MAKERERE UNIVERSITY

A ROBUST DEPRESSION DETECTION CLASSIFICATION AND MONITORING SYSTEM (REMEDI)

By

BSE 20-13

AN ARTIFICIAL INTELLIGENCE SYSTEM

DEPARTMENT OF NETWORKS

SCHOOL OF COMPUTING AND INFORMATICS TECHNOLOGY

A Project Report Submitted to the School of Computing and Informatics Technology for the Study Leading to a Project in Partial Fulfillment of the Requirements for the Award of the Degree of Bachelor of Science in Software Engineering of Makerere University.

Nov,2020

Declaration

We, group BSE 20-13, hereby declare that the work presented is original and has never been submitted for an award to any university or institution of higher learning

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Approval

This project report titled Robust Depression Detection Classification and Monitoring system has been submitted for examination with my approval as the supervisor of group BSE 20-13.

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Dedication

We dedicated this project to all those who have been through depression and those who have suffered mental health related problems that include stress, losing loved to suicide, bipolar disorders, substance disorders and others. It was initiated days after the celebration of the World Mental health day in 2019.

Lastly, we dedicate this project to the Mental health facilities that allowed us visit their premises during the study that include Serenity Centre in Bwebajja, Butabika Hospital among others. Opening your doors for us is the reason for all this.

Acknowledgements

The success of our **A Robust Depression Detection Classification And Monitoring System (Remedi)** would not have been possible without the help of many individuals. Firstly, we would like to thank Dr. Swaib Kyanda K, for their continuous support and guidance throughout the project. We would also like to express gratitude towards our university, Makerere University, specifically the Networks department, School of computing and Informatics Technology, for the logistical support and permission to carry out our experiments, while also providing us with funding that allowed us to conduct our study.

We also thank our parents for the support at school and all the psychological support, financial support and all efforts made towards our studies.

Abstract

Depression is a common mental health problem leading to significant disability worldwide. It is not only common but also commonly co-occurs with other mental and neurological illnesses. Current methods of assessing psychopathology depend almost entirely on verbal report (clinical interview or questionnaire) of patients, their family, or caregivers. They lack systematic and efficient ways of incorporating behavioral observations that are strong indicators of psychological disorder, much of which may occur outside the awareness of either individual. We compared clinical diagnosis of major depression with automatically measured facial actions and vocal prosody in patients undergoing treatment for depression. Both face and voice demonstrated moderate concurrent validity with depression. Accuracy in detecting depression was 70% for face. Accuracy for vocal prosody was 80%. These findings suggest the feasibility of automatic detection of depression, raise new issues in automated facial image analysis and machine learning, and have exciting implications for clinical theory and practice.

List of Abbreviations

AAM – Active Appearance Modelling

CJI – Chepkurui Jacob Isaac

CSV – Comma Separated Values

EDA – Exploratory Data Analysis

FACS – Facial Action Coding System

HD – High Definition

HMRSD – Hamilton Rating Scale for Depression

LCD – Liquid Crystal Display

KJA – Kafeero Jonah Augustine

KNN – Naive Bayes-Nearest Neighbors

ON – Olowo Norman

REMEDI – Robust Automatic Mental Detection Classification and Monitoring System

SVM – Support Vector Machine

SRS – Software Requirement Specification

SDD – Software Design Document

SH – Samir Habib

SMS – Short Messages

OS – Operating System

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INTRODUCTION

This Software Design Document describes the architecture and system design of The Robust Automatic Mental Health Detection, Classification and Monitoring System. It defines and describes the system overview, architecture, data design, component design, Human interface Design and the requirements matrix of REMEDI.

1.1 Purpose

The purpose of this document is to outline the design views of the project which will satisfy functional and nonfunctional requirements stated in the SRS Document of REMEDI. The purpose of this document is to serve as a guideline throughout development phase of the project for developers

The expected audience includes the developers of this project i.e. BSE 20-13, the Project Coordinator, Ms. Mary Nsabagwa and the Group supervisor, Dr. Swaib Kyanda K. Developers are supposed to use this document in the development phase to the structure and design of each component. Lastly, this document could be used for designers who try to upgrade or modify the system being developed.

1.2 Scope

This Software Design Document (SDD) provides necessary information about the project (REMEDI). This document includes design principles of the software with its requirements, functionalities and necessary definitions. This information is aimed to guide any programmer to understand our design and be an assistant in the development phase.

It specifies the structure and design of some of the modules discussed in the SRS. It also displays some of the use cases that have transformed into sequential and activity diagrams. The class diagrams show how the programming team is implement the specific module.

1.3 Overview

This document is written according to the standards for Software Design Documentation explained in “IEEE Recommended Practice for Software Design Documents”.

Section 1 contains the Introduction which explains the Purpose, scope and Overview of the Software Design document for REMEDI.

Section 2 Describes the System Overview which explains the product being developed and describes the different Human Computer Interaction interfaces the system is likely to have.

Sections 3 – 5 Discusses the designs for the project with diagrams, section 6 shows samples of UI from the system, and section 7 contains the class diagrams. The appendices contain the setup and configuration needed for the system, a list of functions that are implemented in this version, and that are to be implemented in future version, and a list of tools and environment used in the entire project, along with the time contribution of team members. The appendices also include the test report and test cases.

1.4 Reference Material

http://macs.citadel.edu/rudolphg/csci656/sp16/project/csci-656-sds-ieee-1016-2009-based.docx

1.5 Definitions and Acronyms

DFD – Data Flow Diagram

HTML – Hyper Text Markup Language

ID - Identity

OS – Operating System

PHP – Hypertext Preprocessor

RAM – Random Access Memory

REMEDI – Automatic Robust Mental Health Detection Classification and Monitoring

UI – User Interface

USB – Universal Serial Bus

WHO – World Health Organisation

2 SYSTEM OVERVIEW

i) Product Perspective

The current method of detecting mental illness for individuals is by use of the questionnaire which in any case and individual might provide biased results making the conclusion either true that they are suffering the disorder or not. Secondly the family members identify it at quite a late stage and seek help from the hospitals or rehabilitation centers. At this stage it is expensive to get treatment unless one uses a public hospital like Butabika or Mulago which are limited by space.

REMEDI provides a much more improved method in addition to the questionnaire that is being used to detect a disorder in particular Depression since different mental disorders have different symptoms and different ways they are detected. This will require three parameters that include the facial emotions recognition, Speech variation recognition and early questionnaire that is acknowledged by WHO to fully determine that the person is a possible victim of mental illness. The project will also provide monitoring for the victims and other users who will be identified as possible victims of the mental disorder.

Design Method

The products design will take on the agile software development method. The different modules shall be developed by different individuals and implemented as a group after coming up with the concrete solutions.

User Interfaces

The interfaces used in this document are samples and therefore might differ from the real implementation interfaces of the actual product at the end of the project. They are mainly for the purpose of representation and also to guide the developing team on what exactly they are supposed to do as mentioned earlier in section 1.2.

- This is the user login page. If he is not a registered member, he will not have access to the system.

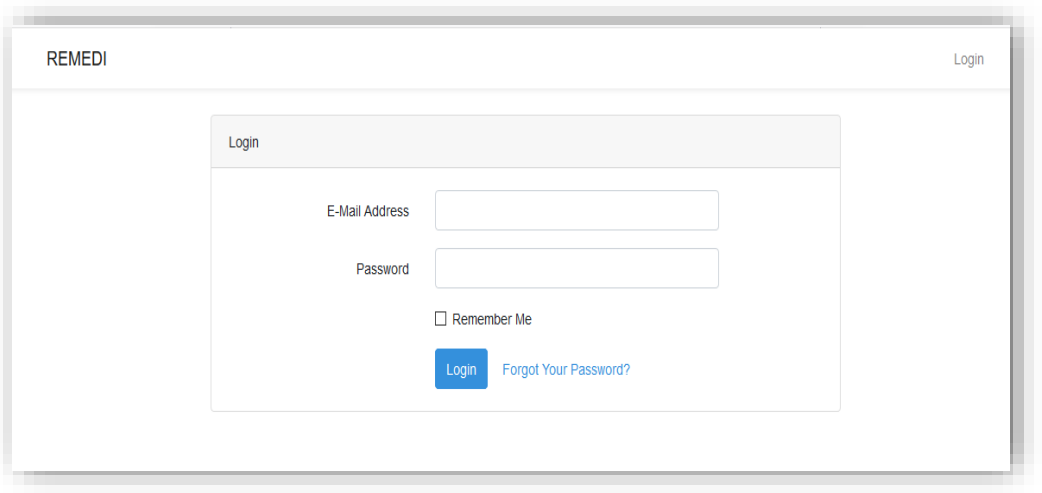


Figure 2.1. Login page for both admin and users.

- The system admin will register new user for the system from this panel.

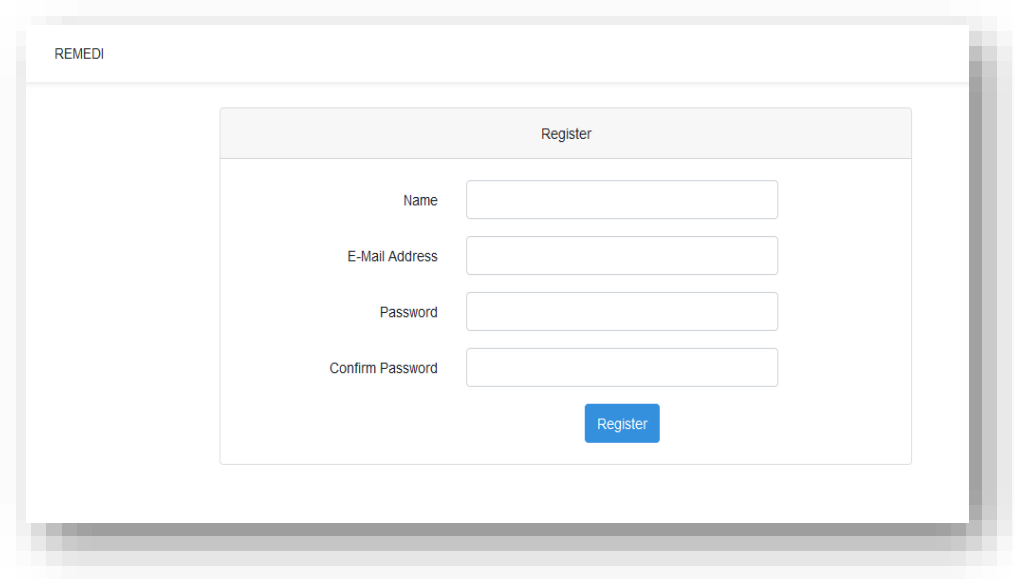


Figure 2.2. Register page for normal users.

- Registered users, on login will be redirected to the home page below. The major buttons on this page include: home, patient data, register user, add patient, help and about us.

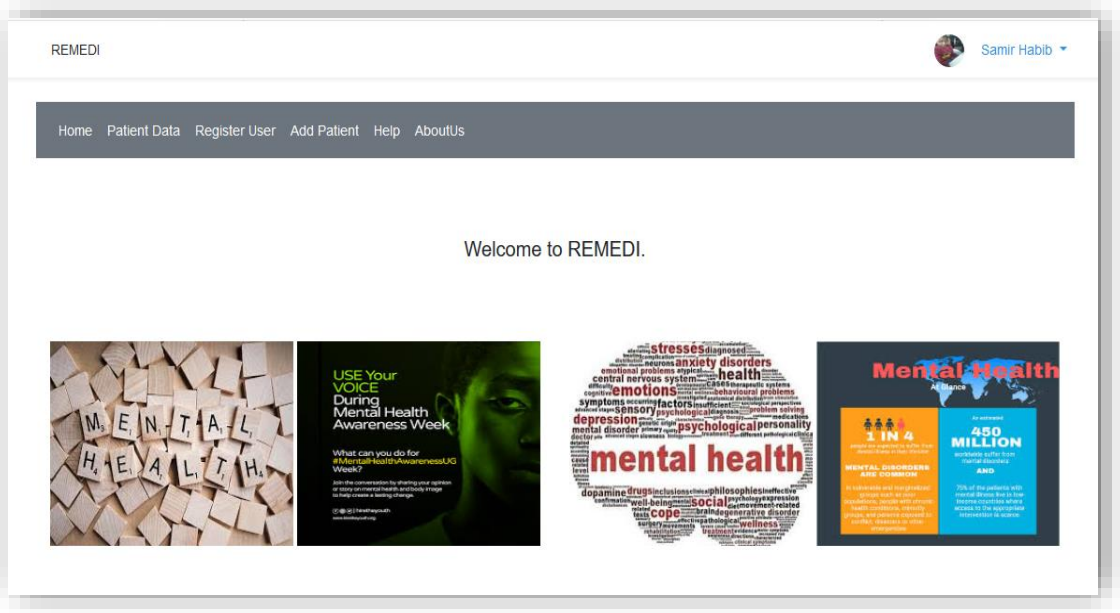


Figure 2.3.Admin dashboard

- From this page the Patient data can be viewed by the system admirations, were they can be able to manipulate the patient data through editing, adding new patient, updating and deleting the patient data.

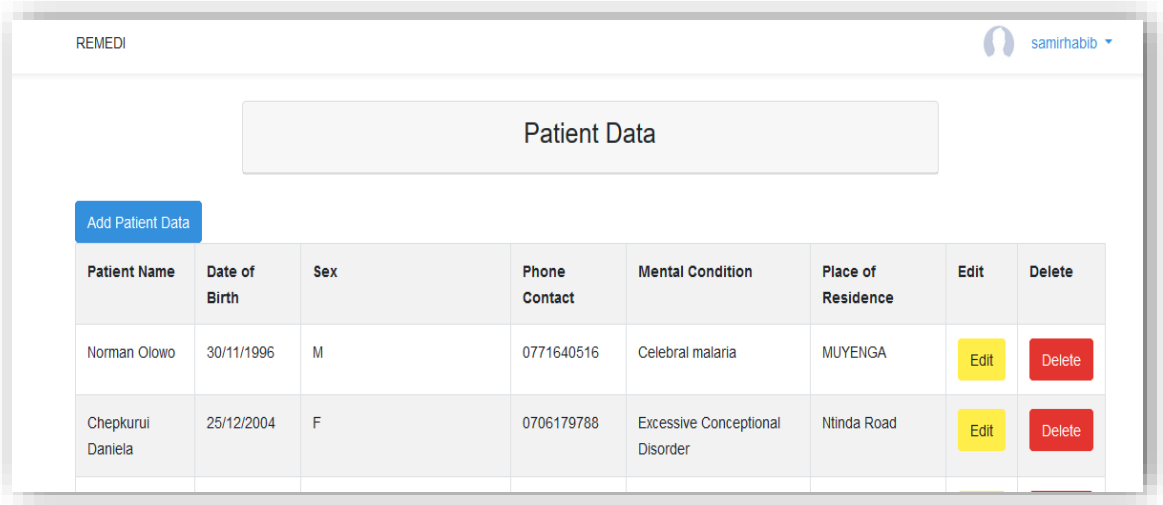


Figure 2.4. Admin panel

- This is the page that contains the form that will be used to add in a new patient/patient information into the system. All the information on this page should be filled correctly.

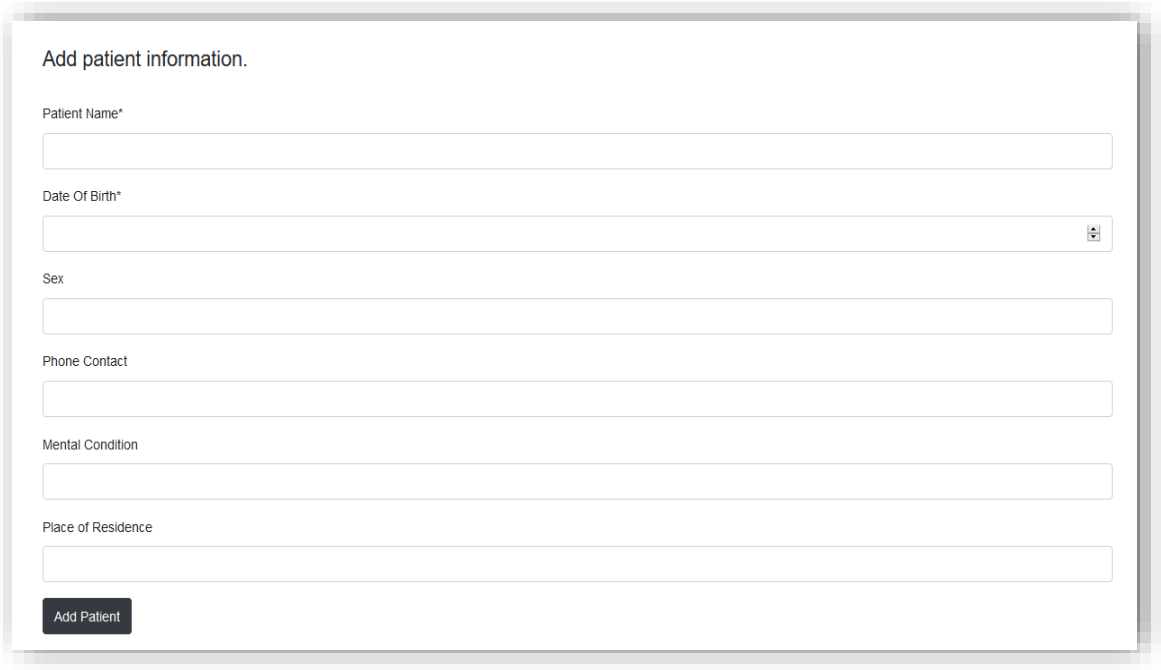


Figure 2.5. Patient registration

- From this page a user can view their health status

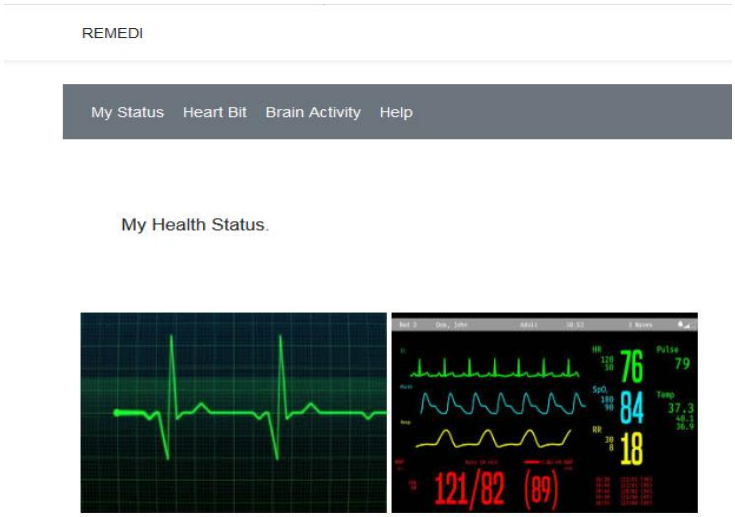


Figure 2.6. Patient view page after taking a checkup.

Hardware Interface

- The system will operate on Windows computer.
- A device with a browser that supports HTML and PHP.
- Other devices will be connected to the system through USB ports

Software Interface

- The system will work with a MySQL or Oracle database to store the user login details.
- Python program will be used to implement the system.
- Window Operating system because its user friendly.

Memory Constraint

The machine on which the program can run must have a minimum of 2GB RAM and 500GB minimum of internal hard drive this is more so for the system admins.

Communication Interface

- The system will be accessed through the web browser by the help of HTTP.
- The system will be highly responsive to the user's commands.
- The system shall also be accessible to other devices using USB ports

ii) Product Functions

REMEDI will be a fully self-contained system that will serve the following functions as stated below:

- PF1- The system should allow the admin register users.
- PF2- The system should allow users login using their User ID and given password.
- PF3- The system should allow other devices connected to it to capture data from users.
- PF4- The system should check their users for mental status using connected devices.
- PF5- The system should allow the admin submit results from the checkups done.
- PF6- The system should detect mental illness using the information from the checkup.
- PF7- The system should issue a message with results to the user who did the checkup.

- PF8- The system should classify the identified mental illness basing on the available information.
- PF9- The system should allow monitoring of the patient's status to keep track of their recovery details.
- PF10- The system should update the persons in charge of the patient's status in case the user is danger.

iii) User Characteristics

- **System admin**

  Admin has the full access to the system which means he is able to manage any activity with regard to the system. He is the highest privileged user who can access to the system.

  Key functions:

  - ✓ Manage patients.
  - ✓ Allocate resources
  - ✓ Register persons and assign user accounts.
  - ✓ Checking for system failures

- **Users/Patients**

  Interacts with the system direct.

  Key functions:

  - ✓ Enter user details
  - ✓ Watch over victims being monitored.
  - ✓ Accept checkup
  - ✓ View results
  - ✓ Receive updates

iv) Constraints/Operating Environment:

Software requirements:

- Windows 10 OS
- Linux (Ubuntu, Kali etc)

Hardware requirements:

- Core i5 processor
- 4GB Ram

- 20GB of hard disk space in terminal machines
- Webcam
- Microphone

v) Assumptions and Dependencies

- Each user must have a valid user id and password
- Server must be running for the system to function
- Users must log in to the system to access only their records.
- Only the Administrator can update records.

vi) User documentation

As a part of the system itself a user documentation is provided to the customers which gives an overview of the system. It will include the full description about the product and complete orderly followed steps to install the software. The users will get the opportunity to use the system without having any trouble. The user manual will include the email addresses to contact us in need. Tasks are listed alphabetically or logically grouped often using cross referenced indexes which helps the users to know exactly what sort of information they are looking for.

3.0 System Architecture

3.1 Architectural styles

3.1.1 The client/server based architecture.

- The client/server architecture was selected because the client/user will be required to connect to the server which can be accessed by the client computer with or without internet. The architecture also has got different application logic layers that help the users with processing tasks.
- This architecture was considered because it has a high processing speed which is facilitated by the programs and data that travels on an internal system which moves data more efficiently.
- The architecture supports an improved response time for example when a user clicks any command, the system will be capable of responding in real time.
- The client/server architecture is more secure that is to say servers have better control access to ensure that only authorized users can access or manipulate the data and server-updates are administered effectively.
- The architecture enables easy maintenance without affecting the clients of the system. Here the system can be upgraded or repaired without inconveniencing the users.

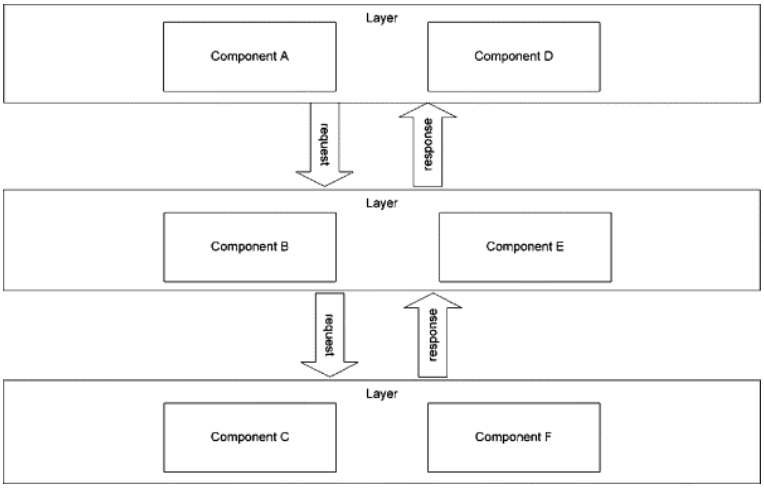


Figure 7. Basic Architecture for Client-Server without Internet

Data Flow Diagram

The diagram explains the general working process for the application/system and how the user can be able to reach the different stages of the application.

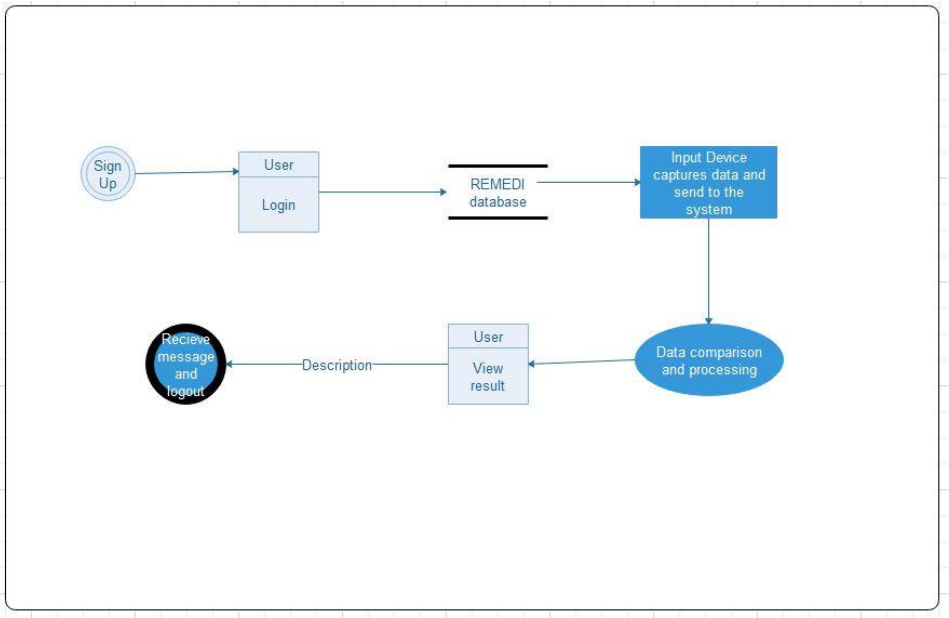


Figure 8. DFD

Decomposition Diagram

Level 0 DFD: Break down of the system usage.

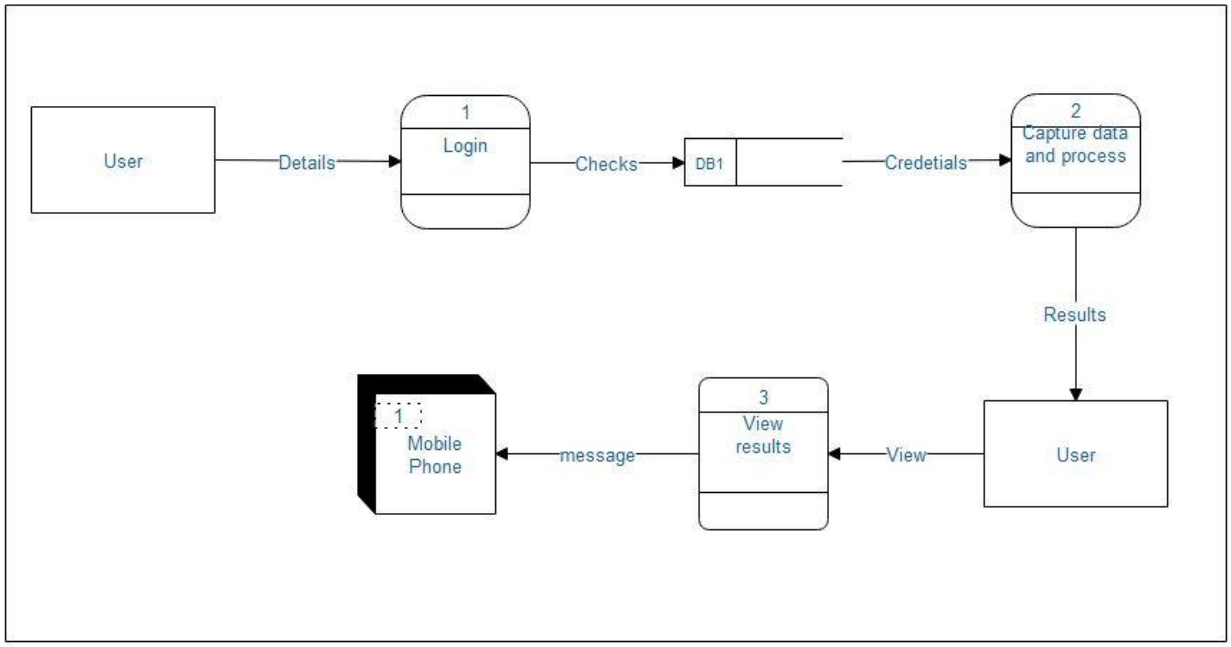


Figure 9 Level 0 DFD

Level 1 DFD

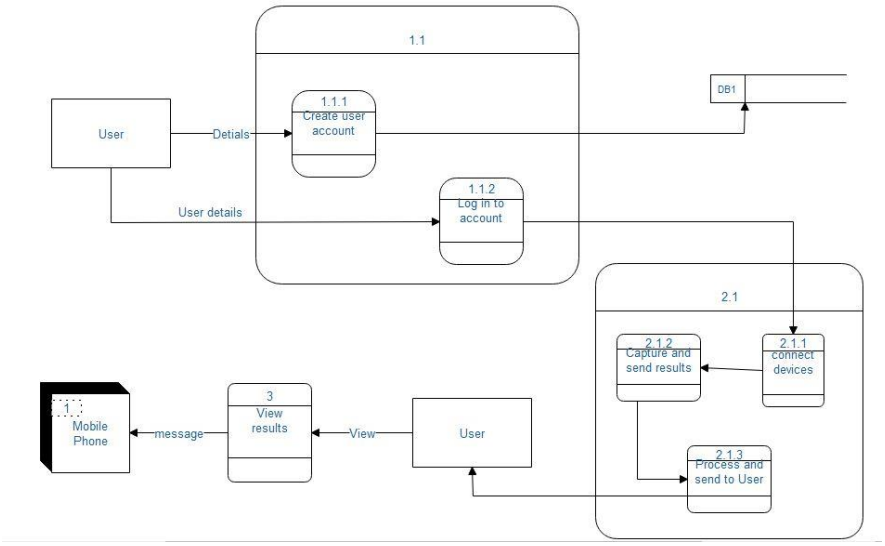


Figure 10. Level 1 DFD

3.1.2 Architectural Diagram

This diagram explains the Application Logic, Database and server processing that the product will contain.

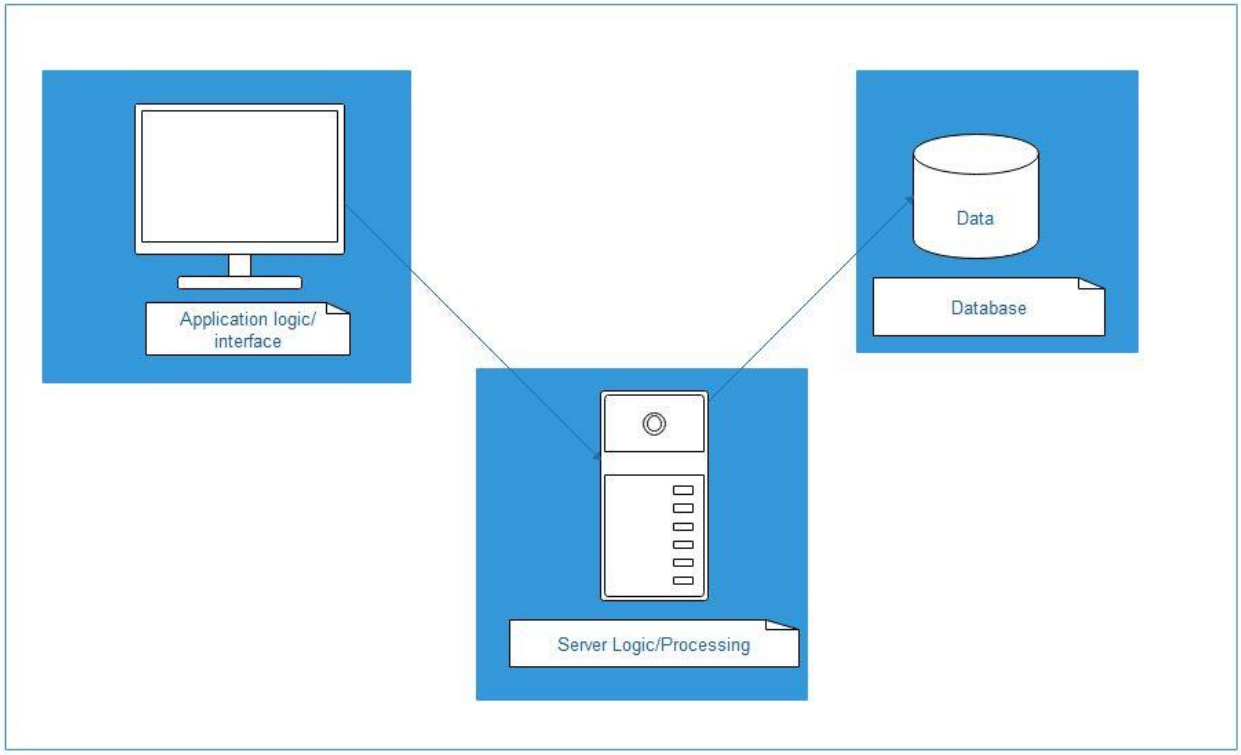


Figure 11. Model View Controller Pattern used explained in section 5.3

3.2 User interface

The system will either be a desktop application or a web app which will require the user presentation to either input data or view output and therefore this section explains the interface development for the system.

- The REMEDI application requires a graphical user interface for all users that is to say the system administrator and the other stakeholders.
- One of the design constraints is to use Python as the major programming language and Django frame work as a programming environment. All the required python packages shall be installed for the development of the system.
- The system will use datasets as the inputs to perform some computations on the data and in turn outputting a number of results.

3.3 Rational

3.3.1 Critical issues

- Data management: The system data has to be stored in a secure data base and can only be altered by authorized persons.
- System Security: The system will be only accessible to those who have logged in
- Data Privacy**:** Patience data will be accessible to only to the system admins and the patients identity should always remain anonymous.

4.0 Data Design

This section explains the data that will captured by the system using database schemas. This data might remain constant and also vary during implementation as the developers might need to do adjustments where necessary.

4.1 Data Description

Next of kin

Field	Type	Null	Key	Default	Extra
id	varchar(32)	NO		NULL	
name	varchar(25)	NO		NULL	

Figure 12. Schema 1

Patience next of kin

Field	Type	Null	Key	Default	Extra
id	varchar(25)	NO		NULL	
patient_id	varchar(25)	NO		NULL	
nextofkin_id	varchar(25)	NO		NULL	

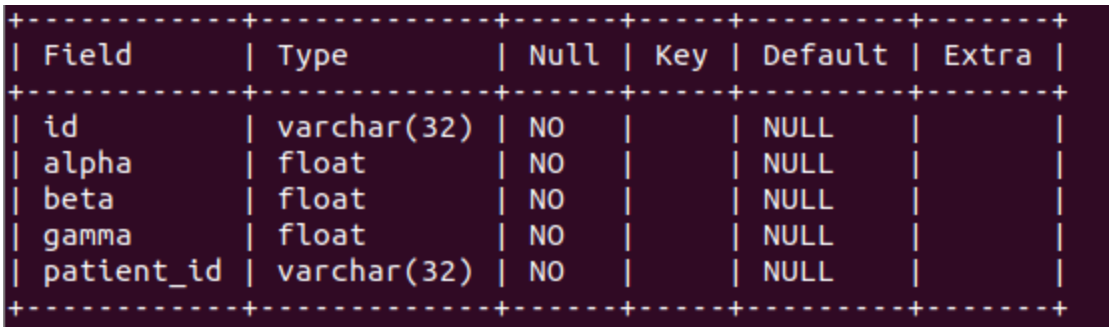
Figure 13 Schema 2

Patient

Field	Type	Null	Key	Default	Extra
id	varchar(32)	NO		NULL	
name	varchar(25)	NO		NULL	
dob	date	NO		NULL	
phone	int	NO		NULL	
username	varchar(25)	YES		NULL	

Figure 14. Schema 3

Tests



Field	Type	Null	Key	Default	Extra
id	varchar(32)	NO		NULL	
alpha	float	NO		NULL	
beta	float	NO		NULL	
gamma	float	NO		NULL	
patient_id	varchar(32)	NO		NULL	

Figure 15. Schema 4

4.2 Data Dictionary

Table 1: Data Dictionary describing a table that contains Next of Kin details

Field Name	Data Type	Field Size for display	Description	Example
Name	Varchar	20	Next of kin name	Sammy kay
Username	Varchar	15	Unique User name	Sammy
password	Varchar	15	password	Adsfasd
Next of Kin ID{PK}	Varchar	20	Next of kin ID	DFGSDGFDSSG464565YD
Phone Number	Integer	10	Phone number	0715654278

Table 2. Data dictionary of Patient

Field Name	Data Type	Field Size for display	Description	Example
Patient ID{PK}	Varchar	20	Unique ID for each patient	67T543WSREFDETR2435E
Name	Varchar	30	Full names of the employee	Chepkurui Jacob Isaac
DOB	Date/Time	10	Date of birth of Patients	15/01/2020
Phone	Integer	10	Phone Number of Patient	0789123323
Username	Varchar	15	Unique username of Patient	Jacobcheps
Password	Varchar	20	Password of Patient	Adkfjadfa12

Table 3. Data dictionary of Tests

Field Name	Data Type	Field Size for display	Description	Example
Patient ID {FK}	VarChar	20	ID of patient	SDFASDFA44
Test ID {PK}	Varchar	20	ID of test	FSDGSDFG44
Gamma Waves	Float	3	Reading of gamma waves	34
Alpha waves	float	3	Reading of alpha waves	69
Beta waves	float	3	Reading of beta waves	80

5. Policies and Tactics

5.1. Coding guidelines and conventions

The project source code implementation will follow a python programming language convention. These conventions will include indentation, comments, statements, declarations, whitespaces, naming and programming practices.

5.2. Django framework

As mentioned above the system will be developed using python programming language and a compatible Version of Django frame work will be used for the case of a web application or desktop application with the help of Meson build that open source build system meant to be both extremely fast, and, even more importantly, as user friendly as possible.

5.3. Design patterns

The implementation of the system will take on MVC (Model View Controller). As shown int the figure 11 it contains the Application logic which represents the views, the Server processing which represents the Controller and the server or database or backend which is the model.

5.4. Test plan

The system shall be tested using the unit testing and integration test methods. Here we shall be able to test the smallest unit of the verifiable software in the application and also combine individual software modules and test them at once.

The system will be tested by the development team with assistance from the project supervisor. The system testing of the most important components that may include among others the input checking and output or detection results shall be tested at all times of development to avoid backlog and giving too much work to testing after the product is done being implemented.

Other testing methods or approaches shall be used the include among others Functional, Nonfunctional Testing, System Testing, Acceptance Testing, Performance Testing, Security Testing and Usability Testing.

Testing shall be done when all the listed system requirements have been implemented. Test environment, the system will be tested on windows operating system and an android or iOS with a various sets of test data inputs.

5.5. Requirements traceability matrix

Requirements source	Requirements	Design element	Code function	Test case
Module 1 Users can be able to register, login and logout from the system.	Security measurements	Use case diagram	Login, Register and Logout.	Ensure that users provide the right credentials. Once the user logs out they are not able to view the home page without logging in.
Module 2 Admin can be able to view and add patients to the system database	Web page with admin page that has view patients and add patients buttons.	Use case diagram	View Request Add Request	Ensure that the form is filled and the information is sent with a success message displayed.
Module 3 User can send their information to the system data base.	Web page with a form the user can fill in.	Use case diagram	Send	Ensure that the patient form is filled and the information is sent with a success message displayed.
Module 4	Credentials for admin user	Use case diagram	Login	Ensure that only the administrator's

Only the admin user should be redirected to the admins page and other users are directed to their home page	and a non admin user			credentials can access the admin page.
Module 5 Users who logged in can view jobs.	Some jobs request must have been sent	Use case diagram	Jobs	Ensure that the system can display jobs on the jobs page.
Module 6 Users who have logged in can edit their profile	User must have registered and have a user account.	Use case diagram	Choose file	Ensures that the users can be able to update their profile picture.
Module 7 Administrator is able to add, edit and delete transporter data.	There should exist some data in the data base.	Use case diagram	Edit, Delete and Add	Ensure that each of the functions, that is Add, Delete and Edit is completed with a success message.

SYSTEM IMPLEMENTATION, TESTING AND VALIDATION REPORT FOR A ROBUST DEPRESSION DETECTION CLASSIFICATION AND MONITORING SYSTEM (REMEDI)

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Version: 1.0

Document Approval

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Chapter 1: Introduction

The field of automatic facial expression analysis has made significant gains. Early work focused on expression recognition between closed sets of posed facial actions. Tian, Kanade, & Cohn [1], for example, discriminated between 34 posed action units and action unit combinations. More recently, investigators have focused on the more challenging problem of detecting facial action units in naturally occurring behavior [2-4]. While action unit detection of both posed and spontaneous facial behavior remains an active area of investigation, new progress has made possible several new research directions. One is the dynamics of facial actions [2, 5-8], which has a powerful influence on person perception [9, 10] and social behavior [11], The packaging of facial actions and multimodal displays, a concept originally proposed in the infancy literature [12], is an especially exciting development. Some work by Tong, Liao, and Ji [2] and Messinger, Chow, and Cohn [13] addresses intra-modal and inter-personal coordination of facial actions. This work and others suggest that continued improvement in AU detection and science of behavior is likely to benefit from improved modeling of face dynamics. Applications of automatic facial detection to real-world problems is a second direction made possible by recent advances in face tracking and machine learning. Several studies have shown the feasibility of automatic facial image analysis for detecting pain, evaluating neuromuscular impairment, and assessing psychopathology. Littlewort, Bartlett, & Lee [14] discriminated between conditions in which naïve participants experience real or simulated pain. Ashraf and Lucey et al. [15] detected pain on a frame-by-frame basis in participants with rotator cuff injuries. Schmidt [16] investigated facial actions in participants with facial neuromuscular impairment. Yang and Barrett et al. [17] investigated feasibility of automated facial image analysis in case studies of participants with Asperger's Syndrome and Schizophrenia. Investigators in psychology have used automatic facial image analysis to answer basic research questions in the psychology of emotion [10, 18, 19].

1.1 Background and scope of the project

REMEDI focused on the detecting of depression or major depressive orders targeting all users who may be in need of knowing their mental status and monitoring. The focus here is basically on the Moods of the person using Facial recognition and Voice recognition (speech) in a given situation which we assume the user will not be biased. The project focused on using a mobile application

for Monitoring the users identified with illnesses and also uses early methods used in clinical analysis which uses the Hamilton Rating Scale for Depression.

1.2 Overview of the document

This document describes the implementation, testing and validation findings for The **Robust Mental Health Detection Classification and Monitoring system (REMEDI)** the It is divided into the following sections:

Section 1: This section gives an overview of the above-mentioned system and the document as a whole.

Section 2: The section offers a brief overview of the system specifications, version of requirements and version control as well as the inputs and outputs of the REMEDI system. The section as well entails the functionality, limitations and safety, default settings, assumptions, and special requirements of the system.

Section 3: In the section, a description of the design output in terms of the implementation, utilities for validation and testing is provided.

Section 4: The section is concerned with the inspection and testing of the system. A testing overview is provided, performances and test plans, test objectives are given.

Section 5: This section provides details about the installation and user system acceptance test where the input files, supplementary files, installed components, and installation qualification of the REMEDI system.

Section 6: This section outlines the Performance, operation and maintenance of the REMEDI system.

Section 7: This section provides the conclusion and recommendations of the REMEDI.

Chapter 2. System Specifications

This section describes and specifies the system completely and also acts as the basis for system validation and verification.

2.1 Version of requirements and Version Control

The Software Requirement Specification Document Version 1.0 and 2.0 suggested some requirement that were considered for the project implementation but with research and a few developments, some of the suggested requirements were eliminated and some adjustments were made as shown below.

Some of the devices the requirements that include Helium Element Access Point (Cellular), Helium Atom Xbee Module, Helium Arduino/mbed Adapter, NeuroSky Mindwave Mobile 2, Seed Grove GSR Sensor, Pulse Sensor and SparkFun Bluetooth Modem - BlueSMiRF Gold were removed due to the complexity and the cost of acquiring them.

The following were considered:

2.1.1 Webcam

The user can use the camera enabled on their laptop on which the desktop application is installed in case the laptop has an enabled webcam. Alternatively, one can acquire a webcam with the following specifications described:

Webcam provides high-definition 1080P video and image, make your video more elastic and purer than ordinary 720P webcam, high quality and light correction, glass lens and Full HD function, means that the image is clear, vivid and colorful. Streaming Computer Web Camera supports manual focus, which is more user-friendly. The camera is Plug & play, easy to use, work with Windows 7/8/10, Compatibility with Mac OSX, Linux, Chrome OS, Ubuntu and Android 4.0 or higher operating systems.

Figure 16. USB Webcam

2.1.2 Microphone

The microphone captures sound from the environment and turns them into signals that will be interpreted by the system. Vocal prosody is majorly capturing the variations in the sound produced by an individual. Our system looks to use a microphone that will capture such with high precision and provide for cleaning noise from the environment so as to provide better quality analysis.

2.1.3 Other requirements

These may include wires and drives required to connect the devices to the system host.

2.1.4 Version Control

The team used GitHub as version control mechanism for this project. We leveraged the usage of branches where every new modification on a requirement version was done on one branch which was later tested and merged to the main master branch which as we compile this document has the latest and final version of this system.

The GitHub link to the project is

https://github.com/BSE20-13/REMEDI

2.2 Input

The system was initially estimated to take in three inputs that is to say data from a Pulse sensor, data from a Skin Response sensor and also data from the Brain Emissions sensors. Due to some research that was done mainly during the implementation phase the inputs were adjusted to provide a product that is less costly and easy to implement. The team came up with the following inputs to suit the project:

2.2.1 Facial image recognition: the system takes in data from the facial expressions of the user in a given state to ensure accuracy of the data captured. This will help in defining the moods in which the user is. This input provides an image with emotions captured by a camera.

2.2.3 Speech Recognition: the system considered the variations in speech to predict the depressive symptoms in individuals. Human's voices are believed to have different tones and variations when in different states or moods as stated later.

2.2.4 Questionnaire: the system also considered the basic metric used to measure persons' mental health by normal standards. The questionnaire used is based on Hamilton Depression

Scale (HMRSD) which is used by Health Researchers and patients for self-report. This questionnaire is deployed on the mobile application designed for this project.

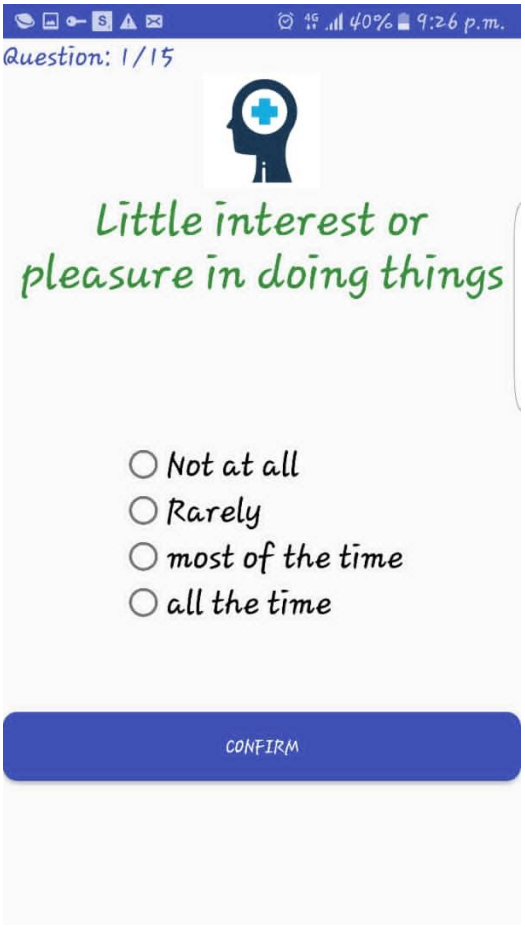

Figure 17. Sample Question on the application

2.3 Output

The system has mainly three types of outputs, Facial Image with emotions detected, a graph to represent the different plots of the prediction analysis and a prediction message as detailed below:

2.3.1 Facial Image with emotions

This output utilizes the monitor of the user to provide a visual image of the face as its being captured with the specific prediction as show in the photo below.

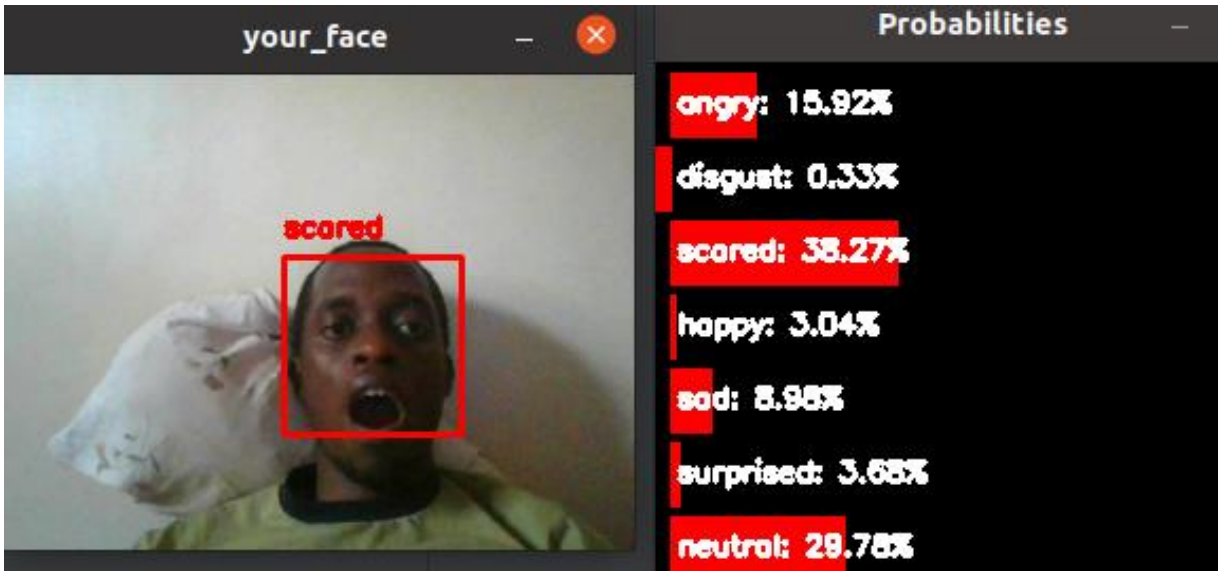

Figure 18. Emotions Prediction

2.3.2. Graphs

This output is displayed on the user's display as well. The graph basically displays the different variations on the user data acquired from speech variations and the Image detection. The predictions are based on the graphs drawn. The display below shows how the graph appears.

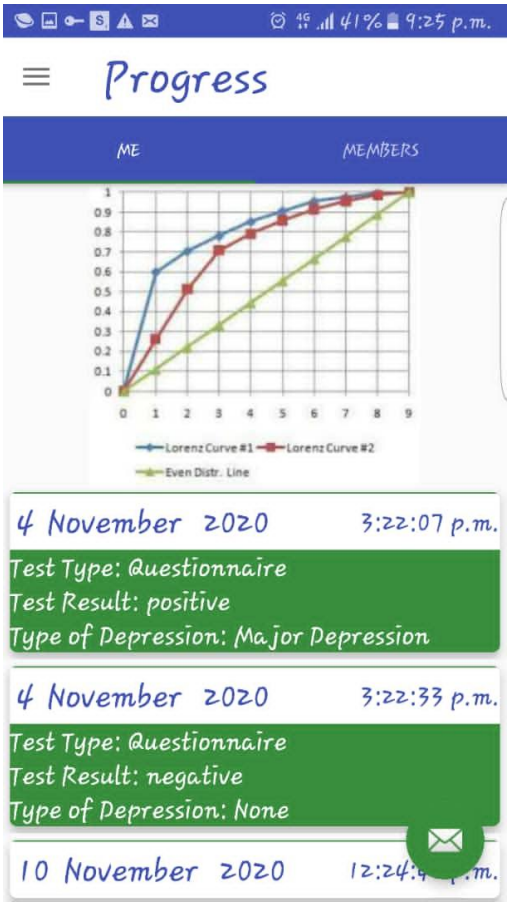

Figure 19. Graph shown in the mobile application and a display of the results from the questionnaire

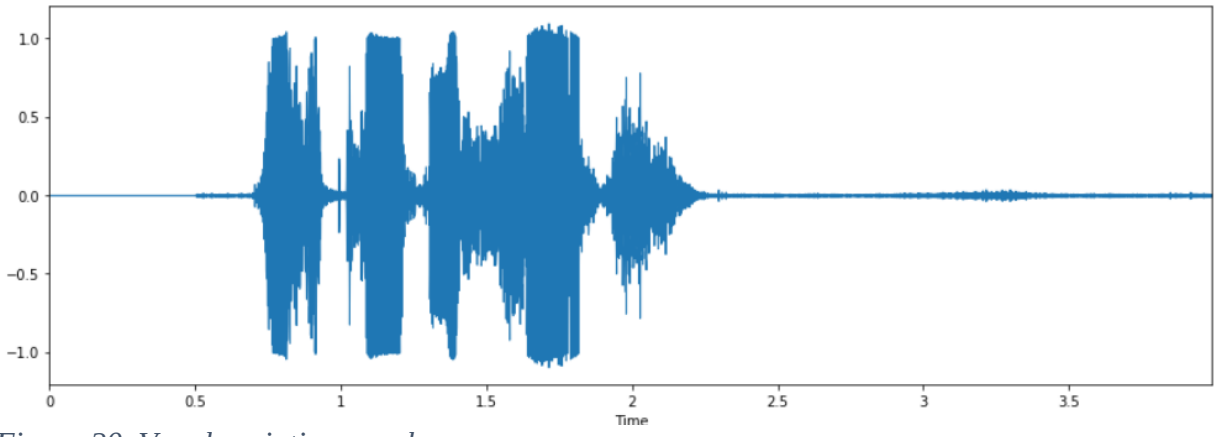

Figure 20. Vocal variation graph.

2.3.3 Message to User

This output is as a result of the prediction that is made by the different parameters that have been considered and analyzed. This is a text message sent to the user with the possible results of the prediction. The image below shows a simple representation of the display.

REMEDI: The results from the test are Negative. You are advised to do regular exercise and eat healthy foods.

2.4 Functionality

2.4.1 Measurements

The system provides a quick and easy mechanism for measuring user's mental health using simple devices like camera and microphone to capture images and sound. The system provides the clearly marked ***TEST*** button which a user presses to acquire measurement. This will take a few seconds to complete.

Given the fact that the information handled by the system is health data it is much more sensitive and requires handling with a lot of confidentiality and privacy. The following considerations had to be taken into account:

- **Privacy:** Before, during, and after the data acquisition, sensitive data about the users must be protected and secured to safeguard their privacy. Users need to be informed about the type of data being collected, the intended use, and the implications. The system considered anonymizing the user's data as a way to keep users' privacy.
- **Storage:** This is how the data is handled and stored during and after the data input process. The data is stored in the internal device memory and sent as a CSV periodically to the system storage.
- **Transmission:** This is how the data is sent from the sensor devices to the computer where the analysis will take place. The data is copied from the device to a host computer with the system through a wired connection (e.g., USB, serial port, etc.).
- **Energy consumption:** This aspect was considered since energy consumption has an impact on usability and data quality and quantity. Collecting data from more sensors and at higher sampling rates provides more information for the analysis causes devices to

decrease their battery life and perhaps discouraging users to participate. At the predictive phase, some or all preprocessing is performed locally on the devices.

- **Data labeling:** In order to learn and find patterns, machine learning algorithms require training data. They rely on the amount and quality of data to generate good predictive models. The data labeling phase consists of tagging the sensor data with their corresponding ground truth state. Normal labeling method were used for this system.

2.4.2 Input Analysis

The system provides automatic analysis of the measured data. The system examines the data it receives from the Image and Voice recognition and then subject it to a standardized algorithm within. This algorithm then deduces the person's mental status is detected given the deviations from standard model it uses.

Exploratory Data Analysis (EDA) was used for this project and the system basically uses a histogram as a data visualization technique. The EDA was also used to detect outliers and identify missing values due to sensor malfunctioning.

Supervised learning algorithms were used for the machine learning and training model inputs and outputs from different sources were used. Supervised learning classifiers have been used for mental states detection are that included Decision trees, Support Vector Machines (SVM), Naive Bayes-Nearest Neighbors (KNN), Artificial Neural Networks and Linear Discriminant Analysis. Vocal analysis was by audio signal processing with a logistic regression classifier

2.4.3 Results display

The system considered displaying results on the user's screen inform of graphs and facial images as shown in the photos in the sections above. Other results included as stated below:

- **SMS Notification:** The system provides a mechanism of alerting the User via SMS of their mental status or state. The user will be notified in an SMS on their phone.

2.4.4 Powering

The system comes with a powering mechanism, a power button is attached on the side of the device which toggles between the ON and OFF states of the system. The system also provides a reset button which MUST be pressed every time a measurement is about to be taken, this clears out the previously measured values that may still be stack inside the system's sensors' memory and may introduce noise to the new measurement.

2.5 Limitations and safety

The system has limitation of energy/power, it simply cannot work when it is not powered up with at least a 5.0V source.

The system may not function as intended when the powering is insufficient (i.e. <5.0V) for all the components that require it. The system may fail when the powering is too much (i.e. >12V).

The user is also advised to pose in an angle where the facial image can be captured well plus the environment should have minimal noise for the voice to be captured well.

The User should keep the devices dry and away from liquid contact, for example it should not be used under strong rains where water can easily enter inside it. Water being a good conductor easily destroys the system electronic components especially if the system is powered.

2.6 Default settings

The system assumes the user is neutral by default that is to say the user is neither positive of Depression nor Negative so the results achieved from the data acquisition determine the state which is sent to the User as message. Other defaults are a user has no account so the administrator creates an account for them to use and user provides the basic data needed during the sign-up process.

2.7 Special requirements

The system has special requirements mainly to ensure security of the users' data and information provide is safe and also minimize error rates. Some are discussed below.

2.7.1 Webcam with Microphone

The webcam for image and speech recognition to predict the emotions of the user. This requirement is crucial for the system.

2.8 Errors and alarms

In case the focus is not good or the sound is not clean thus has much interference, the system warns the users of inconsistencies in the results and advises to correct the focus.

Chapter 3: Design output

3.1 Implementation (coding and compilation)

The system uses a Model View Controller (MVC) architecture, where the interfaces are represented in the views, the backend is in the controller and the model which allows communication among the components as show in the diagram below. The Controller module uses system host hosted on a computer. The models were developed in python language using Machine learning techniques.

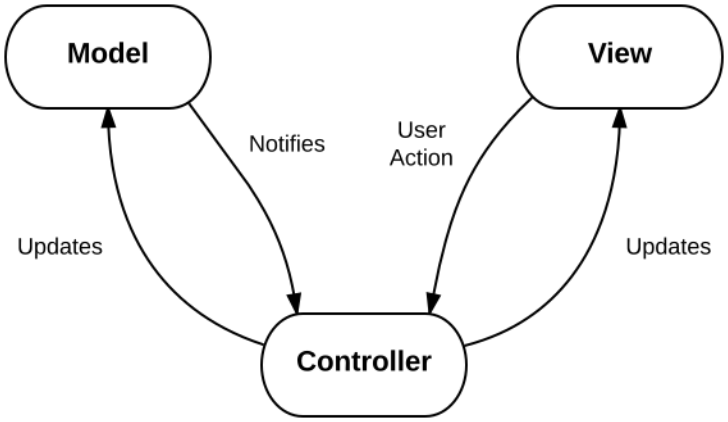

Figure 21. MVC Architecture used for the system

3.1.1 Models

Manages the data and defines rules and behaviors. It represents the business logic of the System. The data is stored in the Model itself and it does the processing and analysis thus it acts as the backend processing for the data collected for the predictions. The model for the project was developed in python.

3.1.2 Views

Presents the data to the user. A View can be any kind of output representation: a HTML page, a chart, a table, or even a simple text output. The system has various views that include the web page, graphs and a text message.

3.1.3 Controller

The controller logic is stored in the system modules that do the processing and analysis of the data received from input devices.

3.4 Documentation

The following documentation has so far been submitted in support for this project and its running:

Project Proposal/Concept Note: This document contained the major idea of the Automatic Mental Health Detection System, its purpose and benefits that system is adding to the users and the community at large.

Software Requirements Specification Document (SRS): This document detailed the users' basic needs of the system that has been developed and the specific outcomes that were projected to be in the system.

Research Paper: This document contained the results from the data collection and findings that were done at the different rehabilitation centers and mental Hospitals that were visit.

Software Design Document (SDD): This document completely describes the system at the architecture level, including subsystems and their services, hardware mapping, data management, access control, global software control structure, and boundary conditions.

Table 4. Design details

Topics	**Design output**	
Good programming practice	Source code is... ☑ Modulized ☑ Encapsulated ☑ Functionally divided ☑ Strictly compiled ☑ Fail-safe (handling errors)	Source code contains... ☑ Revision notes ☑ Comments ☑ Meaningfull names ☑ Readable source code ☑ Printable source code

Topics	**Design output**
Dynamic testing	☑ All statements have been executed at least once ☑ All functions have been executed at least once ☑ All case segments have been executed at least once ☑ All loops have been executed to their boundaries ☑ Some parts were not subject to dynamic test Comments: The libraries used are also indicated.

Chapter 4: Inspection and testing

4.1 Introduction

Inspection and Testing are part of the way's developers ensure a reliable and strong product before they deploy it or host it for the clients/users to make use of it. We used these techniques to come up with a product that will suit the needs of our users by testing all the components using the methods and types of testing as discussed below.

Table 5 Inspection plan and performance

Topics	**3.3.1 Inspection plan and performance**	*Date / Initials*
Design output	☑ Program coding structure and source code ☑ Evidence of good programming practice ☑ Design verification and documented reviews ☑ Change-control reviews and reports Comments: For the system ad mobile application	20th September 2020 KJA CJI
Documentation	☑ System documentation, flow charts, etc. ☑ Test results ☑ User manuals, On-line help, Notes, etc. ☑ Contents of user manuals approved Comments: Not all the documents were completed by then	28th November 2020 ON KJA

Topics	**3.3.1 Inspection plan and performance**	*Date / Initials*
Software development environment	☑ Data integrity ☑ File storage ☑ Access rights ☑ Code protection ☑ Installation kit, replication and distribution Comments:	30th November 2020 ON CJI SH
Result of inspection	☑ Inspection approved Comments:	2nd December 2020 KJA, ON SH, CJI

4.2 Test plan and performance

As part of the delivery of the REMEDI, it was required that the solution meets the acceptance criteria, both in terms of functional and non-functional requirements. The purpose of this section is to provide an outline for non-functional testing of the REMEDI solution. It also provides a high-level overview of the performance testing approach that was be followed for the REMEDI Project.

The test plan was created during the development phase and all elements that are about to be tested were identified. The test plan explicitly described what was tested, test scenarios, test cases and expected results were identified. Evidently the test plan confirmed what was done, what the result was, and if the result was approved. Some tests were done as the modules were being developed.

4.2.1 Test objectives

This section entails the objectives of the testing and validation process that was undertaken to ensure the product meets the standards as required by the users.

Functional correctness:

A demonstration was conducted to prove whether the REMEDI system conformed to the required functionality. These were done several times during the implementation phase and also during the validation exercise

Service Level

The system was verified that it supported the required service level of business. This included system availability and reliability, load and responsiveness.

Usability

The team validated that the system met the required levels of usability. Here we used the Context Inquiry method to obtain information about the user experience from the general public. Test participants were first asked a set of questions about their experience with a product and then observed and questioned while they work in their own environments.

Security

Given the fact that the system will be handling sensitive data concerning people's health, it had to be verified for security checks to ensure the users remain as anonymous as possible with their information not being exposed to others.

Table 6. Test objectives for REMEDI

Category	Objective	Tested component(s)
Functional Correctness	➢ Ability to detect the person's face targeted for the test. ➢ Ability to capture the emotions voice in someone's speech. ➢ Ability to interact (communicate) with the user. ➢ Ability to send SMS to users.	Webcam with Microphone Output devices (LCD).

Service Level	➢ Verify response time of less than 10 seconds for measuring, analysis and result output.	The entire system
Usability	➢ The REMEDI can be used without a lot of effort and resources spent in training the users. ➢ The system features and usage can easily be recalled.	The entire system and all the procedures.
Security	➢ User data is safe from being used or hacked into due to leaving it anonymous	Data Stores

4.2.2 Scope and Relevancy of tests

Scope

The entire system was tested (using System testing technique) and its components including the modules (where Module testing was employed) that were developed in the backend to ensure all the functionality is as described and the different devices that are used to get the test results from the user were tested for powering ability and reaction towards different shocks. The data stores were also tested for their capability to handle data.

The team also tested the Entry (What the user is required to have before they can use the system) and Exit Criteria (what the user must have done before the system completes the predictions) of the system.

Relevancy

Validation tests were carried out to demonstrate to the developer and the system user that the REMEDI meets its requirements. Successful tests showed that the system operates as intended. The test was also intended to discovered defects in the software where its behavior was incorrect or not in conformance with its specification.

4.2.3 Levels of tests

There are basically four levels of tests that are used during the development phase and during testing as well using white box and black box where the technique is applicable. The team employed these four levels that include Unit/Component Testing, Integration testing, System testing and Acceptance testing as shown in the table below.

Table 7. Levels of testing carried out on REMEDI

Testing Level	**specification**	**General Scope**	**Opacity**
Unit/Component	Low-level design: actual code	Files and modules	White box
Integration	Low-level design: High level design	Multiple files and modules	White box, black box
Functional/System	Requirements Analysis	Whole system (REMEDI)	Black box
System acceptance	Requirements Analysis	Whole system in Environment	Black box

4.2.4 Types of tests

Performance testing

Software performance testing was carried to determine the speed or effectiveness of REMEDI. It was discovered that it took about 10seconds for the entire data acquisition, analysis and feedback process to be completed. It was also noted that the results were reliable since they varied consistently depending on the different levels of composition of ethanol in our test subjects.

Usability Testing

First time users with experience of using the system were allowed to interact with the devices by directing them on how to power on the device, take a measurement shot and interpret feedback.

The reaction was very good since the second time to the user repeated process accurately without additional directions.

Acceptance Testing

A formal test was conducted to determine whether or not the REMEDI satisfies its acceptance criteria and to enable the customer to determine whether or not to accept the system. The users were satisfied with the since it met its requirements.

Conformance Testing

The system was tested and given the test results; it was deduced that the implementation conformed to the specification on which it was based. This testing process was performed by testing team**.**

Standardized measurement model Testing

We also tested whether our standardized measurement model works for every person, since

4.2.5 Sequence of tests

There a number of test cases that were done on the system and the details are discussed in the tables below.

Table 8. REMEDI test case 1

Test Case 1	Powering process of the device
Purpose	Verifying device power up using the power button.
Prerequisites	Assumptions that the device is powered up using a >5.0V buttery.
Test Data	Power from a given source
Steps	● Press the power button on the device.
Expected Results	The device to light up light up.

Table 9. Test Case 2

Test case 2	The webcam with microphone to obtain the data.
Purpose	Verifying whether the devices take the measurement and takes them correctly
Prerequisites	Device is fully powered up. And user has answered a questionnaire via the mobile app.
Test Data	Facial image, speech variations
Steps	● For the webcam the use sits Infront of it ● Press the take measurement button. ● Wait for the flash shot to complete ● Wait for a second and observe the output on the LCD screen.
Expected Results	The devices successfully measure reflected light from the target.

Table 10. Test case 3

Test Case 3	Testing Output components when the user has depression symptoms .
Purpose	Verifying whether the output components give the right feedback upon a positive test
Prerequisites	A measurement shot has been made.
Test Data	Measured data
Steps	● Take the measurement shot ● Observe output devices

Expected Results	LCD displays the emotions predicted by the system and a graph of the different data is drawn. A message is sent.

Table 11. Test Case 4

Test Case 4	Output components when the user has no depression symptoms
Purpose	Verifying whether the output components give the right feedback upon a negative test
Prerequisites	A measurement shot has been made.
Test Data	Measured data
Steps	• Take the measurement shot • Observe output devices
Expected Results	LCD displays a normal graph A message stating results is sent.

4.2.6 Configuration tests

When the test was done, we validated how well REMEDI supports on different types of hardware (Webcam, LCD etc.) and software environments that include the applications to access the desktop after deploying it. The result showed that the system was compatible to all the specified hardware and software platforms.

4.2.6 Calculation tests

Calculation tests were made using test data from individuals that had Depression symptoms, we observed that different all these yielded varying and consistent outputs

4.3 Precautions

4.3.1 Anomalous conditions

There is a possibility of anomalous conditions coming up while the system is in use and this may affect the performance of the system. The system uses information collected from users and incase of failure to work properly or biasness in the user input the predictions might be wrong. The other cause of the possible anomaly is in case the user doesn't follow the right way of using

the devices that are connected to the system which may result into malfunctioning of the system. The sms notification might fail to be sent in case there is no active connection to the internet available for the user.

4.3.2 Precautionary steps taken

The team agreed that we cannot archive 100% working without any anomaly but these can be minimized and the system tries to errors. A few precautions are listed below for the user to follow so as to achieve better results from the predictions.

The user should connect the devices well as will be shown in the user manual and ensure there are powered and in good state. The manual is in the lower sections of this document.

The user is also cautioned to avoid being biased so as to get better results from the predictions and ensure for the speech there is less noise in the environment, they are working in.

Chapter 5: Installation and system acceptance test

The validation of the installation process ensured that all system modules were properly fitted configured and installed in the host casing/ system and that the user obtained a safe and complete setup.

5.1 Input files

Image

The camera captures an image/video in the format jpeg, png, gif can be used for analysis by the system. The images are interpreted and used in a compatible format with the system.

Voice

The user's vocal variations are recorded by the microphone and sent in audio formats such as MPEG, mp3 and WMA to be analyzed and represented.

Questionnaire

The system utilizes a questionnaire that scores the user on completion and detects the first signs. The questions are structured and rated basing on the HMRSD.

5.2 Supplementary files

Other files include the trained dataset files that are stored by the system. These are in .hex formats.

5.3 Installation qualification

The system requires the user to download the installation file to their computer and attach a microphone and a camera and lastly also acquire the mobile application so as to access the rating scale with the questionnaire.

Table 12. Checklist of the Installation and system acceptance test

Topics	**Installation summary**
Installation method *Automatic or manual installation...*	☑ Automatic - installation kit located on the installation media ☐ Manual - Copy & Paste from the installation media Comments:
Installation media	☑ Diskette(s) ☑ CD-ROM ☑ Source disk folder (PC or network) ☑ Download from the Internet Comments: Download the app and also the image file from the internet
Installed files	• DBK files • HEX files • PWI files • Plg files • BAK files • Opt files

Table 13. Installation Procedure Check

Topics	**Installation procedure**	*Date / Initials*
Authorization	Person responsible: Kafeero Jonah Augustine	4TH Dec 2020 KJA

Topics	**Installation procedure**	*Date / Initials*
Installation test	☑ Tested and approved in a test environment ☑ Tested and approved in actual environment ☐ Completely tested according to test plan ☑ Partly tested (known extent of update) Comments: The system was not completely tested to exhaust all components.	5th December 2020 ON CJI SH

Chapter 6: Performance, servicing, maintenance, and phase out

At this phase, the REMEDI system was in use and then subjected to the requirements for service, maintenance, performance, and support. All activities during performance resided and decisions about changes, upgrades, revalidation, and phase out were made with the stakeholders involved.

6.1 Service and maintenance

The device casing containing all the components firmly fitted with screws should not do not need servicing. The battery should be continuously replaced preferably a 9.0V camera battery. The camera should always be check to ensure the lens is functioning well.

Future Updates

We may update the system to include treatment of the patients. i.e. the system can have antidepressants and other treatment methods to help reduce depression or even treat it. We hope to also work on extending to other forms of mental health like bipolar disorder.

6.2 Performance and Maintenance

The system takes a total estimated time of 3 seconds to take a measurement shot, analyze the findings and provide feedback to the user. If the device takes way longer than that or does not respond at all, a power connection should be checked and it should be carefully examined if no variations have happened accidentally for some reason disconnected. For the system to work best with maximum performance, the user must ensure the focus of the camera is good at all times such that the image captured is clear enough to bring out the details required for the analysis. The user is also advised to ensure the usage of the microphone in a noise free environment to avoid sound interferences.

The hardware (Camera and Microphone) may malfunction when exposed to liquids like water, the device should hence not be operated in liquid environments.

Table 14. Performance and maintenance details

Topics	**Performance and maintenance**	*Date / Initials*
Problem / solution	The camera image captured was poor quality and the emotions captured were miss represented. This problem was addressed by replacing the camera with that of better resolution.	30th Nov 2020 KJA
Functional maintenance	The SMS module and services are described in a set of standards governed by ETSI. Hence the are mast of operation will need to be situated with cell towers that support and conform to such standards.	30th Nov 2020 KJA CJI
Functional expansion and performance improvement	For the system to work well the user is advised to work upon the following; • Ensure enough RAM to run he application i.e 4GB and above. • Make the setup smaller in size but more reliable	

Chapter 7: Conclusion and Recommendations

7.1. Conclusions

We investigated the relation between facial and vocal behavior and clinical diagnosis of depression. The clinical interviews elicited nonverbal behavior that mapped onto diagnosis as determined from verbal answers to the HMRSD availed on the mobile application REMEDI. The findings suggest that depression is communicated nonverbally during clinical interviews and can be detected automatically.

Our detection come up with a few findings that firstly include that the emotions expressed by individuals in given conditions or situations communicate their mental states a lot. For all the participants in our testing their results communicate a lot the conditions they were going through. Secondly, the variations in individuals' voices also does portray a message about their conditions. This is because the voice of the participants varied a lot when subjected to different mental situations.

Lastly, multimodal fusion may well improve depression detection. In expression recognition, face and voice are known to be complementary rather than redundant. For some questions, one or the other may be more informative. In psychopathology, nonspeech mouth movements have been implicated in subsequent risk for suicide. Face and voice carry both overlapping and unique information about emotion

7.2 Recommendations

Although the use of a highly social context confers advantages in terms of ecological validity, it also presents a number of limitations. First, interviews in general are less structured than the capturing images of emotions and speech variations. All participants were asked the same questions, but how much detail they used in responding and the extent of follow-up questions asked by the interviewer varied during the data collection phase. Unlike with images and speech, it was also possible for participants to influence the experimental context with their own behavior. For example, recent work found that the vocal prosody of interviewers varied with the symptom severity of their depressed interviewees

Second, the specific emotions analyzed in this study (i.e., about depressed mood, feelings of guilt, and suicidal ideation) likely colored the types of emotions and behaviors participants displayed, e.g., these emotions may have produced a context in which positive affect was unlikely to occur.

Future studies might explore the behavior of depressed participants in social contexts likely to elicit a broader range of input like brain activity, skin response and heart rate. The facial behavior and speech variation may change as a function of time, e.g., participants' feelings and goals may change over the course of an interview.

Finally, although the current study represents an important step towards more comprehensive description of facial expressions in depression, future work would benefit from the exploration of additional measures. Specifically, future studies should explore depression in terms of facial expression intensity, symmetry, and dynamics, as well as other aspects of facial behavior such as head pose and gaze. Measures of symmetry would be especially informative for AU 14, as this facial action has been linked to contempt primarily when it is strongly asymmetrical or unilateral

Appendix A: User Manual

User guide for the desktop application

Installation Guide:

Step 1. After acquiring the application installable image (.exe file), save it anywhere on your personal computer.

Step 2. Run the application and a pop up which will request you to continue to install will be availed and click yes.

Step 3. Let the application install and finish then close and restart your computer.

Step 4. You can now use the application.

Use Instructions.

Prerequisites:

Make sure your computer has a webcam and a microphone both being enabled.

Step 1. Run the application

Step 2. A pop requesting to signup will show up and you enter the details required and click next.

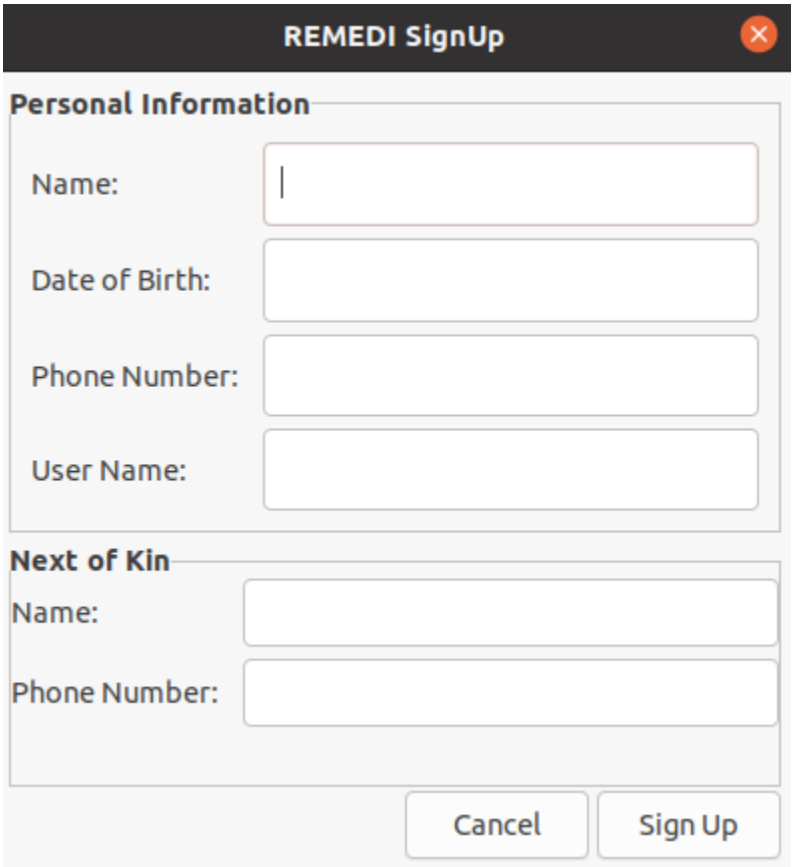

Figure 22. Signup Screen

Step 3. The login using the date of birth and Username and click to enter the data as required by the system.

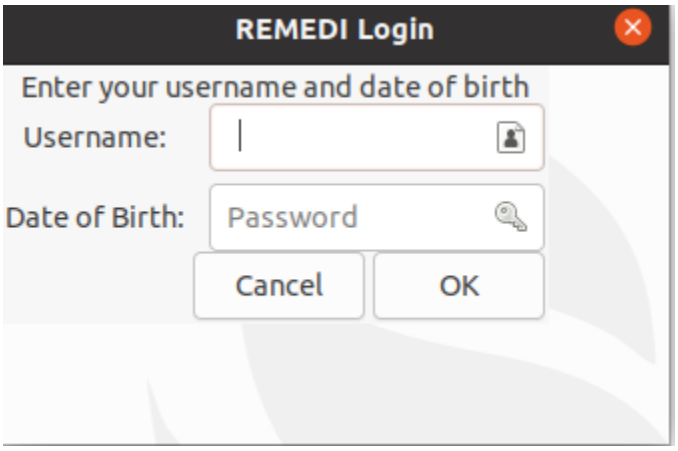

Figure 23. Login form for the desktop application

Step4. After entering required data output will be shown on your screen and a message sent to your contact.

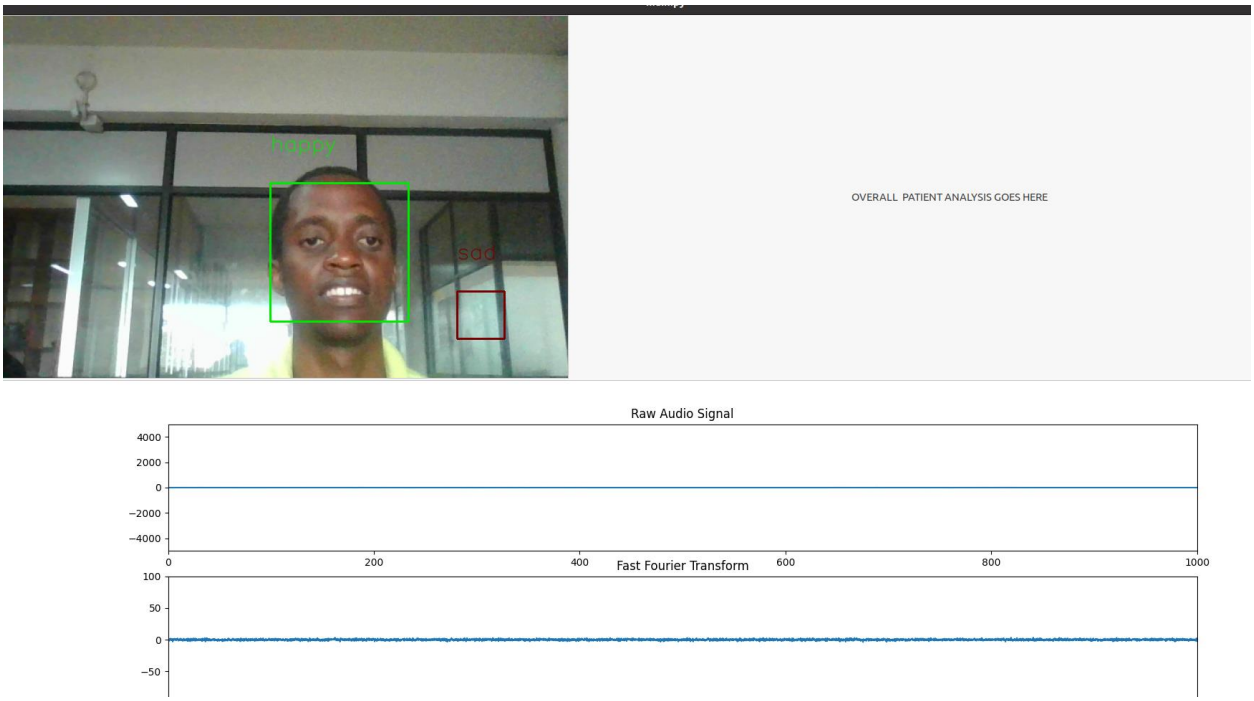

Figure 24. Photo of the output and the predictions

Step 5. Close the application or run another check.

User manual for the Mobile application

Step 1. Locate the application of Google play store. (Unfortunately, it is not yet available on Apple store)

Step 2. Install the application on your phone and run it.

Figure 25. REMEDI Welcome page

Step 3. Step up an account to use.

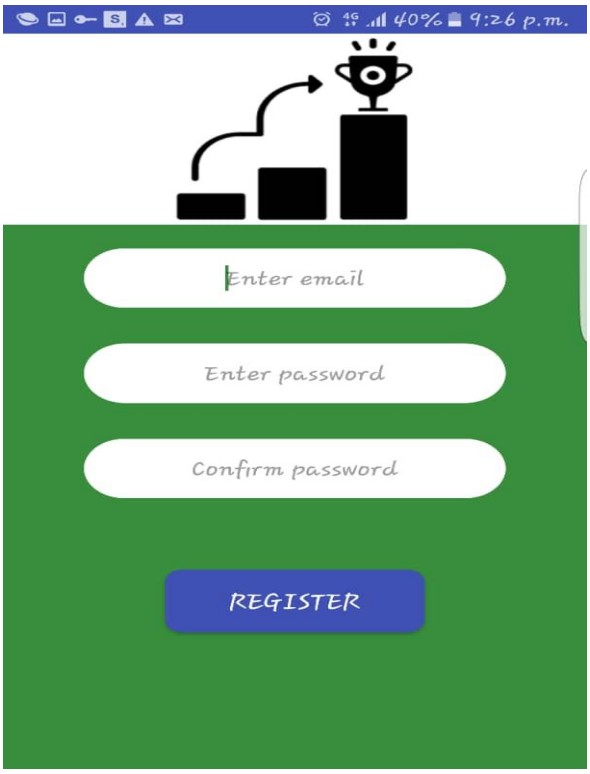

Figure 26. App Sign Up form

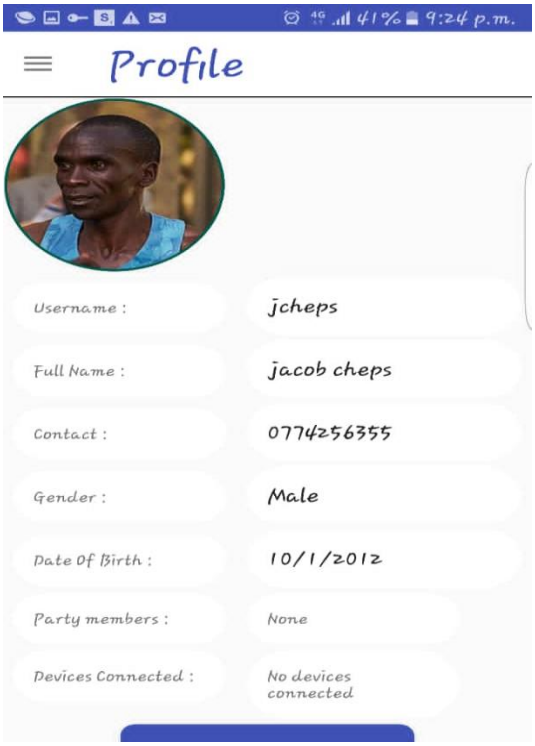

Figure 27. User Profile Example

Step 4. Login

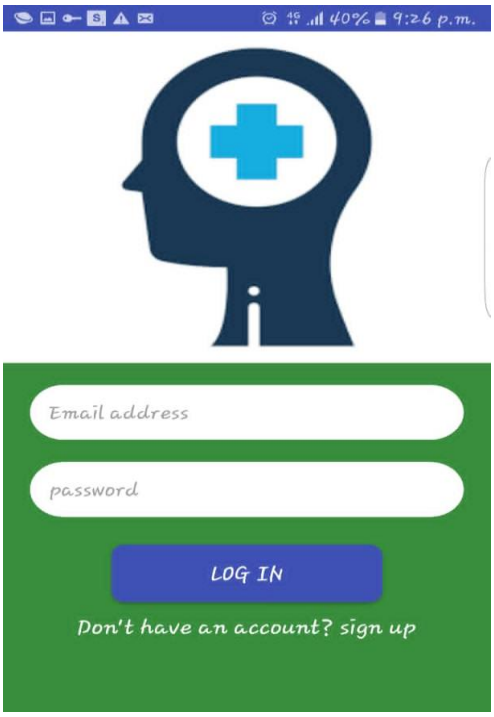

Figure 28. Login Page

Step 5. Follow the questionnaire as your answer the question

Step 6. Finish and Submit.

Step 7. Your results will be displayed for the analysis done according to the answers you have provided.

APPENDIX B: REFERENCES

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