

Software-Assisted Depression Detection and Prevention

Akanksha Gupta
Computer Engineering
San Jose State University
San Jose, US
akanksha.gupta01@sjsu.edu

Abstract— Depression is a medical disorder that affects a person's feelings, thoughts, and actions. It is one of the world's most common yet neglected illnesses. The common symptoms of depression are mood swings, lack or increase in sleep/appetite, and so on. There are several types of depression, for example, bipolar depression, postpartum depression, premenstrual depression, etc. With fast-growing technology, telemedicine is prominent, and health apps are widespread today. But most of these apps are not very effective. The reasons behind the ineffectiveness of these apps are: One, there are multiple types of depression, but these apps give general treatment to all patients. The other reason is the lack of research. As the health apps do not have to follow any standard criteria the apps are pushed in the early stages of research. Moreover, no application provides various diagnosis and treatment features on a single platform. This paper proposes an application that would analyze the mental state of a person, the severity of the illness, type of illness and provide specific treatment like chatbot therapy, music therapy, hobby arena, and other exercises to calm a person down. This app would also be useful to those people who are not suffering from depression but have day-to-day anxiety, suffering from insomnia, and related disorders. The aim is to reduce the adverse effects of depression and rise towards a healthy global population.

I. INTRODUCTION

Depression is a mental health disorder that affects how a person feels, thinks, and acts. It is characterized by a loss of interest in activities and mood disorders that have a detrimental influence on daily life. The common symptoms of depression are reduced pleasure sensations, severe guilt, insomnia, loss or increase of appetite, etc. (Fig. 1) [1]. Based on the severity, clinical features, and illness pattern depression is divided into Major Depressive Disorder (MDD), Bipolar Depression, Perinatal and postpartum depression, Persistent depressive disorder (Dysthymia), Premenstrual dysphoric disorder (PMDD), Psychotic depression, and Seasonal Depression [2].

A. Problem

WHO reveals that about 5% of the global adult population is affected by depression, yet this illness is often ignored [3]. More than 75% of the affected people don't receive treatment due to a lack of resources or ignorance [3]. COVID escalated global depression spread by 25% [4]. WHO's Mental Health Gap Action Program is designed to deal with this issue. Technology is also working hand in hand to reduce illness for the best. During COVID telemedicine facilitated the interaction between the patient and the doctor which proved to be a boon. It has increased access to counseling, especially for financially insecure people, introverts, and other issues.

But even in our rapidly evolving technological world, we are distant from better treatment for depression. Although thousands of mental health apps are available in the market, most are inefficient. The reasons behind the ineffectiveness are the majority of the apps provide general treatment

features for everyone. But as described above there are different types of depression and different severity levels. Providing a single treatment for all types of illness is not sufficient. Moreover, recurrent use of the same treatment over a while has been proven ineffective for depression. Another reason is the lack of research. It takes years to perform a Prospective Randomized Trail to study the effectiveness of any treatment. But these apps don't require proof of any standards. Thus, profit-driven companies launch their apps in the early stages of research without effective measures.

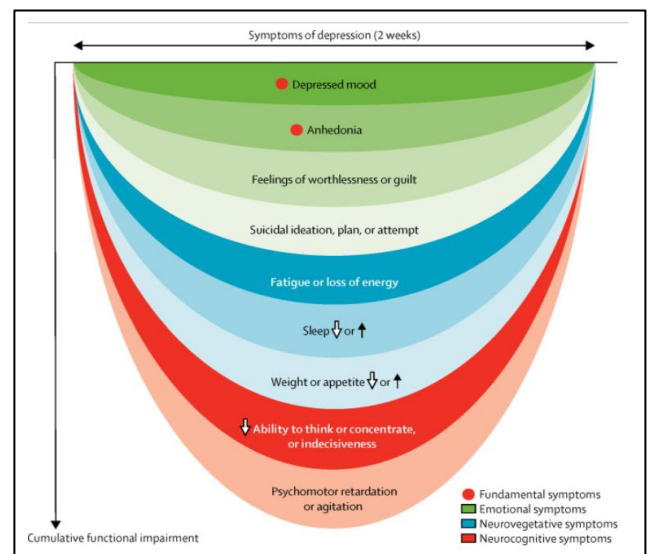


Fig. 1. Common symptoms of depressive disorder [1]

B. Proposed Solution

Today approximately 80% of the population own mobile phones, internet, or computers. So, taking advantage of technology is our best bet. Through this paper, I propose to develop a standalone application that would aim at the correct diagnosis of depression by classifying based on characteristics and severity. The diagnosis would be done by measuring the emotional stability of a person.

Specific treatment will be suggested to the patient depending on the diagnosis. The treatment may range from chatbot or music therapy to Cognitive behavioral therapy. Because technology can't eradicate specialist doctors, this app will provide features to connect to a specialist in case symptoms go extreme or are requested by the user.

This paper includes:

1. Methods to diagnose the illness
2. Methods to treat the diagnosed illness
3. What characteristics influence the result?

II. STATE-OF-THE-ART REVIEW

Most of the work in the software industry is digitizing the diagnosis and treatment methods into machine learning models. While these models prove to be helpful, some challenges are associated with them.

A. Depression Detection on social media

Yang et. al. [5] focus on the early diagnosis of depression. The paper proposes mining the text available on social media using the Contrast module and Knowledge infusion module [5].

The problem with depression detection on social media is people usually post happy moments or pretend to be happy. Moreover, social media is one of the reasons that make people feel worse. Shukla says “...the social media is confusing us. We are getting misled into thinking that happiness is what we want, and that is making us unhappy in a way that we are not happy with” [6]. Secondly, this method may challenge the privacy of the users.

B. Effectiveness of application-based therapy

There has been a lot of research and development on application-based therapy like Cognitive Based Therapy, Chat Bot Therapy, etc. which shows promising results [7][8]. But there are insufficient features that are known to crashes [9]. Rathnayaka et. al. [10] in their study claims “most chatbots extend Cognitive Behavioral Therapy (CBT) into predefined conversational pathways that are generic and ineffective in recurrent use” [10].

C. Overall apps in the market

The available apps in the market don’t have any effectiveness scores. Users choose an application based on other user reviews. Marshall et. al. [11] carried out 6-month-long WHO and ANZCTR registered studies for evaluating the effectiveness of some chosen apps. They found that most of these apps have less than 50% effectiveness on the ill.

III. PROJECT JUSTIFICATION

The purpose of this project is to develop an application that can be proved useful to users who are suffering from depression and in any capacity are not able to visit a specialist. This application is based on existing research and development but aims to broaden the perspective of diagnosis and treatment of depression. As we have seen so far there are a lot of mental health apps available but most of them are either inefficacious or cover less area of the disease. Understanding the shortcomings of existing technology is important as the disease is still increasing rapidly despite various efforts. There is a necessity to develop good-quality mental health apps. For the best interests of society, this paper presents the best methodologies to detect and treat depression all under a single platform. This application would also be useful not only for depression patients but also for those who are suffering from day-to-day anxiety and stress and desire to relax.

IV. ARCHITECTURE

Fig. 2 shows the architectural diagram for the proposed application. A questionnaire would be required when a user visits an application for the first time. This questionnaire is discussed in Table 1. When the user completes and submits this questionnaire, this data would be validated and filtered

for correct prediction. Next, the machine learning model will predict whether a user is depressed or not. And how severe is the depression? If a user is depressed, the user is asked to confirm the symptoms. The symptoms will depict which type of depression the user is suffering from. Based on the type of customized programs will be suggested. If a user is not depressed, they would be redirected to try different programs.

So, this project is divided into two parts: diagnosing the illness and its severity and treating it.

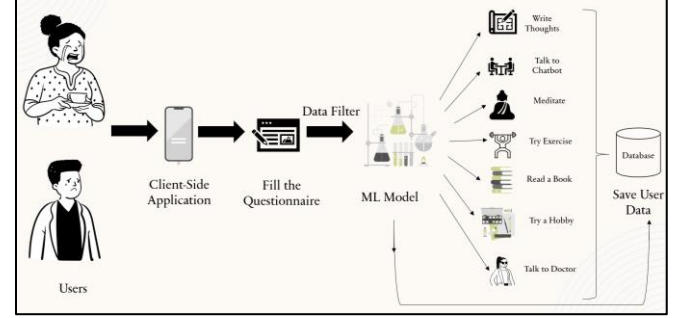


Fig. 2. Proposed Architectural Diagram

V. DIAGNOSTIC METHODOLOGY

A. Big Five Personality Test

For detecting whether a person is depressed or not, The Big Five personality test is conducted. The Big Five personality test was developed by D. W. Fiske [12]. A person visiting the app would require filling out this questionnaire or personality test. The questionnaire looks like Table 1. The first column is Label which is the column name of the rating in the dataset. The rating ranges from 1 to 5 where 1 being the lowest, and 5 being the highest. This questionnaire is adopted from Open-Source Psychometrics Project (details in next sections) [13]. This test divides human behavior or nature into five traits: Extroversion, Agreeableness, Conscientiousness, Neuroticism, and Openness.

TABLE I. BIG FIVE PERSONALITY TEST QUESTIONS

Label	Question	Rating
E1	I'm a party person	
E2	I talk less	
E3	I'm comfortable with people	
E4	I don't like attention	
E5	I'm comfortable initiating a conversation	
E6	My thoughts on a matter are limited	
E7	I talk to a variety of people at any party	
E8	I don't prefer to be in limelight	
E9	I am comfortable with spotlight	
E10	I remain silent around strangers	
A1	My concern for others is limited	
A2	People intrigue me	
A3	I offend people	
A4	I understand people's feeling	
A5	I'm people's troubles don't concern me	
A6	I am quite sympathetic	
A7	I've limited interest in people	

A8	I set aside time for others	
A9	I understand people's emotions.	
A10	I make others feel comfortable	
C1	I preplan everything	
C2	I leave my things everywhere	
C3	I'm very observant	
C4	I'm messy	
C5	I hate procrastinating	
C6	I frequently fail to place things where they belong	
C7	I'm very organized	
C8	I delegate my tasks	
C9	I adhere to a timetable	
C10	I'm precise in my work	
N1	I'm easily agitated	
N2	I'm at ease mostly	
N3	I'm concerned about stuff	
N4	I rarely feel depressed	
N5	I'm readily disturbed	
N6	It's easy to upset me	
N7	My mood often fluctuates	
N8	I often have mood swings	
N9	I'm easily annoyed	
N10	I'm frequently tensed	
O1	I've wide vocabulary	
O2	I face trouble grasping complex concepts	
O3	I've active imagination	
O4	I'm not fascinated by abstract notions	
O5	I get wonderful ideas	
O6	I lack creative imagination	
O7	I'm a fast learner	
O8	I use complicated language	
O9	I often spend time thinking about things	
O10	I'm inventive	

Extroversion is a personality trait characterized by high energy, talkativeness, pleasant feelings, and ease of socializing. It is measured by analyzing whether a person has gregariousness, confidence, excitement, and positive emotions. The first ten questions, E1 to E10, (where the prefix E stands for Extroversion) in table 1 are examples of extroversion. Agreeableness is a measure of a person's ability to have non-conflicting relationships with others. It is also divided into six factors namely, trust, straightforwardness, altruism, compliance, modesty, and tendermindedness. The questions A1 to A10 (where the prefix A stands for Agreeableness) in table 1 depict agreeableness. Conscientiousness is defined as the ability to postpone content, establish long-term goals, and make rational judgments. It is measured by accessing information about a person's competence, order, dutifulness, achievements, etc. C1 to C10 (why the ere prefix C stands for Conscientiousness) in table 1 are example questions of conscientiousness. Neuroticism is characterized by a propensity to have powerful but gloomy emotions. It is measured in terms of anxiety, angry hostility, depression, self-consciousness, impulsiveness, and vulnerability. N1 to N10 (where the prefix N stands for Neuroticism) are example

questions that help analyze neuroticism. Openness is when a person is open to new experiences and information which could be analyzed based on feelings and actions. [14]. Openness can be understood from questions like O1 to O10 (where the prefix O stands for Openness) in table 1.

From Fig. 2 this can be analyzed that people suffering from depression often have low scores in Openness, Conscientiousness, Extroversion, and Agreeableness and high scores in Neuroticism. In other words, Neuroticism is positively related to depression while the other four personality traits are negatively related to depression.

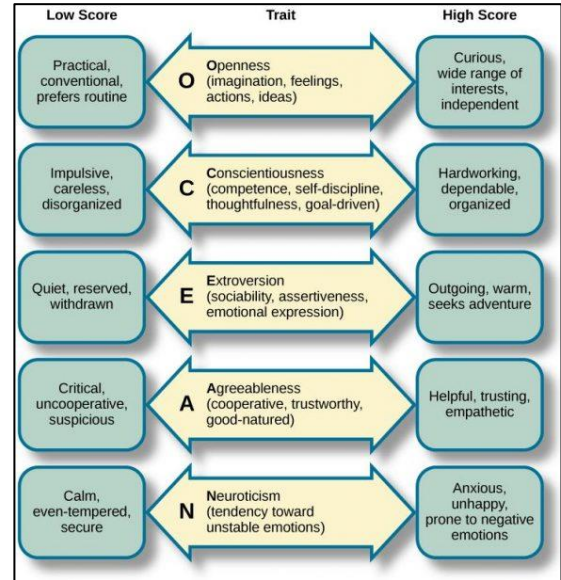


Fig. 3. The Big Five Personality Traits [15]

B. Machine Learning Algorithm to detect the severity

For this paper, the dataset and the calculation method are taken from Open-Source Psychometrics Project [13]. The dataset consists of random data acquired online from people of all ages, races, gender, and nations. It has 50 questions as shown in table 1. There are ten questions on each trait with a five-point scale system as defined in the last section.

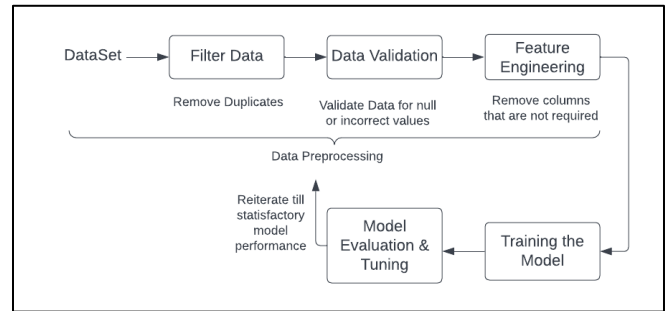


Fig. 4. Architecture for Detecting Depression

1) Data Preprocessing

The data set is stored in a comma-separated (CSV) file, and then data preprocessing is started. One of the major aspects of data preprocessing is to filter the noisy data that would lead to incorrect outputs. The following steps are followed to filter the data:

- The raw data may consist of duplicate entries. Identify and eliminate any duplicate items during the data preparation phase.
- Remove any data points that have null or missing values.
- Get rid of all characters and symbols.
- In Feature Engineering, identify the relevant columns and delete the others.
- In the personality test 50 questions are considered for diagnosing depression. This number needs to be reduced for the sake of the performance of the model. For this, group the columns according to the values; for example, there are 10 questions for Extroversion, and 10 values will be used to convert these 10 columns to 1 using the following formula [13].

$$E = 20 + E1 - E2 + E3 - E4 + E5 - E6 + E7 - E8 + E9 - E10$$

$$A = 14 - A1 + A2 - A3 + A4 - A5 + A6 - A7 + A8 + A9 + A10$$

$$C = 14 + C1 - C2 + C3 - C4 + C5 - C6 + C7 - C8 + C9 + C10$$

$$N = 38 - N1 + N2 - N3 + N4 - N5 - N6 - N7 - N8 - N9 - N10$$

$$O = 8 + O1 - O2 + O3 - O4 + O5 - O6 + O7 + O8 + O9 + O10$$

Therefore, the final ML inputs have 5 values, one for each personality trait. And each score would range from 0 to 40. It can be converted in the range of 0 to 5 by dividing the score by 40 and then multiplying by 5, where 0 is the lowest score and 5 is the highest score. For reference, we are calling this dataset to be Processed Dataset.

2) Machine Learning Model

After the data is ready, five values would be the input to the machine learning model as shown in Fig. 3. These values are E, A, C, N, and O as calculated in the previous section. The next step is to divide the dataset into two groups, i.e., the training dataset and the testing dataset. 80% of the processed data is for the training dataset and the remaining 20% is used for testing the model. Various models were considered during this research. The final choice was to use the Linear Discriminant Analysis algorithm to classify the evaluated values into Normal, Mild Depression, and Severe Depression. The model is then trained using the processed training dataset.

The performance of the model is evaluated using the mean square error method and precision is calculated. The Mean Square Error method is the indicator of the average squared difference between estimated results and evaluated results. While precision is a measure of the number of correct predictions. It can be calculated by evaluating the ratio of correct predictions divided by total predictions.

Before going into treatment, it is essential to understand the symptoms and what symptoms are prominent in which type of depression. Some of the common symptoms of depression are fatigue, extreme loss or gain of appetite with weight changes, poor concentration, and difficulties with making decisions (can be visualized in Fig. 1). Let's look at symptoms that are unique to types of depression.

When a user visits the application and in table 1 responses predict depression. The user will be asked to enter the symptoms and duration of those symptoms. Based on these responses, the type of depression would be deduced for the user.

TABLE II. DEPRESSION SYMPTOMS AND TREATMENT [2],[16]

Depression Type	Symptoms	Treatment
Major Depressive Disorder (Most common)	Disturbance in sleep, appetite, mood, weight, and daily activity. Loss of motivation, and interest. Self-harming thoughts. The patient has most of the symptoms, the majority time for at least 5 days.	Cognitive-behavioral therapy or Interpersonal therapy or Problem-Solving therapy
Dysthymia	Disturbance in sleep, appetite, and mood. Fatigue, Inability to concentrate, hopelessness, Self-harming thoughts. Symptoms persist for at least 2 years with less than a 2-month gap	Cognitive behavioral or interpersonal therapy or psychotherapy
Bipolar Disorder	Excessive energy, Fierce ideas, overly ambitious, talk quickly. Long-term disorder	Require medical attention
Psychotic Depression	Delusions, hallucinations, Paranoia, cluttered thoughts & speech	Require medical attention
Premenstrual Dysphoric Disorder	Same as MDD. Coincide with at least 2 menstrual cycles	Exercise, Medication, Healthy Diet, Cognitive Behavioral Therapy
Postpartum Depression	Same as MDD along with guilt and feelings of isolation. More than two weeks after delivering a baby	Music Therapy, Cognitive behavioral therapy
Seasonal Affective Disorder	Headaches, disturbance in concentration, mood, interest, sleep, and appetite. Self-harming thoughts	Light Therapy Requires medical attention
Atypical Depression	The event triggered vigorous mood swings, uneasiness in hands and legs, Extreme evening sadness	Cognitive behavioral or psychotherapy

VI. TREATMENT METHODOLOGY

In table 2 the treatments that can be delivered by application-based techniques are Cognitive Behavioral

Therapy, Music Therapy, Interpersonal Therapy, psychotherapy, and Problem-Solving Therapy. These therapies can be delivered using a chatbot.

The chatbot is based on the following principles [17]:

- Recognizing and re-evaluating the faulty thinking patterns that are causing issues.
- Understanding other people and their behaviors.
- Enhancing problem-solving skills to handle difficulties.
- Developing confidence.
- Facing fears
- Learning relaxing techniques.

For developing the chatbot the dataset is obtained from the Kaggle dataset [18]. This dataset consists of approximately hundreds of questions and answers to train the machine learning model. The design that is utilized to create this chatbot is rule-based. In a rule-based approach, the users are responded to with predefined data. No new responses are generated. This predefined data is stored in a database.

When a user inputs something in the chat box. Firstly, the data is processed using NLTK which converts lengthy sentences into words. For example: “How are you feeling today?” will be converted to “how”, “are”, “you”, “feeling”, “today”. Then, Term frequency-inverse document frequency is used to detect the weight of any word in a group of sentences. Based on the weight the bot will fetch a similar answer from the predefined data.

This bot will also allow users to book appointments with the doctor who is allotted to them when they sign up for the application.

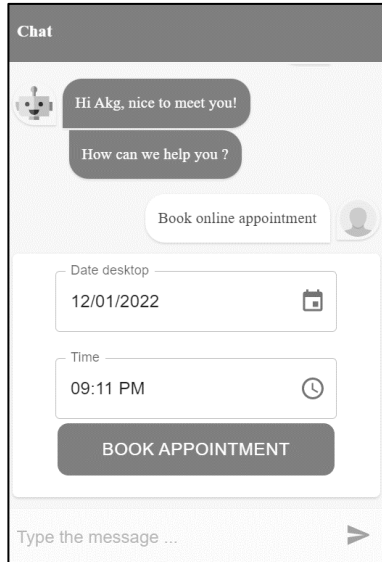


Fig. 5. Chatbot assistance

When a user is diagnosed with let's say, Premenstrual Dysphoric Disorder, the user will be suggested some exercises (as shown in Fig. 7) and food recipes. The user can choose from these exercises and recipes or can do chatbot therapy. This feature is implemented by sending

HTTP requests to Rapid API's Exercise DB [19] and Recipe Search and Diet [20] (as shown in Fig. 6).

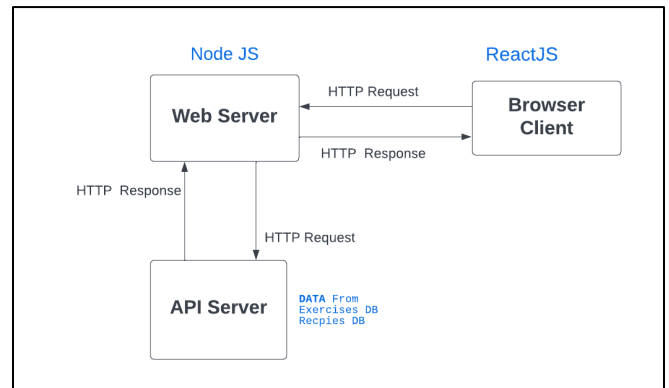


Fig. 6. API Call Structure

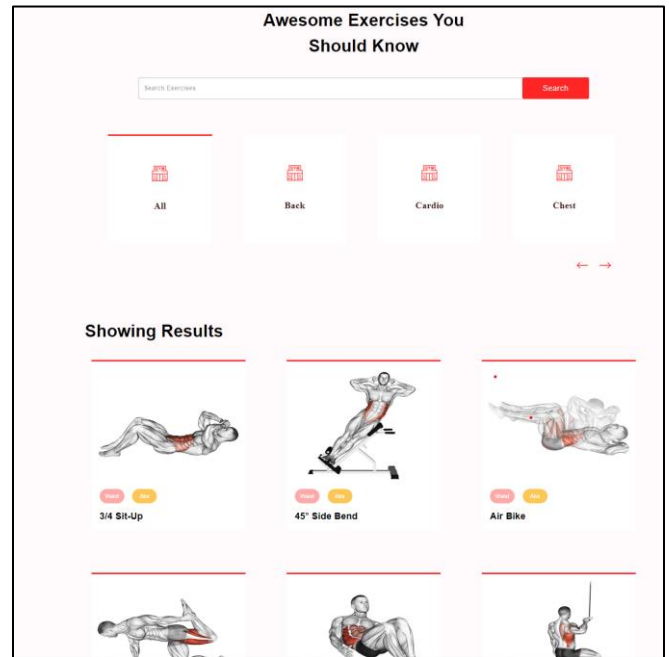


Fig. 7. Exercise Recommendation

VII. RESULTS

This proposed application provides curated features in a single platform. The app utilizes the Big Five Personality trait test to detect the severity of the disorder. A person with an $E = 11/40$, $A = 13/40$, $C = 15/40$, $N = 25/40$, $O = 17/40$ is a case of mild depression. It also talks about the personality of the person, where is room for improvement this person should consider going out with friends and talking to people, which is recommended by the chatbot.

Moreover, on this score, the application asks for symptoms and predicts the possible type of the disorder, and provides relevant chatbot-based best effective treatment like exercise suggestions, recipe suggestions, and so on. It also allows the user to book doctor's appointments.

The model is at 72% accuracy and predicts depression when a score of $N > 20$ and others < 20 . Otherwise, the person is not depressed.

VIII. STRENGTHS

The strengths of the application are:

- state-of-the-art features are included in the application.
- The Big Five Personality test gives insights into the person's personality
- The test also depicts the areas that can be improved, and these areas are also recommended by chatbot therapy. For example, someone with a low openness score would be suggested to try a new adventure.
- It is beneficial to those who are not able to consult a specialist due to lack of resources or time or any other problems.

IX. LIMITATIONS

The limitations of the current model are as follows:

- The personality of a person keeps on changing which would require that the person fills out the questionnaire periodically, to update the treatment process.
- The chatbot currently works on a rule-based approach which has a limited number of responses available in it.
- Researchers claim that Big Five personality traits do not cover the entire personality of a person and believe a lot of information is lost in the Big Five personality test. So, new testing approaches are required.
- It takes a lot more than 50 questions to understand the personality of a person.
- The Big Five test neglects the demographics and health details of a person.

X. CONCLUSION

It is no secret that depression has become one of the most irritating problems in the modern world. Despite this, science and technology are continuously working to resolve the issue and prevent it from happening. This application was designed with such a goal in mind, and it can help tremendously. The application provides state-of-the-art diagnosis i.e., Big Five Personality Test, and prevention techniques i.e., Cognitive Behavioral Therapy.

There's a lot more information we can learn about a person's personality through the Big Five test, but we can further improve the diagnostic methods with research and technological advances. The model has decent accuracy in predicting depression which can further be improved. The current chatbot functionality allows users to take therapy and book appointments.

XI. FUTURE WORK

In the future, a generative chatbot will be added to the application. The benefit of using a generative chatbot is

that it creates custom responses from scratch. For this, it utilizes a machine learning technique known as Recurrent Neural Network (RNN). In RNN, the responses are not only based on current inputs but also a series of past experiences.

Other features like music therapy need to be implemented. The model's accuracy can be improved by further filtering the data. Moreover, the app needs to be updated with state-of-the-art research and technology.

The app needs to go through randomized trials to prove its effectiveness. This would take a lot of time and effort.

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