IT4010 – Research Project - 2024

Topic Assessment Form

Project ID: 24-25J-046

1. Topic (12 words max)

MindSculptor: An Obsessive-Compulsive Disorder (OCD) Exposure and Response Prevention (ERP) Therapy Tool

2. Research group the project belongs to

Software Systems & Technologies (SST)

3. Research area the project belongs to

Bio-Medical and Health Informatics (HI)

4. If a continuation of a previous project:

Project ID	-
Year	-

5. Brief description of the research problem including references (200 – 500 words max) – references not included in word count.

Research Problem: Enhancing Accessibility and Efficacy of ERP Therapy for OCD through Digital Solutions

Obsessive-Compulsive Disorder (OCD) is a chronic psychiatric condition characterized by persistent intrusive thoughts (obsessions) and repetitive behaviors (compulsions). It affects approximately 2.3% of the population and significantly impairs daily functioning and quality of life [1]. Traditional treatments, such as Exposure and Response Prevention (ERP) therapy, have proven effective in reducing symptoms and improving outcomes for OCD patients [2,3]. However, ERP therapy requires extensive resources, specialized care, and consistent patient engagement, which can pose substantial barriers to access and adherence for many individuals [4,5].

In addition to these logistical challenges, there is a significant stigma associated with mental health treatment [6]. Cultural and social factors often contribute to individuals' reluctance to openly seek or express undergoing psychological treatment. Many patients may avoid seeking help due to fears of being judged, discriminated against, or misunderstood by their community and peers [6,7]. This stigma can lead to delays in diagnosis and treatment, worsening the condition and decreasing the overall quality of life for those affected.

Given these challenges, there is a pressing need for innovative solutions that make effective OCD treatments more accessible and personalized while addressing the stigma associated with seeking mental health care. The development of tools like MindSculptor represents a significant advancement in this field. MindSculptor aims to support OCD patients by providing a comprehensive, technology-driven ERP therapy tool that leverages advanced functionalities

such as AI, biometric monitoring, and interactive voice assistants to enhance the identification, monitoring, and treatment of OCD.

The primary research problem lies in the limited accessibility and individualized nature of traditional ERP therapy, compounded by the stigma surrounding mental health treatment. Many patients face difficulties in accessing specialized therapists due to geographical, financial, or logistical constraints [4,5]. Additionally, conventional therapy may not always be tailored to the specific needs and symptom subtypes of each patient, potentially reducing its effectiveness.

References

[1] A. M. Ruscio, D. J. Stein, W. T. Chiu, R. C. Kessler, "The epidemiology of obsessive-compulsive disorder in the National Comorbidity Survey Replication," *Mol Psychiatry*, vol. 15, no. 1, pp. 53-63, Jan. 2010. [Online]. Available: https://doi.org/10.1038/mp.2008.94. [Accessed: Jan. 20, 2024].

[2] E. B. Foa and M. Franklin, *Exposure and response prevention for OCD therapy: A comprehensive guide*. John Wiley & Sons, 2010.

[3] National Institute of Mental Health, "Obsessive-compulsive disorder," Dec. 2019. [Online]. Available: https://www.nimh.nih.gov/health/topics/obsessive-compulsive-disorder-ocd. [Accessed: Jan. 20, 2024].

[4] C. C. Boyd and S. D. Compton, "Dissemination and implementation of evidence-based practices for obsessive-compulsive disorder," *J. Clin. Psychol.*, vol. 61, no. 10, pp. 1255-1267, 2005. [Online]. Available: https://global.oup.com/academic/product/dissemination-and-implementation-of-evidence-based-practices-in-child-and-adolescent-mental-health-9780190628574. [Accessed: Jan. 20, 2024].

[5] P. W. Wang, J. Liang, M. H. Zhao, Y. Sun, and Z. J. Liu, "The status of mental health services for anxiety disorders in China," *Int. J. Soc. Psychiatry*, vol. 59, no. 2, pp. 180-187, 2013. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0749379703000175. [Accessed: Jan. 20, 2024].

[6] P. B. Corrigan and A. C. Watson, "The stigma of seeking professional mental health services: A review of the evidence," *J. Couns. Clin. Psychol.*, vol. 75, no. 4, pp. 461-473, 2007. [Online]. Available: https://psycnet.apa.org/record/2023-30264-001. [Accessed: Jan. 20, 2024].

[7] R. A. Sirey, A. G. Ryder, and M. E. Lasher, "Stigma and mental health services utilization: A review of the literature," *Adm. Policy Ment. Health Serv. Res.*, vol. 34, no. 1, pp. 86-109, 2007. [Online]. Available: https://link.springer.com/article/10.1007/s10488-012-0430-z. [Accessed: Jan. 20, 2024].

6. Brief description of the nature of the solution including a conceptual diagram (250 words max)

The proposed solution is a comprehensive digital therapy platform designed to support in the diagnosis and treatment for obsessive-compulsive disorder (OCD) using a combination of biometric data, artificial intelligence (AI), Machine learning (ML) and Natural language processing (NLP). Users can interact with the application to identify the OCD theme and receive treatment based on their OCD type. This solution has four main functionalities aimed at improving patient care and treatment efficiency.

1. Identify the presence, severity, and sub-types of OCD in patients

MindSculptor enhances OCD diagnosis and treatment by combining dynamic questionnaires, voice analysis, and pitch fluctuation analysis. The component uses Y-BOCS, OCI-R, and custom questions, dynamically adjusting the order of questions based on user responses. It employs ASR APIs, such as Google Cloud Speech-to-Text, to convert voice recordings to text and identifies keywords using TF-IDF and SVM algorithms. Additionally, Librosa is used for analyzing pitch fluctuations in the voice recordings. This integrated approach determines the presence, severity, and subtypes of OCD, offering tailored and effective therapeutic interventions for each patient.

2. Enhanced Exposure and Response Prevention Therapy (VERP Therapy)

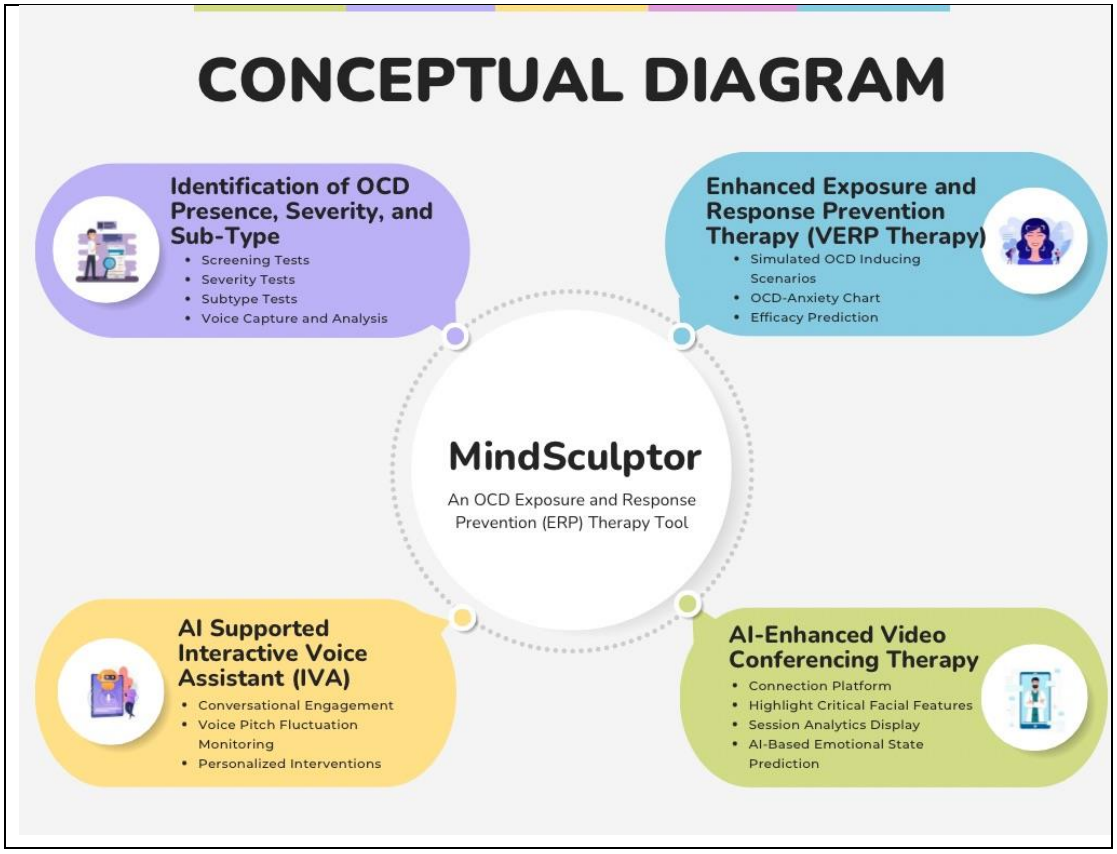
The app simulates OCD-inducing scenarios through videos and images. Utilizes a decision tree algorithm to select trigger media. The system collects patient self-reported data and facial expression data via CNN models such as DeepFace and generates anxiety graphs based on composite scores derived from weighted scoring algorithm. Finally, by analyzing anxiety charts, the system predicts the patient's treatment efficacy.

3. **AI Supported Interactive voice Assistant (IVA)**

The proposed solution is an AI-supported Interactive Voice Assistant (IVA) designed for personalized therapy sessions targeting specific subtypes of Obsessive-Compulsive Disorder (OCD). Using Google's Speech-to-Text API, the IVA converts spoken language into text, which is then analyzed by a supervised learning model to identify keywords related to the OCD subtype. For voice pitch analysis, signal processing techniques using libraries like Librosa or Praat extract and analyze pitch features to assess emotional states. By integrating these analyses with a database of therapeutic dialogues and responses, the IVA guides therapists with tailored interventions, enhancing the effectiveness and personalization of Exposure and Response Prevention (ERP) therapy.

4. AI-Enhanced Video Conferencing ERP Therapy

The solution provides a robust platform for seamless doctor-patient interactions via audio-video link, capturing and analyzing real-time biometric facial features to detect anxiety and stress levels. It highlights critical expressions for accurate monitoring and displays comprehensive session analytics, enhancing the efficiency and effectiveness of OCD ERP therapy.


CONCEPTUAL DIAGRAM
Identification of OCD Presence, Severity, and Sub-Type
Screening Tests
Severity Tests
Subtype Tests
Voice Capture and Analysis
Enhanced Exposure and Response Prevention Therapy (VERP Therapy)
Simulated OCD Inducing Scenarios
OCD-Anxiety Chart
Efficacy Prediction
MindSculptor
An OCD Exposure and Response Prevention (ERP) Therapy Tool
AI Supported Interactive Voice Assistant (IVA)
Conversational Engagement
Voice Pitch Fluctuation Monitoring
Personalized Interventions
AI-Enhanced Video Conferencing Therapy
Connection Platform
Highlight Critical Facial Features
Session Analytics Display
AI-Based Emotional State Prediction

7. Brief description of specialized domain expertise, knowledge, and data requirements (300 words max)

Specialized Domain Expertise: Developing the Interactive Voice Assistant (IVA) and its associated modules requires a multifaceted expertise in several domains. In mental health and psychotherapy, particularly in OCD treatment, understanding the nuances of obsessive-compulsive disorder (OCD) is critical. This includes knowledge of different OCD subtypes, their behavioral patterns, and how they manifest during therapy. In terms of technology, proficiency in AI and machine learning is essential for developing algorithms and models for keyword identification, voice pitch analysis, and therapeutic dialogue management. Expertise in audio processing, natural language processing (NLP), and signal processing is also required to implement accurate and effective solutions.

Knowledge Requirements:

1. **Psychology and Therapy**: Knowledge of OCD subtypes, treatment protocols, and therapeutic techniques such as Exposure and Response Prevention (ERP) therapy.
2. **Machine Learning and NLP**: Understanding supervised learning models (e.g., Logistic Regression), NLP for text preprocessing, and keyword extraction.
3. **Signal Processing**: Experience with algorithms for analyzing voice pitch fluctuations to infer emotional states.
4. **Audio Processing**: Familiarity with tools and libraries like Librosa, Praat, and speechrecognition for handling audio data.
5. **Software Development**: Proficiency in using development frameworks and libraries, including React Native, Node.js, Flask, and WebRTC for video conferencing and remote intervention.

Data Requirements: MindSculptor relies on various data inputs for efficacy:

1. **OCD Diagnosis Data:** Data from standardized OCD scales (e.g., Y-BOCS, OCI-R) and customized questionnaires to assess OCD presence, severity, and subtypes.
2. **Voice Data:** Recorded patient audio for transcription and analysis, including text generated via ASR APIs and voice pitch data.
3. **Therapeutic Dialogues:** A database of predefined therapeutic responses and patient interaction scenarios.
4. **Facial Expression Data:** Video feeds for analyzing facial expressions during therapy, with datasets such as FER-2013, AffectNet and CASME II for training and validation.
5. **Session Data:** Historical session data, including biometric and emotional state metrics, for tracking progress and predictive analytics.

Collecting and integrating these data types are essential for creating an effective IVA capable of providing personalized and adaptive therapy.

8. Objectives and Novelty

Main Objective

Develop an innovative and accessible digital tool for Exposure and Response Prevention (ERP) therapy tailored to OCD patients, integrating advanced biometric monitoring, AI-supported interventions, and comprehensive data analysis to enhance treatment outcomes.

Member Name	Sub Objective	Tasks	Novelty
Vithanage C.S	Identify the presence, severity, and sub-types of OCD in patients	1.1 Questionnaire Implementation. • Develop a dynamic questionnaire consisting of 20 questions based on the Yale-Brown Obsessive Compulsive Scale (Y-BOCS), Obsessive-Compulsive Inventory-Revised (OCI-R), and customized questions tailored for the application. • Create an algorithm to define the order of questions based on the user's responses to previous questions. • Use the responses to generate results for OCD	• Integration of keyword detection from voice recordings into the assessment process, providing a more comprehensive evaluation of OCD symptoms. • Analysis of voice pitch fluctuations to gain additional insights into the patient's emotional state and behavior, enhancing diagnostic accuracy

		presence, severity, and subtype.	
		1.2 Voice Analysis • Capture patient voice recordings describing their OCD experiences. • Use an Automatic Speech Recognition (ASR) API, such as Google Cloud Speech-to-Text or IBM Watson, to convert voice recordings into text. • Train a Support Vector Machine (SVM) model to identify keywords in the transcribed text. • Enhance the results obtained from the questionnaire based on the identified keywords.	
		1.3 Voice Pitch Analysis • Utilize the Librosa library to analyze the pitch fluctuations in the patient's voice recordings. • Derive insights into the patient's emotional state and behavior when explaining their OCD episodes.	

		1.4 Combining Results • Develop an algorithm to integrate the results from the questionnaire, keyword detection, and pitch analysis. • Use ensemble learning techniques to provide a final, robust diagnosis or severity level.	
Illesinghe A.T	Develop customized therapy plans based on patient data and draw the anxiety graph.	2.1 Simulate OCD scenarios • Simulate OCD scenarios using tailored videos and photos to trigger OCD responses. • The images/videos for OCD-inducing scenarios are selected based on the patient's OCD subtype and severity using a decision tree algorithm.	Integrate biometric data to plot detailed OCD-Anxiety charts that reflect both subjective and physiological anxiety responses.
		2.2 Collect patient self-reported data and physiological responses • Collect patient self-reported data and physiological responses (e.g., Facial expressions) during exposure to OCD triggers. • During the therapy session system capture the patient's anxiety and stress	

		level using facial expressions. • A CNN-based facial expression recognition model such as DeepFace can be used to capture the facial expressions.	
		2.3 Generate Anxiety chart • Generate Anxiety chart using patient self-reported data and biometric data. • The system calculates the composite anxiety score using facial expression data and user input data based on their importance or reliability. Here the system uses a weighted scoring algorithm to calculate the final composite anxiety score. • Finally, anxiety graph will be drawn using the final composite anxiety score values.	
		2.4 Analyze the OCD-Anxiety charts over eight therapy sessions to predict the effectiveness of the treatment plan.	

Jayasinghe P.T	Develop an AI-supported Interactive Voice Assistant (IVA) for personalized therapy sessions tailored to specific subtypes of OCD	3.1 Audio to Text Conversion. • Integrate Google's Speech-to-Text API using the speechrecognition library • Use pyaudio to capture audio input from patients.	Combine conversational AI with real-time analysis of voice pitch fluctuations to deliver highly personalized interventions.
		3.2 keyword Identification • Train a supervised learning model to identify keywords related to OCD subtypes from transcribed text. • Logistic Regression algorithm is used for keyword identification.	
		3.3 Voice Pitch Analysis. • Perform voice pitch analysis using signal processing techniques with libraries like Librosa or Praat. • Analyze voice pitch fluctuations using signal processing algorithms implemented with librosa or Praat.	
		3.4 Therapeutic Dialogue Management. • Create and maintain a database of therapist dialogues and expected patient responses. • Design an algorithm to match identified keywords	

		and emotional states to appropriate therapeutic responses (Matching Algorithm). • Implement text-to-speech conversion using gTTS to vocalize the IVA's responses.	
Mallawaarachchi D.E.H	Enable video conferencing for remote intervention	4.1 Develop a robust connection platform for seamless doctor-patient interactions via audio-video link. • Capture video feed using React Native and send it to the Node.js WebRTC server. • Node.js server manages connections using socket.io and forwards video feeds with mediasoup or simple-peer. • React web application displays both original and processed video feeds.	Highlight critical biometric facial features on the doctor's screen and stress and anxiety levels to assess the patient's emotional state accurately and efficiently.
		4.2 Implement real-time biometric facial feature analysis to detect and display the	Predict patient improvement based on previous session analytics and estimate the

		patient's anxiety and stress levels using AI models. • Capture video feed in React Native and send it to Node.js WebRTC server. • Forward video feed to Flask API for preprocessing with OpenCV. • Use AI models like FaceNet for facial recognition, CNNs, and RNNs (e.g., EmotionNet) for stress detection. • Utilize datasets like FER-2013 and CASME II for model training. • Send processed video feed back to Node.js server.	number of sessions required for the patient to become normal.
		4.3 Display highlighted facial expressions on one side of the screen while showing the normal video feed on the other for comprehensive monitoring. • Flask API processes video feed to highlight expressions using Dlib.	

		• Node.js server forwards both feeds to the React web application. • Web application uses HTML5 Canvas to display normal and processed feeds side-by-side. • Use datasets like 300-W for facial landmark detection and CK+ for expression analysis.	
		4.4 Display detailed session analytics, including progress metrics, historical emotional state data, and predictive analytics for comprehensive review. • Store session data in MongoDB/MySQL. • Use Linear Regression and RNNs (e.g., LSTM) for predicting improvement trends. • Utilize AVEC and historical session data for model training. • Provide RESTful APIs for fetching and updating session data.	

		• React web application visualizes analytics using charts and graphs.	

9. Supervisor checklist

a) Does the chosen research topic possess a comprehensive scope suitable for a final-year project?

Yes	✓	No	

b) Does the proposed topic exhibit novelty?

Yes	✓	No	

c) Do you believe they have the capability to successfully execute the proposed project?

Yes	✓	No	

d) Do the proposed sub-objectives reflect the students' areas of specialization?

Yes	✓	No	

e) Supervisor's Evaluation and Recommendation for the Research topic:

This project consists of sufficient novel components for the four members. Hence, I recommend this project.

10. Supervisor details

	Title	First Name	Last Name	Signature
Supervisor	Dr.	Dilshan	De Silva	
Co-Supervisor	Mr.	Samadhi	Rathnayake	
External Supervisor				
Summary of external supervisor's (if any) experience and expertise				

9. Supervisor details

	Title	First Name	Last Name	Signature
External Supervisor	Dr.	Roshan	Fernando	
External Supervisor	Ms.	Sandharu	Fernando	

Summary of external supervisor's (if any) experience and expertise

1. Dr. Roshan Fernando

   MBBS (Kel'ya), MDPsych (C'bo)
   Senior Lecturer (Grade II)
   Department of Psychiatry
   Research Interests -
   - Clinical Psychiatry
   - Biological Psychiatry
   - Psychiatric Epidemiology

2. Miss Sandharu Fernando

   Msc Clinical Psychology(In.)
   Bsc(Hons) Clinical Psychology(In.)
   Psychologist
   Lecturer in Clinical Psychology
   University Hospital – KDU, Werahara

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Topic Assessment Form

<u>This part is to be filled by the Topic Screening Panel members.</u>

Acceptable: Mark/Select as necessary

Topic Assessment Accepted	
Topic Assessment Accepted with minor changes (should be followed up by the supervisor)*	
Topic Assessment to be Resubmitted with major changes*	
Topic Assessment Rejected. Topic must be changed	

* Detailed comments given below

Comments

The Review Panel Details

Member's Name	Signature

*__Important__:

1. According to the comments given by the panel, make the necessary modifications and get the approval by the **Supervisor** or the **Same Panel**.
2. If the project topic is rejected, identify a new topic, and follow the same procedure until the topic is approved by the assessment panel.