BEHAVIOR ANALYSIS FOR DEPRESSION DETECTION.

Project Id: 2021-073

Project Proposal Report

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B.Sc. (Hons) Degree in Information Technology Specialized in Information Technology

Department of Information Technology

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Dr. Pradeepa Samarasinghe

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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.

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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

Depressive disorder (DD) is a mental health disorder that causes life damages every year worldwide. It is crucial to identify and understand the patient's physical, emotional changes however still methods to identify the symptom is relying on methods that originated more than fifty years ago which are filling out surveys and engaging face to face interviews. Therefore, the accuracy and reliability of the above methods can be dependent on human scaling. Early depression identification and understanding are really important, faster the identification of the symptom faster the effectiveness of treatments we offer to the patients. In Sri lank social impact is a major problem when it comes to receiving treatments for mental health disorders like DD therefore people more tend to hide the symptoms and avoiding treatments.

There are potential ways that we can help to identify DD with machine learning and mobile application developments. There are a handful of developments that have been designed concerning the above issues yet most of them are based on questioners, self-reporting.

The purpose of the research is to addresses the above limitations by implementing a mobile application for adolescence which analyze the unexpected behavior changes that might have a high chance of having depression. The result was elevated by tracking Heart rate, sleep pattern data collected from individuals using invasive and non-invasive methods and analyzing them using machine learning algorithms.

Keywords: Depression Disorder, Heart Rate Analysis, Sleep Analysis, Machine Learning, Adolescence

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1. INTRODUCTION

Early-stage identification of depressive disorder is critical because depression has become the second leading cause of deaths age between 15 – 19 worldwide [1] however, Identifying depression has been accomplished by a periodic assessment which can be structured or unstructured clinical interviews that use standard rating scales and advanced methods for severe individuals. The bright side is identification methods shifting from narrow methods which depend on scaling to broader anatomical and neurophysiological understanding of emotion, behavior, cognition, and their disorders [2]. We anticipate the development of a reliable mobile application that uses biometric data for early detection will help improve the diagnosis and assessment of depression therefore, biometrical data from individuals obtained using wearables and non-wearables, can be crucial. Researchers have focused more on biometrical data such as heartbeat, sleep patterns, skin temperature, and mobility to study symptoms of depression ex: [3] [4].

When it comes to psychiatric illnesses sleep patterns of individuals take an important part in both a clinical symptom and an important curative target [5]. Therefore, sleep pattern data can be used as an important parameter to identify early depression changes moreover insomnia can be a sign of leading to depression [6]. Sleep disturbances are usually a risk factor for amplifying anxiety and depression [7]. Heart rate changes during sleep can be a biomarker of depression therefore heart rate is an important parameter to consider identifying early depression, moreover, increased and reduce HRV in both conscious and sleep is a link with depression [8]. When we seek to achieve identify early depression by behavioral changes using biometric data, we must examine heart rate and sleep pattern as important parameters.

1.1 Background & Literature Survey

One of the most frequent physical changes of a depressive patient is sleep, in the research Epidemiology of insomnia by Maurice M Ohayon have mentioned approximately 80% of individuals with a current major depressive episode have co-occurring sleep difficulties [9]. Besides sleep patterns, heart rate is another physical factor that we can recognize in depression patients therefore the research from the South China University of Technology, Guangzhou with Danni Kuang et al. proved Depression patients have lower HRV than healthy subjects. Therefore, HRV may be used to distinguish depression patients from healthy people by using Bayesian Networks [10].

A study from the Faculty of Science and Technology, Keio University, Kanagawa, Japan has developed a machine-learning algorithm to screen for depression and assess severity based on data from the wearable device [11]. Furthermore, Dartmouth College USA researched track depression using an app and wearable data they took heart rate through warble and some other parameters like sleep details, mobility through the app called The Student Life [4]. There is a study from Media Lab, MIT, Cambridge, MA predicting the Hamilton Depression Rating Scale (HDRS) using data captured from E4 wearable wristbands and sensors in an Android phone [12].

A study by Isaac Moshe et al has aimed to explore the extent to which data from smartphone and wearable devices could predict symptoms of depression and anxiety. They have used wearable The Oura Ring which provides measurements related to sleep (total sleep time, sleep onset latency, wake after sleep onset, and time in bed) and heart rate variability (HRV). Through the study, research has proved significant positive associations between total sleep time and depression, time in bed, and depression [13].

Summing-up, the existing studies have focused on show links between depression and biometrics, develop an algorithm to monitor depression using wearable data, and predict depression with wearable data. Most of the studies have acquired wearable data and but there can be people who refuse to use wearables. Therefore, the development of a mobile application that includes biometrical data obtained using invasive and non-invasive techniques to behavior analysis for depressive disorder, may help people for self-awareness on the mental health state. To the best of our knowledge, studies have not been found in Sri Lanka that focused on a similar approach of automated analysis on depressive disorder identification using unexpected behavior changes.

1.2 Research Gap

When we considered the studies conducted within the area of depression detection based on invasive and non-invasive the study [11] have focused only about collect data through the invasive method and provide an algorithm o screen depression. Furthermore, the research by Dartmouth College USA [4] have used both invasive and noninvasive method to collect data but they don't acquire the same data from invasive method through an app and they focused on track depression in their study. When we observe the study [12] they have predicted the Hamilton depression scale using data based on an invasive method therefore as we can see they did not focus on invasive methods in the study. Lastly, the study by Isaac Moshe and team [13] they have to explored the parameters from the invasive method to identify positive associations between total sleep time and depression. A comparison of previous studies and the proposed system summary indicate in table Table (1.1).

Table 1. 1: Comparison Between the Previous Studies.

	[11]	[4]	[12]	[13]	Proposed System
Depression analysis base on biometrical parameter changes.	✓	✗	✓	✓	✓
Screen and track depression using data acquired using wearable	✓	✓	✓	✗	✓
Explore which data can be collected using a wearable to predict depression.	✗	✗	✗	✓	✓
Invasive method to acquire parameter data	✓	✓	✓	✓	✓
The noninvasive method is an alternative to acquiring the same parameter data.	✗	✗	✗	✗	✓
Probability of early depression analysis based on biometric data.	✗	✗	✗	✗	✓

There are a handful of mobile applications that have to develop considering depression disorder. We can them access through "Appstore" or "Play Store".

The app " **Sleepio**" is developed as Cognitive Behavioral Therapy for insomnia (CBTi). When the app collects data using an in-depth questionnaire from individuals then it builds a program for users to improve their sleep habits [14].

"**StressScan**" is a Stress level tester that collects heart rate through the phone camera then "Stress Scan" will analyze changes in the user's heart rate interval and scientifically measure the level of your mental and physical stress on a scale of 1 to 100 [15]. " **Welltory**" app is also a Stress level

tester but with more outputs like Measure stress, energy, and resilience with a smart. The result is evaluated using Track blood pressure and heart rate of the individual [16].

"**Moodpath**" an assessment tool that aids in tracking individuals' physical and emotional well-being everyday mindfulness, sleep improvement, and stress management. The data is collected using self-reports every. As output app will retrieve a report weekly. Special features of the app are individuals can share reports with mental health professionals, self-compassion exercises are also available within the app [17].

Below table (Table 1. 2) indicate a summary of existing app related to depression analysis based on invasive and noninvasive technique.

Table 1. 2: Existing Mobile Applications Using Biometrics.

	Sleepio [14]	Stress Scan [15]	Welltory [16]	Mood Path [17]	Proposed app
Track most critical factors Biomatrix data	✗	✓	✓	✓	✓
Invasive method to collect Factor's data	✗	✗	✗	✗	✓
Non- invasive method to collect Factor's data	✗	✓	✓	✗	✓
Depression analysis based on Biomatrix data (HRV, Sleep pattern)	✗	✗	✗	✗	✓
Notify Gaudian.	✗	✗	✗	✗	✓
Extensive Report Generation.	✓	✓	✓	✓	✓

1.3 Research Problem

Depression disorder has become a burden disease all over the world with affecting more than 264 million people [1]. Depression is becoming the most common health problem among the younger generation, a considerable amount of the younger generation is affected by this mental health condition due to various reasons like self – esteems, social life, career achievements, and follow unhealthy practices for a long time. However, if we cannot identify depression in the early stages and inherit it for a long time it can cause life damages.

When we come to Sri Lankan population, individuals endeavor to hide the symptom and avoiding medications with the negative social impact as well as most of the individual doesn't know they are suffering from depression because they don't have a solid idea about the early-stage behavioral changes that are signs of depression. The methods that have been used to identify depression are self-assessment reports, surveys, and questioners however these methods are conducting by clinical professionals therefore individuals tend to hide their disorder rather than visiting a psychiatrist.

There are biometric parameters that can be used to identify early-stage depression by behavioral changes therefore it will be effective if we can design self – awareness mobile application based on those biometric parameters. There are apps that have design considering biometrics data for depression individuals but most of them have focused on therapy, which is giving daily plans for the effective day, sleep, etc. The limitation of those apps is they have collected data from users using surveys, questioners, or recordings.

In order to address the above issues, we can design a mobile application that is easily accessible, reliable, and accurate with the use of machine learning algorithm analysis of the biometric data collected using invasive and non-invasive methods.

The shortcoming in the industry regarding depressive disorder can be summarized below.

- Difficulties of two weeks manual monitoring individuals.
- The social impact that makes individuals avoid medication and understand symptoms.
- Lack of the automated applications that focus on identify early depression disorder using biometric parameters.
- Lack of systems that acquire data without the user's contribution.

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 of the proposed research is to Acquire invasive and non-invasive data analysis for early identification of depressive disorder.

2.2 Sub – Objectives

The Main object is separated into sub-objectives as following.

1) Recognize health parameters that can be collected using a wearable device to identify early depression symptoms.

There are several biometric data that we can use to identify depression, but we need to recognize the most suitable and accurate parameters that we can collect from the Invasive method.

2) Identify techniques as alternative methods to collect the same parameter data.

There should be an alternative method to collect the same parameter data that collect from wearable because there can be time warble won't work as well as individual may not use the wearable.

3) Collect data using invasive (wearable) and non-invasive techniques and build methods to identify early depression symptoms

The model will be trained using a machine learning algorithm that is most accurate among several algorithms.

4) Predict the probability of abnormal physical changes towards depression with the designed models.

If the user can lead to depression or not will be identified from the prediction based on biometric data.

5) Integrate both models into the mobile app.

After Serialization of the prediction from model outputs will be retrieved to the designed mobile app.

The additional objectives that interacting with the main objective as following,

6) Implementing interfaces of the mobile application.

Fronted development of the proposed mobile application will be complete in this stage.

7) Mobile Application development.

The mobile application development will be developed using flutter to collect the data from the user as well as to retrieve the analysis data to the user.

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.

Acquire Data

Sleep pattern and heart rate data have been recognizing as the most curial biometrics parameters to identify early depression. The invasive method will be the Xiaomi MI band which is categorized as a fitness band. The band is accurate, lightweight, and cost-effective. Using the band heart rate and sleep pattern data will be obtained from the individual [18]. The proposed noninvasive method to collect sleep pattern data is accessing the mobile phone accelerometer and collect x, y, z parameters, convert them into sleep data using python package "sleepPy" 0.2.21 [19]. By using Both MI band and Phone accelerometer data will be collected from individuals.

Pre - Process

The biometrics raw data that have been gathered from both invasive and non-invasive methods should be in a suitable form in order to feed to the machine learning model therefore preprocessing is an important stage [20]. The preprocessing stage includes select necessary data, clean data, encode data, and trainset splitting.

There are several ways we can conduct data cleaning which are,

- Delete Rows with Missing Values
- Replacing with Mean/Median/Mode
- Assigning A Unique Category
- Predicting the Missing Values
- Using Algorithms Which Support Missing Values [21].

Training and testing data are split before the model training. In industry mostly use the 8: 2 method which is 80% for training and 20% for testing. The "scikit-learn" Python machine learning library can be used to trainset the splitting process [22].

Build the model and retrieve

Using the 80% of data that have passed from the trainset split will be conducting the feature extract and store as vector data to ensure the privacy of the individual's data. A Decision-making model requires to be handled among several machine learning algorithms which are support vector machine, k – neatest, binary regression in order to ensure accuracy.

As a flow, the build model will be validated using training, serialized using python object serialization and the predictions will be retrieved through the mobile app [23].

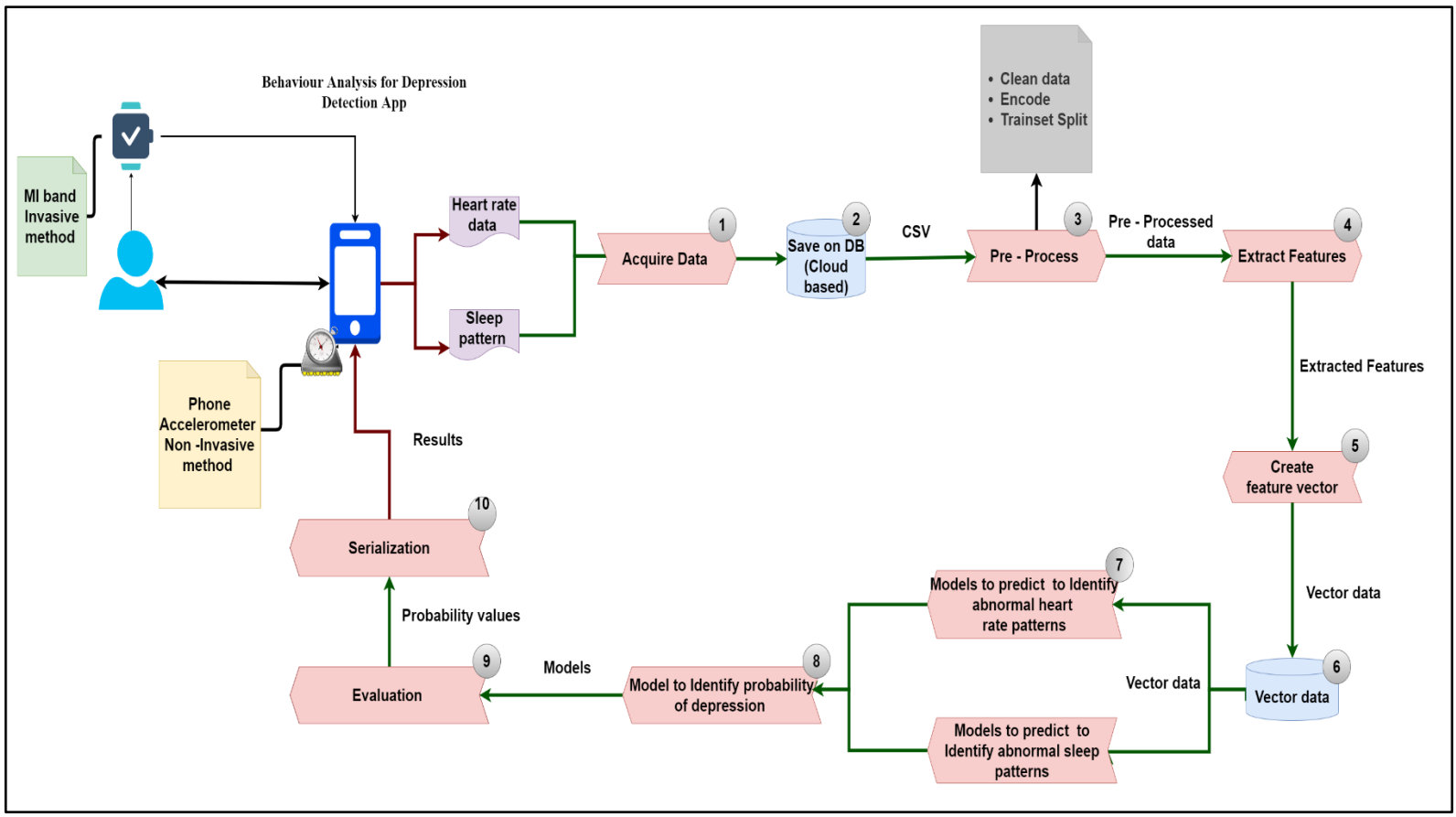

Figure 3. 1: System Diagram of abnormal Sleep and heart rate analysis

3.2 Project Flow Diagram

Figure (Figure 3.2) indicates the flow of the model training process.

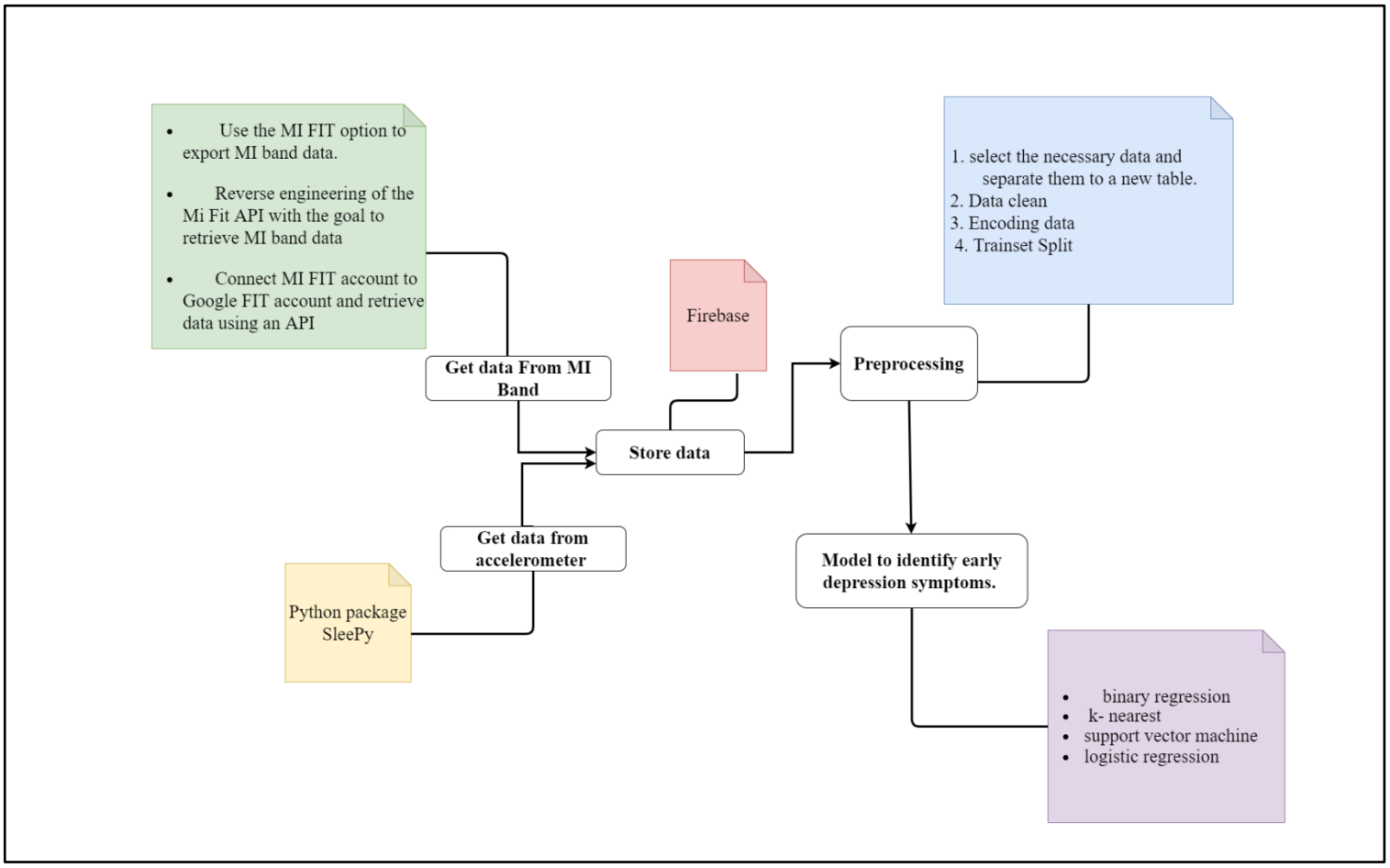

Figure 3. 2: Implementation Process for abnormal sleep and heartrate analysis model.

The interface design of the mobile application indicates in Figure 3.3.

Step 01 – User register to the mobile application in order to launch.

Step 02 –User must log in to the Application.

Step 03 – Getting user permission to access phone details and sensors to collect data.

Step 04 – Dashboard summarize the accurate track details.

Step 05 – User can check daily summer about sleep and heart rate.

Figure 3. 3: Invasive & Non – Invasive methods mobile application Flow.

3.3 Technologies

The following technology will be used for the implementation of the system.

- Machine Learning:

  In order to train data for identifying early depression behavioral changes according to sleep and heart rate data.

Following tools, libraries, environments, and technologies will be used for the process of the system indicates in the table (Table 3.1)

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

Technology	Description.
Spyder/Jupyter Notebook IDE	Open-source IDE that can perform scientific programming in python.
Python pickle	Python Pickle module use to serialize and deserialize Python object structure.
Firebase	Firebase is the database to store the data that collect from the mobile app.
Anaconda 3 Environment.	Use to manage all the required packages used for the implementation of the system.
Scikit-Learn	Machine learning library for Python that supports regression, support vector machines, and classification.
Python Flask	Use to write endpoints which is a framework written in Python.
Pdfkit	Library of python that using for pdf document generating purposes.
Flutter & dart	Flutter is an open-source UI software development kit dart is the programming language which use to code in a flutter.

3.4 System Test

To ensure the anticipated system output and performance, therefore we need to conduct several test phases unit testing, component testing, integration testing, and system testing.

3.4.1 Model Test

The machine learning model performance evaluation will be performed using test data. There are several methods to evaluate the performance of the model and the most basic way is classification accuracy.

3.4.2 Mobile Application Test

The intended mobile application must follow proper evaluation phases beforehand into users therefore we can ensure that the application can satisfy user requirements and improve commercial value.

- **User interfaces testing –** The mobile application must perform interface testing; therefore, we can ensure usability, visibility, consistency, and compatibility of the final product.

- **Functionality testing –** The mobile application must be functions as intended because the accuracy of the model depends on inputs from the application therefore the mobile application must undergo a feature testing phase.

4. PROJECT REQUIREMENTS

The section will be focused on the necessary functionalities for the implementation of the mobile-based application. Figure 4.1 explains the Gantt chart of the development process and Figure 4.2 Indicate work breakdown structure.

4.1 Functional Requirements

- Analysis biometrics parameter data to identify individuals with abnormal behavioral changes toward depression.
- Predict the probability of having early depression symptoms based on analysis of biometric data gathering invasively & non-invasively.
- Users should be able to check a daily summary of biometric data that has been collected.
- Users must provide necessary notifications when accessing the phone sensors.
- The user should be able to connect warble to the mobile application.
- Generate the comprehensive report summary regarding the user's mental status.
- Notify the guardian or mental health care provider.

4.2 Non-functional Requirements

- **Security** – The system must be aware that the wearable is connected without error to the application before collect data.

- **Privacy** - the system must be responsible to keep the confidentiality of the user data and analysis information.

- **Reliability** – User must be provided with highly accurate probability values toward depression based on Biometric data analysis.

- **Availability** - The application must be accessible for users 24/ 7, as well as the data acquiring, should be available for the necessary time period.

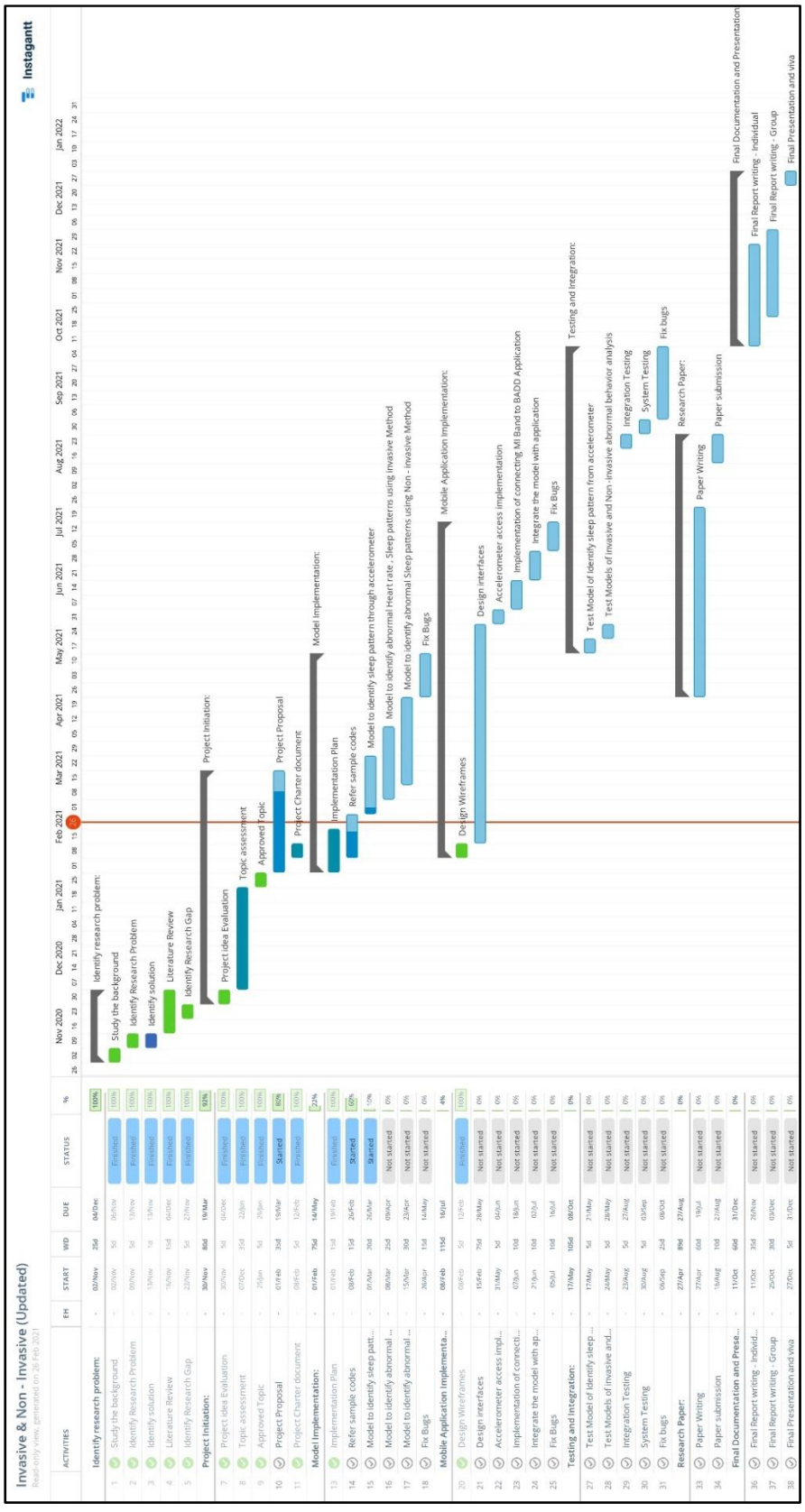

Figure 4. 1: Gantt Chart of Implementation.

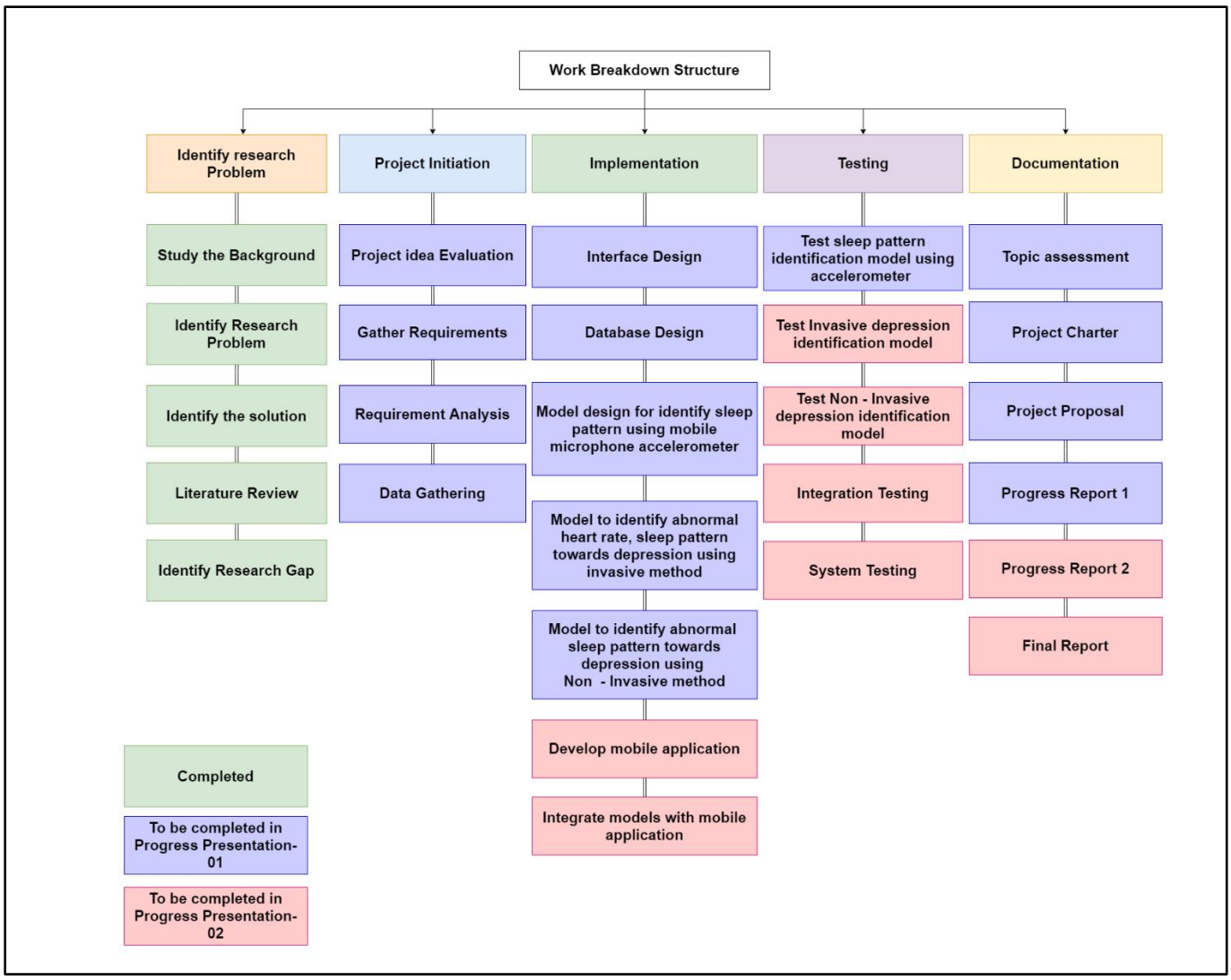

Figure 4. 2: Work Breakdown Structure.

5. COMMERCIALIZATION

Biomimetic parameter changes must be considered when it comes to identifying depression. Early depression detection can minimize the potential of life damages, but the social impact can lead individuals to prevent medications.

Self-awareness app can address individual's concerns and help them to receive effective and efficient medications since the application proposed to notify the responsible guardian about the individual's mental health level. The economic benefit of the mobile application proposed is listed below.

5.1 Community Value

5.1.1 Advantage to the public

- An expanded review of behavioral changes without user direct interaction.
- Daily summary about sleep pattern and heart rate data.
- Automated notifications about the analysis to the guardian or health provider.
- Automatic biweekly monitoring without user contribution.

5.1.2 Advantage to The Mantel HealthCare Providers.

- Automated monitoring of individuals for two weeks.
- Extensive summary about user abnormal behaviors toward depression.
- Notification about an individual's mental health level.
- Immediate treatment soon as two-week analysis.

5.2 Risk and Advantage Assessment

5.2.1 Risks of the Study.

- Individuals' details disclosure.
    - Personal information and health status will be protected.
    - The mental health reports only are shared with trusted sources that users allowed.

5.2.2 Advantage of the Study

- Monitor abnormal behaviors of the patients using the proposed system with high accuracy.
- mental health providers can expand summary about individual’s mental health status easily.
- Individuals can encourage to immediate medications.

- Analysis without user contribution.
- Doctors can more be focused on individuals' medication methods.

5. 3 The Validity of the Research.

5.3.1 The scientific value of the research

- Early depression detection based on abnormal biometric parameter changes towards depression is not yet studied in Sri Lanka.

- Biometric data collect using both invasive and non-invasive methods to identify early depressive symptoms is not yet considered in the field of study.

5.4 Confidentiality and privacy

5.4.1 Personal Information

The personal information collecting from the user for analysis will be protected from the public.

5.4.2 Report Analysis

The reports that contain individual health summaries only will be shared with the trusted sources.

5.5 Budget and Budget Justification.

We have used a wristwatch as an invasive method to collect data which is MI band 5 by Xiaomi. Therefore, we have cost around Rs. 6000 – 7000. Furthermore, the cost for appointments and the cost of the internet has been added to Table(5.1).

Table 5. 1: Estimated Project Overall Cost Summary.

Event	**Amount (LKR)**
Invasive method to collect data	RS. 6500 - 7000
Appointments for Mental Healthcare Provider	2500.00
Internet	500.00 * 12
Total (Approximately)	Rs. 16 000.00

The mobile application will be available for the users in the “play store” with packages of 2 which are basic and Premium details is explained in the table Table(5.2).

Table 5. 2: Application Estimated Monthly Revenue Summary.

Users	**Package**	**Price (Monthly)**	**Product Description**
Public	Basic	-	• The app can be installed through the “Play Store” for Free of charge. • Daily Biometric parameter change summary. • Monitor User’s Sleep and heart rate for up to two weeks. • Summary report of Changes in biometric parameters.
	Premium	Rs. 500.00	• Basic + • An expanded report of biometrical parameter changes toward depression. • The feature of the report can be shared with a guardian or doctor.
Mental HealthCare Provider	Premium	Rs. 750.00	• Notifications about patients' behavioral changes. • An expanded report of patients' health statuses according to 2 weeks monitoring.

6. DESCRIPTION OF PERSONAL AND FACILITIES.

Shalindi Pandithakoralage - Clinical Psychologist

A clinical psychologist with qualifications in who qualified in Cognitive Behavioral Therapy (CBT), Psychological Assessment, social services, statistics, and reaches. She received her primary degree from the Missouri University of Science and Technology as well as she obtained MPhil focused in Clinical Psychology from the University of Colombo. moreover, she has engaged in working with clients who have difficulties with depression, anxiety, obsessive-compulsive disorder, trauma, and relationship and marital issues. She engages with both Humanistic and Cognitive-Behavioral principles depending on the client's needs and maintains a client-focused approach.

She will be the external supervisor for the research with her inters towards the research.

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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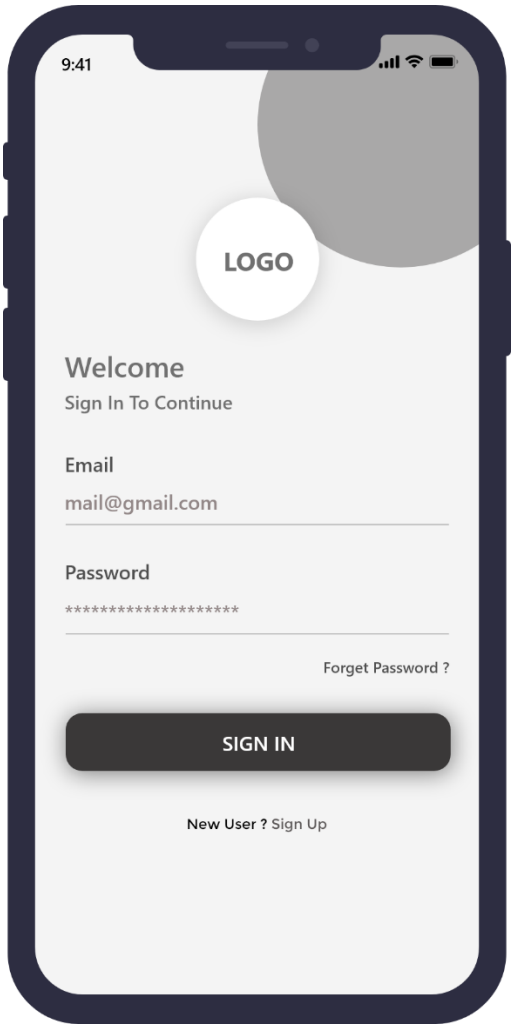
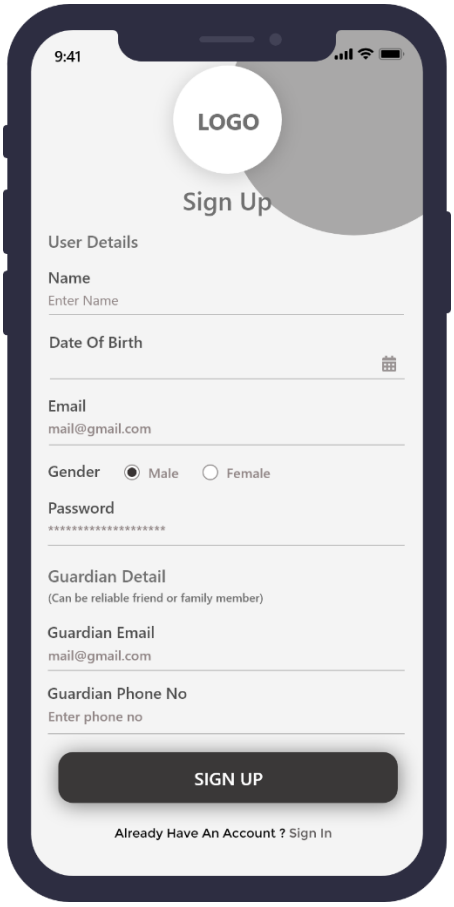
APPENDIX A: Final Application Design Flow

Logo

Login



Signup



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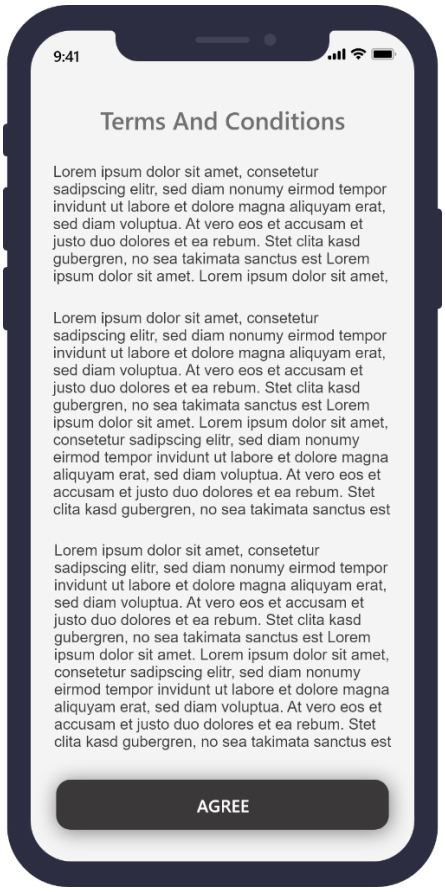

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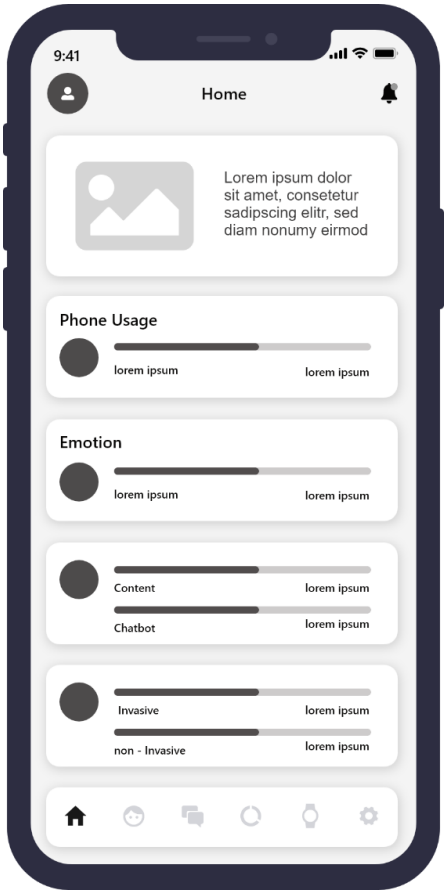

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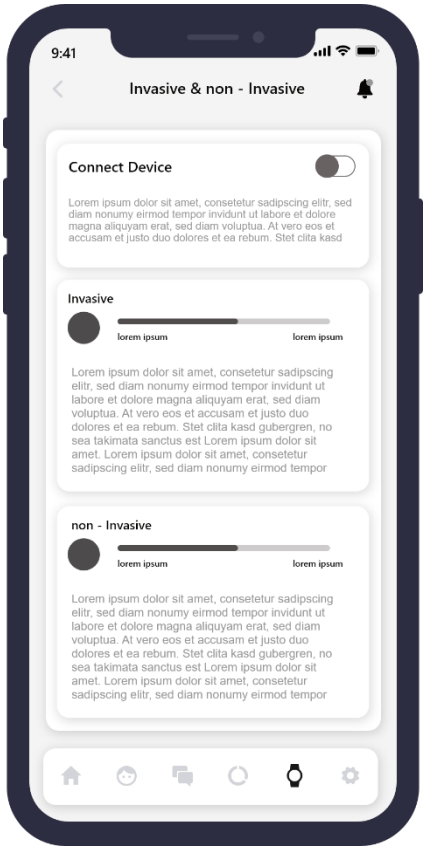

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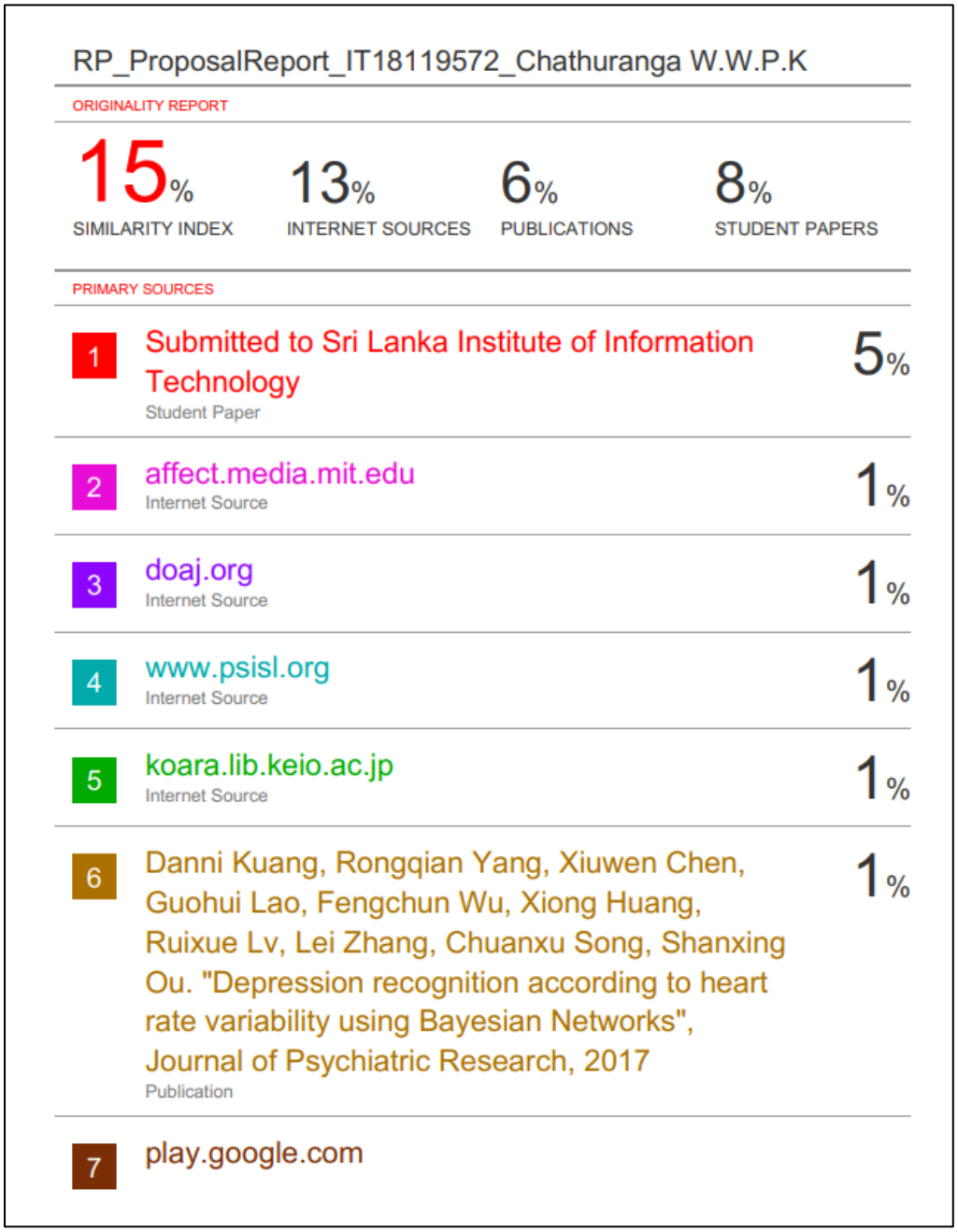

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