affected by depression, anxiety, and phobias worldwide, there is a pressing need for accessible, engaging, and effective treatment methods. Current therapeutic models, though clinically sound, often face barriers related to cost, stigma, and availability. The motivation behind this project is to leverage the immersive potential of VR to provide interactive, AI-powered mental health interventions that transcend these limitations. Unlike conventional talk therapy, VR allows patients to actively engage in therapeutic scenarios, enhancing motivation and emotional engagement. This project aims to redefine mental health treatment through immersive design and intelligent assistance, making therapy more engaging, proactive, and inclusive.

1.5 RESEARCH OBJECTIVES

Design an Immersive VR Therapy Application: Develop interactive and immersive VR therapy modules aimed at managing depression, stress, and phobias. These modules will simulate real-life scenarios to facilitate emotional regulation, cognitive restructuring, and gradual exposure in a safe virtual environment.

Integrate AI-Powered Virtual Counseling: Utilize a large language model (LLM) to analyze user-provided audio inputs, detect emotional cues, and provide context-aware, personalized feedback and lifestyle recommendations, simulating human-like virtual counseling sessions.

Evaluate Behavioral and Emotional Responses: Incorporate intelligent tracking through scoring mechanisms, speech and sentiment analysis, and therapy progression metrics to evaluate user engagement, emotional state, and therapeutic outcomes over time.

Enhance User Engagement Through Gamification: Implement engaging gamified elements such as point systems, progress levels, badges, and rewards to foster motivation, encourage consistent participation, and make therapy feel more interactive and rewarding.

1.6 PROBLEM STATEMENT

Mental health disorders such as depression, anxiety, and specific phobias affect over 970 million individuals globally, with many cases going undiagnosed or untreated due to stigma, geographic barriers, and limited provider availability. Traditional treatment approaches face significant challenges including high dropout rates (20-60%), difficulty creating realistic exposure scenarios, and limited personalization capabilities. Although digital mental health interventions have emerged as potential solutions, most current platforms suffer from poor engagement metrics, limited interactivity, and insufficient immersion. Virtual Reality (VR) technology offers unique advantages over conventional and digital alternatives through its unparalleled immersive capabilities, allowing for precise environmental control, graduated exposure intensity, and physiological engagement impossible in other formats. Unlike mobile apps or web-based tools that maintain psychological distance from therapeutic scenarios, VR creates presence and embodiment that activates the same neural pathways as real-world experiences, potentially accelerating habituation and learning while maintaining user safety. This project leverages these distinctive VR affordances to create engaging therapeutic environments that simultaneously increase accessibility, enhance treatment adherence, reduce stigma through private engagement, and provide personalized, adaptive interventions across multiple mental health conditions with significantly higher ecological validity than existing solutions.

1.7 PROPOSED SOLUTION

This project introduces a comprehensive VR-based mental health intervention platform that leverages immersive technology to address the limitations of traditional and digital therapeutic approaches. The proposed solution utilizes virtual reality's unique capacity for creating presence and physiological engagement to deliver evidence-based psychological interventions through an integrated ecosystem of interactive applications. By combining principles from cognitive-behavioral therapy, exposure therapy, mindfulness practices, and emotional regulation techniques with immersive technology, this platform creates safe, controlled environments where users can engage with therapeutic content at personalized intensity levels. The solution incorporates natural language processing for conversational support, real-time biofeedback mechanisms, progressive difficulty adjustment, and performance analytics to create a highly adaptive therapeutic experience. This approach addresses accessibility barriers through location-independent delivery, reduces stigma through private engagement, enhances treatment adherence through gamification elements, and improves therapeutic efficacy through high ecological validity simulations. The platform's modular architecture allows for targeting multiple mental health conditions including anxiety disorders, specific phobias, and stress-related conditions within a unified technological framework that can be expanded as treatment protocols evolve.This solution represents a significant advancement in digital mental health by bridging the gap between clinical efficacy and technological innovation in a user-centered design framework.

1.8 ORGANIZATION OF THE REPORT

This report is organized into 6 chapters, detailing each aspect of the VR-based mental health treatment system, supported with illustrative examples, system diagrams, and design rationales.

CHAPTER 2: Literature Review explores existing research and technologies relevant to virtual reality in mental health treatment. It reviews clinical approaches to phobia exposure therapy, depression and anxiety management, and examines previous implementations of VR in healthcare settings.

CHAPTER 3: System Architecture presents an overview of the architecture of the proposed VR system. It outlines how different modules—such as the VR Psychiatrist, Fear Simulator, and Rage Game—are integrated, and provides information on the technologies used, including Unity, AI-based tools, and VR development frameworks. It also describes both front-end interaction and back-end logic.

CHAPTER 4: System Design describes the design choices for each of the modules in the VR application. It includes interaction design, 3D environment modeling, audio processing techniques, dialogue system for the VR Psychiatrist, and level structures for fear exposure modules. This chapter also outlines the user interface design and flow.

CHAPTER 5: Implementation elaborates on the development of the VR modules, including avatar creation, game logic, scene transitions, and user input handling. It details the integration of AI for conversation-based therapy, implementation of phobia-specific simulations, and design of the Rage Game. **Results and Analysis** discusses the user experience testing, performance evaluation, and engagement metrics.

CHAPTER 6: Conclusion and Future Work summarizes the outcomes and significance of the VR application in mental health therapy. It highlights the system's potential to deliver immersive, accessible treatment experiences and discusses future work, such as integrating biometric feedback, expanding phobia simulations, and enhancing personalization through machine learning.

CHAPTER 2

LITERATURE SURVEY

This chapter deals with the existing work carried out in the domain of Virtual Reality (VR) and Artificial Intelligence (AI) for mental health therapy. It provides a review of various methodologies, technological innovations, and clinical findings that support the development of immersive and intelligent tools for treating mental health disorders.

2.1 THERAPEUTIC POTENTIAL OF VR IN MENTAL HEALTH

Virtual Reality (VR) has emerged as a transformative tool for mental health interventions. Damarla et al. [1] illustrated how VR-based applications create controlled, customizable environments that facilitate mental health support, offering exposure therapy, behavioral assessments, and interactive tasks that reduce anxiety, phobias, and depressive symptoms. Bell et al. [2] reinforced the value of VR in clinical settings, enabling more accurate diagnoses and tailored treatment plans by simulating real-world situations. Freeman et al. [3] demonstrated the efficacy of VR-based automated psychological therapy for treating acrophobia. In line with these findings, numerous studies [4, 5, 6, 7, 8, 9, 10] confirm VR's effectiveness in treating mental health disorders such as depression, PTSD, and schizophrenia by enhancing patient engagement and improving treatment outcomes. Additionally, studies like those by Wiederhold et al. [6] and Rizzo et al. [10] further emphasize the therapeutic benefits VR offers in mental health care, including the treatment of anxiety disorders and phobias. The immersive and interactive nature of VR not only helps in reducing symptoms but also provides patients with a safe space to confront and overcome their fears. Moreover, VR has shown promise in enhancing traditional therapeutic approaches, enabling patients to experience situations they may otherwise avoid in real life.

2.2 CHALLENGES IN ADOPTION OF VR THERAPY

While the therapeutic potential of VR is clear, its widespread clinical adoption faces several challenges. Dellazizzo et al. [11] reviewed various VR-based psychiatric therapies, finding positive effects across conditions like PTSD, schizophrenia, and anxiety, but also highlighting the need for higher-quality clinical trials. Selaskowski et al. [12] pointed out the lack of standardized protocols and high-quality studies as major barriers to the broader acceptance of VR therapy. Birckhead et al. [13] proposed that VR clinical trials should follow standardized methodologies, with iterative designs and user-centered evaluations to improve effectiveness and ease of implementation. Donker et al. [14] examined self-guided VR-based CBT for acrophobia, noting that such applications could reduce the cost of care but require further investigation for broader use. Additional studies [15, 6, 16] emphasize the need for cross-disciplinary collaboration, device compatibility, and data security to integrate VR into clinical settings effectively. Challenges like hardware cost and user experience were further detailed by Waller et al. [16] and Cooper et al. [15], who discussed the limitations in existing VR setups and recommended improvements for broader accessibility

2.3 AI-POWERED MENTAL HEALTH SUPPORT SYSTEMS

AI has proven to be a valuable addition to mental health systems by enabling intelligent assessments and personalized interventions. Olawade et al. [17] highlighted how AI systems using natural language processing (NLP) and deep learning can empower virtual counselors and chatbots to offer personalized feedback. These systems can help in behavioral tracking and provide support in real-time. E.E. Lee et al. [18] elaborated on the practical applications of AI in clinical environments, including early diagnosis, predictive modeling, and intervention systems. Further studies [19, 20, 21, 22, 23, 24] discussed the growing importance of AI-driven chatbots and voice analytics in detecting distress signals, providing timely interventions, and simulating therapeutic dialogues. Notably, Patel et al. [20] and Barak et al. [23] emphasized the role of AI in delivering scalable mental health solutions that are highly effective for diverse populations, making mental health support accessible and affordable.

2.4 IMPLEMENTATION BARRIERS AND PERSPECTIVES

The integration of AI and VR in mental health care faces several barriers, particularly related to ethics, data privacy, and accessibility. Espejo et al. [25] warned of ethical risks, including data privacy concerns and model transparency, in the integration of AI and VR systems. Wainberg et al. [26] discussed global implementation challenges, emphasizing the need for scalable frameworks that can be applied in underserved regions. They argued that public health policies must be tailored to support digital mental health solutions globally. Other studies [27, 28, 29, 30] highlight the importance of infrastructure, training, and policy frameworks to ensure smooth integration of AI and VR technologies into existing healthcare systems. Specifically, the challenges of data security, regulatory frameworks, and the ethical implications of AI-based decision-making were discussed by Liu et al. [28] and Powell et al. [29].

2.5 COGNITIVE BEHAVIORAL AND EXPOSURE THERAPY

Cognitive Behavioral Therapy (CBT) and exposure therapy are well-established therapeutic techniques, and VR is enhancing their accessibility and effectiveness. Boeldt et al. [31] demonstrated the success of VR-based exposure therapy for treating anxiety disorders by immersing patients in anxiety-provoking, yet controlled, environments. Freeman et al. [32] also provided evidence of VR's efficacy in treating acrophobia. Langarizadeh et al. [33] supported VR's viability as a telemental health option, especially in resource-limited settings. Additional studies [34, 35, 36, 37, 38] have found that VR enables graded exposure and cognitive restructuring, significantly improving symptom severity in various mental health conditions, including PTSD, phobias, and depression. The studies by Rizzo et al. [35] and Marshall et al. [34] emphasized VR's unique ability to deliver immersive and individualized therapeutic experiences.

2.6 FUTURE OF PERSONALIZED & PRECISION MENTAL HEALTH TREATMENT

Johnson et al. [39] discussed how precision medicine principles, when combined with AI and VR, can lead to highly personalized experiences. Studies like [35, 19, 23, 28, 5] support a future where emotion-aware and behavior-adaptive systems respond in real time to individual needs. These innovations pave the way for VR counselors and AI systems to jointly track biometrics, voice stress, and patient interactions—creating dynamic feedback loops. Ethical frameworks and design principles proposed in [40, 25] also guide responsible AI-VR development to prevent harm and ensure inclusivity. Future research [43-53] will be crucial in addressing existing challenges and ensuring these technologies reach their full potential. As these technologies continue to evolve, they hold the promise of creating more accurate, effective, and accessible mental health care solutions. This integration of advanced technologies is expected to enhance the scalability of interventions, making them widely accessible to underserved populations.

2.7 SUMMARY

Virtual Reality (VR) has proven to be a transformative tool in mental health care, offering immersive environments for exposure therapy, behavioral assessments, and the treatment of disorders such as anxiety, depression, PTSD, and schizophrenia. By providing a controlled and customizable experience, VR enhances patient engagement and allows individuals to confront their fears in a safe space, improving treatment outcomes and complementing traditional therapeutic approaches.Despite its potential, the adoption of VR therapy faces challenges such as the need for standardized protocols, high-quality clinical trials, device compatibility, and addressing hardware and user experience issues. Additionally, there is a growing need for improved collaboration across disciplines and further research to overcome these barriers.

AI is playing a significant role in mental health care by enabling personalized interventions through natural language processing and deep learning. AI-driven systems can track patient behaviors, detect distress signals, and offer real-time support, making mental health care more accessible and scalable, especially through chatbots and voice analytics.However, the integration of AI and VR in mental health care also raises concerns around ethics, data privacy, and accessibility, particularly in underserved regions. Ensuring data security, establishing regulatory frameworks, and addressing ethical concerns are essential for the responsible use of these technologies.The combination of VR with Cognitive Behavioral Therapy (CBT) and exposure therapy is particularly effective in treating mental health conditions. The future of mental health care lies in the continued integration of AI and VR, providing personalized, real-time support that can adapt to individual needs. This will enhance the accessibility and scalability of mental health treatments, especially for underserved populations, and drive more accurate and effective care in the future.

2.8 CONCLUSION FROM LITERATURE SURVEY

The literature reviewed clearly highlights the therapeutic potential of both VR and AI in mental health interventions. VR provides controlled, immersive environments that facilitate exposure therapy and behavioral interventions, while AI enhances these experiences by offering personalized, real-time feedback. Despite ongoing challenges such as clinical validation, ethical concerns, and the need for standardized methodologies, the effectiveness of VR-based therapies in treating disorders like PTSD, anxiety, and depression is well-documented. The integration of AI allows for more adaptive, real-time treatment strategies. Looking forward, the combination of VR, AI, and precision medicine will likely revolutionize mental health care by providing scalable, accessible, and personalized interventions for a wide range of mental health conditions.

CHAPTER 3

SYSTEM ARCHITECTURE

This chapter presents the system architecture of the VR-based mental health therapy system which is provided in the Figure 3.1, integrating immersive virtual reality environments, AI-driven therapy sessions, and gamified exposure-based simulations. The architecture outlines the modular design for phobia treatment, depression counseling, anxiety regulation, and focus enhancement, with each component tailored to provide therapeutic support for users through real-time interaction and assessment.

3.1 ARCHITECTURE OF THE SYSTEM

The VR-based mental health therapy system presents an innovative approach to psychological treatment through immersive virtual reality experiences. The architecture integrates multiple specialized modules connected through a unified framework, enabling personalized therapeutic interventions across various mental health conditions. The system employs advanced technologies including language models, speech processing, physiological monitoring, and interactive 3D environments to create engaging and effective treatment experiences. A centralized evaluation framework measures user progress across all modules, collecting metrics specific to each therapeutic goal. This modular design allows for scalability and customization, enabling therapists to tailor treatment plans to individual patient needs while maintaining consistent therapeutic approaches throughout the system. The architecture emphasizes accessibility, engagement, and clinical effectiveness through its carefully structured components that work together to create a comprehensive mental health intervention platform.

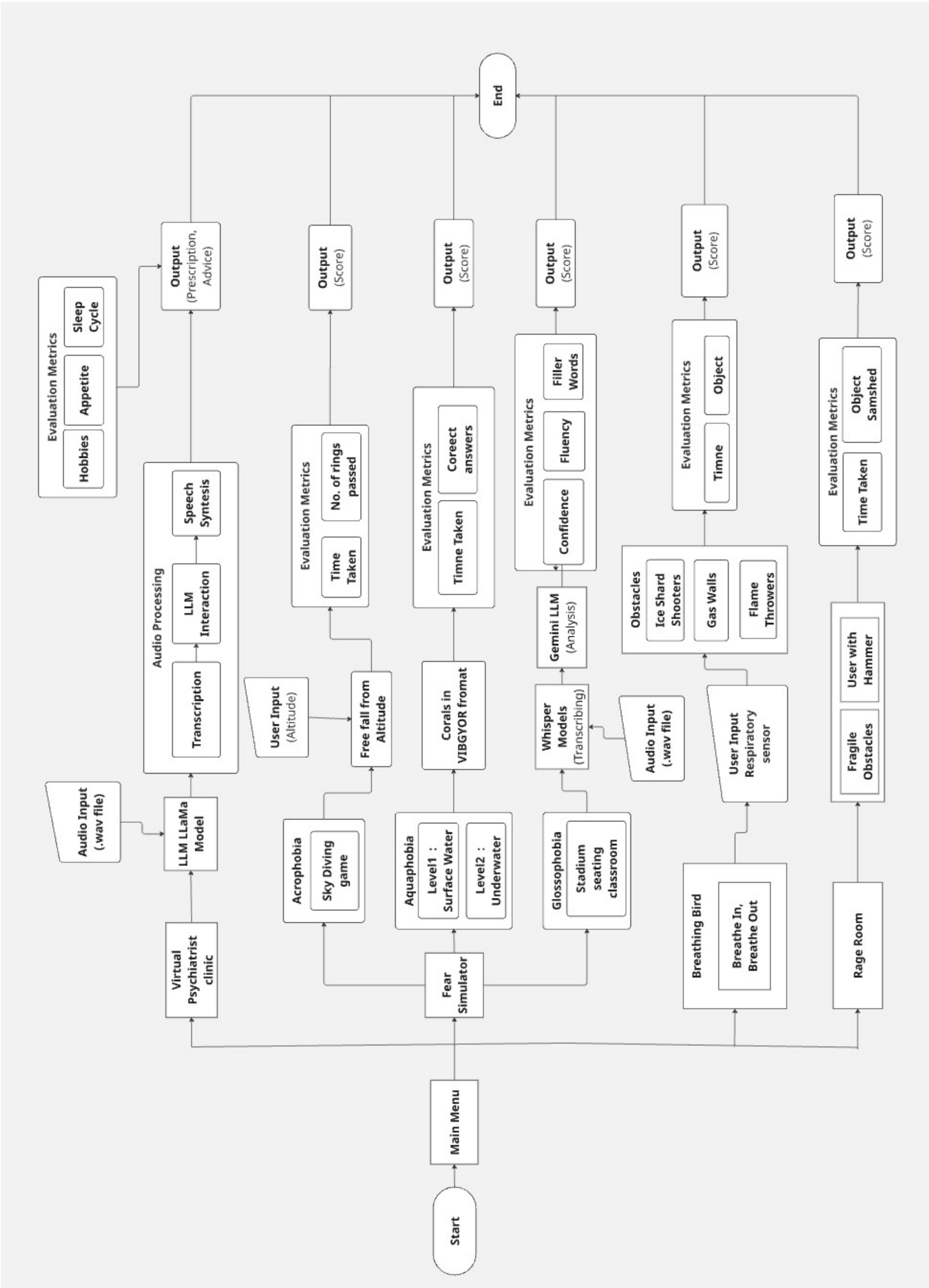

Figure 3.1: VR Mental Health Therapy System Architecture

3.2 CORE MODULES

3.2.1 Therapeutic Interaction Module

This module serves as the virtual consultation environment where users can engage in therapeutic dialogues. It incorporates natural language processing capabilities via a language model backend that enables realistic conversation with a virtual therapist. The system processes audio input from the user, transforms speech to text, generates appropriate therapeutic responses, and converts these responses back to speech for an immersive experience. Evaluation metrics track user engagement through monitoring hobbies, appetite patterns, and sleep cycles to provide personalized therapeutic advice.

3.2.2 Fear Simulation Module

This module provides controlled exposure therapy environments for various phobias. Through progressive immersion techniques, users confront fearful stimuli in safe, virtual settings. The system incorporates evaluation metrics including completion time and task accuracy to measure therapeutic progress. The architecture employs user input systems tailored to specific phobia types, allowing for customized interaction methods across different exposure scenarios. This adaptive design ensures therapeutic efficacy across various phobia profiles.

3.2.3 Stress Management Module

This component focuses on teaching emotional regulation and stress reduction techniques through interactive experiences. The module incorporates respiratory monitoring and provides immediate feedback mechanisms to help users develop mindfulness and emotional control. Through gamified experiences, users learn practical skills for managing stress responses in daily life. The architecture includes evaluation metrics that track time spent in activities and interaction measurements, providing quantifiable data on user progress and engagement levels.

3.3 BACKEND AND DATA HANDLING ARCHITECTURE

The VR mental health treatment system employs a sophisticated backend architecture that integrates various technologies and services to process user interactions, analyze data, and deliver therapeutic responses. This section outlines the key backend components and data flows that power the system's therapeutic modules.

3.3.1 Cloud-Based Language Model Integration

The Therapeutic Interaction Module implements a distributed computing architecture that leverages cloud resources to run computationally intensive language models while maintaining responsive user interactions in the VR environment.

3.3.1.1 Google Colab Server Integration

Due to the computational requirements of large language models (LLMs), the system utilizes Google Colab's GPU resources to host and run the therapeutic conversation model. This architecture includes:

- A FastAPI application running on Google Colab that loads and manages the LLM (”EmoCareAI/ChatPsychiatrist”)

- The model is configured with GPU acceleration using PyTorch's float16 precision and automatic device mapping for optimal performance
- Ngrok tunneling to create a secure public endpoint for the Colab-hosted API
- In-memory database system that maintains conversation history for each user session
- Response generation system with controlled parameters (temperature, beam search) to ensure appropriate therapeutic responses

3.3.1.2 Local Flask Server Bridge

A local Flask server acts as an intermediary between the Unity VR application and the cloud-based LLM service:

- Audio processing pipeline using Speech Recognition for transcribing user voice input
- API client that communicates with the Colab-hosted LLM service via the Ngrok tunnel
- AWS Polly integration for high-quality text-to-speech conversion, creating natural-sounding therapeutic responses
- Session management for tracking conversation state and context
- Asynchronous processing system that allows the VR experience to remain responsive while audio processing occurs

3.3.2 Speech Analysis Pipeline

For the public speaking therapy component, the system implements a dedicated speech analysis pipeline:

- Audio capture and storage system using UUID-based identification for speech recordings
- Local Whisper model deployment for efficient speech-to-text conversion
- Gemini 1.5 Pro API integration for advanced speech analysis, including:
  - Confidence assessment
  - Fluency measurement
  - Filler word detection and quantification
  - Content relevance evaluation
- RESTful API architecture allowing the VR application to request analysis and receive structured feedback
- Recording management system for storage, retrieval, and deletion of speech samples

3.3.3 Physiological Data Integration

The respiratory biofeedback component incorporates real-time physiological monitoring through sensor integration:

- Arduino-based respiratory sensor interface that captures breathing patterns

- Serial communication protocol for transmitting sensor data to the Unity application
- Signal processing algorithms that normalize and interpret breathing data
- Real-time data streaming architecture that maintains low latency for immediate feedback
- Calibration system that adapts to individual user breathing patterns

3.3.4 Data Flow Architecture

The system implements a cohesive data flow architecture across all modules:

- Input capture systems specific to each therapeutic context (audio, physiological signals, user interactions)
- Processing pipelines that transform raw data into therapeutic insights
- Feedback generation systems that convert analysis into therapeutic guidance
- Performance tracking and metrics collection for therapeutic progress evaluation
- User session management to maintain context across treatment sessions

This multi-layered backend architecture enables the system to provide sophisticated therapeutic interactions while maintaining the immersive quality of the VR experience, creating a seamless integration between advanced computational processing and therapeutic methodologies.

3.4 TOOLS AND TECHNOLOGIES USED

The system utilizes diverse technologies to deliver an interactive and intelligent therapy platform:

- **Unity3D** - Powers the core VR environment, implements gameplay mechanics for therapeutic games (fear simulators, rage room, breathing exercises), and handles VR interactions.
- **Blender** - Used for creating 3D models and animations for the virtual psychiatrist, game environments (underwater scenes, skydiving elements), and interactive objects.
- **Python** - Drives the backend systems including speech recognition, natural language processing, and therapeutic response generation.
- **Hugging Face Transformers** - Implements the psychiatric conversational model (`EmoCareAI/ChatPsychiatrist`) providing therapeutic responses.
- **FastAPI/Flask** - Creates REST APIs that connect Unity front-end with Python backends, enabling real-time processing of therapy sessions.
- **Whisper** - Handles speech-to-text transcription for the public speaking module, converting user speech to text for analysis.
- **Google Gemini 1.5** - Analyzes speech performance in the glossophobia module, providing metrics on clarity, confidence, and fluency.

- **AWS Polly** - Converts text responses from the virtual psychiatrist into natural-sounding speech for immersive therapy experience.
- **ngrok** - Facilitates secure tunneling between local development environments and public endpoints, enabling remote API access.

This technology stack creates a comprehensive mental health platform that addresses multiple phobias through immersive experiences while providing professional-grade therapeutic interactions.

3.4.1 Evaluation Metrics

The system employs multiple evaluation metrics for performance assessment. **Single Turn Evaluation** is used to evaluate the VR psychiatrist's conversational effectiveness. For the glossophobia module powered by the Gemini 1.5 model, global benchmarks such as **MMLU Accuracy** and **GPQA Performance** are considered. Together, these metrics provide a comprehensive overview of the system's capabilities across different therapeutic modules.

CHAPTER 4

SYSTEM DESIGN

In this chapter, we will discuss the system design of the Virtual Reality Therapy app, which is developed to assist individuals in overcoming mental health challenges such as depression, anxiety, and phobias through immersive therapeutic experiences. This system integrates AI-driven analysis, interactive virtual simulations, and real-time physiological tracking to provide tailored therapy for users.

4.1 Therapeutic Interaction Module

The **Therapeutic Interaction Module** serves as an AI-powered therapy assistant, guiding users through sessions in a virtual environment while analyzing their speech patterns and mental health indicators. This system ensures dynamic interaction between the user and the virtual therapist through advanced **speech recognition**, **text-based analysis**, and **AI-generated responses** as shown in the **Algorithm 1.1**.

4.1.1 Model Training and Dataset

The application is powered by the **ChatPsychiatrist model**, an Instruct-tuned LLaMA-7B model fine-tuned with counseling domain instruction data. The training data, known as **Psych8K**, consists of 8,187 query-answer pairs derived from approximately 260 real counseling conversations in English. These conversations cover diverse mental health topics including emotions, family relationships, career development, academic stress, and more. The data processing pipeline included the transcription of real counseling recordings to obtain raw textual data, data cleaning and information extraction to remove

Algorithm 4.1 Therapeutic Interaction: Audio-to-Therapeutic Response Generation

Input: Patient audio input (`patient_speech.wav`)
Output: Synthesized therapist response (`therapist_speech.mp3`)
Step 1: System Initialization
Initialize audio recognizer: `recognizer = sr.Recognizer()`
Initialize text-to-speech engine (AWS Polly client)
Establish API session and set base URL for LLM-powered therapy service
Step 2: Audio Transcription
Load patient audio file:

with `sr.AudioFile("patient_speech.wav")` as source:

```
  audio = recognizer.record(source)
```

Transcribe audio to text using Google Speech Recognition:

```
patient_message = recognizer.recognize_google(audio)
```

Exception e
`Log error and request user to repeat input`
Step 3: Therapy Response Generation
Prepare payload:

```
payload = { "user_id": "vr_session", "message": patient_message}
```

Send request to LLM-based REST API:

```
response = requests.post(THERAPY_API_URL, json=payload)
```

Extract response:

```
therapist_response = response.json()["response"]
```

Append `(patient_message, therapist_response)` to chat history
Step 4: Speech Synthesis
Convert therapist response to audio using AWS Polly:

```
polly.synthesize_speech(Text=therapist_response,
    VoiceId="Arthur", OutputFormat="mp3")
```

Save output as `therapist_speech.mp3` Exception e
`Log synthesis error and alert user`
Step 5: Output to VR Environment
Load and play `therapist_speech.mp3` within Unity-based VR environment
Display visual subtitles if enabled for accessibility

sensitive information while preserving educational content, query-answer pair generation using GPT-4 to create structured training data, and testing data development with 100 additional query-answer pairs covering topics like Addiction, Anger, Anxiety, Depression, and more. The model was evaluated using a specialized **Counselling Bench** comprising 229 queries designed specifically to assess performance in counseling scenarios. Evaluation metrics included Information Provision, Direct Guidance, Approval & Reassurance, Restatement & Reflection, Interpretation, Self-disclosure, and Information Gathering capabilities.

4.2 VR Psychiatrist Application

The **VR Psychiatrist Application** implements the Therapeutic Interaction Module within an immersive virtual reality environment. This application creates a safe, private space for users to engage with an AI therapist modeled after JohnyTest, a professional and empathetic psychiatrist persona.

4.2.1 Application Workflow

When a user enters the VR environment, they are greeted by a virtual representation of JohnyTest, the AI psychiatrist. The session begins with JohnyTest introducing himself and asking the user about their concerns. The interaction follows this process: User speaks into their VR headset microphone, creating a `patient_speech.wav` file; the Flask backend processes this audio, transcribing it using Google Speech Recognition; the transcribed text is sent to the ChatPsychiatrist API hosted via ngrok; the API generates an appropriate therapeutic response based on the user's input and conversation history; AWS Polly converts this text response to speech, creating a `therapist_speech.mp3` file; the audio response is played through the VR environment, with the virtual therapist's avatar animating in sync.

4.2.2 User Experience and Interaction

Users experience therapy in a comfortable virtual environment designed to reduce anxiety and promote openness. The application maintains conversation context across sessions, allowing for continuity in therapeutic progress. The virtual therapist responds with empathy and professional insight, drawing from its training on real counseling data. Key features of the user experience include natural conversation flow with the AI therapist responding contextually to user concerns, visual representation of the therapist to enhance the sense of presence and connection, session persistence allowing users to continue therapy across multiple sessions, and accessibility features including optional subtitles for hearing-impaired users.

4.2.3 AI-Powered Speech Analysis

Users communicate their mental health concerns, including sleep disturbances, appetite changes, and stress factors, by speaking directly to the virtual therapist. The system utilizes **Google Speech Recognition** technology to transcribe spoken dialogue into text. This processed text is then analyzed by the **ChatPsychiatrist model**, which is specifically designed to identify emotional patterns and mental health indicators. The system effectively identifies potential signs of depression, anxiety, and other mental health conditions, enabling it to provide personalized therapeutic responses.

4.2.4 Personalized Therapy Responses

Once the user's input has been processed, the **ChatPsychiatrist model** generates customized responses to guide them toward improved mental well-being. The AI leverages previous conversations, contextual data, and therapy best practices to craft meaningful and supportive guidance. Speech synthesis via **AWS Polly** enhances engagement by transforming text-based therapy responses into natural-sounding speech using the ”Arthur” voice, ensuring an immersive experience.

4.3 Fear Simulation Module

The **Fear Simulation Module** serves as a virtual reality-based therapeutic approach for treating specific phobias through systematic desensitization and exposure therapy. This module contains three specialized VR games targeting aquaphobia (fear of water), acrophobia (fear of heights), and glossophobia (fear of public speaking). Each game provides a safe, controlled environment where users can confront their fears gradually while learning coping mechanisms and strategies to overcome anxiety responses. The module utilizes Unity-based VR technology to create immersive environments that simulate fear-inducing scenarios with increasing levels of difficulty, allowing users to progress at their own pace.

4.3.1 Aquaphobia Treatment Game

The Water Gem Challenge is a therapeutic VR game designed to help users overcome aquaphobia through gradual exposure to water environments. The game features two distinct levels of increasing difficulty to accommodate users at different stages of their treatment. In Level 1 (Surface Swimming), players navigate a surface-level aquatic environment where they must locate and collect seven gems arranged in the colors of the rainbow (VIBGYOR - Violet, Indigo, Blue, Green, Yellow, Orange, Red). Each gem is associated with a gemstone guardian who presents the player with multiple-choice questions about water safety and anxiety management techniques. Upon answering correctly, players unlock important mantras or coping strategies for overcoming fear of water, while incorrect answers result in a 30-second waiting period before continuing. The game implements a scoring system based on completion time, with players earning between one and three stars depending on their

Algorithm 4.2 Fear Simulation: VR-Based Exposure Therapy Process

Input: User's phobia type, anxiety baseline measurements
Output: Post-session anxiety measurements, progress metrics
Step 1: User Assessment & Game Selection
Identify specific phobia type from user profile
Select appropriate simulation environment:
  Aquaphobia → Water Gem Challenge (Surface/Underwater)
  Acrophobia → Skydiving Simulation
  Glossophobia → Public Speaking Simulator
Step 2: Environment Initialization
Load VR environment based on selected phobia type
Set initial difficulty level based on user's prior experience
Initialize biometric monitoring (if available) for real-time anxiety tracking
Display pre-game instructions and relaxation techniques
Step 3: Exposure Session Execution
Begin with lowest anxiety-inducing scenario level
Monitor user engagement and anxiety indicators
if anxiety levels exceed threshold **then**
  Trigger in-game calming mechanisms
  Reduce difficulty temporarily
end if
Gradually increase challenge level as user progresses
Provide positive reinforcement for completed challenges
Collect performance metrics (completion time, success rate)
Step 4: Therapeutic Intervention
Present relevant coping strategies at key moments
for each learning milestone **do**
  Pause simulation for knowledge reinforcement
  Present question or challenge related to coping mechanism
  Provide feedback based on user response
end for
Step 5: Session Analysis & Progress Tracking
Calculate performance score based on game-specific metrics
Present summary of learned coping strategies
Step 6: Session Closure
Guide user through post-session relaxation exercise
Display achievements and progress visualization
Schedule recommended follow-up session based on performance

performance. This gamification element encourages repeated play while reinforcing positive associations with water environments.

Level 2 (Underwater Swimming) escalates the exposure therapy by immersing players in a sophisticated underwater environment complete with realistic marine elements. Following the same gem-collection mechanic as Level 1, this advanced stage presents questions specifically focused on underwater swimming techniques and overcoming deep-water anxiety. The progressive nature of moving from surface to underwater environments aligns with established exposure therapy protocols, allowing users to build confidence gradually as they master each level. The game's therapeutic value lies in combining educational content about water safety with actual simulation of water environments, helping users develop both practical knowledge and emotional resilience when faced with aquatic situations.

4.3.2 Acrophobia Treatment Game

The Skydiving Simulation offers an immersive therapeutic experience for users suffering from acrophobia (fear of heights) through a carefully designed first-person virtual reality environment. The game places users in a realistic skydiving scenario where they must overcome their fear while completing challenging objectives during a controlled free-fall. Players begin at extreme altitude and must navigate through suspended rings as they descend through the atmosphere, earning points for each successful ring passage. The simulation introduces a critical decision point at approximately 1000 meters above ground level, where users receive an indication to deploy their parachute. This moment serves as both a gameplay element and a therapeutic trust exercise, teaching users to follow safety procedures while managing height-related anxiety.

After parachute deployment, the game transitions to a precision landing challenge where players must guide themselves onto a target consisting of concentric rings valued at different point levels (inner red ring: 100 points, middle blue ring: 75 points, outer yellow ring: 50 points). This final phase reinforces concepts of control and mastery over height-related situations. Throughout the experience, the immersive VR environment creates a sense of presence that activates genuine height-related anxiety responses, while the structured gameplay provides users with achievable goals that distract from fear and build confidence. The point-based scoring system provides concrete feedback on performance improvement across multiple sessions, allowing both users and therapists to track progress in overcoming acrophobia through repeated exposure.

4.3.3 Glossophobia Treatment Game

The Public Speaking Simulator creates a virtual stage environment where users can practice speaking in front of a simulated audience to overcome glossophobia (fear of public speaking). This therapeutic game utilizes advanced speech recognition and AI analysis to provide detailed feedback on the user's speaking performance. Players stand on a virtual stage and deliver speeches into their microphone, with the audio being recorded and sent to a sophisticated backend system powered by Google's Gemini 1.5 AI model. The system first transcribes the speech using the Whisper model and then performs comprehensive analysis on multiple parameters crucial for effective public speaking.

The AI evaluation assesses three primary metrics: clarity, confidence, and fluency, each weighted equally to produce an overall score out of 100. The system also includes specialized detection for filler words (such as ”um,” ”uh,” ”like”), implementing a unique scoring mechanism that follows the

Fibonacci sequence for penalties beyond the first two instances (3rd word: -3 points, 4th word: -5 points, 5th word: -8 points, etc.). After each practice session, users receive detailed feedback that identifies specific strengths and areas for improvement, offering personalized guidance for enhancing their public speaking skills. The game's therapeutic value comes from providing a safe, judgment-free environment for repeated practice, combined with actionable feedback that builds both technical skills and psychological confidence. Users can track their progress across multiple sessions, creating a data-driven approach to overcoming glossophobia through gradual improvement and positive reinforcement.

4.4 Stress Management Module

The **Stress Management Module** functions as a complementary therapeutic component to the VR psychiatry application, offering interactive experiences designed to alleviate stress and anxiety through experiential learning. This module contains two specialized VR games targeting different aspects of stress management: emotional release through physical expression (Rage Room) and physiological regulation through controlled breathing (Breathing Bird). Each game provides users with practical techniques for managing stress responses that can be incorporated into their daily lives. The Stress Management Module utilizes Unity-based VR technology to create engaging environments that translate abstract therapeutic concepts into concrete, interactive experiences, making evidence-based stress reduction techniques more accessible and memorable for users.

4.4.1 Rage Room Game

The Rage Room game provides users with a controlled virtual environment for the healthy expression and release of negative emotions through simulated destruction. This therapeutic application draws from principles of

Algorithm 4.3 Stress Management: Dual-Mode Therapy System

```
Input: User's stress levels, physiological data
Output: Stress reduction metrics, session performance
procedure StressReductionModule
    Assess user's current stress state
    Present therapy options: Active (Rage Room) or Passive (Breathing Bird)
    Load selected VR environment based on user choice
    if Rage Room selected then
        Initialize physics-enabled destructible objects (plates, bottles, glasses)
        Equip user with virtual hammer
        Allow free destruction of objects
        Track destruction metrics and force applied
        End session when X button pressed
        Calculate and display destruction score
    end if
    if Breathing Bird selected then
        Connect Arduino with respiratory sensor
        Calibrate sensor to user's breathing pattern
        Initialize bird character and obstacle course
        Display breathing instructions panel
        Map inhalation to upward bird movement
        Map exhalation to downward bird movement
        Generate obstacles requiring specific breathing patterns:
            Poison gas clouds, spikes, ice formations, eruptions
        End session when course completed or timer expires
    end if
    Record session metrics for therapy progression tracking
    Provide immediate feedback on stress reduction performance
end procedure
```

catharsis therapy, allowing individuals to externalize feelings of frustration, anger, and tension in a safe, consequence-free setting. Upon entering the virtual rage room, users are equipped with a digital hammer that responds to their physical movements through the VR controller. The environment contains a variety of destructible objects including ceramic plates, glass bottles, wooden crates, and other fragile items that shatter realistically when struck, providing satisfying audiovisual feedback that reinforces the emotional release experience. Each destroyed object contributes to a point-based scoring system, with different items valued according to their size, fragility, and position within the environment.

The game implements sophisticated physics simulations to ensure realistic object behavior, with proper collision detection, fragmentation patterns, and sound effects that enhance immersion and therapeutic benefit. Users can freely move through the environment, selecting targets for destruction based on their personal preference or emotional state. The session continues until the user decides to conclude it by pressing the X button on their controller, at which point a final score is calculated and displayed. This score serves as both a gamification element to encourage engagement and a quantifiable metric of emotional expression that can be tracked across multiple sessions. The therapeutic value of the Rage Room extends beyond mere entertainment, teaching users that emotions can be acknowledged and expressed in appropriate contexts rather than suppressed, while simultaneously providing immediate stress relief through physical activity and sensory satisfaction.

4.4.2 Breathing Bird Game

The Breathing Bird game functions as an interactive meditation tool that teaches diaphragmatic breathing techniques through an engaging metaphorical experience. This therapeutic application transforms abstract breathing exercises into a visually concrete challenge where proper respiratory patterns directly control game outcomes. Players embody a bird character whose movement through a colorful, stylized environment is governed entirely by the player's breathing rhythm—inhaling moves the bird upward while exhaling guides it downward. This direct mapping between physiological action and visual feedback creates an intuitive understanding of breathing control that would be difficult to achieve through conventional instruction alone. The game environment features an instruction panel that provides real-time guidance on proper breathing techniques, helping users establish healthy patterns of deep, controlled breaths that activate the parasympathetic nervous system.

As players progress through the game, they encounter increasingly complex obstacle patterns including poison gas clouds, razor-sharp spikes, glacial ice formations, and volcanic eruptions. Each obstacle requires a specific breathing pattern to navigate safely—some demanding quick, shallow breaths while others requiring deep, sustained inhalations or exhalations. This variety ensures that players develop flexibility in their breathing techniques, adapting to different stress situations just as they would need to in real life. The game's therapeutic efficacy stems from its ability to make breathing exercises engaging and rewarding while simultaneously building muscle memory for proper diaphragmatic breathing. Through repeated play, users develop an automatic association between controlled breathing and stress reduction, gaining a portable skill that transfers readily to real-world anxiety-inducing situations. The Breathing Bird game thus serves as both an educational tool and a practice environment for one of the most fundamental stress management techniques in psychological therapy.

4.4.2.1 Hardware Integration

The system incorporates an Arduino Uno microcontroller connected to a Pro3D Respiratory Sensor that provides precise tracking of the player's breathing patterns. The respiratory sensor captures real-time breathing data, which is then processed by the Arduino and transmitted to the VR application, creating a direct connection between the player's physical breathing and the bird's movement in the virtual environment.

4.4.3 Conclusion of System Design

The Virtual Reality Mental Health Therapy system represents a comprehensive integration of cutting-edge technologies designed to address various psychological conditions through immersive therapeutic interventions. By combining an AI-powered virtual psychiatrist backend using the EmoCareAI/ChatPsychiatrist model, exposure-based therapy modules targeting specific phobias (aquaphobia, acrophobia, glossophobia), and biofeedback-enhanced relaxation games, the system creates a holistic treatment approach. The architecture successfully bridges the gap between traditional therapy and digital innovation through a robust technical implementation that includes real-time speech processing, dynamic environment generation, and physiological feedback loops facilitated by Arduino hardware integration. The modular design ensures scalability, allowing for future expansion to address additional mental health conditions while maintaining therapeutic integrity. This system design demonstrates how strategic application of VR technology, artificial intelligence, and biometric sensors can work in concert to create an effective, accessible mental health intervention platform that addresses both acute phobia treatment and ongoing stress management needs.

CHAPTER 5

IMPLEMENTATION RESULTS AND DISCUSSION

A deep down analysis on how the VR module of this project was developed using Unity to create immersive, interactive experiences tailored to various mental health challenges. Each game within the application is designed with a therapeutic objective, leveraging psychological principles such as exposure therapy, cognitive behavioral techniques, guided relaxation, and biofeedback mechanisms.

5.1 Implementation of Therapeutic Interaction Module

Input: The user provides verbal responses that include detailed information about their sleep patterns, appetite levels, daily lifestyle habits, and emotional well-being. This data is processed by a Virtual Psychiatrist powered by a Large Language Model (LLM).

Step 1: Data Collection and Processing

Audio Input Processing: The system captures the user's audio response using a microphone and converts it into text using Automatic Speech Recognition (ASR) models, such as OpenAI's Whisper. The transcribed text undergoes preprocessing steps including noise removal, tokenization, and normalization to prepare it for semantic analysis.

Sentiment and Behavioral Analysis: Advanced Natural Language Processing (NLP) techniques, such as Named Entity Recognition (NER), sentiment polarity detection, and topic modeling, are used to identify critical emotional cues, recurring symptoms, and behavioral traits embedded in the user's narrative.

Step 2: AI-driven Counseling

LLM-based Response Generation: The preprocessed and semantically analyzed text is input into a fine-tuned Large Language Model (LLM), such as LLaMA or GPT-based models, which is trained on mental health-related datasets. The model generates empathetic and informative counseling responses tailored to the user's psychological profile.

Therapeutic Feedback System: Based on the detected behavioral patterns, the system provides the user with actionable recommendations related to improving sleep hygiene, managing stress levels, promoting healthy eating habits, and fostering emotional resilience. The goal is to simulate a therapeutic session and provide consistent follow-up advice.

5.2 Implementation of Fear Simulation Module

Input: The user engages with interactive VR environments specifically designed to simulate and address common phobias such as acrophobia (fear of heights), aquaphobia (fear of water), and glossophobia (fear of public speaking).

Step 1: Environment Design

Virtual Skydiving (Acrophobia): A realistic skydiving scenario is presented where users can select from varying altitude levels. As they descend, they must navigate through floating rings, simulating high-altitude exposure therapy. The VR physics engine creates dynamic motion and environmental effects to enhance immersion and encourage desensitization through progressive exposure.

Underwater Exploration (Aquaphobia): The aquatic therapy module contains two levels. In Level 1, users explore a colorful surface environment featuring coral structures in VIBGYOR order. As users approach each structure, they are prompted with multiple-choice questions (MCQs) related to swimming and water safety. Level 2 immerses the user in a deeper underwater world, requiring exploration and answering of MCQs while coping with environmental stressors such as murky water and limited visibility.

Public Speaking Simulation (Glossophobia): Users are placed in a virtual classroom with a large audience. They are instructed to deliver a speech, during which their audio input is captured and transcribed using ASR models like Whisper. The transcribed content is analyzed by an LLM (e.g., Gemini) to assess the user's confidence level, fluency, and usage of filler words. The aim is to simulate stage conditions and reduce anxiety over repeated sessions.

Step 2: Performance Analysis

Scoring and Feedback Mechanism: Each module of the Fear Simulator tracks performance metrics such as time taken, number of rings passed, accuracy of answers, and speech quality. The system calculates a score based on these metrics and provides constructive feedback to guide the user's psychological progress.

5.3 RageRoom Game

Input: The user participates in a virtual rage room environment, interacting with destructible objects using hand-held tools like hammers or by throwing items, providing a safe space for emotional catharsis and stress relief.

Step 1: Physics-based Object Interaction

Collision Detection and Physics Simulation: Each object in the rage room is assigned physical properties like mass, breakability, and impact response. When struck or thrown, objects react using real-time physics engines to simulate shattering, bouncing, or deformation, providing a satisfying sensory experience.

Step 2: Emotional Release Metrics

Impact-based Stress Reduction Analysis: The system logs the number of objects smashed, types of interactions used, and the intensity of actions. These data points are analyzed to derive emotional intensity indicators, which can be used to suggest future stress management techniques or track therapeutic progress over time.

5.3.1 Breathing Bird

Input: The user controls a virtual bird avatar in a hostile environment by regulating their breathing patterns, detected through a wearable breath sensor.

Step 1: Breath-Activated Control Mechanism

Real-time Respiration Detection: A respiration sensor detects inhalation and exhalation in real time. Inhaling causes the bird to rise and exhaling brings it closer to the ground. This intuitive control mechanism trains the user in mindful breathing by encouraging deep, rhythmic patterns needed to overcome environmental challenges such as gas walls, flame throwers, and ice shard shooters.

Step 2: Stress Reduction Tracking

Mindfulness Training and Relaxation Scoring: As users navigate through the path by maintaining consistent breathing, the game monitors their rhythm and provides a relaxation score. Feedback is offered to improve the user's control and increase resilience to stress and anxiety through guided breathwork.

5.3.2 Expected Output

Each VR module integrates gamified therapy with immersive technology to promote mental health recovery. By encouraging exposure, self-expression, emotional release, and mindfulness, the application aims to improve user engagement and therapeutic outcomes through interactive and measurable treatments.

5.4 Implementation Results of VR Psychiatrist

5.4.1 Evaluation Metrics

The VR Psychiatrist was evaluated using the Single Turn Evaluation methodology, assessing the model's ability to generate relevant, therapeutic responses to standalone queries. It measures content relevance, determining how well the responses address the user's immediate concerns.

5.4.2 Performance Analysis

The VR Psychiatrist achieved a strong performance with an overall content relevance score of **94%**. This highlights the model's consistent ability to generate contextually appropriate and therapeutically valuable responses. The EmoCareAI/ChatPsychiatrist module effectively engages with user concerns while adhering to therapeutic communication standards.

5.5 IMPLEMENTATION RESULTS OF FEAR SIMULATOR

5.5.1 Evaluation Metrics

The Fear Simulator module, encompassing three distinct therapy games, was evaluated based on user engagement levels, scenario completion consistency, and phobia reduction indicators. Engagement was measured through behavioral cues such as attention span, responsiveness, and willingness to continue across sessions. Completion metrics reflected the frequency with which users fully navigated through the designed fear-inducing scenarios without opting out. Phobia reduction trends were assessed by comparing pre- and post-simulation behavioral responses, self-reported anxiety levels, and observable physiological indicators such as heart rate variations during exposure.

5.5.2 Performance Analysis

The evaluation of system performance was conducted using Gemini 1.5 Flash, which demonstrated high reliability in analyzing user speech and behavioral data for fluency, confidence estimation, filler word detection, and hesitation patterns. The model accurately identified speech disfluencies, assessed variations in user confidence through tonal and verbal analysis, and detected filler words and pause frequencies with strong consistency. Overall, Gemini 1.5 Flash effectively supported the therapeutic goals of the simulator by providing robust, real-time analysis essential for monitoring progress and delivering adaptive feedback to users.

5.6 IMPLEMENTATION RESULTS OF STRESS MANAGEMENT MODULE

5.6.1 Evaluation Metrics

The Stress Management Module, combining the Rage Game and Breathing Bird experiences, was evaluated using impact intensity tracking, emotional feedback analysis, session completion rates, breathing synchronization accuracy, relaxation effectiveness, and user engagement. In the Rage Game, interaction intensity and realism of object destruction were measured to assess emotional relief, supplemented by user surveys. Session completion reflected engagement levels across full rage cycles. In the Breathing Bird module, system responsiveness to real-time breathing inputs determined synchronization accuracy, while relaxation effectiveness was evaluated through physiological stress markers and user-reported outcomes. Overall engagement across both games was assessed based on interaction quality, focus maintenance, and participation consistency.

5.7 VISUAL GUIDE TO THE VR APP FEATURES

5.7.1 Application Overview

The VR application runs on the Unity game engine and can be implemented further as both web-based and also as an android application that can be connected with a suitable VR kit and can be used by the player to play the various games.

5.7.2 Main Menu Page

The VR app has various menu pages with one main menu page which is shown in Figure 5.1. From the main menu, we can access all 4 games present in the VR app. The application part is discussed as follows.

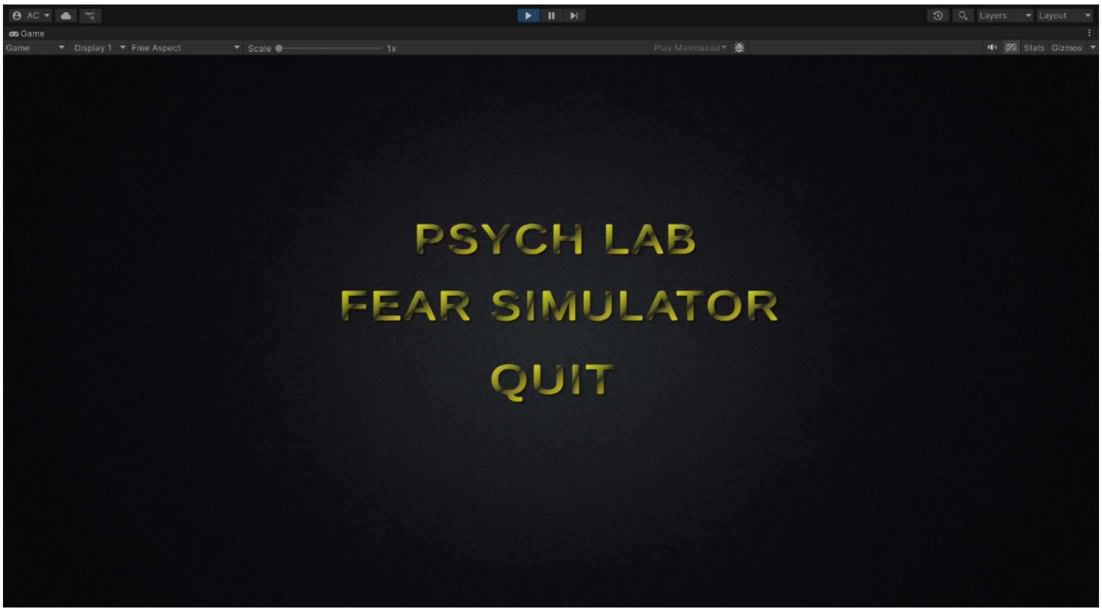

Figure 5.1: Main Menu Page

5.7.3 VR Psychiatrist

The VR Psychiatrist module serves as a virtual mental health assistant. The system transcribes the user's speech using a local Whisper model and sends it to a large language model (Gemini) to generate personalized advice and therapeutic guidance. An example interface of the VR Psychiatrist module is shown in Figure 5.2.

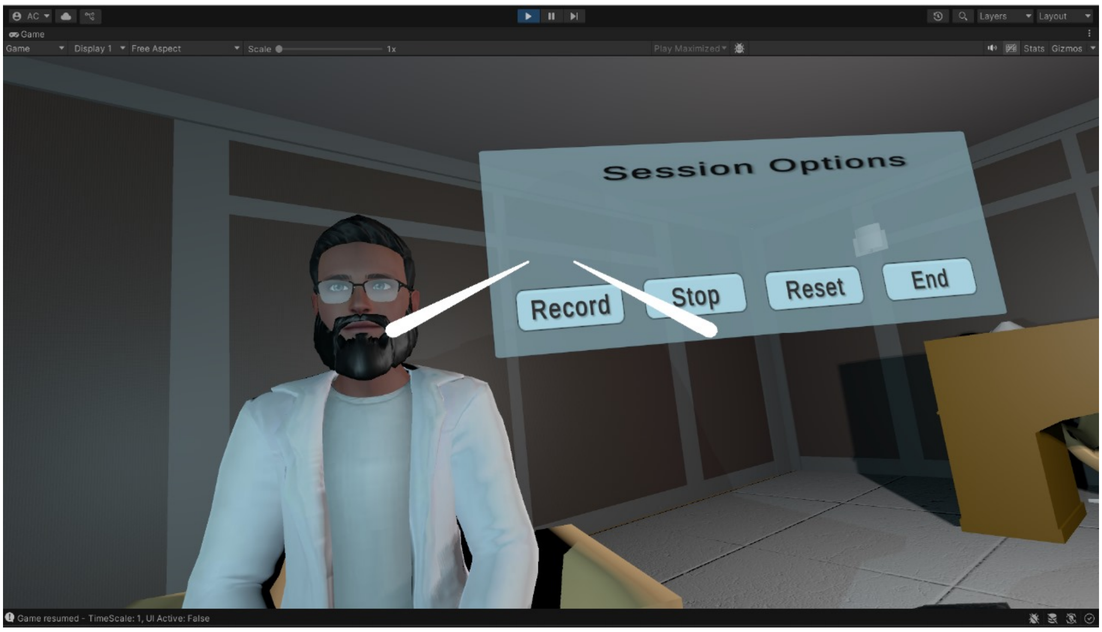

Figure 5.2: VR Psychiatrist Landing page

5.7.4 Fear Simulator

The Fear Simulator module is designed to help users confront and gradually overcome specific phobias using immersive VR environments. Users can select from three distinct scenarios—Acrophobia, Aquaphobia, and Glossophobia—each tailored to trigger as shown in Figure 5.4 and then therapeutically address their specific fears. This exposure therapy approach leverages interactivity and gamification to enhance the desensitization process.

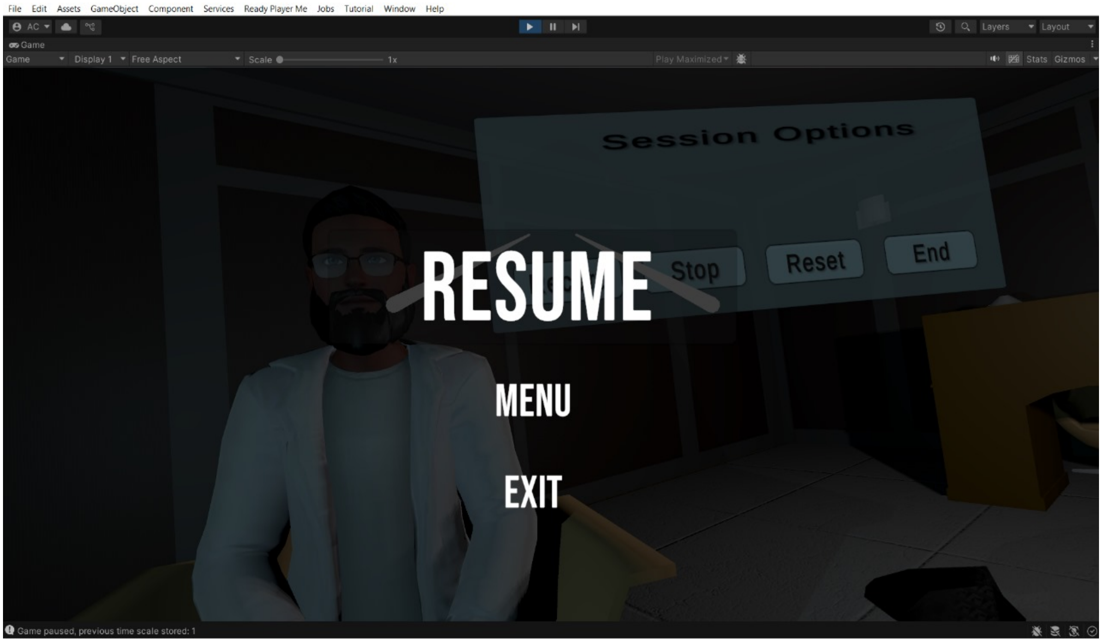

Figure 5.3: VR Psychiatrist Pause Menu

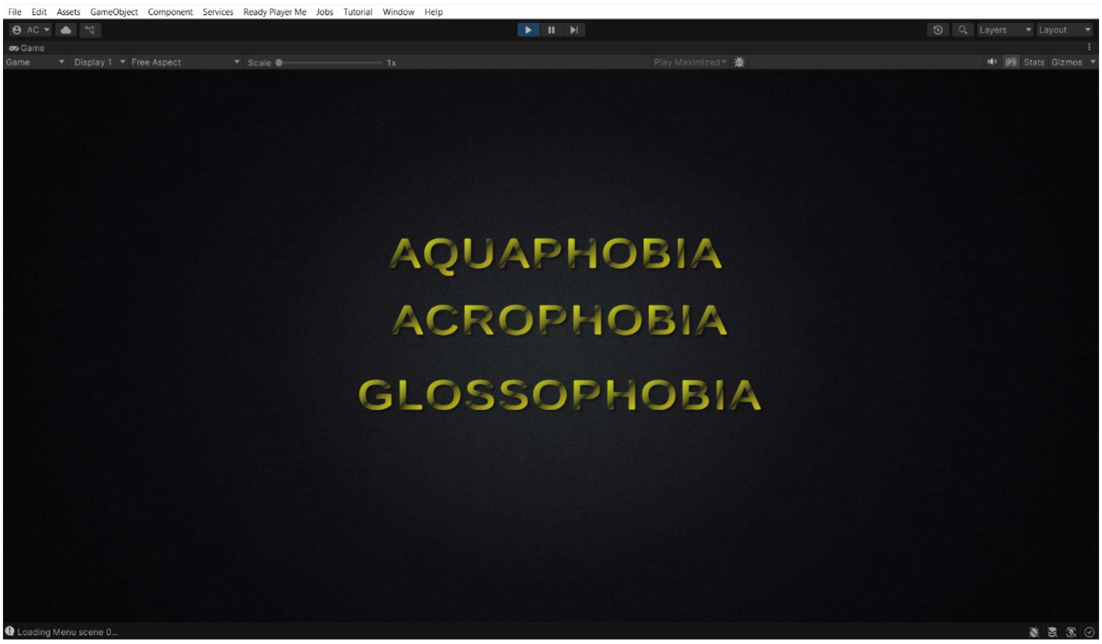

Figure 5.4: Fear Simulator Menu

Acrophobia - This level simulates a skydiving experience as shown in Figure 5.5 and Figure 5.6from user-selected altitudes. The user earns points by accurately navigating through floating rings while descending, encouraging engagement and comfort with heights. The task aims to reduce fear by repeated exposure to virtual height-based challenges in a controlled setting.

Figure 5.5: Acrophobia Simulator Menu

Figure 5.6: Sky Diving First Person View

Aquaphobia - divided into two levels as shown in Figure 5.7: the first focuses on surface water exploration with colorful VIBGYOR structures as shown in Figure 5.8and multiple-choice questions related to swimming. The second level immerses users underwater as shown in Figure 5.11, challenging them to answer further questions while completing tasks within a time limit. This gradual exposure is designed to lessen anxiety related to water.

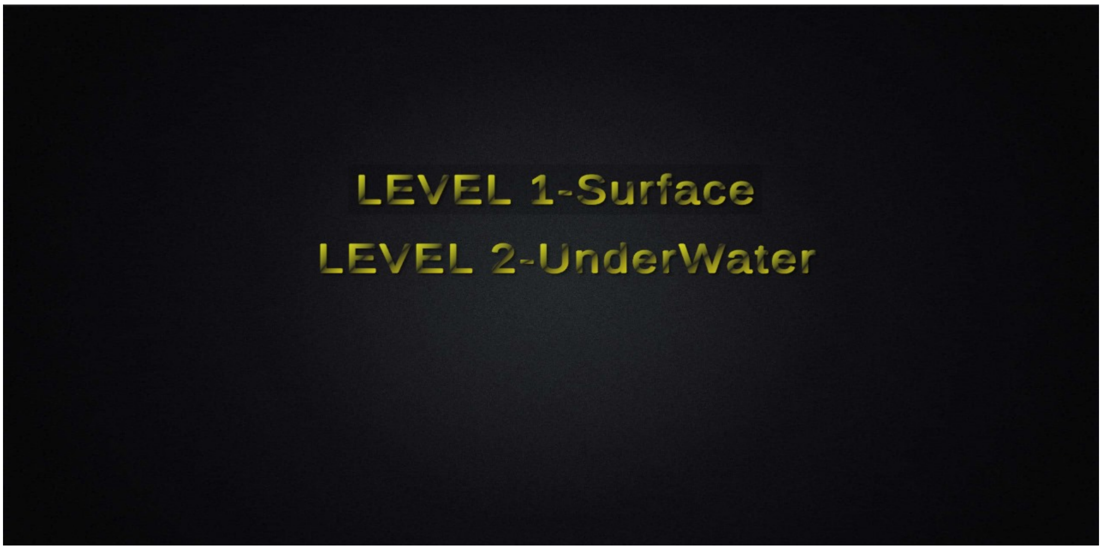

Figure 5.7: Menu with 2 levels of Aquaphobia Simulation

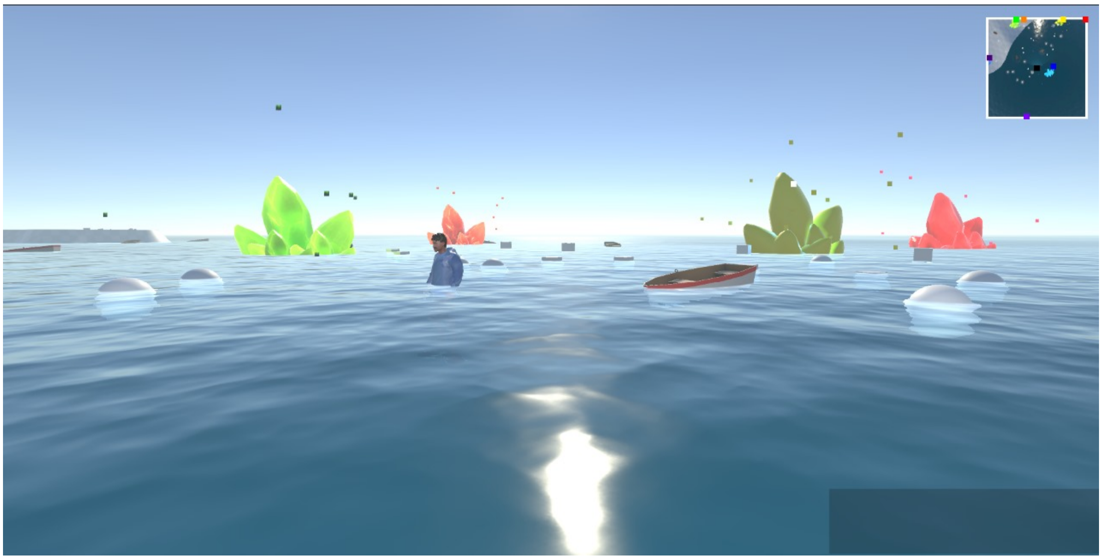

Figure 5.8: Level1 of Aquaphobia Simulation

Glossophobia - In this module, users stand before a virtual classroom as shown in Figure 5.12and deliver a speech. The system analyzes vocal inputs to evaluate fluency, confidence, and hesitation, providing feedback to improve public speaking skills as shown in the Figure 5.13, 5.14 5.15. The goal is to build confidence and reduce stage fright through realistic practice scenarios.

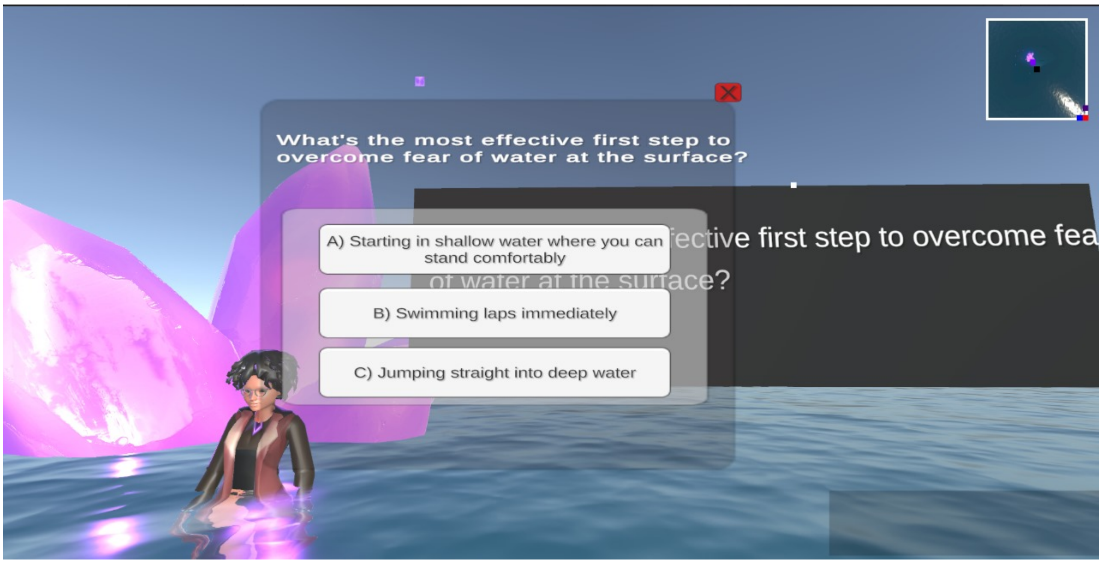

Figure 5.9: Quiz in Level1 Simulation

Figure 5.10: Scoreboard Level1 Simulation

5.7.5 Rage Game

The Rage Game provides a safe virtual environment as shown in the Figure 5.16for stress release. Users can smash fragile objects like glass items or electronics using tools such as hammers or by throwing them as shown in Figure 5.17. Each object broken adds to the score, making the experience both therapeutic and gamified for emotional regulation.

Figure 5.11: Level2 of Aquaphobia Simulation

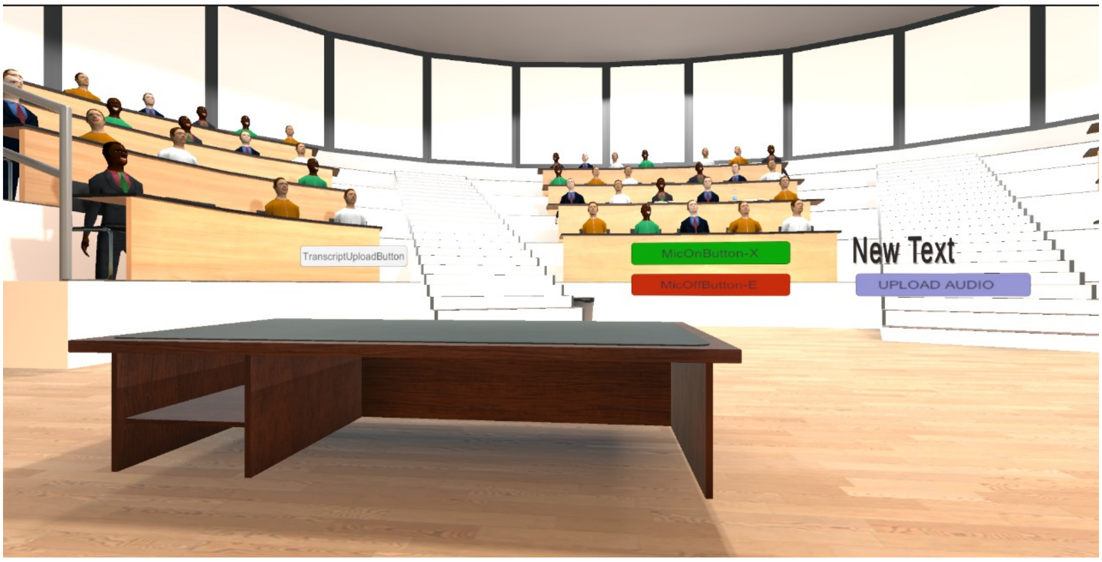

Figure 5.12: Classroom environment in Glossophobia Simulation

5.7.6 Breathing Bird

Breathing Bird is a relaxation-based game where the user takes the form of a bird flying through a tranquil environment as shown in the Figure 5.19. Controlled by real-time breathing patterns—inhale to ascend, exhale to descend—the game promotes rhythmic breathing. It serves as a calming exercise for reducing stress, anxiety, and depressive symptoms.

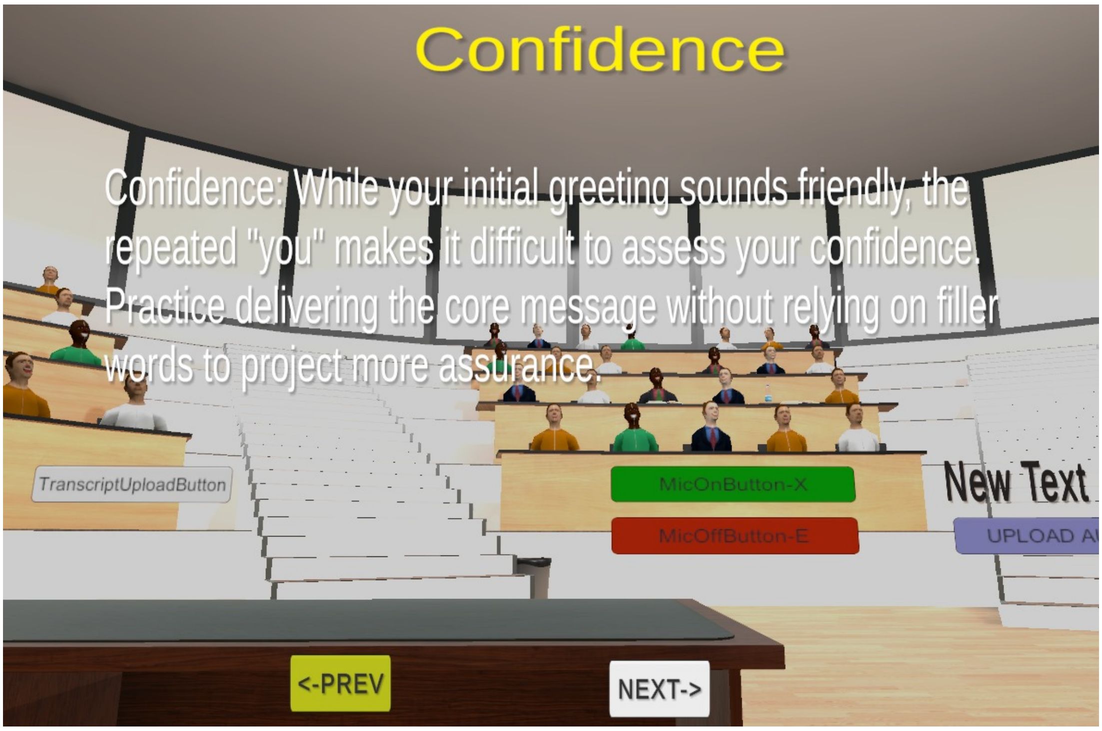

Figure 5.13: Feedback on Confidence (Glossophobia)

Figure 5.14: Feedback on Clarity (Glossophobia)

Figure 5.15: Feedback on Fluency (Glossophobia)

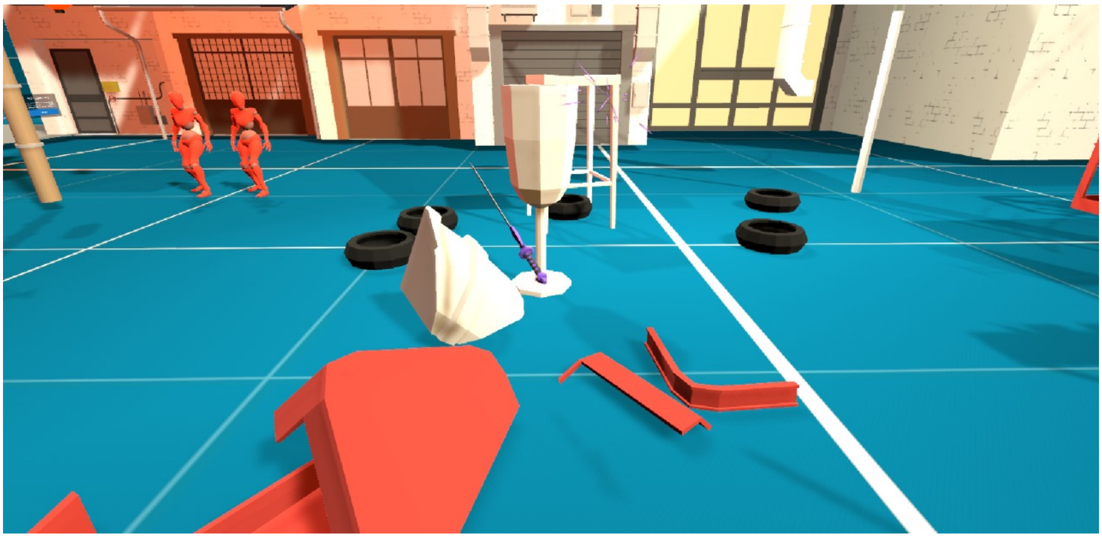

Figure 5.16: Virtual Environment of Rage Game

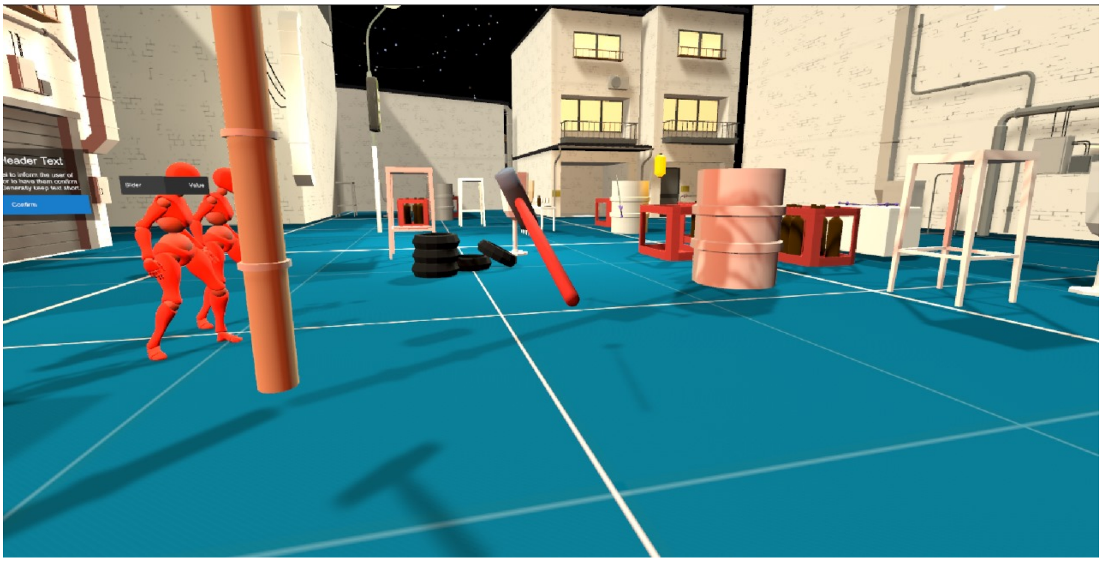

Figure 5.17: Objects smashing using Sword, Hammer & Grapple Throw

Figure 5.18: Scoreboard of Rage Game

Figure 5.19: Landing Page of Breathing Bird Game

Figure 5.20: GamePlay of Rage Game

Figure 5.21: GamePlay of Rage Game

Figure 5.22: Scoreboard of Breathing Bird Game

CHAPTER 6

CONCLUSIONS AND FUTURE WORKS

This chapter provides a concluding overview of the VR-based mental health treatment application, summarizing the key achievements of the project and laying the groundwork for its future development.

6.1 CONCLUSION

The project successfully presents a comprehensive Virtual Reality (VR) application designed to support mental health treatment through immersive, interactive modules targeting Depression, Anxiety, and specific Phobias. The application is built around a user-friendly menu interface that grants access to multiple therapy-oriented modules: a VR Psychiatrist powered by an LLM for intelligent counseling, phobia exposure games such as Skydiving for Acrophobia and underwater exploration for Aquaphobia, a Glossophobia speech module with audio analysis, and a Rage Room game for stress relief. Each module was tailored to address specific emotional and behavioral symptoms by leveraging VR's ability to simulate real-world scenarios in a controlled and customizable environment. The VR Psychiatrist offers an AI-based conversational interface that analyzes user responses regarding sleep, appetite, and lifestyle, providing personalized therapeutic feedback. Meanwhile, the phobia modules employ gradual exposure combined with tasks and quizzes to facilitate desensitization and cognitive restructuring. Audio input is utilized to evaluate speech fluency and confidence in the Glossophobia module, while the Rage Room enables users to release pent-up emotions through physical interaction. The system demonstrates high user engagement potential and aligns with clinical frameworks for cognitive-behavioral therapy

(CBT) and exposure therapy, offering scalable mental health support in both clinical and home settings.

6.2 FUTURE WORK

Future enhancements will focus on expanding the therapeutic scope and improving the adaptability of the VR system. A major milestone will be the integration of real-time biofeedback using EEG signals and wearable sensors to monitor physiological responses such as stress, heart rate, and brainwave activity during sessions. These inputs will dynamically adapt the VR environment, offering a more personalized and responsive therapeutic experience. Additional modules will be introduced to target other mental health conditions, such as PTSD and OCD, broadening the system's impact. Support for multi-language and culturally adaptive content will ensure accessibility for diverse populations. Integration with mobile VR platforms and cloud-based analytics will further increase portability and scalability, allowing remote therapy sessions and continuous mental health monitoring. Multimodal data such as facial expressions, voice tone, and user interaction logs will be used to enhance AI-based behavioral assessment and feedback. Longitudinal user tracking and progress visualization dashboards will help both patients and clinicians monitor therapeutic outcomes over time. Moreover, collaboration with psychiatrists, therapists, and healthcare institutions will support clinical validation and refinement of the system, ensuring it meets real-world diagnostic and therapeutic standards.

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