Deep Care: Smart Depression Counselling System through Emotion Recognition and Opinion mining using Deep Learning

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Abstract

Depression is a common mental condition that can significantly affect both person's daily life and mental health. The goal is to create a Depression Detection system for students and patients. The system consists of a depression quiz that takes the opinion of users (Questionnaire) and records a video which is then analyzed to determine the sentiments of patients. In this study, we have used Facial Emotion Recognition – A Kera's-based Deep Learning model which generates six universal sentiments: angry, sad, disgusted, surprised, fearful, and happy this is then mapped with curated standard questions asked by counsellors. These approaches are then synchronized to produce a depression score which is used to prepare health reports. This health report is sent to the counselor for further treatment.

1. Introduction

Depression [7] is a common mental condition that may affect anybody at any age and results in a constant sensation of unhappiness and loss of interest. The issue is that it is frequently still not recognized and addressed, which harms both a person's physical and mental health. One's inability to identify the issue or hesitation to seek help may be the largest barrier to addressing depression. According to Marcus et al. (2012), it is often differentiated by a lack of interest, feelings of guilt or low self-worth, disturbed sleep or food, exhaustion, and impaired focus, as well as social isolation and slower speech. It hurts a patient's physical health, including severe aches and pains, insomnia or hypersomnia, and weight issues. In extreme situations, untreated depression might result in suicide. Depression is divided into six categories as shown in Fig. 1, out of which major depressive disorder is the most severe [10].

As per a case study done by the National Health Survey [16] (NHS) in 2019 in the United States of America among civilized citizens over the age group of 18 based on the severity of depression and sex. Figure 2 shows the following important key findings:

1. In 2019, 2.8% of people had severe depression symptoms in the preceding two weeks, 4.2% reported moderate symptoms, and 11.5% showed mild symptoms [16].
2. The percentage of persons experiencing any symptoms of depression was highest among those aged 18–29 (21.0%), followed by those aged 45–64 (18.4%), 65 and over (18.4%) [12], and 30–44 (16.8%).
3. Women were more likely than males to have mild, moderate, or severe depressive symptoms.

To solve the problem of depression, we must first identify depression. As per Fig. 3: Various methods have been invented to detect depression [14]. Two methods with the highest accuracy are being used in our model i.e., Psychometric Tests, which help predict the level of depression using depression score, and Emotion Detection verifies the mood and mental state of a person.

1.1. Psychometric Analysis

Psychometric Analysis or Psychometric assessment as shown in Fig. 4 helps in evaluating a person's cognitive skills and personal traits. It helps understand the mental ability and behavioral style an organization cannot find during meetings. There are many popular psychometric tests in the market for calculating depression such as DASS'21 (Depression, Anxiety, Stress Scale) or PHQ-9 (patient health questionnaire 9), or BDI-II (Beck Depression Inventory) [4]. It uses a self-scoring system in which the end produces a depression scale.

1.2. Emotion Detection

Emotion Detection is the task of recognizing the mental state or mood of the patient while attempting the test. Emotion detection is carried out using either voice or facial images. According to "Ekman and Friesen" [17] using facial images in Fig. 5, Emotions are classified into six categories like Happiness, Sadness, Angry, Fear, Surprise, and Disgusted.

Figure 6 block diagram is divided into 4 steps which are as follows –

1. **Image Pre-processing**: As a Machine Learning Engineer, it is a crucial step that every engineer takes before building an actual model. Image Pre-processing focuses on improving picture data by suppressing unwanted distortions or enhancing visual properties essential to subsequent processing and analysis tasks.
2. **Feature Extraction**: The goal of feature extraction is to minimize the number of features in a dataset by developing new ones from existing ones (and then discarding the original features).
3. **Face Detection**: A deep learning model is built which matches the facial features on training data with testing and identifies the face in the video stream or input image.
4. **Emotion Classification**: Emotions are classified into six fundamental categories using Naïve Bayes Classifier by extracting facial features and displaying emotion on the monitor.

2. Literature Survey

The Literature Review of this paper consists of 3 sections. The first subsection highlights research done to identify depression using sentiment analysis of tweets from Twitter. The discussion in the second sub-section is on the use of psychometric tests to identify depression. The third subsection highlights research done to identify depression using facial expressions [15] (image and video processing). All these sources use machine learning and deep learning Techniques.

2.1. Twitter Sentiment Analysis – Text Processing.

Natural Language Processing is a sub-branch of Data Science that is used to extract meaningful information from Text. It focuses on how computers can handle and analyze unstructured text, including human language, and how they can do things like translate languages, grasp semantics, and extract information [10].

The method proposed in [1] is implemented using Twitter Sentimental Analysis and Natural Language Processing to identify depression among Teenagers. The first step is Data-Collection which includes Keyword-based Searching and storing tweets in JSON format. This data is then converted into CSV (Comma Separated File) which is later given to the Machine learning model for Training and Testing in the ratio of 80:20. The second step is Data Cleaning in NLP which includes Tokenization, stop words removal, Stemming and Parts of Speech Tagging (POS) which is then chunked and then converted into a bag of words for feeding it to Training and Testing model by converting into vectors. The third step is Testing the pre-trained model and then the confusion matrix is calculated which proves Naïve Bayes works better than SVM (Support Vector Machine) in terms of Accuracy and F1 Score [8].

The method [2] proposed could identify depression levels using social Media Posts. Support Vector Machine (SVM) and Naïve Bayes are two well-known classifiers to classify depression into four categories: (Minimal, Mild, Moderated, and Severe) based on data collected from 3 Social Media Sites: Facebook, Twitter, and Live Journal. This model is tested using Red Miner and results were analyzed based on Confusion Matrix and accuracy based on Recall and Precision.

The Research mentioned in [3] uses various Machine Learning techniques. Processes for filtering and classifying data are explained to analyze depression. The results of time-perceptron research are dependent on how much time a person spends on social media, which raises anxiety levels. To identify a person's emotions, various social media posts are analyzed using syntax and semantic analysis. A person's emotions and ideas are detected through their tweets using machine learning (ML) techniques, and depression is discovered in all age groups.

2.2. Psychometric Tests:

Psychometric Tests are a set of standard Questions used by doctors to find the depression scale of users based on the past 2–3 weeks. The proposed method is a widely used Psychometric test used by psychiatrists to determine the depression score of patients. This test calculates depression levels over 2 weeks. It contains a total of 21 Questions which include a scoring card of a maximum of 63 marks – which tells person is severely depressed or not depressed. The [4] BDI-II is now intended for those aged 13 and above and consists of items about somatic and mental signs of depression, including weariness, weight loss, and lack of interest in sex as well as cognitions like guilt or emotions of being punished [11].

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2.3. Facial Expression (Image and Video Processing):

There are currently serious worries due to an upsurge in mental health problems and cases throughout the world. Depression has a significant impact on the depressed person as well as the community at large. Deep learning and artificial intelligence (AI) technologies have lately gained popularity, and they may be useful in the field of medicine to assist physicians in identifying and predicting mental health conditions like depression early on and treating them before they cause major harm [5].

A study conducted in [6] indicates that facial expression helps detect the emotions of patients and is further used to calculate depression in patients. Facial Muscles and facial Landmarks generated by the Media Pipe Library are useful to detect emotions and its further divided into 4 stages Images Pre-processing,

Features Extraction, Face Detection, and then Emotion Detection. In this study, five Universal Emotions i.e., Happy, Sad, Neutral, Angry, and Sad were considered and YALE facial expression database was used to classify emotions. If features weren't extracted, then Gaussian Filtering was used to filter unwanted features and noises from images. The Human Facial Coding System [FACS] was used to convert facial features like eyebrows, mouth, jawline, and other facial landmarks to convert into emotions and detect depression in patients [9].

3. Proposed System Methodology

3.1. Design Goals:

This project is aimed to create a depression detection system for students and patients by combining two popular approaches: Opinion Mining and Emotion Detection. This project is made to overcome the drawbacks of Existent Systems and deliver cost-effective, time-saving quick results to counselors and deliver portable applications to users. It can be accessed 24*7 by all users by sitting at home and checking their health status via our web portal through Signup and if in case of severe depression consult doctors or psychiatrists for further treatment. The Fig. 7 shows that system is for both depressed patients and anyone willing to check their health status.

3.2. Data Flow Working Model of Deep Care:

Figure 8 explains the working of Deep Care, a Smart Depression Counselling System created using the MERN stack. The Whole Project is initially created in ReactJS including all pages and user quizzes and dashboards. Then all user information is stored in Mongo dB – A unstructured database. Fetching all information via requests and responses is carried out by Express JS which sits over the Node JS – the backend of our app. Now let us visualize and understand Fig. 8 in detail as shown in the points below.

3.2.1. Front End-Home Page of Deep Care App:

The home Page as shown in Fig. 9 is a starting page of our Project created in ReactJS where users or students can register for the test by clicking on the *Start Test Now* button. After which they will be redirected to the Login Page. If the user is already registered, then they will simply log in to our website and start a new test. Else they will Register themselves on the Register page as shown in Fig. 10.

3.2.2. Register page of Deep Care App:

If a new user visits our page, he/she must register on our app as shown in Fig. 10, and fill in important attributes like Full Name, and Email ID – which acts as a primary key in our database. And then we check

if our user is a student or working professional and by making a strong password they register in our app. After successfully registering, all the data is stored securely in our database. And the user can start with the test by allowing Camera Permission to record their mood and mental state.

3.2.3. Quiz Component of Deep Care App:

After a user has successfully registered in our app. Then the user reads the instructions page carefully and after his consent only then he is questioned with a standard set of 21 questions as shown in Fig. 11 taken from *the* Beck Depression Inventory [4] which is taken as a reference to generate the ideal depression score of users, once he has successfully attempted the test. Each question consists of 4 questions marked with (0,1,2,3) marks which will be added to finally generate an ideal depression score out of 63 marks and displayed on the user dashboard page.

3.2.4. Implementation of the Emotion Detection Model using FASTAPI:

recognition

Figure 12 helps us to explain the working of the emotion detection model which is separated into three parts i.e., Front-End, Back-End, and Web-Sockets [15].

3.2.4.1 Front End:

The front end of the app is made using React JS which takes user video via (react-webcam) library as input and produces frames of images, which are then given to the back-end which produces a dictionary of sentiments and max sentiment emotion via Web Socket in output and this process continues until the user has successfully answered the whole quiz and submitted all answers.

3.2.4.2 Back End:

The back end of the app contains the Python file containing an implementation of the TensorFlow JS model which is a face detection pre-trained model used to detect faces in an image using Single Shot Detector architecture with a custom encoder (Blaze-Face). Then FASTAPI is used which receives video frames and is given to TensorFlow Kera's pre-trained model which classifies 7 diverse types of emotions happy, sad, fear, surprise, angry, disgusted, and neutral.

When the fast API (Application Programming Interface) server sends a response, the response payload contains two keys: "_predictions_" and "_emotion_." The "_prediction_" key contains the model's prediction probabilities for each emotion, which is utilized for dynamic emotion change with each frame. The prevailing emotion is represented by the "_emotion_" key, which is utilized for dynamic changes in bounding box color based on the dominant emotion for each frame.

3.2.4.3. Web Socket

Web Socket is a Bi-Directional, full-duplex protocol that is used in the same context as HTTP (Hyper Text Transfer Protocol); however, unlike HTTP, it begins with ws:/ or wss:/. It is a stateful protocol, which implies that the connection between client and server will remain active until either side terminates it (client or server**).** The connection is ended from both ends once either the client or the server closes the connection.

3.2.5 Synchronizing emotion detection and opinion mining

Table 1
Multiplication factor

Emotions	**Negative**	**Neutral**	**Position**
Classification	Sad, Angry, Fear, Disgusted	Neutral	Happy, Surprise
Multiplication Factor(m)	1	1	0

In this project, the emotion detection model is combined with the psychometric questionnaire (opinion mining) by combining the sentiments-emotions with answers using multiplication factor - (m) which is decided based on certain steps listed below.

3.2.5.1. Algorithm:

1. Identifying the sentiments of answers used in psychometric questions in Figure 11 using NLP sentiments analysis.
2. Sentiments are classified as Positive, Negative, and Neutral in Table 1.
3. As per our research, we found that out of 63 sentiments: 38 sentiments are negative emotions,19 sentiments are positive emotions, and 6 falls in the neutral category.
4. This suggests that most depressed students while meeting doctors majorly convey negative emotions like sadness, anger, or fear.
5. So, if the user emotion detected using the model is either negative or neutral, the multiplication factor used will be (1) to show the negative mood of the student.
6. And if the student's mood is positive, the multiplication factor assigned is (0) which indicates that either our model is having an error (or) the user is happy and giving a false depression report.

4. Case Study: Testing Functionality of Deep Care:

Table 2. Case study of Deep Care test subject

B	C	D	E	F	G	H
MongoDB ID	**Answers Options**	**Answer ID**	**Patient ID**	**Question**	**Emotion Model**	**Multiplicatoin Factor**
64229706aa41630715dcd16d	I do not feel sad	0	PID01	Sadness	neutral	1
6422970daa41630715dcd16f	do not expect things to work out for me	2	PID01	Pessimism	neutral	1
64229712aa41630715dcd171	I have failed more than I should have.	1	PID01	Past Failure	neutral	1
64229716aa41630715dcd173	get any pleasure from the things I used to	3	PID01	Loss of Pleasure	neutral	1
64229722aa41630715dcd175	over many things I have done or should I	1	PID01	Guilty Feelings	angry	1
64229725aa41630715dcd177	I expect to be punished.	2	PID01	Punishment Feelings	angry	1
64229727aa41630715dcd179	I have lost confidence in myself.	1	PID01	Self-Dislike	angry	1
6422972aaa41630715dcd17b	n't criticize or blame myself more than us	0	PID01	Self-Criticalness	angry	1
6422972caa41630715dcd17d	I would kill myself if I had the chance.	3	PID01	icidal Thoughts or Wishe	angry	1
6422972daa41630715dcd17f	I cry more than I used to.	1	PID01	Crying	angry	1
6422972eaa41630715dcd181	so restless or agitated, it's hard to stay s	2	PID01	Agitation	angry	1
64229731aa41630715dcd183	interested in other people or things than	1	PID01	Loss of Interest	angry	1
64229732aa41630715dcd185	greater difficulty in making decisions tha	2	PID01	Indecisiveness	angry	1
64229734aa41630715dcd187	nsider myself as worthwhile and useful as	1	PID01	Worthlessness	angry	1
64229735aa41630715dcd189	don't have enough energy to do very muc	2	PID01	Loss of Energy	angry	1
6422973daa41630715dcd18b	I don't sleep as well as I used to.	1	PID01	hanges in Sleeping Patter	sad	1
64229742aa41630715dcd18d	I am much more irritable than usual.	2	PID01	Irritability	sad	1
64229746aa41630715dcd18f	My appetite is no worse than usual.	0	PID01	Changes in Appetite	sad	1
64229748aa41630715dcd191	ard to keep my mind on anything for very	2	PID01	Concentration Difficulty	sad	1
6422974baa41630715dcd193	more tired or fatigued more easily than u	1	PID01	Tiredness or Fatigue	happy	0
64229754aa41630715dcd195	ot noticed any recent change in my intere	0	PID01	Loss of Interest in Sex	happy	0
		28				27

To test the functionality of our web app – Deep Care we had taken student from a college whose data is confidential he accepts and read all rules and tested our app by attempting the quiz, on their device by accessing camera permissions. In the background, after submitting every answer (clicking the next button), all the data is stored in our database with the MongoDB ID as shown in Table 2 along with their corresponding multiplication factor (m).

Psychometric Score = $\sum_{i=1}^{21} (a_i)$

= (0 + 2 + 1 + 3 + 1 + 2 + 1 + 0 + 3 + 1 + 2 + 1 + 2 + 1 + 2 + 1 + 2 + 0 + 2 + 1 + 0)

= 28

Synchronized Score = $\sum_{i=1}^{21} (a_i * b_i)$

= (0*1 + 2*1 + 1*1 + 3*1 + 1*1 + 2*1 + 1*1 + 0*1 + 3*1 + 1*1 + 2*+1*1 + 2*1 + 1*1 + 2*1 + 1*1 + 2*1 + 0*1 + 2*1 + 1*0 + 0*0)

= 27

Where a = Answer ID and b = Multiplication factor from

The Ideal Depression Score is 28 which lies in the category of (21–30), hence patient should have moderate depression. The Actual Depression score of the test subject combined with the emotion detection model is 27, which falls in the category of (21–30), hence patient is having symptoms of moderate depression. This proves that our proposed app can accurately gauge users' depression status. This whole analysis of the test subject by calculating both ideal and actual depression scores is done at the back end of our app and the final step of Fig. 8 is data visualization for user understanding is seen in the student Dashboard section

5. Experimentation and Results

After the user has attempted the quiz, the user is redirected to the dashboard section where the student can see the Ideal Depression Score in Fig. 13, and Actual Depression Score in Fig. 14, and the Mental State of the user in Fig. 15, there he gets the option to check his depression and download the complete report in pdf format.

After the user has checked his depression status and mental state using the emotion detection model, he can download his report and exit the Deep Care app via the log-out button. This help to ensure the privacy and security of the user.

Overall, keep in mind that our Deep Care depression detection web app is not a substitute for expert medical guidance. If you are suffering signs of depression or other mental health disorders, you should always seek medical attention.

6. Conclusion

Depression is becoming an epidemic disease that is affecting people from all socio-economic groups, races, and countries. It might be difficult to spot persons who want assistance because of a mental disorder but are unable to articulate their needs owing to the fundamental nature of solitary. Even unhappy individuals typically ignore these folks. Textual sentiment analysis is a semi-method that is always traceable and controllable, which can help in the diagnosis of the ailment. This is a crucial tool in the battle against depression since it helps us to identify joyful and sad times without seeing a psychologist, allowing us to act right away when necessary. It is possible to recognize, evaluate, and prevent depression using facial expressions (image and video processing) Several deep learning techniques, including picture pre-processing, feature extraction, and [13] classification algorithms, are synchronized with a questionnaire using multiplication factor (m) identify emotions and consequently detects depression. All these approaches make our system time-saving, cost-effective, and portable

Declarations

Ethical Approval

The paper points to creating a Depression Counselling System which is applicable to humans only. This paper follows BDI-II [4] inventory guidelines which are helpful in calculating depression levels using multiplication factor as shown in Table 1. and psychometric depression scores as shown in Figure 13.

1) Consent to participate:

During trials of Deep Care, many users voluntarily participated in testing our model by agreeing to the below terms and conditions which are mentioned on the Instruction Page of the Deep Care depression test.

Terms & Conditions:

1. Confidentiality: All information collected through the depression detection program will be kept confidential and will only be accessible to authorized personnel who needs it for research purpose.
2. Accuracy: This program is without any warranty of any kind. This is because the accuracy of the depression detection findings may vary owing to varied individual characteristics, hardware, or environmental circumstances.
3. Consent: You understand that participation in this program is voluntary and that you have the right to withdraw your consent at any time without any consequence.
4. Data handling: The collected data will be used solely for research and analytics purposes by the organization implementing the program, without any personal identification or commercial use.
5. Responsibilities and Liabilities: You agree to assume full responsibility for your participation in this program and understand that the organization is not liable for any damages or consequences resulting from the use of the depression detection program.
6. Disclaimer: The Deep Care program is not intended to be a replacement for professional medical guidance, diagnosis, or care. It is not intended to be used for self-diagnosis but rather to help discover potential indicators of depression by scanning facial expressions.

Consent to publish:

After the user had read the terms and conditions, they give their consent to publish their results for research purposes and publication use by agreeing to the Declaration and Consent as shown in Figure 16. of Deep Care, the user can attempt the test and get their depression status.

Declaration and Consent:

 I have read, understood, and agree to the Terms and Conditions listed above and give my consent to voluntarily participate in this program and allow to use my results for publication use.

Availability of supporting data

This paper uses Psychometric scores gathered using BDI-II inventory questions [4] and Facial Expression Recognition Library [17] developed by Justin Shenk.

Competing interests

Not Applicable

Funding

Not Applicable

Authors' contributions

Conceptualization, A.A.; methodology, H.S. and R.H.; software, R.H. and H.S.; validation, A.A., B.N.,M.K., and M.S.; formal analysis, A.A. and M.S.; writing—original draft preparation, Y.J and S.P.; writing—review and editing, H.S., Y.J.; visualization, H.S. and R.H.; supervision, A.A.; project administration, A.A., B.N. and M.S. All authors have read and agreed to the published version of the manuscript.

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Conceptualization, A.A.; methodology, H.S. and R.H.; software, R.H. and H.S.; validation, A.A., B.N.,M.K., and M.S.; formal analysis, A.A. and M.S.; writing—original draft preparation, Y.J and S.P.; writing—review and editing, H.S., Y.J.; visualization, H.S. and R.H.; supervision, A.A.; project administration, A.A., B.N. and M.S. All authors have read and agreed to the published version of the manuscript.

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Figures

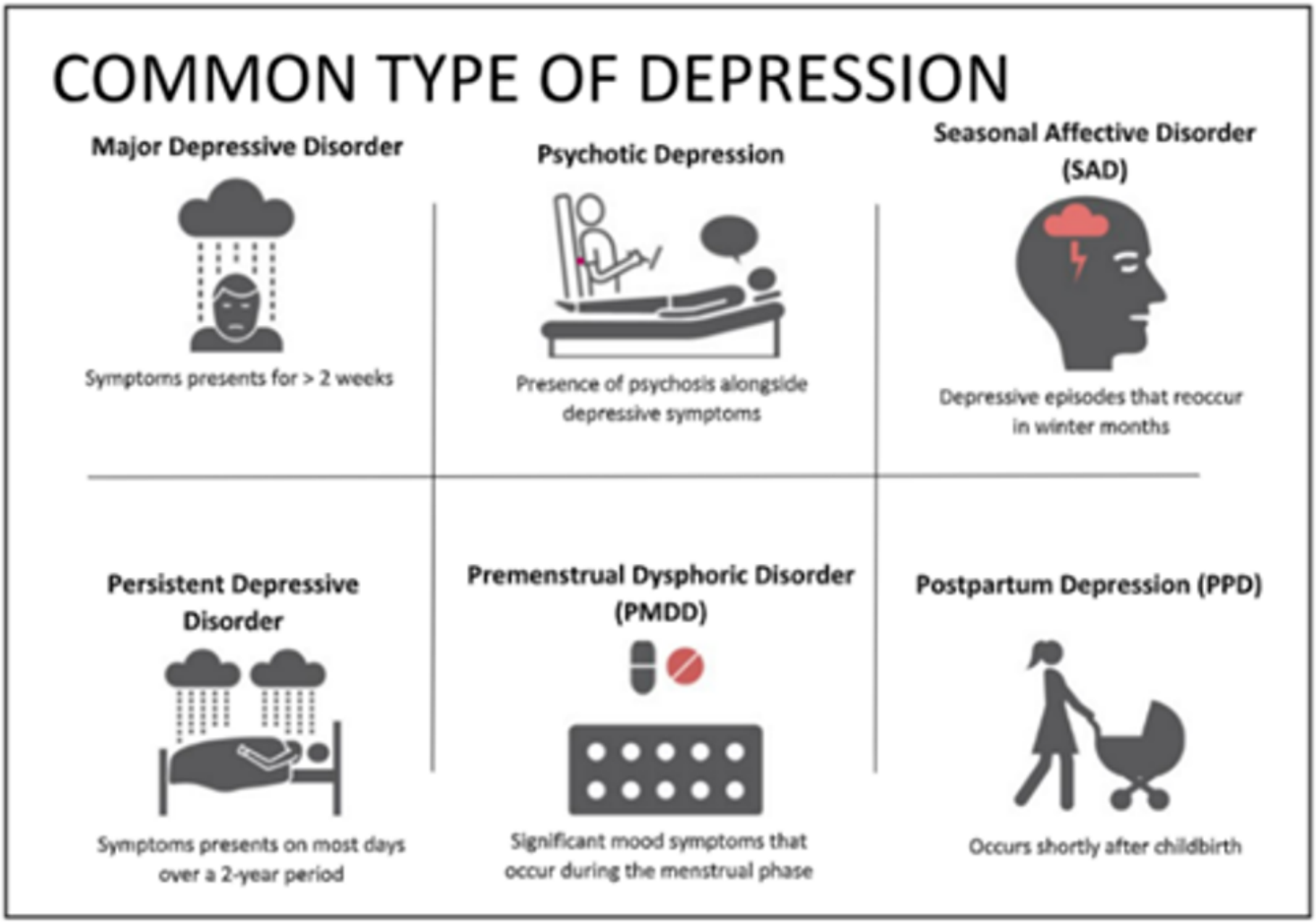


Figure 1

Common types of depression

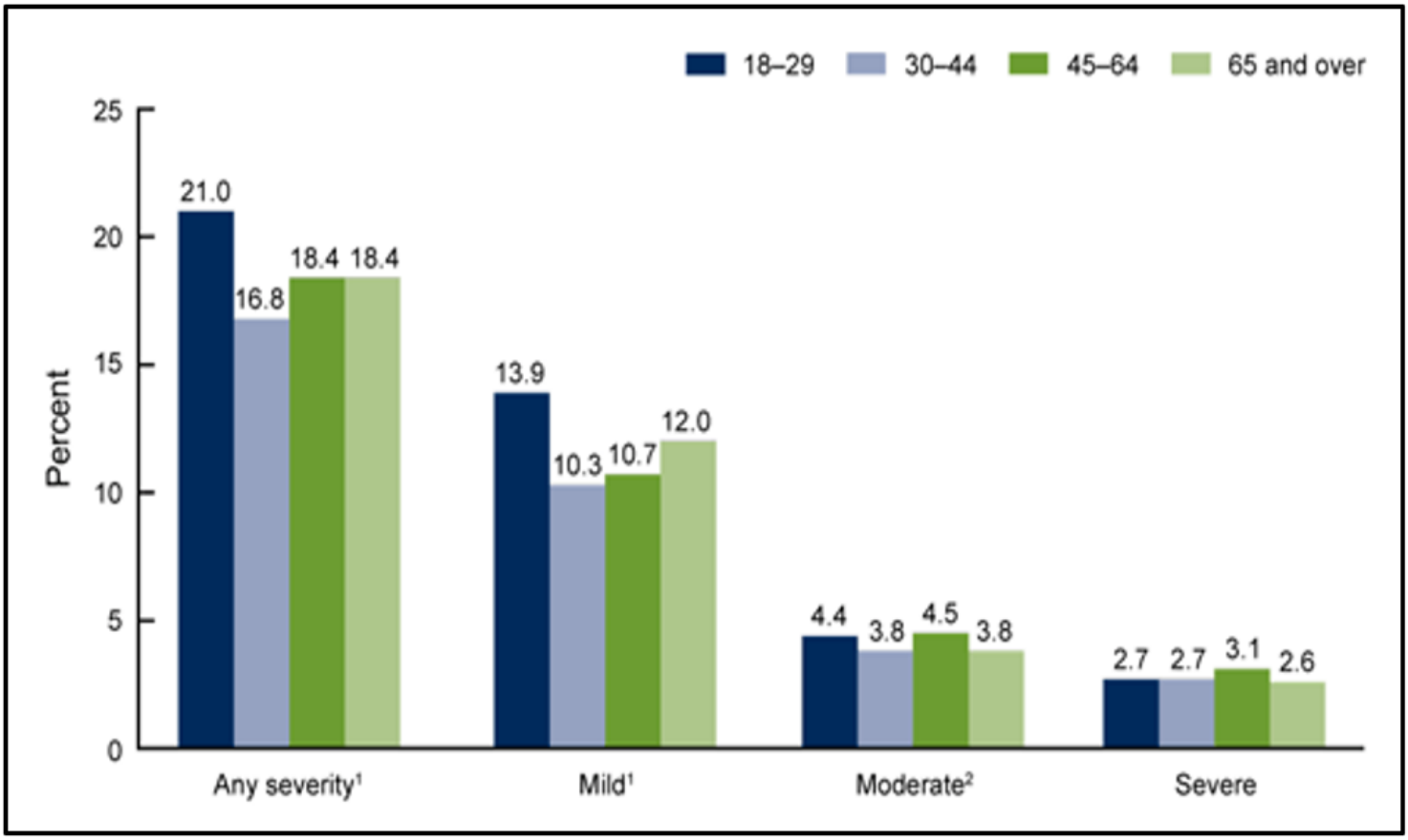


Figure 2

Severity of depression

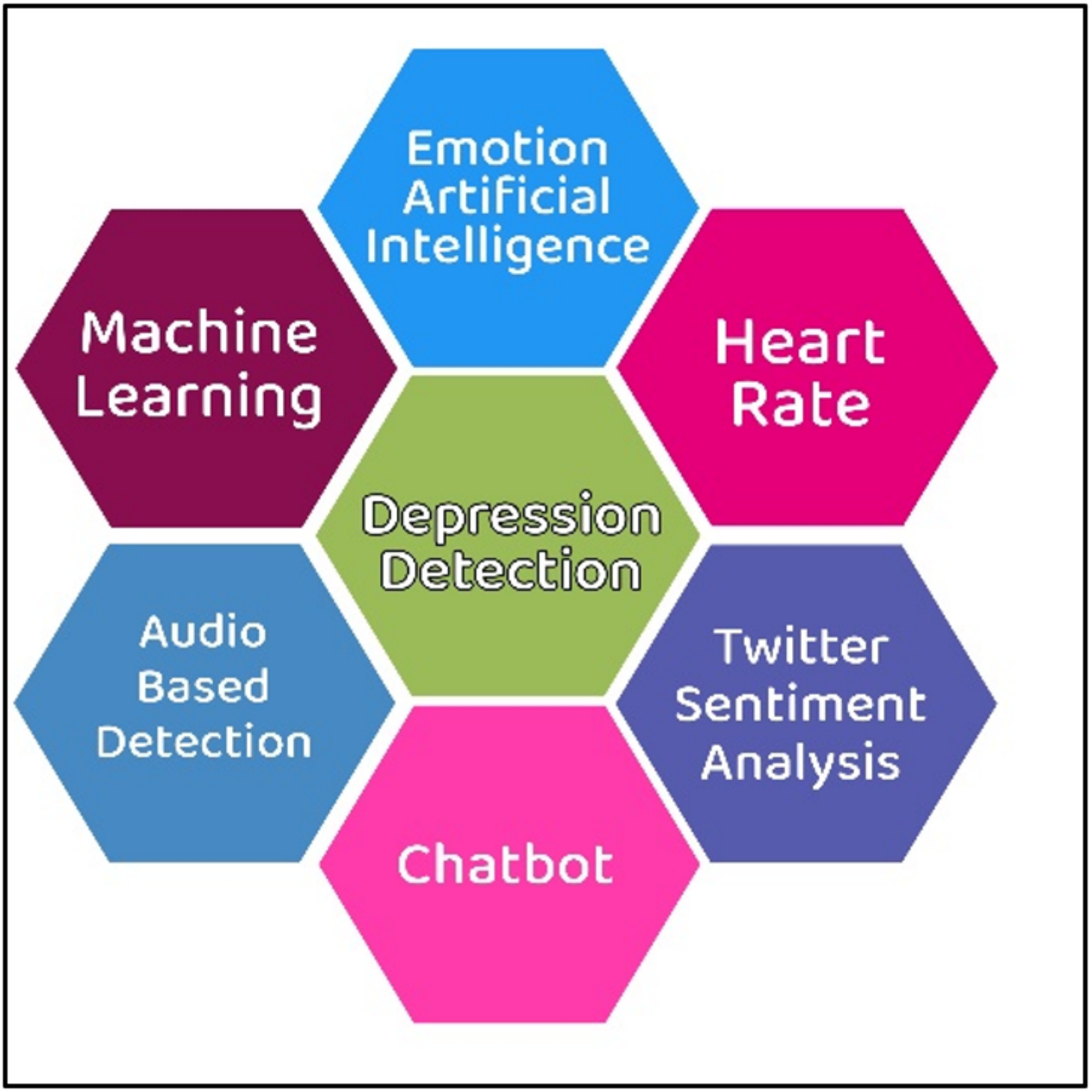


Figure 3

Separate ways to detect depression

Figure 4

Psychometric analysis depression

Figure 5

Six fundamental facial emotions

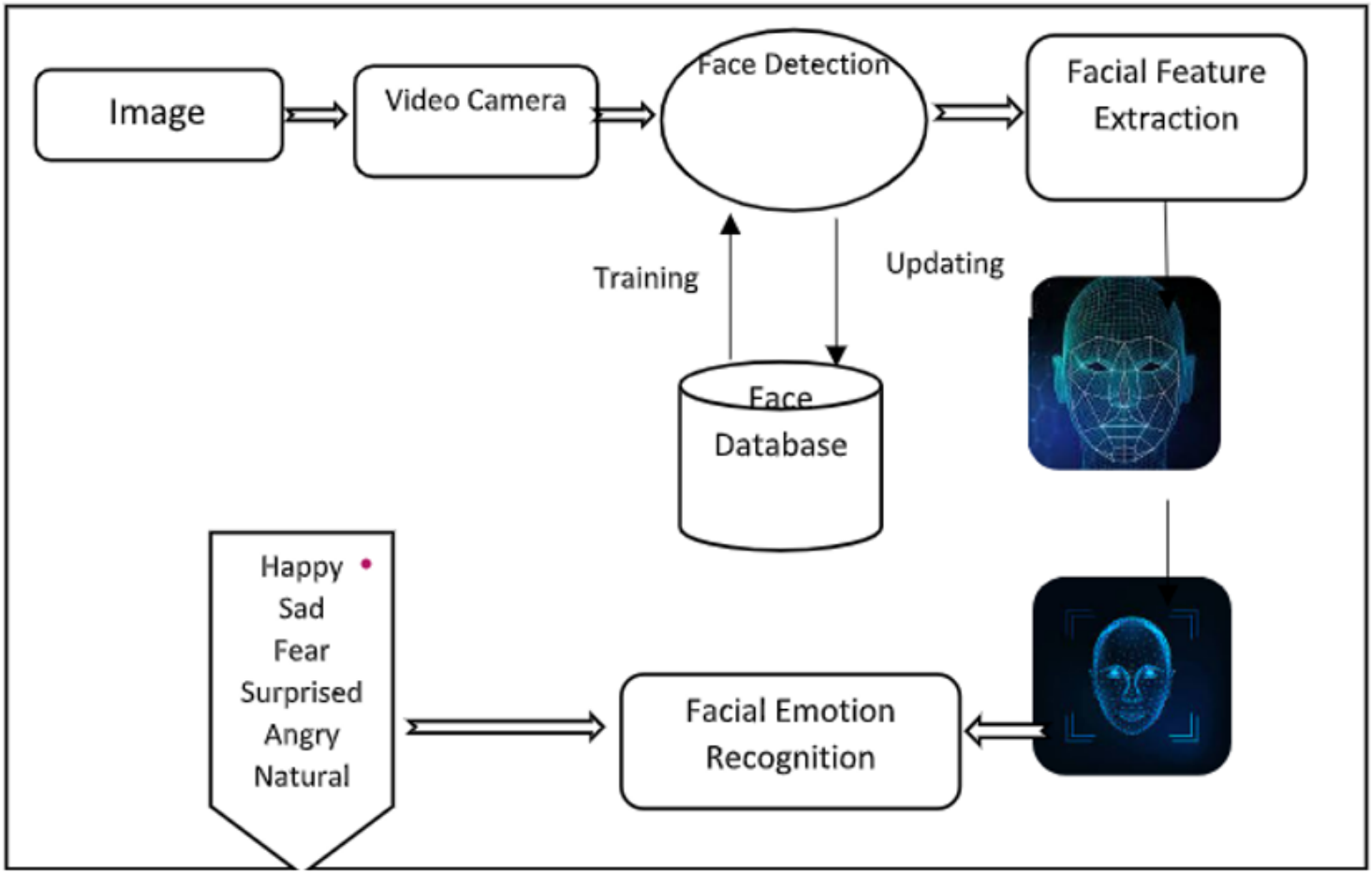


Figure 6

Block diagram of facial emotion recognition

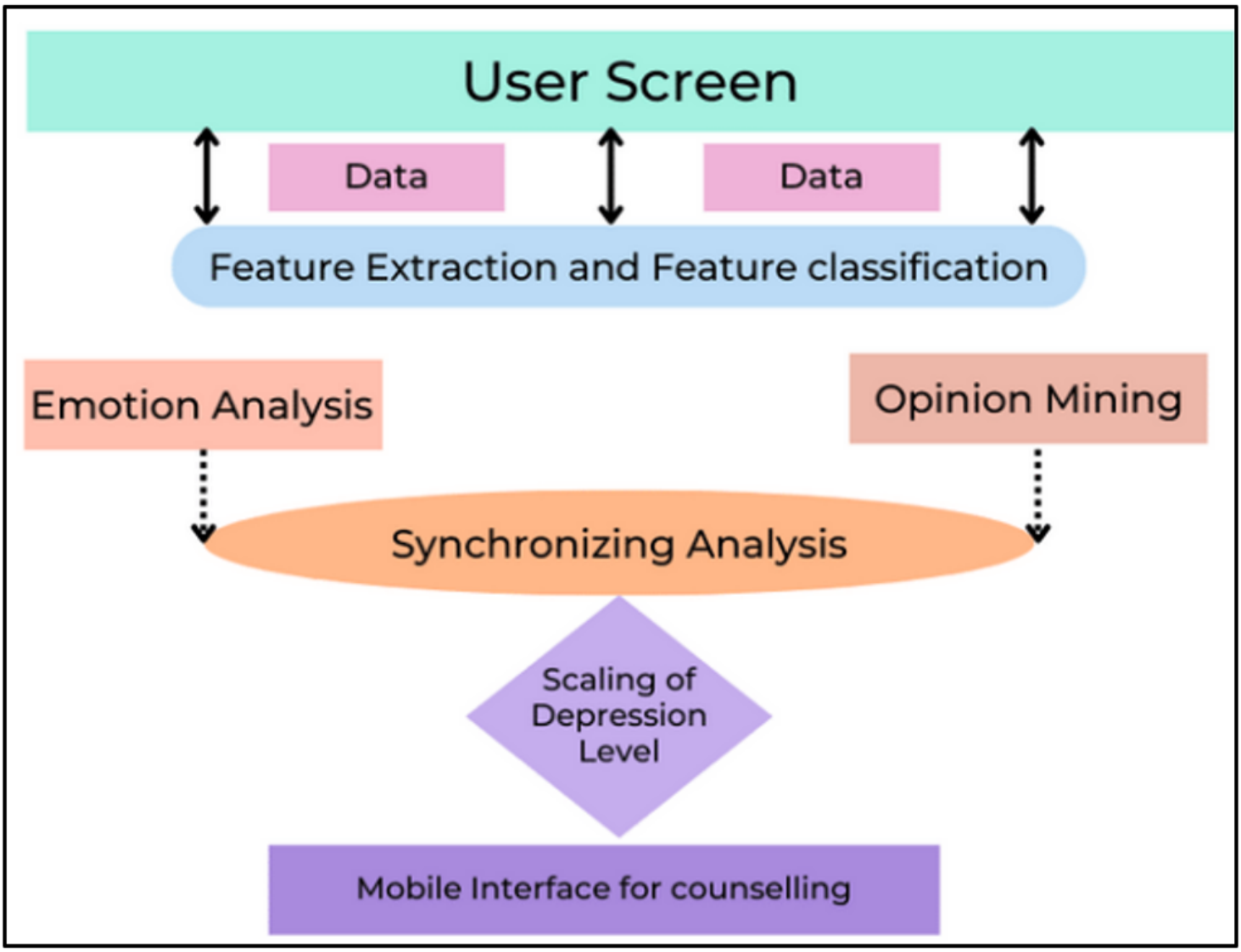


Figure 7

System architecture

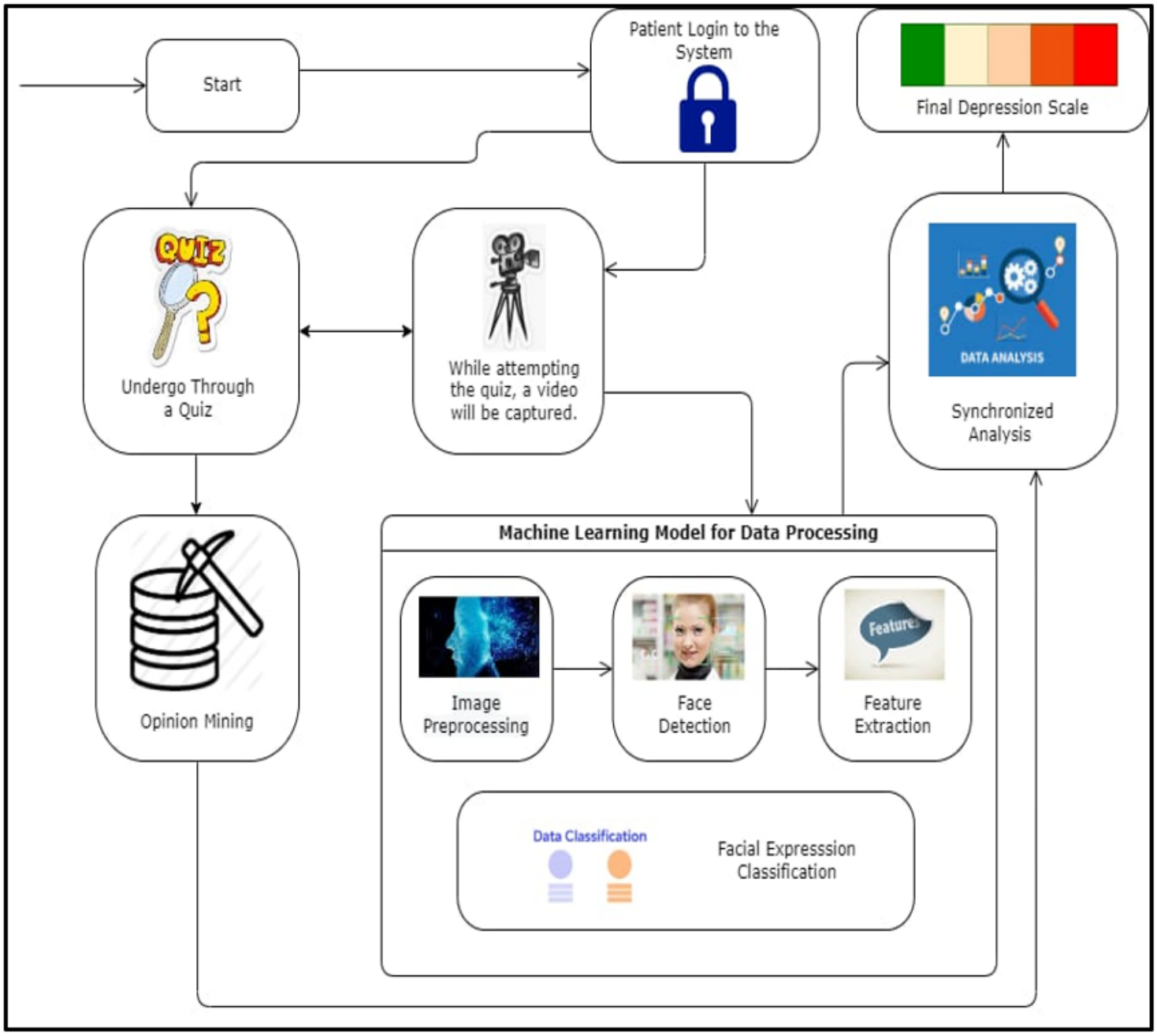


Figure 8

Data flow working diagram

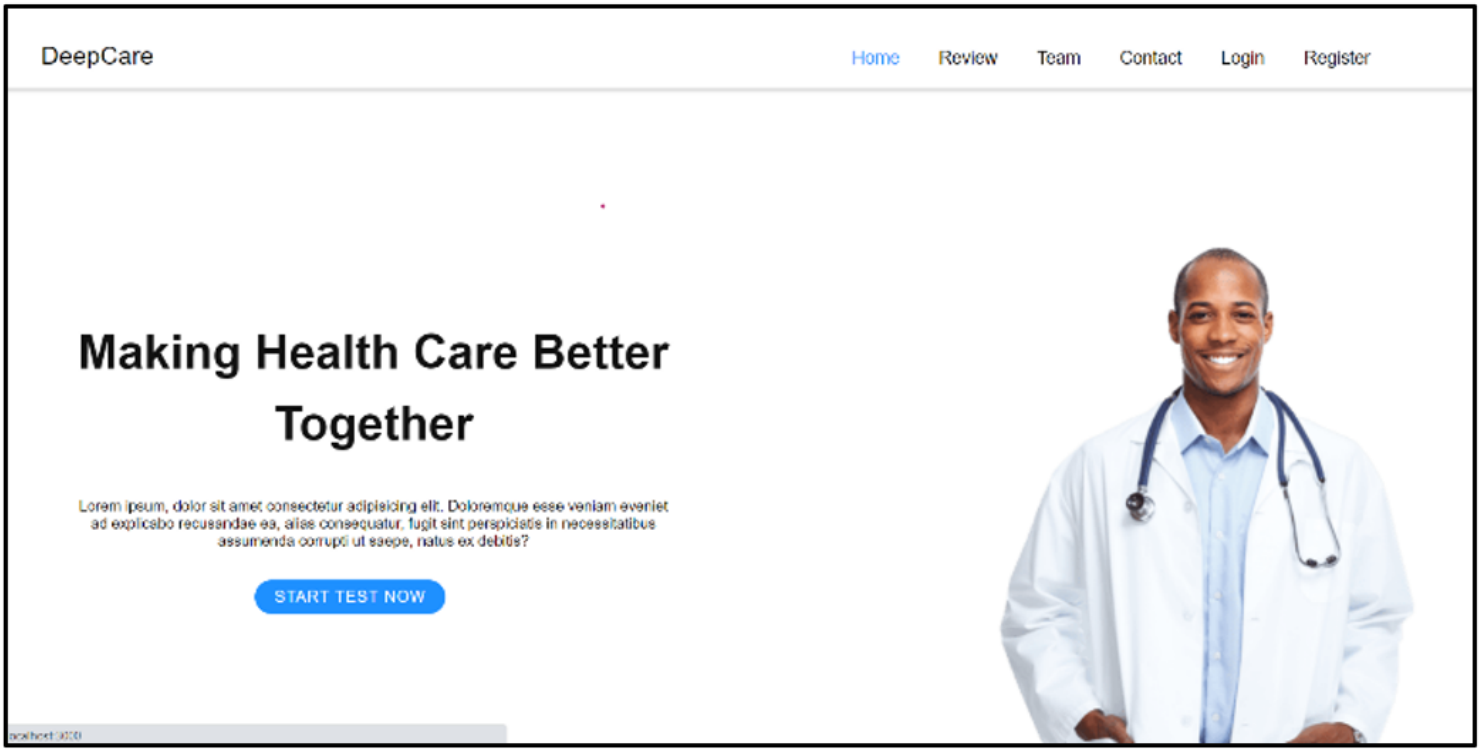


Figure 9

Home page of Deep Care

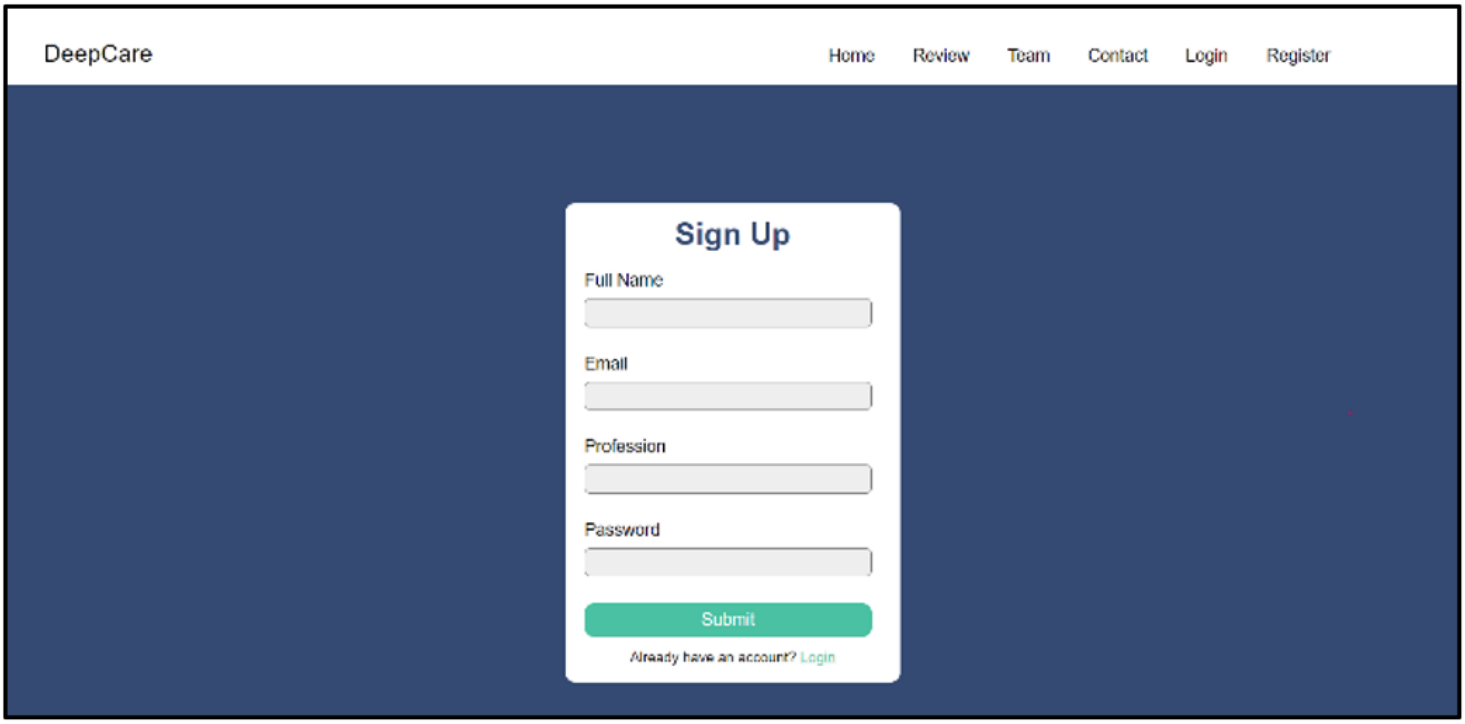


Figure 10

Deep Care registration page

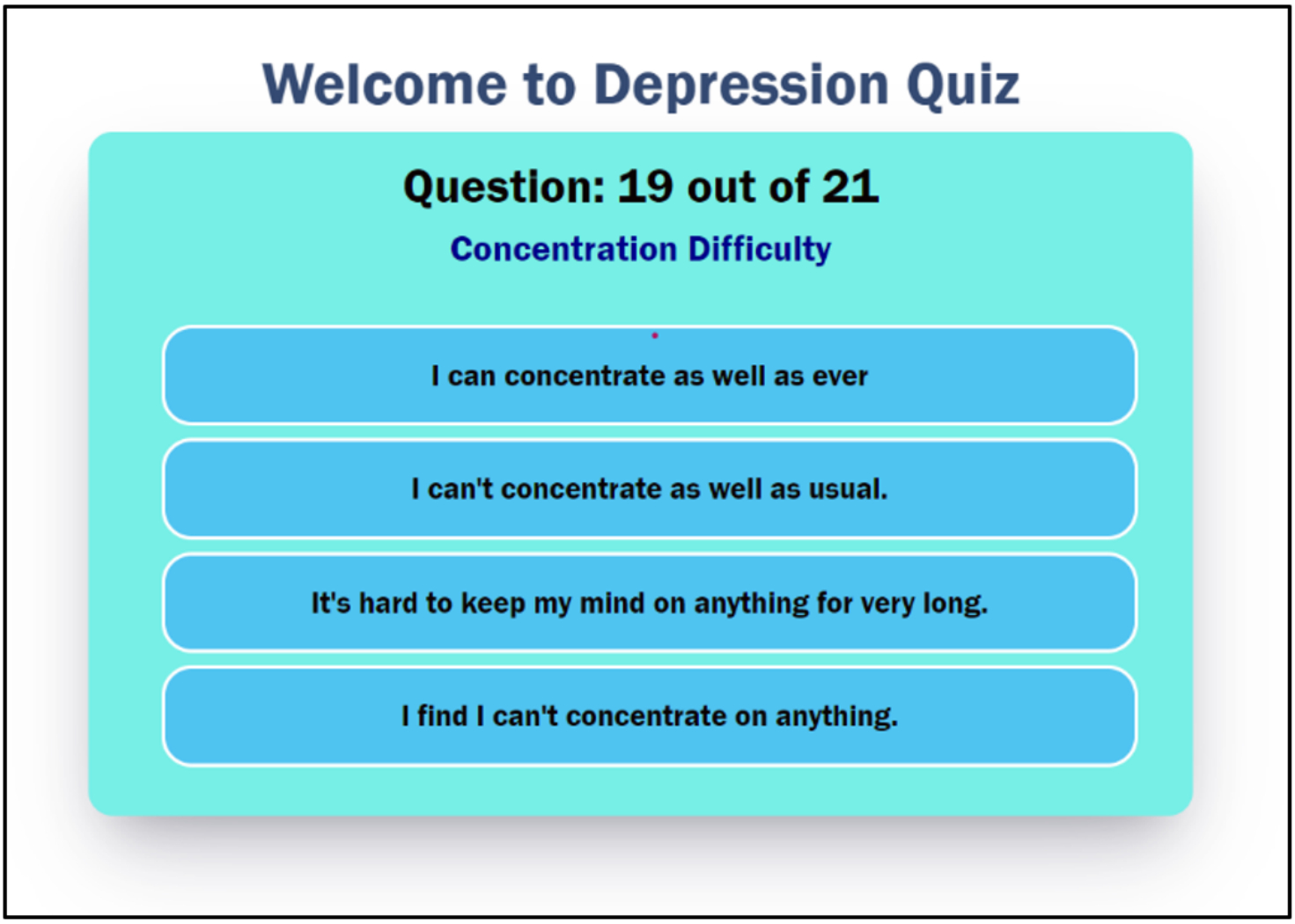


Figure 11

Quiz of Deep Care

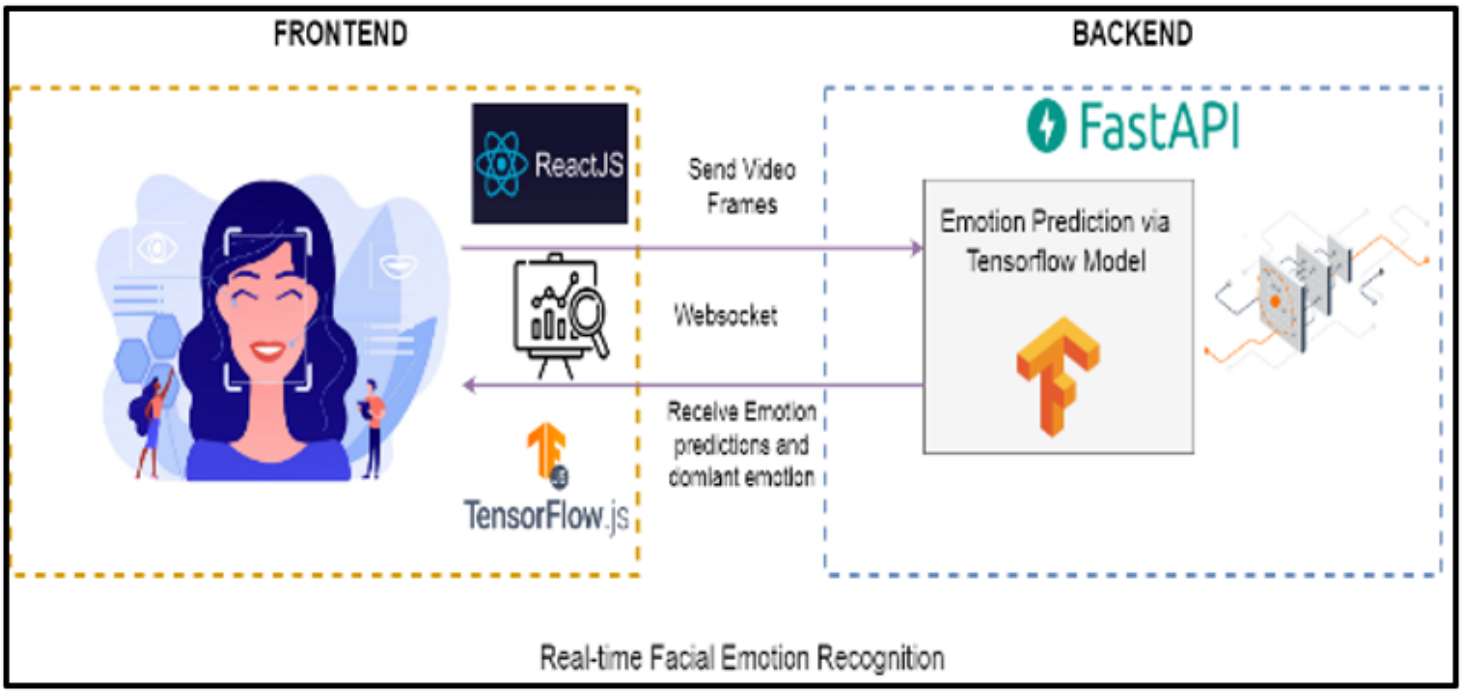


Figure 12

Block Diagram of real-time facial emotion recognition

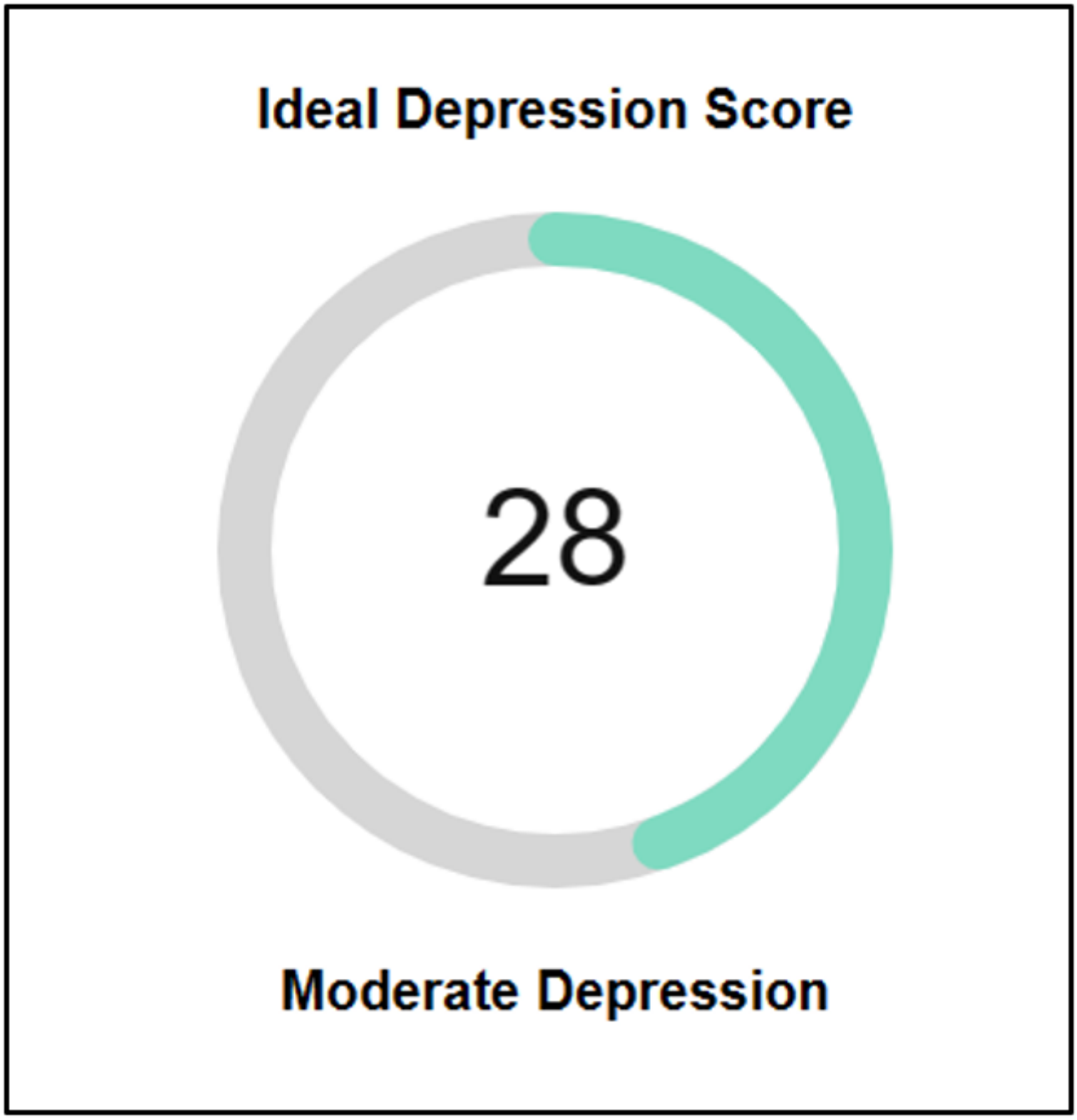


Figure 13

Ideal depression score

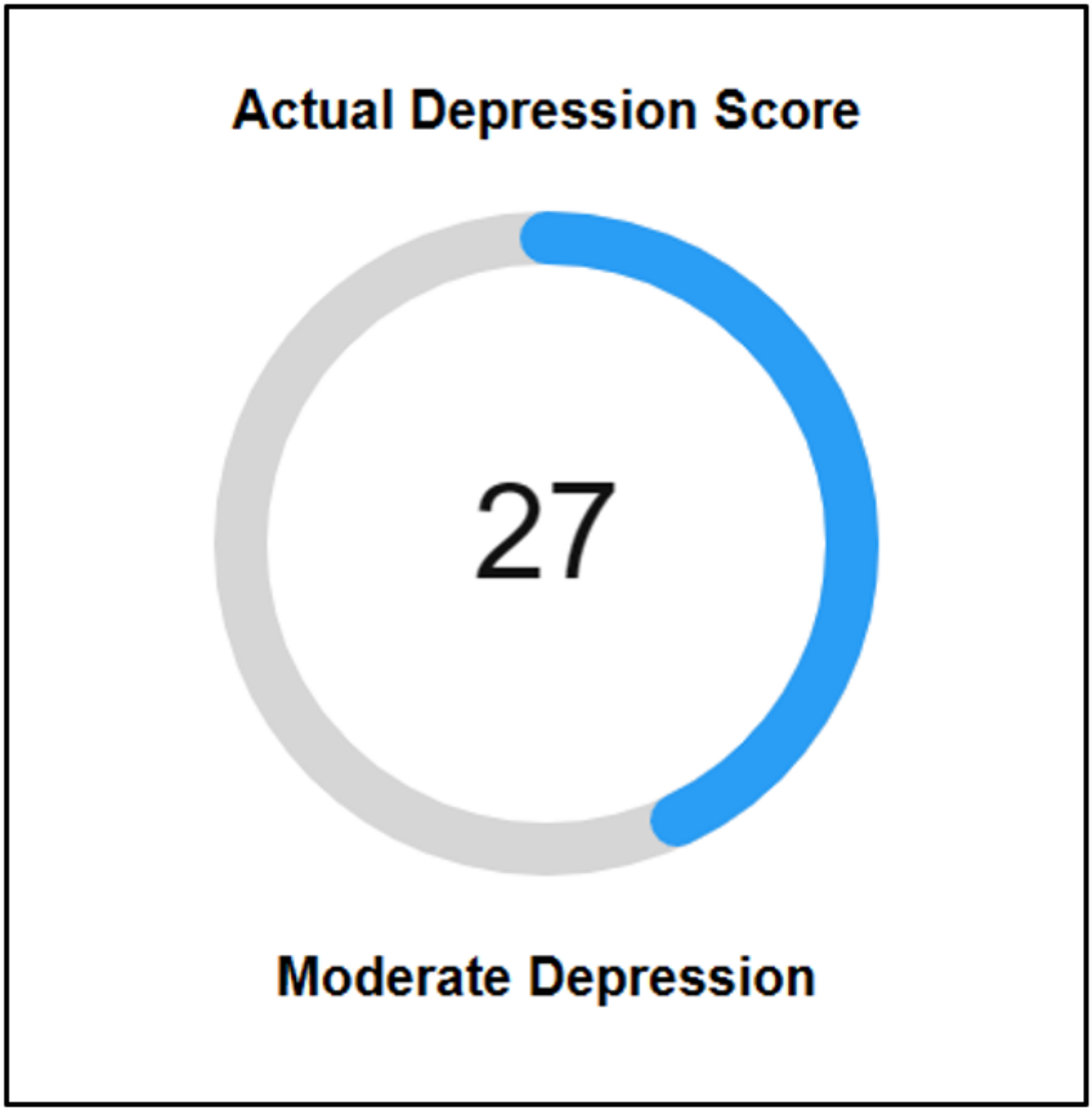


Figure 14

Actual depression score

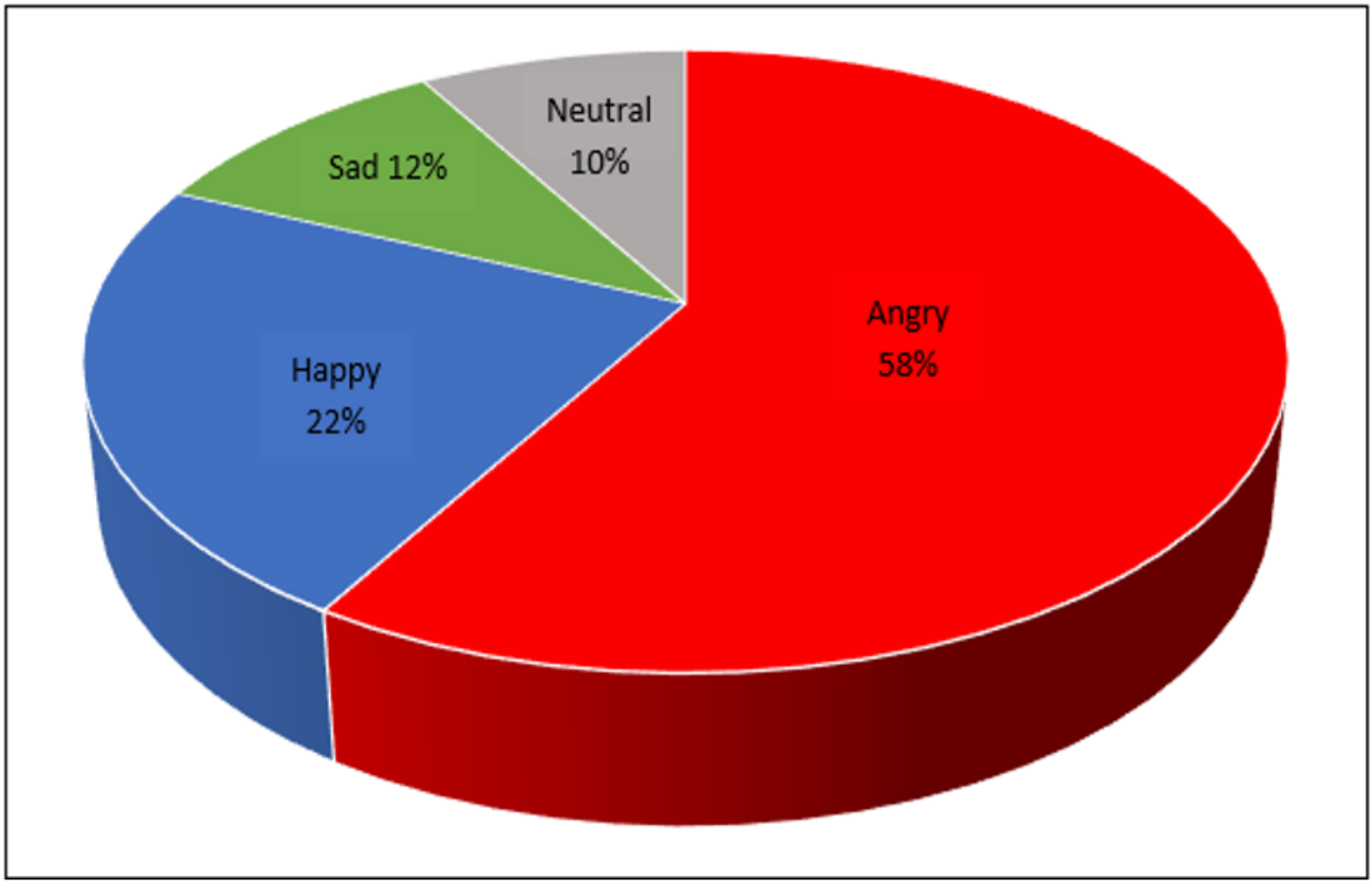
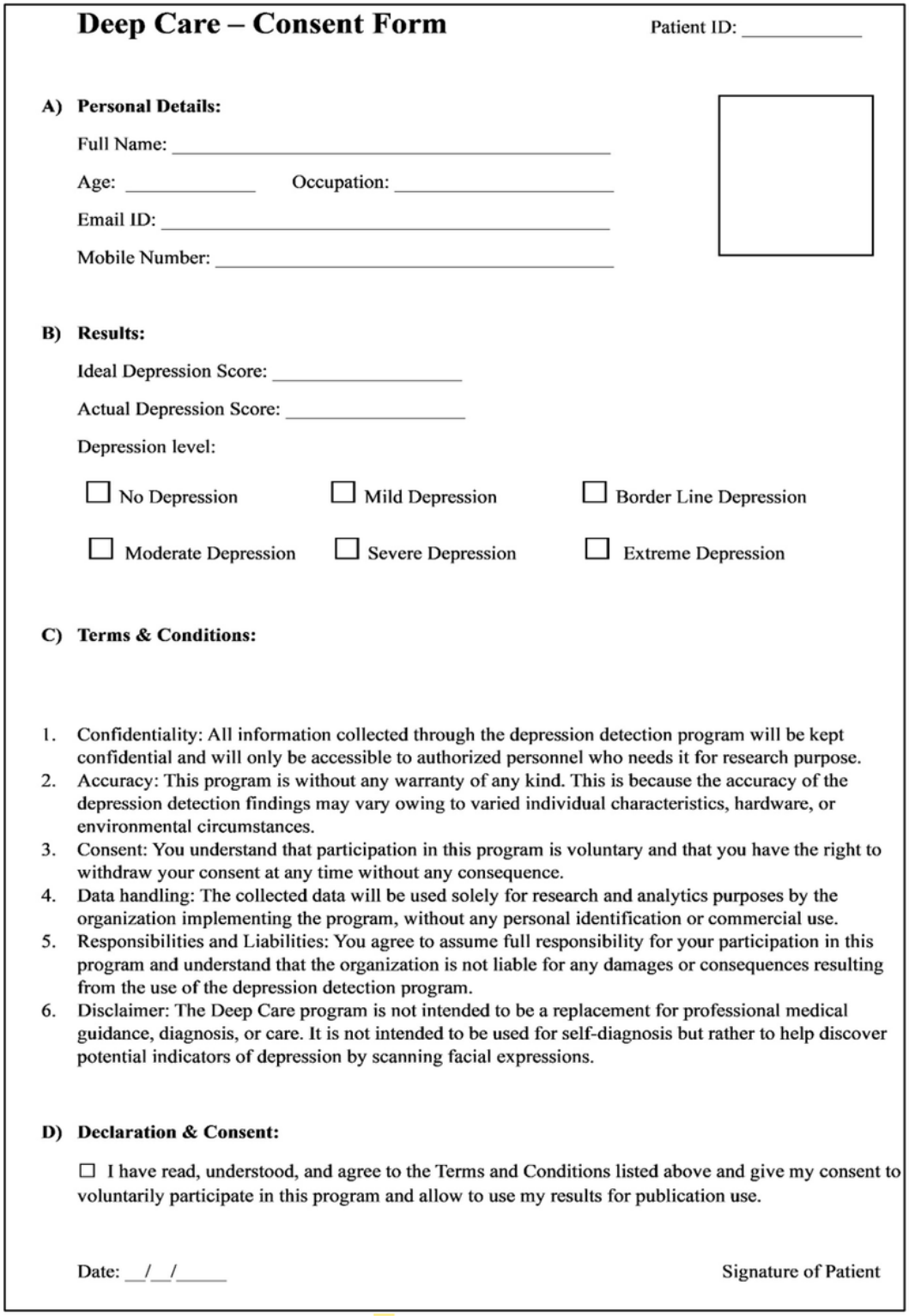


Figure 15

Mental state of patient



Deep Care – Consent Form

Patient ID: _____

A) Personal Details:

Full Name: _____

Age: _____ Occupation: _____

Email ID: _____

Mobile Number: _____

B) Results:

Ideal Depression Score: _____

Actual Depression Score: _____

Depression level:

☐ No Depression ☐ Mild Depression ☐ Border Line Depression

☐ Moderate Depression ☐ Severe Depression ☐ Extreme Depression

C) Terms & Conditions:

1. Confidentiality: All information collected through the depression detection program will be kept confidential and will only be accessible to authorized personnel who needs it for research purpose.
2. Accuracy: This program is without any warranty of any kind. This is because the accuracy of the depression detection findings may vary owing to varied individual characteristics, hardware, or environmental circumstances.
3. Consent: You understand that participation in this program is voluntary and that you have the right to withdraw your consent at any time without any consequence.
4. Data handling: The collected data will be used solely for research and analytics purposes by the organization implementing the program, without any personal identification or commercial use.
5. Responsibilities and Liabilities: You agree to assume full responsibility for your participation in this program and understand that the organization is not liable for any damages or consequences resulting from the use of the depression detection program.
6. Disclaimer: The Deep Care program is not intended to be a replacement for professional medical guidance, diagnosis, or care. It is not intended to be used for self-diagnosis but rather to help discover potential indicators of depression by scanning facial expressions.

D) Declaration & Consent:

☐ I have read, understood, and agree to the Terms and Conditions listed above and give my consent to voluntarily participate in this program and allow to use my results for publication use.

Date: __/__/_____ Signature of Patient

Figure 16

Deep Care consent form