BEHAVIOR ANALYSIS FOR DEPRESSION DETECTION.

Project Id: 2021-073

Project Proposal Report

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Department of Information Technology

Sri Lanka institute of Information Technology

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Dr. Pradeepa Samarasinghe

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February 2021

DECLARATION

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

Name	Student ID	Signature
Oshadi Yashodhika G. B.	IT18120226	

The supervisor/s should certify the proposal report with the following declaration. The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

…….. …….

Signature of the Supervisor: Date

[Dr. Pradeepa Samarasinghe]

…….. ……

Signature of the Co-Supervisor: Date

[Ms. Vijani Piyawardana]

ABSTRACT

Depression refers to a mood disorder that negatively influences an individual's mental and physical condition. Early signs of severe depression are necessary to identify and ensure the affected person obtains immediate medical assistant. Emotions can use to identify early depressive states in individuals. However, psychotherapy determines depression levels based on verbal reports that may bias the diverse aspects of individuals. Currently, the mobile applications associated with depression are using standard questionnaires to assess the depression level. In Sri Lanka, people may obscure the state of their minds due to social stigma and fear. However, a mobile application can evaluate the mental health of an individual. It can notify early depression symptoms to appropriate people, which can be more valuable to remit the danger. This study aims to develop an automated system that captures facial images and identifies early symptoms of depression by analyzing facial features. The proposed model includes the head movement pattern analyzer to provide accurate analysis. In the proposed model, image processing techniques study the frontal face features, and computer vision and deep learning techniques consider identifying early signs that may lead to a depressed person.

Keywords: Depression, Computer vision, Facial features, Feature extraction

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1. INTRODUCTION

The latest World Health Organization study estimation state that 264 million people are affected by depression worldwide. Depression is a chronic disease, and at its most critical level, it can lead to suicide [1]. The suicide rate among untreated depressive disorder individuals is nearly 20% [2]. The moderate and severe level of depression considers in Psychological and pharmacological treatments. However, in low and middle-income countries, often limited or underdeveloped the treatments and support services. Limited access to treatment in these countries increases the number of individuals suffering from mental health [3]. As indicated in [4], underdeveloped countries fronted 79% of global suicide in 2016.

It is necessary to monitor the individuals suffering from depression to provide better treatment. Early depression symptoms monitoring is crucial as the individuals may obscure the state of mind due to social stigma and fear. Also, the mental health industry in Sri Lanka fronts a key concern of lacking acceptance of depression due to social stigma. Emotions play a vital role in identifying early depressive states in individuals used by mental health professionals in the industry. Mental health professionals identify symptoms of depression by monitoring the behavior and using standard rating scales. Several studies evaluated depression detection by using different techniques. The studies focused on detecting depression using upper body movement rather than identifying early depression symptoms.

1.1 Background & Literature Survey

J. F. Cohn et al. investigated facial and vocal behavior relation in diagnosing depression, which was the first automated facial image analysis and audio signal processing to assess depression. The study used the person-specific Active Appearance Model (AAMs), Manual Facial Action Coding System (FACS), and vocal prosody to detect depression [5]. S. P. Namboodiri and Venkataraman proposed a system to detect depression among college students. This study considered frontal face images of happy, contempt, and disgust face in the video frame to analyze the depression. Viola-Jones face detection algorithm used to extract faces from each image [6].

Few studies have analyzed the link between depression and upper body movement. S. Alghowinem et al. examined the head pose and movement patterns of depressed individuals compared to healthy subjects using clinically validated real-world data. The statical analysis on the head pose and movement patterns showed a significant difference between healthy and depressed individuals [7]. The feasibility of a cross-cultural method to assess depression severity was investigated by S. Alghowinem et al. The study based on temporal aspects of the eye gaze and head position of the participants by using video-recorded clinical interviews (Australian, US, German) from three different datasets (BlackDog, AVEC, Pittsburgh) [8]. J. Joshi et al. study explored the upper body movements and gestures for automatic depression analysis. Upper body movements and intra-facial movements were computed using Space-Time Interest Points (STIP) feature, while head movement analysis was assessed by selecting rigid facial fiducial points [9].

1.2 Research Gap

Several studies focused on depression analysis based on facial expression and head pose estimation. The study of [5] focused on facial expression-based depression analysis, while the team in the research [7] explored the head movement-based depression analysis. Similarly, the study of [6] considered facial expressions to analyze the depressive features, while the research team of [8] studied the depression analysis by considering the head movement patterns. The research group in [9] analyzed the depressive features by considering both the facial features and head movement features. However, none of the studies considered to provide the probability of early depressive features. Summary of the limitations in the previous studies explains in Table 1.1.

Table 1. 1: Comparison between the previous studies

	[5]	[6]	[7]	[8]	[9]	Proposed System
Facial Expression based depression Analysis	✓	✓	✗	✗	✓	✓
Head Movement based Depression Analysis	✗	✗	✓	✓	✓	✓
Probability of early depression features based on facial expression	✗	✗	✗	✗	✗	✓
Probability of early depression features based on head movement	✗	✗	✗	✗	✗	✓

There are mobile applications in the market that recognize the symptoms of depression. New classifications of managing mental health have been explored in various applications.

“MindDoc” is a mobile application that mainly tracks the emotional state based on a set of daily questions. The application can detect patterns by tracking emotional states and identify areas that can improve. Application is generating extensive evaluation regularly, detailing symptoms and providing a summary of your emotional state. However, the “MindDoc” application does not include the technique to detect real-time emotion based on images and videos to analyze the depression symptoms. The analysis merely depends on the user response to the set of questions, which can easily bias from the situation [10 - 12]. “ImoodJournal” is an app that helps individuals to track mood many times per day. A comprehensive summary provides a graph with complete mood history. Although the app keeps tracking the emotion to deliver an extensive mental health status, this is not considered the real-time emotion capture. Direct involvement of the individual in the mood tracking process does not provide a productive analysis since the analysis can bias accordingly [13 - 16].

Mobile App “Sanvello” is a self-care app that helps individuals manage stress, anxiety, and depression. The app includes mood tracking as well as thought and habit tracking. Sanvello progress assessment represents the connection between emotions, activities, and experiences [17 - 19]. Mood journal “Daylio” tracks the mood and related activities and information presented in various graphs as average daily mood and monthly mood chart [20, 21]. UP! is an automated mood diary that provides the

warning signs of depression, mania, and hypomania. The app is capable of managing journals of sleep habits, work-life balance, and physical activity. Up! provide the ability to connect with a health provider or trusted person by using a paring code, which enables effortless information sharing. However, the mobile apps do not consider the real-time emotion recognition as well as the head movements pattern that can accurately analyze the early depression symptoms [22, 23].

The existing mobile applications with the proposed system are compared in Table 1.2 as follows.

Table 1. 2: Existing Mobile Applications for mental health

	Mind Doc [10-12]	Imood Journal [13-16]	Sanvello [17-19]	UP! [22, 23]	Daylio [20,21]	Proposed App
Track emotion state	✓	✓	✓	✓	✓	✓
Identify real-time Emotion	✗	✗	✗	✗	✗	✓
Identify real-time Head Movement Pattern	✗	✗	✗	✗	✗	✓
Depression analysis based on emotion	✗	✗	✗	✗	✗	✓
Analyze mood	✓	✗	✗	✓	✗	✓
Notify care provider	✗	✗	✗	✓	✗	✓
Extensive Evaluation	✓	✓	✓	✓	✓	✓

1.3 Research Problem

Treatments would be more effective if depressed individuals have self-awareness of the mental health. Mobile application, which includes emotion-based behavior analysis for depressive disorder, may help people for self-awareness on the mental health state. Generally, the existing mobile applications focused on tracking moods. The analysis might be more biased since it considers daily mood records logged by the end-user. A mobile application that eliminates sort of manipulation by analyzing upper body movement would accurately assess early depression signs. To the best of my knowledge, a similar approach of automated analysis on depressive disorder using unexpected behavior changes that might have a chance of having depression is not yet studied in Sri Lanka.

Shortcomings in the field of depression and the mechanism to diagnosis the symptoms are summarized as follows.

- Individuals do not attend counseling sessions due to social stigma.
- Lack the automated solution to identify early depression symptoms using facial expression.
- Lack the automated mechanism to identify head movement patterns of a depressed individual.

2. OBJECTIVES

The objective of the research is to analyze the early signs that may lead to being a depressive person. The study proposes to focus on a mobile application to identify behaviors that could be highly anticipated to contribute to depressive disorder.

2.1. Main Objective

The main objective focus on Emotion-based behavior analysis for early identification of depressive disorder.

2.2. Specific Objectives

The Emotion-based behavior analysis for early identification of depressive disorder is divided into specific objectives as follows.

- **Create datasets to retrieve facial emotions of depressed/likely depressed individuals.**
    - Datasets will be created of depressed/ likely depressed individuals to retrieve the facial emotions.

- **Identify emotions of depressed/likely depressed individuals based on images and videos.**
    - Emotions of depressed or likely depressed individuals will be identified using an algorithm. The analysis is based on the images and videos.

- **Improving the existing methods to capture subtle emotional changes.**
    - Existing methods to capture the subtle emotional changes will be improved when comparing to the existing methods.

- **Identify head movements pattern of depressed/likely depressed individuals based on videos.**

- Head movement patterns of depressed or likely depressed individuals will be using an algorithm. Videos will be used to analyze the head movement pattern of depressed/ likely depressed individuals.

- **Build a classifier to model, abnormal behaviors based on facial emotions and head movements.**
  - A classifier will be built to identify abnormal behaviors based on facial emotions and head movements.

- **Predict the probability of abnormal behavior towards depression with the designed model.**
  - Abnormal behavior towards depression will be predicted using the designed model. The probability of the analysis will be provided in the designed model.
  -

- **Integrate the classifier to Mobile Application.**
  - Integration of the mobile application and the built model will be done using an Application Programming Interface (API).

Additionally, the objectives to develop the mobile application is explained as follows.

- **Responsible for implementing interfaces.**
  - The interfaces of the proposed system are focused on frontend development.

- **Mobile Application development for facial movement and head movement analysis.**
  - The mobile-based system will develop using flutter, to analyze the facial movement and head movement of depressed/ likely depressed individuals.

3. METHODOLOGY

3.1. Introduction

This section explains the implementation methodology in identifying the early depression symptoms. Figure 3.1 depicts the system diagram explaining the way of achieving research objectives.

Real-time emotion recognition - Emotion recognition classification in real-time can be implemented using OpenCV techniques to access the video with the frontal camera in the phone.

Image Preprocessing - The aim is to enhance the input image quality by applying preprocessing techniques. Data cleansing smooth the image by removing noise [24].

Data Augmentation - Deep learning models often require extensive data amount. The data augmentation technique increases the size of data that can use to train the model. New image samples can generate using Generative adversarial Networks [25].

Split Data - Preprocessed data need to split as training and testing data. The model will be built using the training data and the model will be trained using training data.

Face detection and Feature extraction – Viola-Jones Face Detection algorithm used to detect the face from the image. The algorithm uses Haar basis feature filters. Facial feature extraction will use techniques as Local Binary Pattern (LBP), Gabor filters [6], [9].

Classification - Previous studies have already considered various classifications. However, Neural Network techniques as Radial Basis function, Error Back Propagation, Multilayer Perceptron [26]. The study will consider building the model using the Convolutional Neural Network (CNN). CNN is the most popular for image classification.

Validation - Model building needs to be validated whether the model is learning the proper features. The model will validate using the training data.

Databases - Model will be trained using CK+, JAFFE datasets, and Clinical psychology interview videos on the YouTube platform. CK+ and JAFFE datasets will use to build the emotion identification model and head movement identification model. Clinical psychology interview videos will be using to build the model that will identify early depression symptoms.

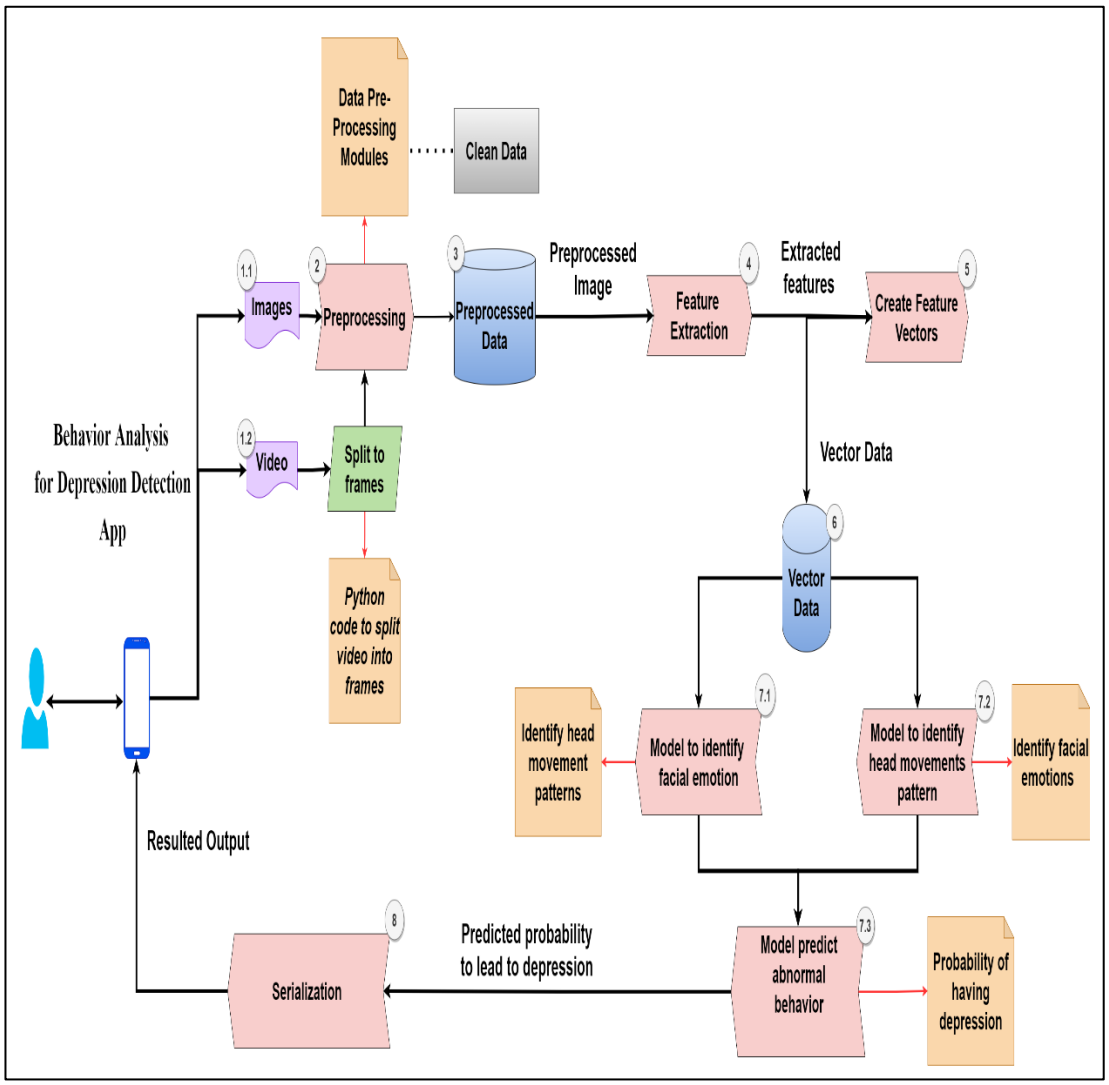

Figure 3. 1: System Diagram of abnormal behavior analysis

3.2.Project Flow

The process of training the model explains in Figure 3.2.

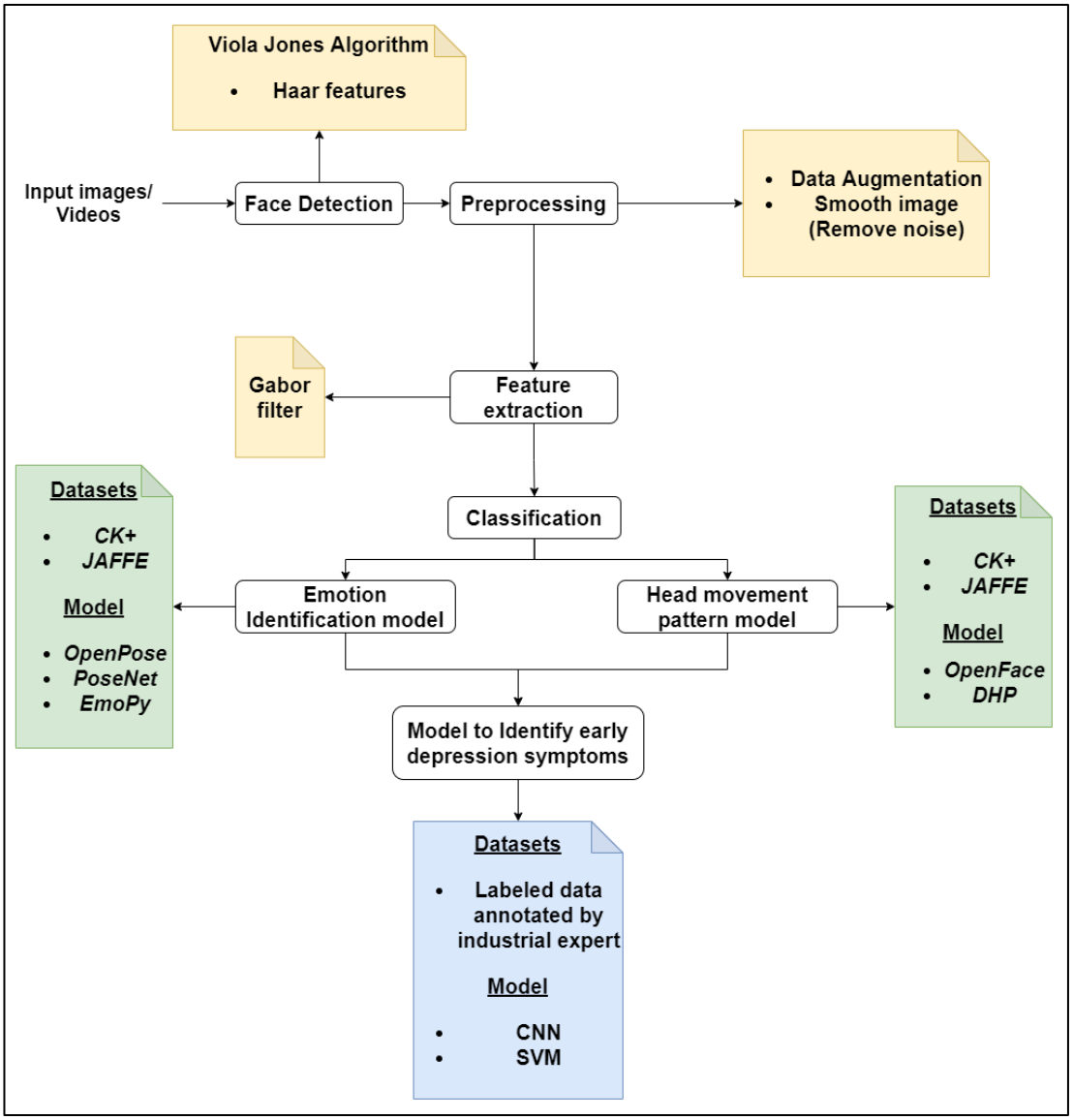

Figure 3. 2: Implementation Process for abnormal behavior analysis model.

The interface design of the mobile application includes in Figure 3.3. The mobile application will consist of the following interfaces to perform the intended functionality.

Step 01 – The user Registration process is required to launch the application.

Step 02 – User can log in to the system by using the login interface.

Step 03 – The user should agree with the terms and conditions to use the application.

Step 04 – Dashboard summarize the accurate track details.

Step 05 – User can Access the camera through the application.

Figure 3. 3: Mobile Application Design Flow

3.3.Technologies

This section describes the tools, libraries, and programming languages that will use in the proposed system implementation.

Table 3. 1: Technologies, tools, libraries for the proposed system.

Technology	**Description**
Python Programming Language	Object-oriented, high-level, and general-purpose programming language to implement the model.
Anaconda Environment	Anaconda Distribution will manage all the packages required to implement the model. Packages can be installed, upgraded downgraded easily.
OpenCV	The Image Processing technique will use the open-source library, OpenCV to acquire the real-time images relevant to the analysis
OpenPose	Real-time multi-person system for human pose estimation on single images. Emotion Identification and Head movement pattern recognition will be done using the OpenPose library.
Flutter	Frontend development will be done using the Flutter UI software development kit.
Visual Studio Code	Environment use for mobile app implementation. VS code is a freeware source-code editor.
TensorFlow	The model will be trained using the open-source library, TensorFlow.
Firebase	The proposed system will use Firebase to save the processed data.

3.4.System Testing

The proposed system will undergo various testing phases to ensure the intended performance. The testing phase includes unit testing, component testing, integration testing, and system testing.

3.4.1. Model Testing

The test data will use to validate the performance of the trained algorithm. The most basic way to test the training model is by classification accuracy [25].

3.4.2. Mobile Application Testing

To have a satisfactory user experience, the expected mobile application must undergo a testing process. The features should properly assess to maximize the competitive advantage of the mobile application.

- **User Interface testing –** To identify compatibility with the different mobile devices, the interfaces will be tested by considering various aspects. The evaluation requires the user interface design, output at different screen resolutions, and screen orientations. Additionally, elements of the interface will evaluate to optimize the market benefit of the software.

- **Functionality testing –** The model accuracy of abnormal behavior towards depression depends on the input from the user. The functionality to access the phone frontal camera needs to be properly implemented for acquiring accurate user input.

4. PROJECT REQUIREMENT

The required functionalities in the implementation of the mobile-based application are explained as follows. Figure 4.1 explains the Gantt chart of the development process.

4.1. Functional Requirements

- Analyze facial expressions to identify individuals with abnormal behaviors towards depression.
- Analysis of head movement pattern of the individual with abnormal behaviors towards depression.
- Predict the probability of having early depression symptoms based on analysis of the facial emotions and head movement pattern
- Extensive report generation including the probability of having early depression symptoms.
- Notification to the health care provider or guardian.
- The application should track the emotional state of a depressed or likely depressed individual.

4.2.Non-functional Requirements

- **Reliability** – Depression should be precisely analyzed and provide immediate treatments since it is a very crucial disorder. Therefore the application should provide accurate analysis to the healthcare provider.

- **Security** – The system needs to be secured since it includes confidential details of the user.

- **Availability** – Depression monitoring can be at any time. Therefore, the availability of the system essential.

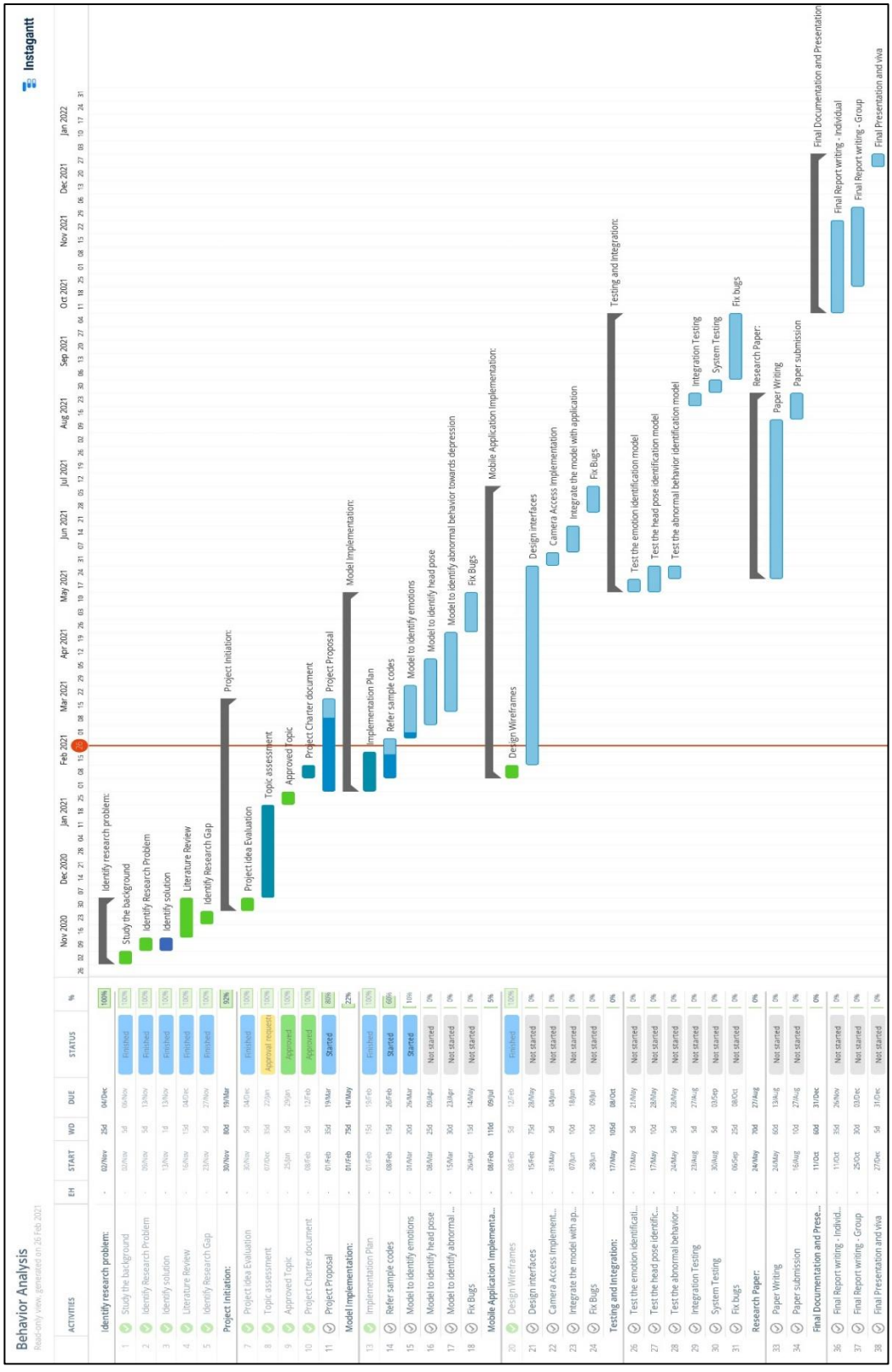

Figure 4. 1: Gantt Chart

Figure 4.2 depicts the work breakdown structure as follows.

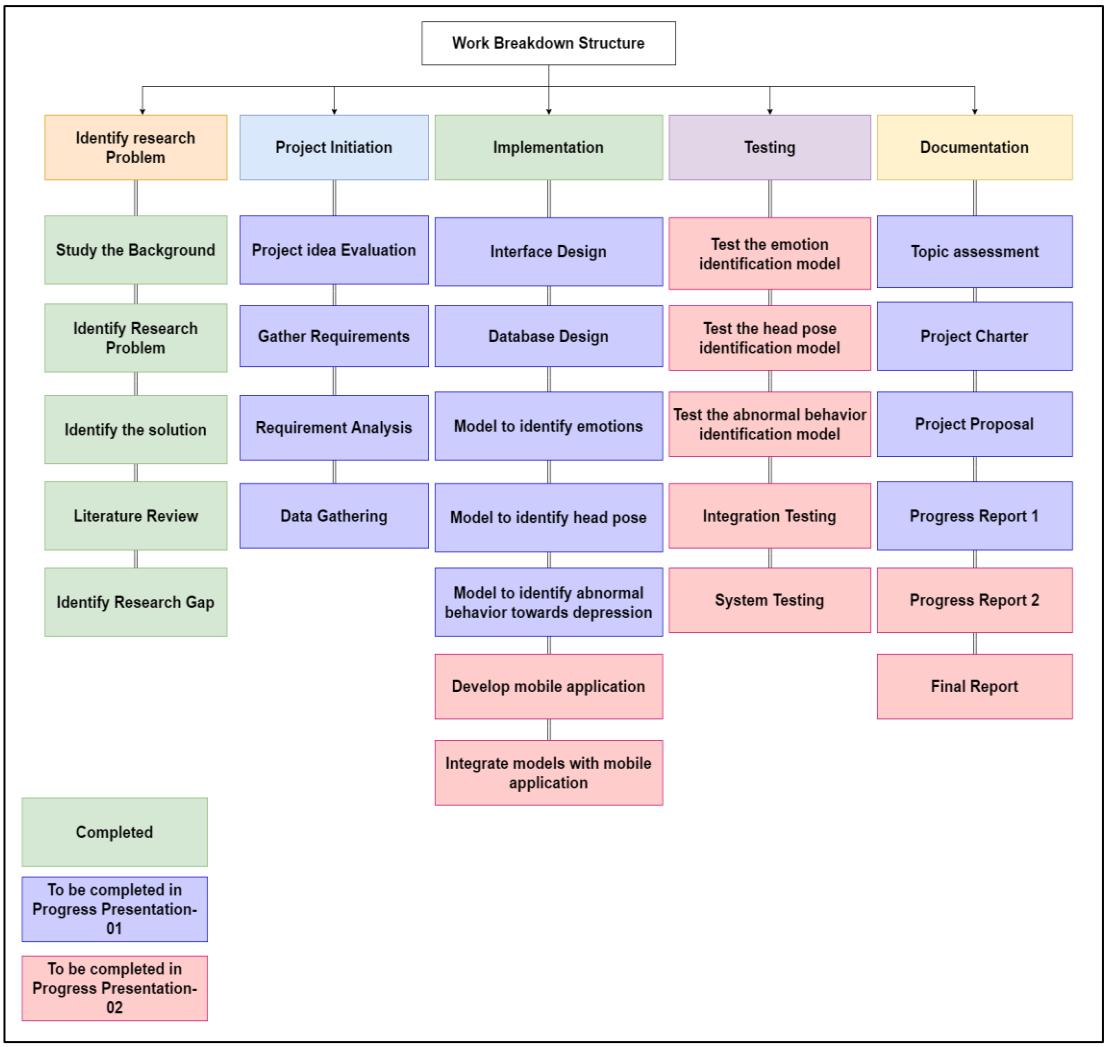

Figure 4. 2: Work Breakdown Structure

5. COMMERCIALIZATION POTENTIAL

Mood swings must monitor to obtain appropriate mental health care. Early detection of depression encourages the individuals and the provider of mental health services to remit the future risk to life. However, social stigma prevents people by forcing them back from appointing health care providers for effective service.

Individuals will be able to receive effective services from psychiatrists by notifying the responsible person through the proposed application. The economic benefit of the mobile application proposed is listed below.

5.1. Community Value

5.1.1. Users of the Application

- Notify the family and healthcare provider about abnormal behavior.
- Easy to track emotions without direct involvement from the user.
- Broad view about daily emotions.
- Save time from biweekly psychiatrist appointments that merely monitor the behavior changes.

5.1.2. Mental Healthcare Provider

- Extensive summary on the mental health of the patient.
- Receive notifications about the mental health of the patient.
- Provide immediate treatment effectively.
- Monitor abnormal behaviors of the patients using the proposed system.

5.2.Confidentiality and Privacy

- User information will be hidden from the public.
- The user will be authenticated before login into the system.
- The comprehensive summary of the patient’s mental health will be shared with trusted sources.

5.3.The research Validity

- The real-time emotion analysis to identify early depressive symptoms is not yet considered in the field of study.
- Head movement pattern analysis that identifies the abnormal behavior with individuals is not yet studied in Sri Lanka.
- An automated analysis on abnormal behavior towards depression is not yet studied in Sri Lanka.

5.4. Risk and Benefits Assessment

5.4.1. Risk of the research

- Patient details disclosure to the public may affect the research.
    - The research will anonymize the personal information.
    - Reports will be shared with trusted sources.

5.4.2. Benefits of the research

- Monitor abnormal behaviors of the patients using the proposed system with high accuracy.
- Mental Healthcare Providers will have an extensive summary of the mental health of the patient.
- Individuals will have immediate treatment effectively.
- The analysis will conduct without direct user involvement.

5.5.Budget and Budget Description

The estimated overall Cost to complete the project explains as follows in Table 5.1.

Table 5. 1: Overall Estimated Cost

Event	**Amount (LKR)**
Appointments for Mental Healthcare Provider	2500.00 (For an appointment)
Internet	500.00 (Per Month)
Total	9500.00 (Approximately)

The following table 5.2 includes the estimated monthly revenue for the project.

Table 5. 2: Estimated Monthly Revenue

Users	**Package**	**Price (Monthly)**	**Product Description**
Public Users	Basic	-	• Free installation through “Play Store”. • Daily emotional state summary. • Monitor emotions for two weeks. • A summary report indicating the probability of depressive symptoms.
	Premium	Rs. 500.00	• Free installation through “Play Store”. • Daily emotional state summary. • Monitor emotions for two weeks. • Monitor emotions for four weeks. • An extensive report indicating daily emotions and probability of depressive symptoms.
Mental HealthCare Provider	Premium	Rs. 750.00	• Receive notifications from patients. • Extensive report including the mental health details of the patient.

6. DESCRIPTION OF PERSONAL AND FACILITIES

Shalindi Pandithakoralage - Clinical Psychologist

An experienced Clinical Psychologist, who qualified in Cognitive Behavioral Therapy (CBT), Psychological Assessment, social services, statistics, and reaches. She obtained her first degree from the Missouri University of Science and Technology. MPhil focused in Clinical Psychology was obtained from the University of Colombo. Furthermore, her areas of interest and expertise include working with clients who have difficulties with depression, trauma, anxiety, relationship and marital issues, and obsessive-compulsive disorder. She engages with both Humanistic and Cognitive-Behavioral principles depending on the client's needs and maintains a client-focused approach.

She will externally supervise the research with her industrial expertise and research interest. The accuracy of the acquired depressed data will be validated by her using a gold-standard approach. She will guide the research team towards accurate analysis.

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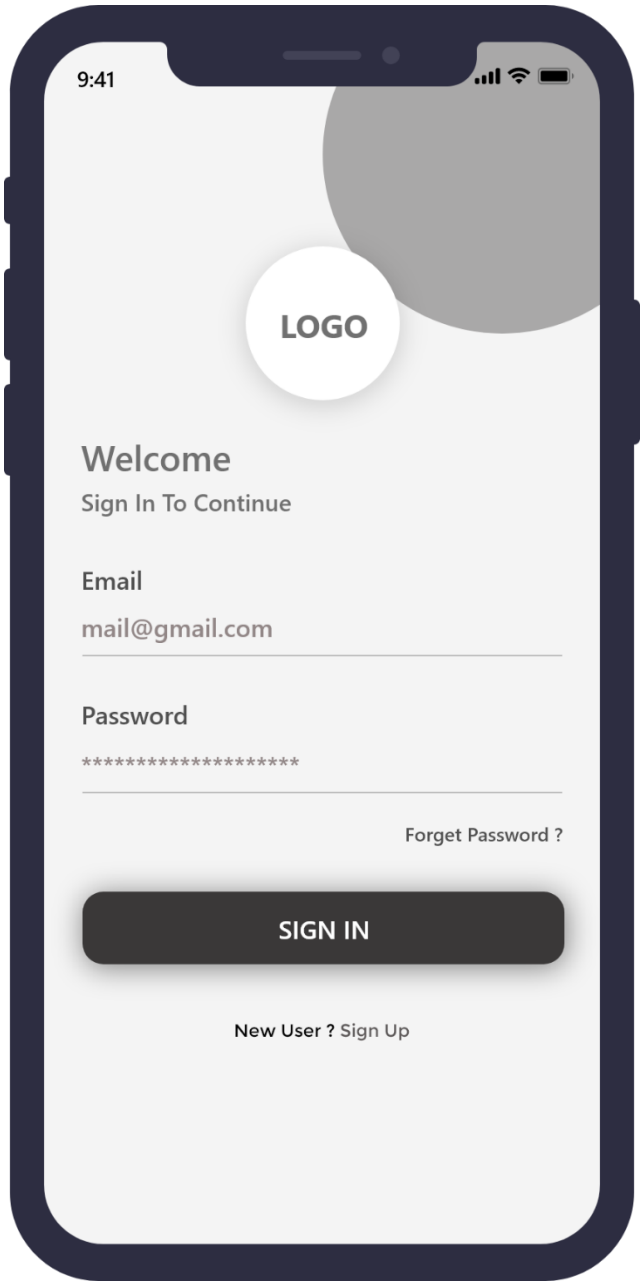
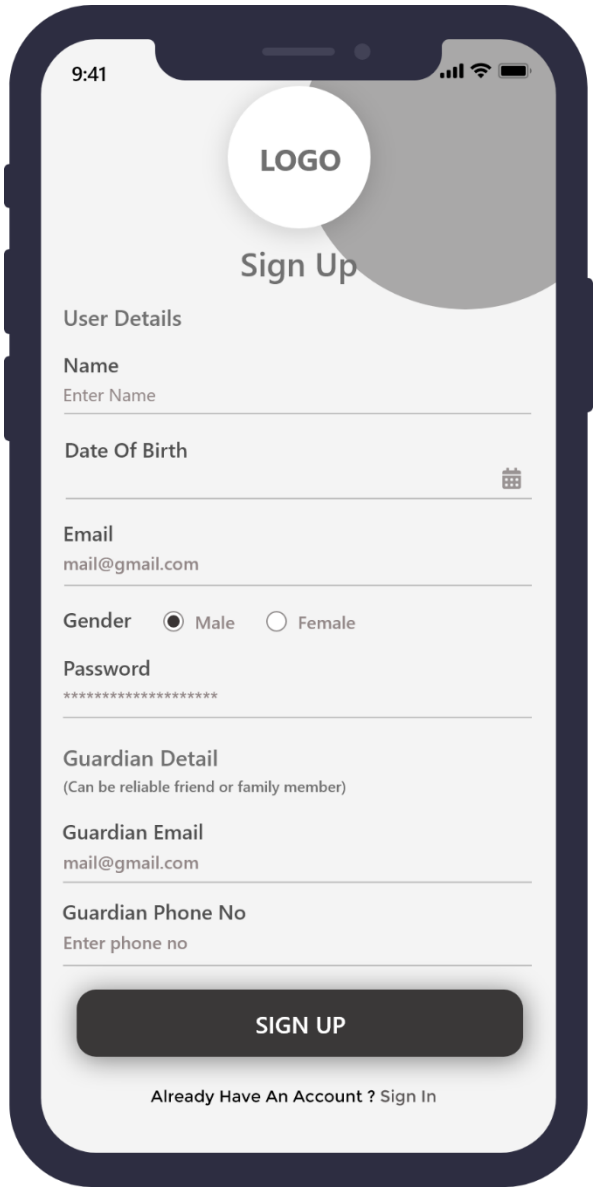
Appendix A- Final Application Design Flow

Application Initialization

Login to the Application

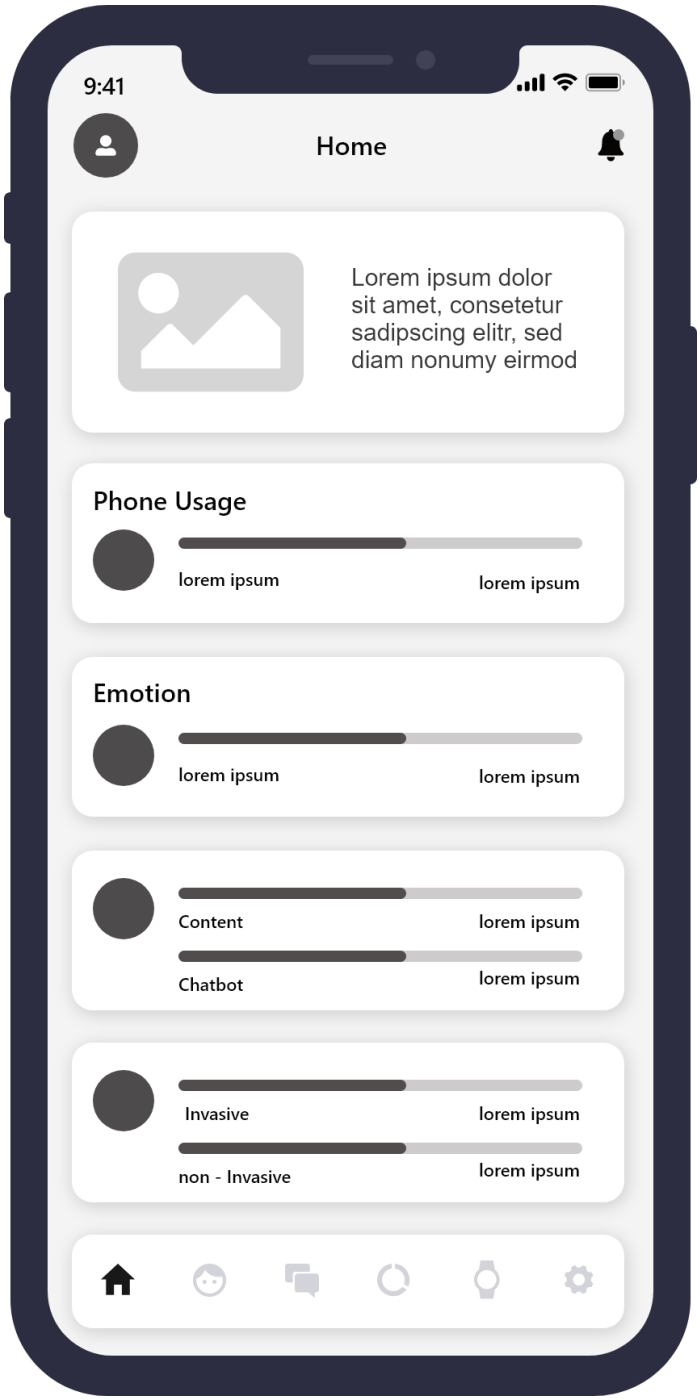


Sign up to the Application

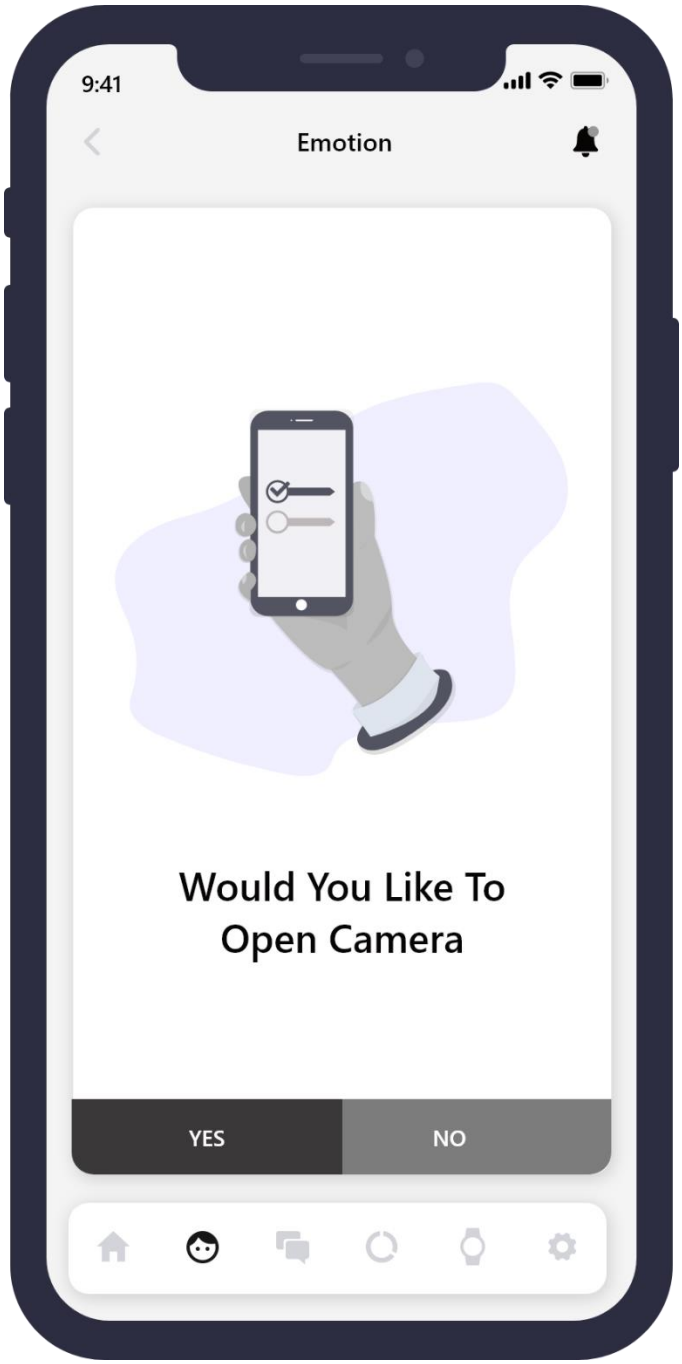


User Agreement

Application Dashboard



Camera Access initiation through the application.



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