

**EFFECTIVENESS OF MACHINE LEARNING FOR MENTAL HEALTH:
OBSERVING THE MENTAL STATE OF BANGLADESHI PEOPLE**

BY

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This Report Presented in Partial Fulfillment of the Requirements for the
Degree of Masters of Science in Computer Science and Engineering

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APPROVAL

This thesis titled **Effectiveness of Machine Learning For Mental Health: Observing The Mental State Of Bangladeshi People**, submitted by Sayda Umma Hamida, ID No: 201-25-880 to the Department of Computer Science and Engineering, Daffodil International University has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of M.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 3rd June 2021.

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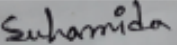
I hereby declare that this thesis has been done by me under the supervision of **Mr. Narayan Ranjan Chakraborty, Assistant Professor, Department of CSE, Daffodil International University**. I also declare that neither this thesis nor any part of this thesis has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

Analyze and finding the most used AI applications or methods in the Mental Health sector and suggesting appropriate directions for advanced research is the primary objective of this research. With this purpose, the author selects papers reviewing to analyze thirty-one articles included two books, two conferences, six generics, one report, and 16 journals. The author identified that most of the research followed the same theories although, some are different or merge. The researcher found the most used recognizing technologies in real life; find out from a person's voice or speech and eye-tracking and neuroimaging technologies for checking brain abnormalities. Besides, the chatbot is the most used AI assistant in digital health or virtual life. As the main aim is to analyze the Bangladeshi youth's mental health, the researcher has done a survey on 19-29 years people. With the result of this survey, the researcher becomes clear about the upcoming danger that will only for mental disorders like as- Anxiety, Depression, and PTSD. Not only that, this will cause a huge loss for people's unaware attitude. This research also offers an implication for future research directions and also identified existing knowledge gaps. Besides, a three-phase model proposed in the study is a combination of virtual and real-life AI technologies. Moreover, this review did not include any psychiatrist techniques of treatment or, any real-life dataset from patients. So, it was a limitation and a future working scope also. Applying deep learning, machine learning algorithms (e.g. support vector machine (SVM) random forest), BCI, virtual reality in mental illness detection, and treatments are also used effectively as founded by reviewing those articles.

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CHAPTER 1

INTRODUCTION

1.1 Preliminary

A recent article by MSF [1] and the World Health Organization mentioned that, around the world, one in four people are suffering from a different kind of mental health disorder.

Moreover, about 60 percent of sufferers do not seek help. Here, they mentioned the following factors of poor mental health: childhood conditions (i.e. traumas, abuses or, neglects), social loneliness (e.g. isolation), stigmas, and experiencing discrimination. Although, there are too many explored or unexplored factors that remain mental disorder issues only but have no solution yet.

Another study published in 2020 shows that in 2018, 47.6 million adults (i.e., 19.1%) in the United States suffered from mental illness. Also that year, about 11.4 million adults (4.6%) went through various significant mental illnesses. In 2016 that was about 7.7 million among young people [2]. This National Alliance on Mental Illness study by S. Fielding also included, although many countries are still trying to start discussions on mental health; Yet America ranks third for adults with untreated mental and behavioral disorders. Because more than half (57.2%) of their population was mentally ill [2].

1.2 Motivation

WHAT comes to your mind immediately when you see the word 'mental health'? Or, can you feel anything? If it is a No, then you are the luckiest person in the present situation. Yes, you read that right- considering the people who have lived through violence, trauma, or natural disaster and whose survival goes beyond ensuring physical well-being. Even, after the physical injuries had been a treat and fully recovered, hidden psychological wounds can remain same as it was. Now imagine if they have anyone to listen, support, and provide mental health care mainly to help heal the patient's psychological wounds, so the traumatic experiences do not come to define their lives. That must be very conducive, and that was the base idea of this research.

1.3 Rationale of the Study

As we can see, worldwide, the rate of mental illness patients is growing. But the lack of proper treatments, negative reduction procedures or, prevention is still below the necessity. Moreover, for developing countries like Bangladesh, mental illness is the scariest situation because of several stigmas, fear of society, and superstitions.

However, the main objective of this study is to record the short term mental health of the people of Bangladesh (i.e. COVID-19) and analyze the mental health data using AI algorithm, Python. Also, this study will be a systematic review with a brief analysis of worldwide article that included the use of AI technologies or methods; which were used previously to treat the most alarming mental health issues like; depression, anxiety, phobia, PTSD, suicidal tendencies. Besides, those AI technologies still have many scopes to find a suitable model for mental health care that can be a combination of several AI technologies or applications.

1.4 Research Question

I have developed some research questions which have been stated the issues of my thesis focuses on and outlined the tasks that have to be completed. For this review, mainly three questions followed that added below-

- 1) What grows the destructive behavior & suicidal tendency of people?
- 2) How did mental disorders reduce the creativity & mental strength of people?
- 3) What were the most effective AI strategies for motivating people?

1.5 Expected Output

There is a lot of research works exists that can classify mental disorder data but have a bunch of limitation. Besides, previous works related to similar topics were classified and comparatively completed and some were based on information from psychiatrists.

But in contrast to the south Asian developing country 'Bangladesh', none of this has been mention about using artificial intelligence in real life to identify or treat disorders patients; or the validity of applications in this regard or to identify patients' symptoms. That special problem will be focused on throughout this research, survey, analysis mental

health data with algorithms and most importantly the result of the study will expose the most used real-life implementation of such devices for people to assume their mental condition very easily. Besides, how AI technologies are beneficial for today's mental disorders treatment will be discussed briefly.

1.6 Report layout

Report layout of this work has followed an order. Here, the introduction is the first chapter where the very basics of my project will be focused. As per research, how the idea of artificial intelligence collaborates with these disorders its main point is included here. Moreover, some questions related to this thesis work will become in front. The next chapter is background or literature review; where I have got a clear idea about this thesis will be discussed here as well, but briefly. For example what the previous researchers have done, how their work was, and what they couldn't able to implement. The third chapter will contain the methodology of this research; where I will include how the project will be get done through or which procedure being followed. Since the main component of this work is reviews and surveys, so the main focus will be on it. The fourth chapter is the most important part of the project where all the experimental setup will be discussed briefly. The experimental result and descriptive will be given in this section which will focus on the key AI technologies founded by the researcher and end of the section a through the simple short way the whole section will be summarized. Most importantly, my research question and online survey results will be discussed here. Chapter five of this thesis is about the impact on Society, Environment, and Sustainability; where I will discuss how the findings of my study impact society and the environment. Besides, how the study will be sustainable will be described briefly. In chapter six, the whole project will be summarized very shortly and the limitations found in and the further implication will be given.

CHAPTER 2

BACKGROUND

2.1 Introduction

Artificial intelligence is like a buzzword as this AI platform has a significant contribution to human life. The use of AI is like basic needs- food, garment, education, accommodation, and health. In today's mental health, the common AI subdomain applied for human's betterment are- machine learning (ML), neural network, big data, expert system, fuzzy logic, and natural language processing (NLP). When, Anxiety, Depression, Bipolar, PTSD, Mood, Psychotic, Dementia, or Eating disorders are the most common mental disorders.

An article by H. Ritchie showed that the number of worldwide mental health disorder's patient more than 792 million; globally, which is like one person per ten (10.7%) [3]. It also shared the number of males (9.3%) and females (11.9%) with any mental health disorder. This study also revealed that in the United States, mental healthcare is the most expensive sector of the healthcare system with annually more than \$201 billion spending's; still, more than 50% of mental illnesses remain untreated [3].

Different statistics showed that, so far, South Asians are the most suffering community, and India, Bangladesh were the two most depressed counties in 2016 [Figure 2.1.1]. In the year 2017, mental disorders were shared the total disease burden from 1990 to 2017 which showed Bangladesh as the most affected S. Asian country [Figure 2.1.2]. Another study on South Asians found that keeping quiet about mental health problems was one of the main reasons they suffered the most; even they were ashamed to talk about mental health. Even their socio-culture is not interested in discussing this [4]. Despite the stigma attached to the source of mental health care, cultural identity and, collective stigma [5], the Roshni Project launched a research program for communities in the last few years. Their goal was to promote mental health among young South Asian women [[6] and [7]]. Although, Bangladesh is the second most risky country with 160 million people. But, still, now, they had only 50 clinical psychologists and 250 psychiatrists. Most

importantly, statistics revealed 80,000 people with mental health per specialist was the worst situation [[8] and [9]]. A 2019 report by a Bangladeshi journalist specifies 17% of Bangladeshi grownups experience the ill effects of emotional well-being issues. Even about 18% of them are female patients and 16.7% are male. Besides, among them, 92.3% did not seek medical help [10].

In 2020, a Human Resource for Mental Health report revealed that Bangladesh has a higher prevalence of depression (2.8%) than the South Asian region (2.2%), especially for women (3.6% vs 2.7%). It is also worth noting that the suicide rate of women in Bangladesh is higher than that of men (7.7 vs. 8.6); this suicidal death is tragic with their 100,000 population [11].

OVERALL	DEPRESSION	ANXIETY
China	China	China
India	India	India
U.S.	U.S.	U.S.
Brazil	Brazil	Brazil
Russia	Bangladesh	Indonesia
Indonesia	Russia	Pakistan
Pakistan	Indonesia	Bangladesh
Nigeria	Nigeria	Iran
Bangladesh	Pakistan	Nigeria
Mexico	Iran	Germany

Figure 2.1.1: Lists of the Most Depressed Countries in the World [12]

This complete review only covers relevant literature that is not limited to a research methodology or journal, or geography. However, the proposed model is primarily for controlling the mental disorders of the people of Bangladesh. This research is aimed at

reviewing the best helpers in dealing with this situation where 31 articles from different departments of psychology are included. As the number of mental health initiatives in Bangladesh is almost zero, and many sectors have not been open-up yet. So the research has been done by looking at the work of some suitable and well-known AI technologies like EEG, MRI, ECG, eye or speech track. Speaking of AI robots, it is also very renowned among virtual assistants.

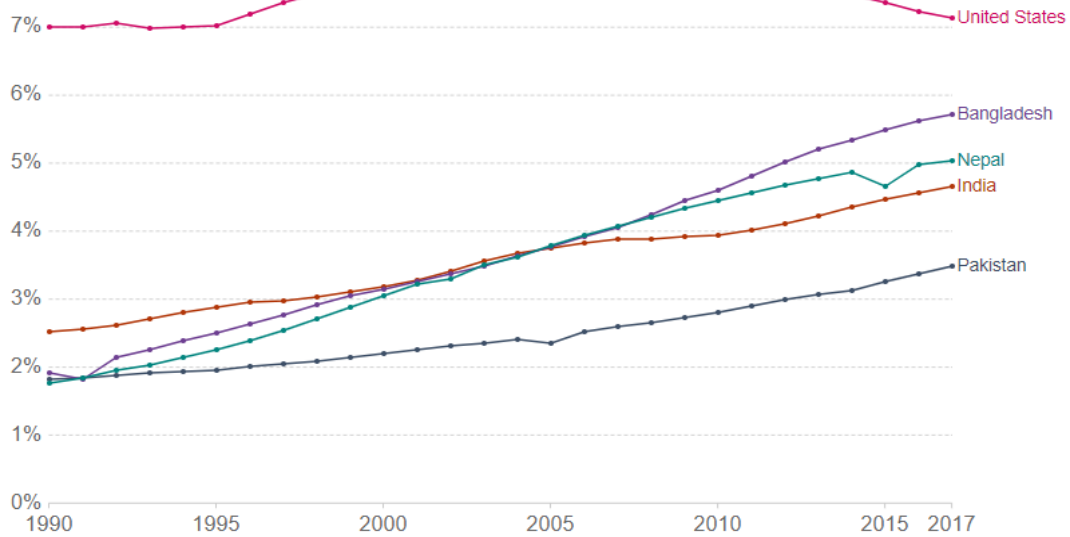


Figure 2.1.2: Show the mental disorders condition through the year 1990 to 2017

2.2 Related Work

I am not the very first to work on this topic so far so much research work has been done on this. So many renowned scholars have been working on this for many long. Here, summarizing some of the notable research considering this combination of AI technology and mental health is given below-

2.2.1 Neuroimaging Techniques

In mental health issue detection, brain image is counted as the most significant domain, as every imaging tests are very efficient here. This research included several neuroimaging technologies such as; EEG, MRI, fMRI.

➤ **Electroencephalography (EEG)**

EEG is known as the father of neuroimaging, as it was the first (1924) brain imaging application. This electrophysiological monitoring method uses mainly to note the electrical motion of the brain [13]. Moreover, it is more agile, affordable, and convenient insights concerning brain purpose, with a snug temporal analysis. In this research, five journals related to EEG discussed below-

In G -D. Liu et al., they represent an observation technique [Figure 2.2.1] for the psychiatric disorder that was a combination of EEG, MRI, and kinesics. Here, the change in brain structures, particularly neural circuits and brain function employing MRI comprehend. They also investigated micromolecular variations, such as protein expression conducting EEG. Because of too many undetermined factors, the final results of EEG recording showed a large amount of noise. So, they suggest a clean start for EEG recording as for advanced work. Besides, they had no extensive computer configurations, and the imaging process takes a long time; so, they marked that as a future direction to resolve [14].

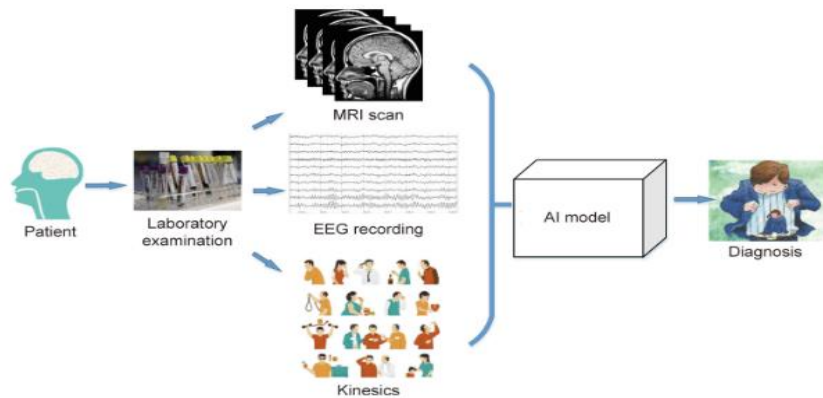


Figure 2.2.1: Shows Major observation techniques for psychiatric disorders

In R. Buettner et al. article, they used their theory and proposed a machine learning-based classification system to diagnose schizophrenic patients using EEG technology. They used a random forest classifier to identify patients from mentally healthy people. They used 1- minutes EEG recording to detect schizophrenia but, the result founded inaccurate,

as influenced by the medication and personality. Besides, their classifier was not well trained and tested. Moreover, the inner validity of their model was very high because of the strict K-fold cross-validation. So they mentioned re-evaluating their classifier in the future and triangulated the EEG sensor data. They even planned to experimentally value; whether their approach becomes strong under different conditions of the user's knowledgeable workload [15].

In O. AI Zoubi et al. research, they primarily focused on general EEG-ms (microstate) properties although they aimed to describe the irregularities of EEG-microstate in mood and anxiety disorders. They did data acquisitions, pre-processing, microstate analysis, and finally, the information-theoretical analysis. They also modified the kmeans and utilized the AAHC (agglomerative hierarchical clustering) for segmenting the EEG points. But, their underlying neurophysiological mechanism of microstate was unclear; the study cohort was very heterogeneous; so they suggest EEG-ms within the mood and anxiety cohort should warrant future study [16].

In Y. Wang et al. research, they proposed and implemented an EEG-based 3D convolutional NN architecture named AnxietyDecoder. They divided their methods into two-part one is forward engineering, and another is reverse engineering. Combining these two engineerings, they proposed a 3D Conflict Focused CNN called 'Anxiety Disorder'. Although, their first model was a 2D system, for the black box error this new 3D system was proposed. According to them, based on the EEG record, it accurately predicts anxious behavior. Besides, it can inherit feature innovation capacity and open the black box. Moreover, this anxiety biomarker research could sprinkle some spotlight [17].

➤ **Electrocardiogram (ECG)**

In J.W. Ahn et al. research, they developed a wearable device with an EEG signal recorder on the left side and right side of the head to measure the pressure with a measurement of the ECG signal by three electrodes on the forehead [Figure 2.2.2]; which used for stress monitoring in daily life. Besides, they applied Stroop color examination and a reasoning arithmetic analysis as a stressor. They followed four steps in working-

system design, recording from EEG and ECG, stress experiment, and data analysis. Moreover, for statistical analysis, HRV feature and EEG parameters employ. Thus, they found meaningful time and frequency from HRV (high-resolution imaging) and EEG in the two detached stressors. Their stress assessment and system specification were notable. Even they founded a great EEG alpha wave result and ECG comparison also. They mentioned five groups of models; four for building the model but the remaining one employed for validation. These validation results display the most excellent performance, in short 87.5% of accuracy. They had limitations; all samples were just male participants and using the wet electrode. So, advanced work indicated a large number of participants (any gender); of course, dry electrodes to grow the efficiency of using the device [18].

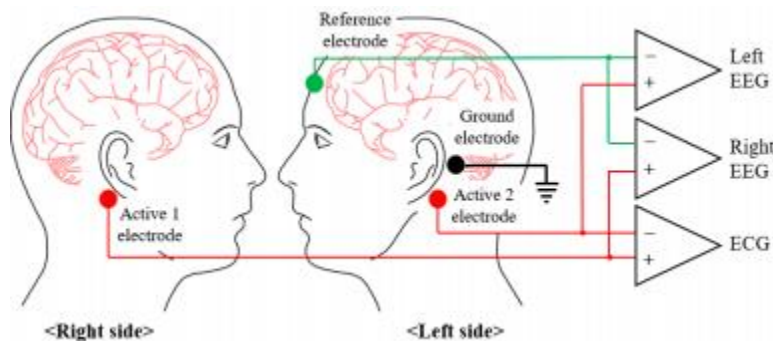


Figure 2.2.2: Placements and differential inputs for recording the EEG and ECG signals

➤ **Magnetic Resonance Imaging (MRI)**

Another neuroimaging technique that can create images of anatomy and physiological processes in the body is MRI. The structural MRI is another member of the MRI family that allows the determination of neuro-morphology and neuro-morphometry in early mood disorders. It works with anatomy, pathology, and cerebral lesions of the brain. So, for this sMRI test, no offensive tactics are required [19].

Article of X. Chen et al. was a bibliometric and visual analysis, where their study investigates the state and aims of study reports concerning the applicability of Artificial Intelligence concerning brain MRI. By this analysis, they had found the top five discussed Artificial Intelligence swelled MRI processing- image segmentation (10.14%),

operative interface connectivity (8.62%), mental disorder (8.71%), Alzheimer's condition (8.51%), and MRI study algorithm (8.39%). Although they did not mention any limitations or never suggest any future direction, they conclude by including an advanced MRI approach named csMRI and a mapping technique QSM for future research groups to employ [20].

➤ **Structural magnetic resonance imaging (sMRI)**

As bipolar disorder (BD) is uncertain and BD patients always differ by their condition, some are in the starting stage or, some may in the final stage of the disorder. So, the article of N. Dusi et al. was a review paper where they aimed to summarize sMRI by examining the association between brain diagnosis and clinical consequence included the therapy response, cognitive deprivation, and inclusive functioning. Although they planned to make an order list of the selected article, they did not get any stable outcome. So they picked psychopharmacological terms to select paper. Thus they found the white matter hyper-intensities and gray matter reduction as the summary of sMRI; mainly, in front limbic regions associated with graver result in Bipolar Disorder. Besides, they shared some limits of studies like as the absence of widely shared definitions, database, shortage, and inconsistency on the outcome, which also can consider as the future direction [21].

The L. Dai et al. also worked on a review article following the keyword search method with several factors such as- gray matter, white matter, and cerebrovascular changes. They aimed to prepare a literature review on the MRI technologies as an auxiliary tool for the psychiatrist to perform an early and accurate diagnosis of depression. According to their research, brain function abnormality in depression counted as some factors like- salience interface, regional brain activity changes, change in default mode network (DMN), brain network functional connectivity changes (ICA and SCA), convenient executive network (CEN). They noticed the low coherence and reproducibility of their investigation outcome also, the shortfall of clinical particularity at the suitable level. As for the future, they suggested enhancing the uniformity of the individual and accumulate

endless information from patients of a few age gatherings, signs, and related confusions to get a particular outcome [22].

➤ **Functional MRI (fMRI)**

The fMRI holds the tiny variation in blood flow that transpires with cerebellum motion and identifies irregularities inside the brain that never obtained with other imaging techniques.

C. Sripada et al. had raised an engaging question concerning whether variations in connectivity exemplar among the network through youth were imminent or not, an exceptional work of previous research by W. K. Thompson et al. [23]. Their existing analysis examines this investigation leveraging the initial record's release from Adolescent Brain Cognitive Development (ABCD) internals considerations. They collected data from twenty-one sites nationwide; go through a sequence of data acquisitions and fMRI preprocessing. Then, they perform the Bayesian probabilistic principal components analysis (BPPCA), inclusion or exclusion ABCD and brain basic set modeling (BBC), data mode network (DMN), and the linear regression with MatLab programming. In their additional analysis to estimate the robustness of the impending forms, there were three neurocognitive precincts. So, they organized only prevailed ability as generalizable across the section and robust. As the other two were much small, the consequence was not generalizable, did not have sizable signs in the dormant state. As for the future, they suggest using any alternative classifiers (SVM), modalities (task-based schemes) or, quest approaches that will be much-utilized [24].

➤ **Magnetoencephalography (MEG)**

Magnetoencephalography, or MEG scan, is likewise an imaging procedure that classifies brain motion and holds small magnetic spheres designed in the brain [25].

This article on multilayer MEG by A. C. Nugent et al. was a convincing work that applied a multilayer analysis to examine variances in MEG essential connectivity within healthy controls (HCs) and individual major depressive disorder (MDD) with a singular

focus on the three nucleus networks. They followed the comparison, correlational study for the five symptoms factor suicidal views, depressed feeling, tension, negative thought, and motivation [26]. They organized 25 with HCs and 29 participators with MDD. Their primary outcome of depression was by the MADRS. Moreover, they added two portions- lessened appetite and spoiled sleep to get a better result. Then, sequentially, they complete the data acquisition, MRI pre-processing (fMRI mainly), MEG data analysis with MNE- Python and Pyctf toolbox, and a linear mixed effect use for statistical analysis. The electrophysiological connectivity and consequence of suicidal cognition in MDD both strongly associated as they claimed [27]. They mentioned a small sample size, missing graph analysis, unprofessionalism as their limitation. For the future, they desired to coverage on a single model for suicidal ideation with a perfect graph analysis; suggest an extensive amount of data for this type of research.

➤ **Brain Computer Interface**

Currently, the brain-computer interface (BCI) technique is at the heart of numerous medical studies as a feasible tool for testing prosthetic appliances with the mind. This BCI technology works by arranging electrodes on the brain exterior for neural signals to interact with the prosthetic permits it to move [28].

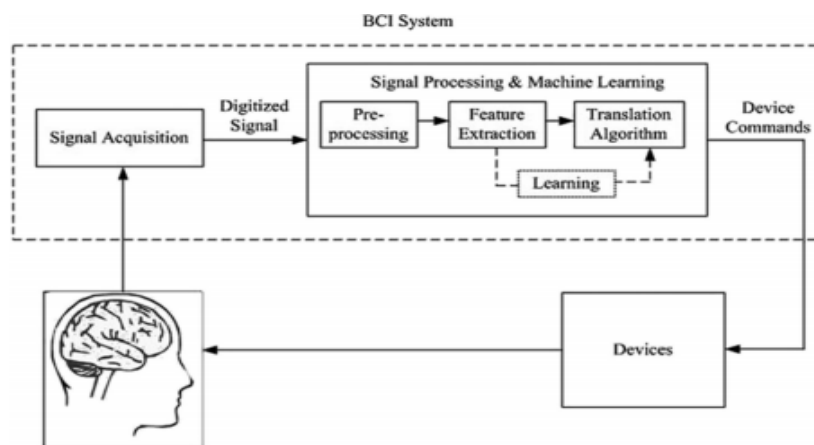


Figure 2.2.3: Working process and basic layout of a BCI system

This article of G. Papanastasiou et al. was about to explore a paradigm shift in BCI research; to intervene in the best exercises for practice and restoration of students with

neurodevelopmental ailments. To emulate individuals' brains and discuss the congenial understanding for each student's neuro-developmental illness was their primary aim. Their BCI system included the data acquisition, preprocessing, feature extraction, and translation algorithms [Figure 2.2.3]. Mainly, it had three primary groups- one is invasive, then non-invasive, and partially invasive. This paper investigated only non-invasive nature utilization because this representation was the most sustained and most affordable. According to their result, Dyslexia was one of the knowledge diseases handled by BCI EEG neurofeedback exercise. They also organized BCI's training state that attaches to learners' immersion, creativity, and sensory abilities. As they suggested, more investigations should reflect ADHD's clinical heterogeneity and observe sufferers with ADHD for a more extended time and with long-term checkups. Another significant concern was to estimate the strength of the BCI-based drill performance and to bypass an unrealistic treatment effect. Besides, there were unsolved points that limit BCI systems' extensive use in disciplines named speed and correctness. Moreover, some additional portions had abounded influence on the BCI performance as- demographic properties (i.e. age, gender), practice/habits (operating a musical tool, video games, sports, typewriting), and user's surroundings. So they suggest a well-designed controlled trial in the future [29].

2.2.2 Recognizing Techniques

Emotion recognition is the method of classifying human emotion by calculating expression, gesture, and sound [30]. To date, the most directed on automating the recognition of facial eloquences from the video [31], spoken discloser from eye movement and audio [32], written expressions from the text, and physiology as covered by the wearable.

➤ Recognizing Emotion from speech

In F. A. Shaqra et al. article proposed and worked with four models for emotion recognition from speech; a simple model with a single classifier, then a hierarchical classification model with gender only, an age-based, and the last one was a compound

model. Here, they adopted a blend classification guide that extracts all prediction possibilities toward per label from the earlier three patterns; sequentially inquired various feature collections and examined performance on classifying the age, gender, and sentiment of the speech. They mentioned only eGeMAPS features were sufficient for emotion and identifying gender. Besides, their emotion features for age identification were significant as it increased the accuracy from 78.76 to 87.5. Moreover, their separate classifier for every gender and different age collection gave a more beneficial representation rather than one prototype for both. Thus, they investigated the mixture of age with gender synchronically, got an ideal result, and obtained the highest accuracy as 74% [33]. They did not mention any future directions but, they have planned for advanced experiments with several factors.

In H. Aouani et al. article, they proposed a sentiment recognition method based on speech signs in a twostep model, specifically feature extraction and classification engine. Here, they only used six basic emotions- anger, disgust, fear, happiness, sad and surprise; besides, six different languages were selected for the dataset but finally used only English. Their proposed scheme consisted of some factors MFCC [34], autoencoder (AE), Teager energy operative (TEO), zero-crossing rate, and harmonic to noise rate. They had extracted audio of 42-dimensional vectors with 39 coefficients. They even examined the support vector machine as a classifier system based on a union of the four (HNR, MFCC, ZCR, TEO) features. Their result showed the utilization of AE dimension decrease improved the classification rate by almost 72.83% when the substance regularization parameter was 0.00001. Moreover, they planned for future work with other types of features, bases, and a much larger dataset [35].

➤ **Recognizing emotion from Eye Tracking**

In S. Lask et al. article, they describe a well-organized review and meta-analysis on the region identifying emotion by eye movement. They used keyword search on the different databases related to the eye-tracking method to associate the proximity of initial diligence toward the warning and a consequent avoidance in anxious and out anxious youth. Their result declared that thirteen likely studies involving 798 associates age 3 to 18 shortened.

Moreover, neither youth with nor without anxiety, revealed significant preference in the first obsession. But they find that biased leading toward the warning did not discriminate between anxious and non-anxious children and adolescents. Besides, their meta-analytic findings measures by eye-tracking with adult RT seem inappropriate [36]. They did not found any within group alertness influence in anxious or non-anxious youth, also any moderating impact of age. They even noticed several studies in this meta-analysis, unclear representations about the blend of stimulus-driven and strategies method. Additionally, the entire stay arrangement score was deficient to gather specific examples of acknowledgment predisposition across time. Along these lines, they encouraged doing additional research to distinguishing how RT-based images relate to the eye-following signs. They likewise inferred to chips away at time windows with fixations and stay periods across different times [37].

2.2.3 Digital Mental Healthcare

In 2016 a researcher group stated that they had roughly nine psychiatrists per one lakh people in advanced countries; for lower-income nations, it less than 0.1 for each 10 lakh [38]. Then, this Chatbot technology began with a new ambition. Some have specified them the future of therapy in the mental well-being sectors where artificial intelligence techniques parody human-like responses and present an undertaking focused construction with arising exchange to take part in the conversation. Although from the year 2013, this digital mental health already started to help people defeating all limitations and obstructions. Besides, this virtual reality is one of the most famous uses of AI technology that more helpful. So, some of this not physically existing but virtually enhance the mental healthcare mentioned below-

➤ Chatbot

In A. N. Vaidyam et al. paper, they present chatbots or conversational specialists as an advanced specialist existing either as equipment (e.g., Amazon Alexa) or software (e.g., Google Assistant or Siri on Apple) [Figure 2.2.4]. Their motivation was to examine the current sign for conversational specialists or chatbots in the domain of psychiatry and

their exhibition in screening, analysis, and treatment of dysfunctional behaviors employing the keyword search method. In their examination, they founded the privilege of conversational agents in self-psychoeducation and adherence potential. Their results imply that the possibility of weakness from the utilization of chatbots almost zero, with an all-out awkward occasion pace of 1 of every 759 enrolled members. This investigation mentioned several factors- the danger of mischief with a conversational specialist and the excessive affection with Robot as they incapable of reacting to mental health difficulties or, Robot cannot recognize the emotions, exactly. So their first suggestion was to create chatbots with empathic behaviors. They also mentioned it as a significant research area. Besides, they indicate the liability issues to consider as there were no such things yet [39].

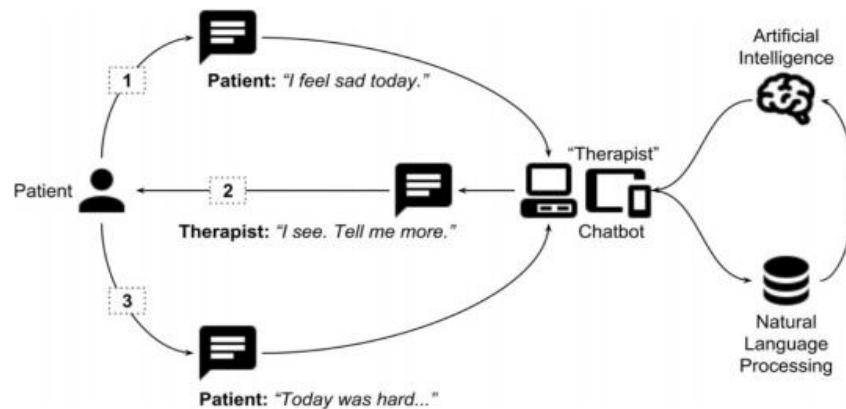


Figure 2.2.4: A sample of interaction between the bot therapist and a bot user (patient)

In Bendig E. et al. article, the primary objectives were to imagine the extent of chatbots in clinical therapy and psychotherapy. They operated following keyword exploration, inclusion, and exclusion. From nonclinical populations, they discovered more than 50% of the members in all the studies were female. So, they mentioned, another perspective of the reason for chatbots in a clinical preliminary was to address individuals in lack of treatment which could link the expecting time before the admiration of psychotherapy and present low-threshold entrance to consider that may include as an improvement. Additionally, this application for chatbots can associate with psychotherapy, where Chatbots could upgrade treatment goals by supporting adherence to psychological social

examination as they presented. The graphical representation of their proposed chatbot is in attached below in Figure 2.2.5. They even mentioned several limitations with the sample size, shortage of enough analytical power for a high quality effectiveness estimate. According to their inquiry, the original influence was the obligations of data isolation and assurance of chatbots. They recommend further investigation to improve the psychotherapeutic substance of chatbots and inspect their greatness all through clinical preliminaries. Also, symbolize a necessity for analysis into diverse forms of value, and requirements analysis could considerably intensify the exploration writing on the headway of chatbots for use in treatment [40].

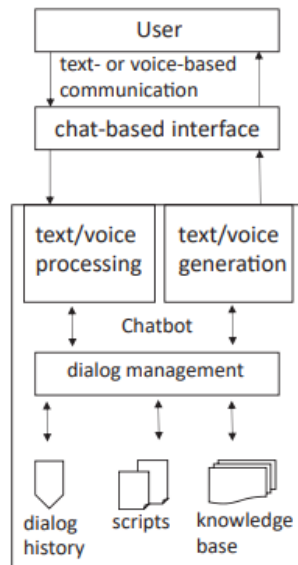


Figure 2.2.5: Realistic portrayal of the specialized execution of chatbots

In G.Cameron et al. article, they observed to describe the system of a chatbot to be utilized within mental health counseling when one of the primary causes of the burden of disease worldwide was mental health problems. Here, they mainly did the paper review and included their Demo Chatbot details. As a new approach, the demo had several limitations as a rigid response and had no option for the user to type freely; the risk of use inappropriately. Besides, they included a lack of knowledge in developing any digital intervention, privacy, and security. Although many studies reiterate this point but yet, no suitable approach developed. Furthermore, from their research, they founded the question

of deceiving a patient into thinking that they were interacting with a human rather than a computer will be unethical or not [41].

S.M.Jungmann et al. article was a differentiated case experiment to finding the accuracy of the advanced user where they investigate the Ada (i.e., chatbot) with the diagnosis of mental disorder. In the study, they described their method and working procedure in an ADHD representation. They mainly used the mental health apps data of participants. They also included some cases from different age groups (e.g., childhood, adults). They founded a notable result with almost 0.65 for adult cases and 0.41 for adolescence and childhood data. They found several disorders related to pieces of knowledge, agreement rules, and reliabilities also. They had several limitations as- the small sample size and consumer level experiment. Besides, they could not detect the variations in anxiety and mutism data. So, they suggest for future analysis and indicate to open their bot for primary users. Moreover, they suggested using a large sample for the experiment to inquiry about the accuracy of mental disorders [42].

In S.Greer et al. study, they mention a chatbot (i.e., Vivibot) for the post-cancer patient. They followed some requirements to choose participants. In the study, they examined the anxiety and depression symptoms of patients. They work on the well-being of the chatbot and positive or negative emotions rating. But they could not find any favorable result from the study. Even they had several limits also. They had a small sample size with less significant effects. Besides, this chatbot limits the participant's willingness and access ability to Facebook messenger. Moreover, it could not detect the stages or types of cancer. So a further study was suggested with a large sample and including more messengers group (e.g., WhatsApp and other messenger apps) with proper accessibility [43].

In this study of Oh J et al., they examined the efficiency by using panic disorder patient data from chatbot (e.g., Todaki) [44]. They did the intervention, evaluation of the selected data, and analysis of them statistically. Their result collected from four-week research data collected from two predefined groups. In the chatbot group, the severity of PDSS was less; at the same factors, there was no change in the control groups. Besides,

comparing to the control group, they founded a notable result for phobia or helplessness scores in the chatbot group. They boldly mentioned several limitation points in the study as not having a specific age group on study selection, fewer participants, technical imperfection, unclear technical problems, and short study time. Besides, they suggest future implementations using AI chatbot and get a perfect outcome [45].

A. A. Abd-Alrazaq et al. examined a meta-analysis to finding the safety and effectiveness of chatbots. For their investigation, they collected bibliographic data from seven different databases. Then, they did the data extractions process and synthesized the data using statistical methods. They mainly get info from several chatbots on eight outcomes (e.g., depression, anxiety, stress, affection, wellbeing, acrophobia, safety, and distress). They founded a comprehensive result with an appropriate sample size data from different outcomes and chatbots. They also included some limits of their study. At first, they mentioned the chatbot software working with only a web browser. The study could not accurately comment on the effectiveness of those chatbots. Moreover, they had restricted article search (i.e., English). Even, they only use post-intervention data for each group. Finally, they suggest further work on this and indicate implementing a chatbot system for other countries like developing countries [46].

➤ **Digital Care**

According to E. G. Lattie et al., in 2014 a research group work on a systematic analysis concluded that web-based digital mental healthcare could be effective for university students with any mental disorder [47]. Then another group did a similar analysis and founded a notable effect on a fixed range of mental disorders. Here, this review paper also followed the studies but, they only used the college student data. They mainly followed a sequence as- literature search, selection, data extraction, result search, and synthesis in the study. Their study established a significant result based on data on the psychological problems of most college students. They had the power of unlimited paper selection and an extensive collection of tests (e.g., random or non-randomized). Even they had no limits on this study. But they suggested future research according to the student's disorder with designing, methods, and testing [48].

Table 2.2.1: Openly usable Mental Health Apps classed by Measure of Proof Based Treatment Components

Application Name	Rating	Downloads	Treatment Number
Daylio	4.8; 4.8	5M-10M	1
Meditation Game	4.8; 4.5	500K-1M	2
Relax Lite	4.7; 3.8	500K-1M	3
Calm	4.8; 4.6	10M-50M	4
Headspace	4.9; 4.5	10M-50M	5
Simple Habit	4.8; 4.7	500K-1M	6
Youper	4.9; 4.8	100K-500K	7
Wysa	4.3; 4.5	100K-500K	11
Pacifica	4.7; 4.4	500K-1M	11
Mood Tools	4.4; 4.3	100K-500K	11

According to A. R. Wasil et al., they endeavored to explore the degree to which current psychological wellness applications (MH applications) for melancholy and nervousness incorporate treatment subtleties found in exactly progressed psychotherapy decorums. Even though proof based attacks exist for various psychological well-being challenges, the vast majority who require therapy do not accept them. They followed an order as-keyword seeking, reading, and coding scheme on their work. They endowed that interference apps usually had more extended therapy elements than the appraisal or state of mind following applications. Transparently usable MH Applications classed by Measure of Proof Based Treatment Components in Table 2.2.1. They additionally ordered specific rest between proof-based treatment conventions for youth discouragement and tension and psychological wellness (MH) applications. Besides, they blessed that numerous applications were transdiagnostic, as developed to treat signs of different issues (i.e., gloom and nervousness) or vague ramifications (i.e., rest issues, well-being, emotional well-being, trust). They mentioned individual limitations in their study as they only adopted apps from the top of the quest outcomes. Also, this was not satisfactory to communicate causal affirmations about the components affecting the viability of MH applications. Moreover, their adult psychotherapy etiquettes were limited. Their verdicts recommend that imminent investigations could assess the

adequacy and strength of MH applications using sickness, critical thinking, and other rarely applied treatment components. At long last, they pronounced that the other point is well known MH applications could give to their viability or pervasiveness (e.g., Conspire articles, analyze motor enhancement techniques, promotion strategies) [49].

2.2.4 Virtual Reality

As we know, Virtual Reality (VR) performs an immersive background to users. It operates by forming pragmatic visions and publicizing the virtual representations to the user with a head-mounted display (HMD) with fundamental components of VR.

In J. M. Lee et al. article, they introduced an innovative scheme for building up an adjustable and adaptable HMD for VR in a savvy custom. Besides, they adopted a Modular design methodology in which virtual reality (i.e., HMD) can comfortably print with 3D printers. This scheme had characteristics of flexible IPD and the changeable interval within the visuality lens. It had a display that served to moderate the vergence and convenience ambivalence issuance. Although various methodologies had been showing towards IPD and meet advantages for VR HMD, the improved cost and intricacy thwart the chance for clients who wish to join their VR HMD for different purposes (e.g., Do-It-Yourself instructing). After associating with VEGO, they scrutinized every member with three inquiries regarding their experience. All those questions and participants answer was taken as Yes or, No. Before experiencing VEGO, first question survey results give a median of 3 and a mean of 3.44. But after enduring examination, resembles had a positive standpoint with a median of 4.5 and a mean of 4.22. For the second question, from 20 participants, IPD adjustment was Y-16, N-4; focus adjustment Y-13, N-7. The last user study question, from 20 participants ‘Yes’ from 12 and 8 participants [50]. As a limitation, they mentioned several factors as their current infirm setup and limited user input. Henceforth, an outside gamepad or a regulator may execute later on with the current program to take into consideration client connection with the virtual climate.

2.2.5 COVID-19 and Mental Health

M. Ali et al. article was a review paper where authors examined the prevalence of mental disorders (e.g., anxiety, depression, or insomnia) in caregivers of a city (i.e., Dhaka) during this COVID-19. Their working procedure was simplistic. They only followed the study design and participants; measurement of socio-demographic, clinical, and occupational data; item GAD-2 (Generalized Anxiety Disorder); PHQ-9 item depression module; ISI to measure disorders symptoms, respectively. They chiefly worked three relapse models to group the indicators of nervousness, gloom, and sleep deprivation. Their results appeared in three districts definite information, determinants associated with entanglements manifestations, and the indicators of tension, gloom, and a sleeping disorder signs. This investigation set up a high universality of tension, wretchedness, and a sleeping disorder indication with HCW (Medical care Laborer) in Dhaka city of Bangladesh battling in clinical foundations during the Coronavirus pandemic. They also established the currency of anxiety (20.7%), depression (26.5%), and insomnia (44.2%) indications among HCW in Europe and different parts of the world among the Coronavirus pandemic uncovered that the female and single HCW had all the more often depicted uneasiness and misery manifestations. Moreover, a past report likewise showed a profoundly remarkable relationship between monetary difficulty and emotional well-being among Bangladeshi specialists [51]. Besides, any weaknesses of cross-sectional investigations were avoided for this analysis. Thus, they proposed an enormous model augmentation examination to relate the psychological well-being of cutting-edge HCW with the establishment will likewise be endorsed [52].

In Y. Tanoue et al. article, they considered the hour of Covid disease 2019 (Coronavirus) pandemic, the clairvoyant strength of both the tainted and non-contaminated was a developing concern [53]. Henceforth they coordinated to find a bona fide result that will represent a fundamental commitment to focus on the check and execution of psychological wellness and psychosocial help customized to family, close family members, and companions of Coronavirus victims. They had mentioned a social networking service (SNS) app named LINE. According to their investigation, Kanagawa

Prefecture started an individualized help application for prefectural residents utilizing LINE’s chatbot to procure information from SNS. Here, they explored the central reaction of 16,402 clients at least age 15 years and more seasoned more than about fourteen days to dissect the connection between the appearance or nonappearance of a Coronavirus patient in shut point of view and mental enduring levels. They assembled three explanations for each K6 part and irrational discomfort rates. They had various shortcomings as their information was just accessible for LINE application clients; scored just the dynamic clients and; collected effectively addressed the poll in the prompt stages and detailed helpless tone. For these purposes, their outcomes were not significantly symbolic of the usual group of Kanagawa or the Japanese community as a gross [54].

Table 2.2.2: The mental effect of Coronavirus on the overall residents and serving clinical workers

Classification	Mental impact
General public	Anxiety Panic disorder Depression
Medical workers	Depression anxiety, insomnia, traumatic disorder Stress

According to S. Wang et al. article, with the increase of COVID-19 patients number announced by several nations every day, several psychological problems started rapidly, such as anxiety, panic disorder, and depression. So in their investigation, they considered the psychological impacts of COVID-19 in various levels of people such as prevailing people, caregiver workers, and sufferers with a mental disorder. They referenced the online emotional well-being administration or telemedicine and different amounts as support; throughout the pandemic situation. They indicated china’s announced guideline sets in irrational crisis for arbitration and affective alignment during the COVID-19 blast. Which uncovered that bigger than half of the respondents thought about the unreasonable impact as sensible to severe; around 33% of the respondents expressed normal to persevering uneasiness, and 16.5% arrived at moderate to thorough burdensome signs. The mental impact of COVID19 on the general citizens and serving workers in medical found in the analysis was showing in Table 2.2.2. Besides, online mystic well-being help

demonstrated as the activity to determine the psychological well-being necessities in the pandemic on account of its high practicality; yet, there were additionally the accompanying challenges: extremely low usage, problematic improvement, the viability of online emotional well-being intrusions in low-and center income countries not judged; the assortment of online emotional wellness administrations was befuddling to be guaranteed; and nonattendance of carried out with telemedicine, sum, and regulative designs, state privileges, hospital-to-clinic affirmation, and focus on execution [55]. They skipped to suggesting any future direction as it the COVID-19 situation.

2.2.6 Combination of AI Technologies

In S. Graham et al. article, they provided a sketch of AI and its modern treatment applied for mental healthcare. To concentrate this review on lately published research, they covered only the study of the year 2015-2019 written. They investigated 28 investigations of man-made intelligence and emotional wellness with singular keys. They accumulated and characterized information from EHRs, temperament assessment scales, mind imaging information, novel checking frameworks (e.g., smartphone, sound, video), web-based media stages (e.g., Twitter). According to their judgments, the most current techniques or methods of learning employed for healthcare schemes were- SML, UML, Deep Learning, NLP, Semi-supervised, and Reinforcement. They mentioned depression as the most familiar mental illness reviewed article. They also identified the instances of AI employed to schizophrenia and other psychiatric disturbances, self-destructive ideation/efforts, and overall mental health. They also combine that SML was the most current AI technique, and symmetry of pieces of knowledge also used NLP before applying ML. They had several limits as- lack of clinical validation, shortage in the sample, and unclear studies concerning the consequence or pragmatic meaning of emerging realization metrics. According to their research, later on, DL approaches will be now and again unavoidable (over SML strategies) to manage this heterogeneous information, and the trouble will be in getting that these examples are clinically interpretable ideally than a "black box". Moreover, Social correspondences see

additionally may strengthen manifestations in the online help or, their reactions could normally be relevant as they referenced [56].

This Z. Zhang et al. article was a deep learning multimodal framework for recognizing disorders mentioned. They used this model to addressing mental disorders issues by the visual, acoustical, and textual features. They mainly proposed and worked on a multi DDAE model. They used fisher vector to detect and, encoding audio-visuals of disorders like depression, anxiety, and stress. Besides, for embedding the documents or transcript of the interview, they included a paragraph vector. They discussed their method in three steps- Multimodal Learning Framework, Bipolar Disorder Recognition, and Depression Detection. They also used a tree-based model (e.g., random forest) for data redundancy and salient selection. They had no such mentionable limitations. Although, they planned for advanced work with the same model but using different audio or visual dataset [57].

Table 2.2.3: Estimations of various measures for various order techniques

Classifier	Dysfunctional behavior	Exactness	F1 Score
Support Vector Machine	Anxiety	0.678	0.448
	Depression	0.803	0.765
	Stress	0.667	0.651
Naive Bayes	Anxiety	0.733	0.497
	Depression	0.855	0.836
	Stress	0.742	0.558
K-Nearest Neighbour	Anxiety	0.698	0.527
	Depression	0.721	0.687
	Stress	0.714	0.700
Random Forest	Anxiety	0.714	0.470
	Depression	0.798	0.766
	Stress	0.723	0.711
Decision Tree	Anxiety	0.733	0.492
	Depression	0.778	0.723
	Stress	0.628	0.592

In A. Priya et al.'s study, they used a machine-learning algorithm to detect or predict mental disorders. They included checking on several prior studies about mental disorder

detecting ML algorithm and technique named HMM, RFT, CNN, and SVM. Besides, they founded about using python programming for advanced modeling technologies. According to the prior survey, they choose a combination of ML algorithms for this study. Five different machine learning algorithms were- SVM [58], naive Bayes [59], K-nearest neighbor [60], decision tree [61], and random forest [62] as they mentioned. Their study revealed various symptoms of GAD, depression, and stress. For scanning mental disorder data they used DASS21. In their analysis result, several factors revealed that used for detecting disorders severities-mild, normal, severe, moderate, extremely severe, etc. Besides, the error rate, f1 scores, specificity, precision also examined by algorithms. They founded a simple imbalanced class in result; for stress, normal severity levels were 43 but, in mild levels, it was 19. Similarly goes for depression (37, 12), anxiety, or GAD (25, 7). They declared random forest as the best ML algorithm for detecting mental disorders. In their findings, the accuracy rate was high for the naive Bayes algorithm. For some imbalanced results, they also applied f1 score in analysis that showing on Table 2.2.3. Thus they managed to complete this study. They did not mention any limits or future working scope [63].

This research of D. Bzdok et al. described the machine learning challenges and opportunities towards mental disorders. They mainly worked on the correctness of psychiatry. In this study, they mentioned combining various machine technologies for advanced psychiatry. They also introduced other researchers and clinicians to the most used machine learning methods. In this survey, several machine learning algorithms and analysis methods including, SVM, validation, classifications, advanced neural network, and cross-validation. In this survey paper, they highlight big data into clinical relevance. According to their study, focusing on prognostication, observational paradigm evaluation, two-step schemes, accommodated observational data, supervise many consequences at once, and investigating manifolds in heterogeneous data were the opportunities specifying in ML. Besides, the information superintendence, reproducibility, statistics availability, longitudinal data, sovereignty on fragmentary data, and confounding were study incitements in ML. They did not mention any modifications or noticeable future instructions without machine learning methods as a future solution [64].

2.3 Research Summary

As my primary aim was to find out the Artificial Intelligence technologies used for mental disorders solutions which are used to identify different symptoms of different diseases. So, by this review, I found mainly two types of technologies, one is for virtual treatment, another one is real-life technologies for the patient. But, both were used repeatedly throughout the developed country for mental disorder treatment.

2.4 Scope of the Problem

The first step of my study was to find the AI technologies used for the treatment of mental disorders. The geographical location I covered in the study is the worldwide population because I didn't find an appropriate article for the study that is from Bangladesh. Although, main purpose of this study was to do the survey and analysis participants mental health but before go through I must have to check which AI algorithms are mostly used now. Here, I like to include the duration of my study was four months. Besides, the topics or theories that I will discuss are the virtual and real-life artificial intelligence subsidiary technologies that are used for people's mental disorders.

2.5 Challenges

The most faced problem in any analysis is Data. In my case, I also faced the same problem. As I planned to use real-time data for analysis but I couldn't have managed to talk with the patients. As we know, these types of patients have some sensitive issues; they also have privacy concerns so that their relatives or doctor's both denied allowing us to talk with them. Even I didn't get any positive response from any psychiatrist. Then I make a survey form to collect data and that's how I manage the dataset regarding this thesis.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

Following the step by step of methodology, any research work can accomplish. So, here in this chapter, I will discuss my research methodology and the sequences I have followed.

3.2. Research Subject and Instrumentation

My study mainly focused on the Artificial Intelligence domain and I choose to find out its helpful technologies and techniques. So that, those AI technologies may help to use as helpers in mental disorders in the future in a developing country such as Bangladesh.

From paper selection to the result in a discussion, all I have used is just software, Internet. For searching, storing, writing a paper or, doing the analysis, applying algorithm everything was on different software or soft instrument. Figure 3.2.1 including below shows the working procedure briefly-

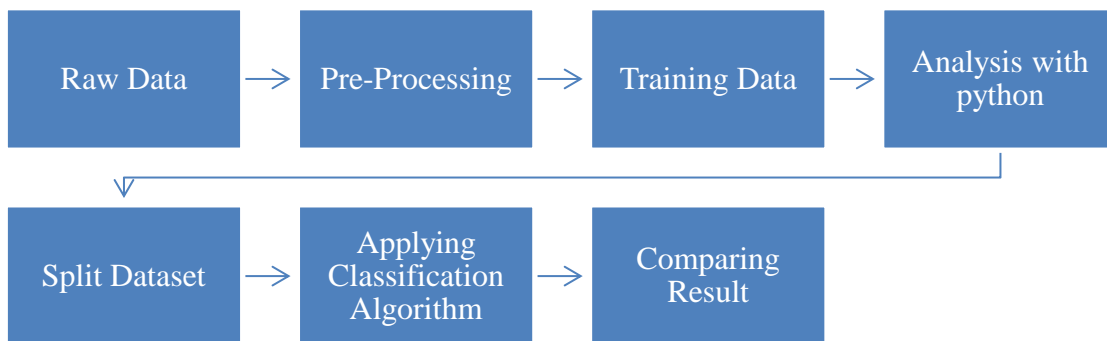


Figure 3.2.1: Working Procedure

3.3 Literature Review

As a primary work, I have started with reading and reviewing papers. So here are the steps I have followed-

3.3.1 Search Strategies

As a first step in starting the review, I have fixed three questions for this review. After forming the questions, these two thoughts came to mind first; where to search data and what can be the term of searching. So, I first select the search engine and keywords for this review.

3.3.2 Sources Selection

I started with search engine selection as there are so many search engines that are not for general use. So, for collecting databases, I choose the three most commonly accessed and most reliable scholarly search engines, namely, Google Scholar [65], Pubmed [66], and ScienceDirect [67], to collect papers for the review. I also used a website (i.g. shadow library) named Sci-Hub because it provides gratis entry to millions of explorations (e.g. journal papers, conferences, and books); without considering the copyright [68].

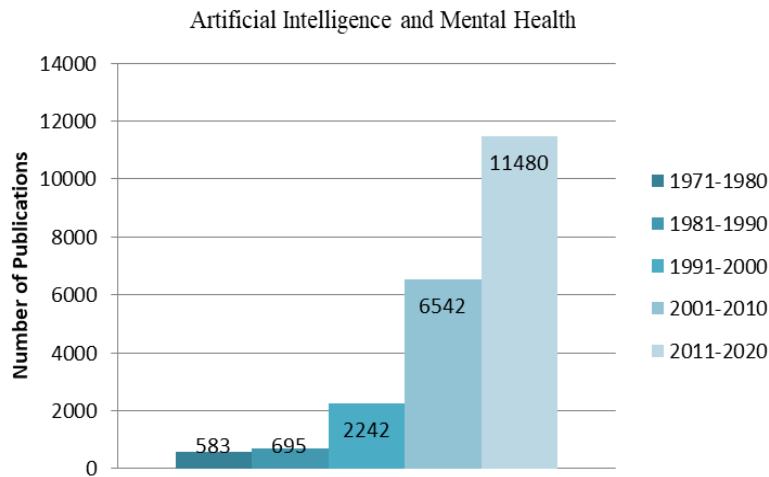


Figure 3.3.1: PubMed result of the number of publications by time

3.3.3 Terms Selection

Primarily listed keywords for this review were “Mental Health” or “MH” or “Mental Disorder” + “AI” or “Artificial Intelligence” or “chatbot” or “Machine Learning” or “Deep Learning” + “Bangladesh”. But later on, I have to add more Electroencephalography or EEG or MRI + Technology or Treatment + “psychiatric” or,

“psychology” or, “Psychiatrist”, etc. In my first search on PubMed with “AI” + “Mental Health” shows in Figure 3.3.1, get a high range of data from 2011 to 2020.

So, for a close look, the keyword “Bangladesh” is added to the search. But unfortunately, it found a few numbers of publications. Moreover, with too many keywords ”psychiatric” OR ”psychology” OR ”Mental Disorder” OR ”Mental Health” AND ”Bangladesh” AND ”Artificial Intelligence” has only seven publications. On the other hand, applying quest phrases artificial intelligence” and ”mental health” without Bangladesh, the keyword ”psychiatric” OR ”psychology” OR ”Mental Disorder” OR ”Mental Health” AND ”Artificial Intelligence” shows a result of 9,118 publications. In Table 3.3.1, these types of differences are showing.

Table 3.3.1: Showing the differences of with or without term “Bangladesh”

Search Term	Result	AND Bangladesh
Depression	531,540	388
Anxiety	257,774	212
PTSD	44,828	31
Phobia	17,035	3
Destructive Mentality	1,454	3
Suicidal Tendency	1,462	1

3.3.4 Study Selection Procedure

For insufficient publications, I have to explicit the term “Bangladesh” and made a list of inclusion criteria to select the paper for the review.

❖ Inclusion criteria

For including in studies the following criteria checked:

- 1) Mental health or disorder related.
- 2) AI domain or, any sub-domain of AI (ML, DL, NN, NLP, Robotics, etc.)

- 3) Mostly used AI technology
- 4) Review article of EEG or MRI or Chatbot for Mental Disorder
- 5) Article from year 2017 to 2020
- 6) Language- English

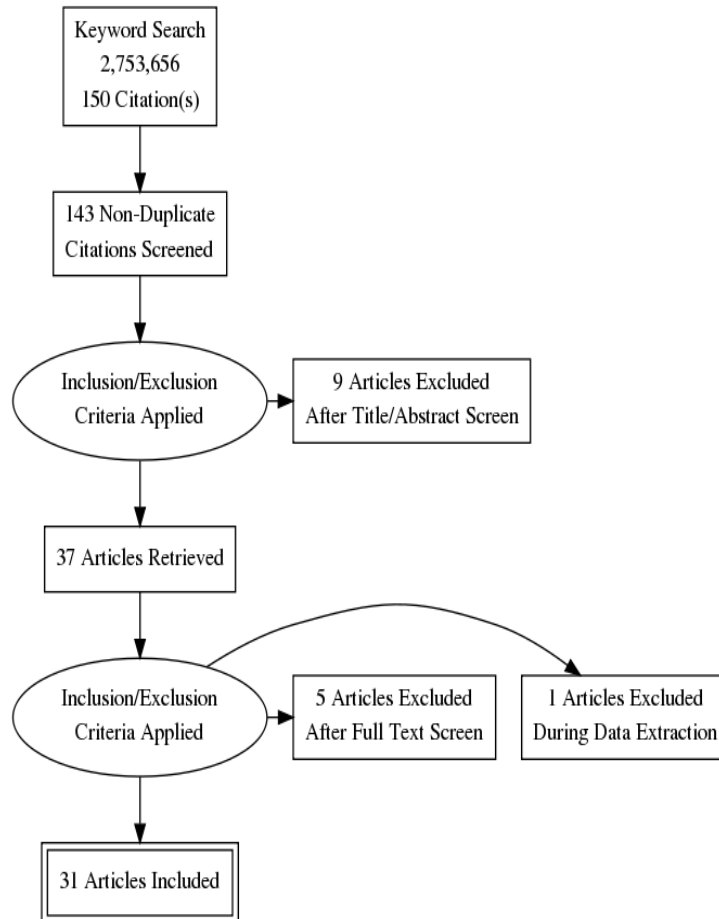


Figure 3.3.2: PRISMA flow diagram of literature selection process

❖ Selection Process

I searched using key terms and looked for relevant literature with the most cited. As newly published articles have fewer citation numbers; so, in this case, I only checked the relevant papers. Thus, I finalized thirty-one articles for literature review. Figure 3.3.2 shows the selection process of my entire systematic review by a PRISMA flow diagram.

For reading, I select several types of review articles with or without a new perspective or consisting most used method as these reviews contain various algorithms approaches or a summary of these used by others.

❖ **File Sources**

I file the sources of selected papers using Mendeley and Zotero manager which consist of article type, title, author's name, year, publication, etc as they have the advantages of making notes and give permission to cite the important part of any article. Besides, they provide the facility to make a perfect citation. I also used reference management software named Qiqqa to find perfect references.

3.3.5 Organize Literature

I followed the methodological organization methods to reviewing the works of literature. In this concept-based approach, I separately discuss the virtual and real-life mental health treatment technologies and peripherals.

Mental health problems have increased rapidly in recent COVID-19 situations. In this crisis, the contribution of digital mental healthcare or chatbots is undeniable. Also, there has been significant use of fictional reality as a digital treatment for mental illness. Thus, I have included the most frequently used virtual healthcare methods in my review.

3.3.6 Annotated Bibliography

I checked articles and summarize them with the factors study design or method, theories, results, limitation, and future direction. In my bibliography, I attached a summary; with each title, author name, and year.

3.4 Online Survey

As for my paper analysis, I did not found many Bangladeshi works that appropriate and may beneficial. Most importantly there was no such article that discussed using AI technologies for patients who suffer from a mental disorder.

So, I made a form to take general people's opinions where I included several sets of the questioner to get the info of contributors with their overall mental conditions.

This survey was designed in two different sections; the first section for collecting participant's info and vote for the proposed model I planned for future work. In the second section four sets of questioners were included for counting the number of a healthy person and suffering (e.g. Depressed, Anxious and PTSD) but live like a healthy one.

My sample dataset was prepared only for the age range of 19-29 people and to check on healthy people if they are as healthy as they behave like.

3.5 Analysis and Comparison Algorithm

The last step of my thesis was to analyze the survey result and compare the accuracy of the results. For analysis and plotting from the survey dataset, I have used python programming and MS-Excel.

3.5.1 Data Preprocessing

Data Cleaning: Data cleaning is the most broadly utilized preprocessing procedure in the information preprocessing stage. By utilizing this I supplant missing qualities in my dataset for improving exactness and achieve better execution.

Replace missing values: As I have utilized pandas library in my code for information preprocessing with its 3 essential standards for supplanting missing qualities and those are-Delete whole column if there is a missing worth, Delete whole line if there is a missing worth and furthermore dependent on some condition for different traits and Replace the missing worth point with mean worth (0.5). In any case, I have no such missing worth in the dataset so I don't need to utilize this.

3.5.2 Apply Algorithm

Foreseeing psychological wellness levels utilizing AI requires picking an exact classifier for appropriate grouping and improving exactness. As from my writing survey I have

discovered that Decision Tree, Random Forest and Support Vector Machine were the most utilized ML calculation. Besides, many researchers recommended SVM for their accuracy level. Thus, I have additionally utilized these three calculations on my survey data.

- **Classification using Decision Tree**

The general motive of using Decision Tree is to create a training model which can use to predict class or value of target variables by learning decision rules inferred from prior data (training data).

- **Classification using Random Forest**

As decision trees are a lot simpler to decipher and comprehend I have used another similar algorithm named Random Forest.

Random Forest classifier makes a bunch of choice trees from a haphazardly chosen subset of the preparation set. It at that point totals the votes from various choice trees to choose the last class of the test object.

- **Classification using Support Vector Machine**

A Support Vector Machine is a classifier wherein given named preparing information (managed learning) the calculation yields an ideal hyper-plane that orders new models. For order, relapse, and other various works it tends to be utilized.

3.5.3 Comparing the results

As I have mentioned before, on my filtered survey data set, I have applied three machine learning algorithms named Decision Tree, Random Forest and Support Vector Machine.

I used these three algorithms to find the accuracy of mentally ill people with python programming and then compare the results. All of this python code was run in Google Colab.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This is the most important part of my thesis. Results of my review will be discussed here, briefly. Moreover, the experimental result and descriptive will be given in this section which will focus on the key AI technologies founded by the researcher and end of the section a through the simple short way the whole section will be summarized. Most importantly, my survey result that formed based on research question will be discussed here.

4.2 Analytical Results of Literatures

I have a total of 31 papers with different genres; eighteen journal articles, four conference proceedings, one report, two books, and six generics (parts of book) included. Almost, 52% of those papers are from 2020; the rest are from 2017, 2018, and 2019. Besides, I found that the lowest publication in between (2017-2020) was in 2020 (707), where the highest work on AI in mental healthcare was in 2019 (1372). About 71% of my papers discussed real-time AI assistants and the remaining 29 percent focused on digital mental illness support. From this study, I have found the most commonly used artificial intelligence methods; that are helpful in the identification or treatment of mental disorders, Table 4.2.1 shows the details. I also found several technologies such as Machine Learning, Virtual Agents, Natural Language Generation, Deep Learning Platforms, Image Recognition, Text Analytics and Natural Language Processing (NLP). My findings are discussed below in two parts: Real and Virtual Mental Health.

4.2.1 Realistic Mental Health

About 45% of the articles on realistic AI assistants included in my review are from 2020; almost 23% are from 2019; some of which used in the most article included below-

Neuroimaging: The most commonly used neuroimaging technique nowadays is EEG [14], [15], [16] and [17]].

Table 4.2.1: Yearly distribution of Methods and Limitations

Year	Authors	Suggested or used AI Methods	Limitation
2020	M. Ali et al.	GAD-2, PHQ-9, Regression model	Small sample size
	Y. Tanoue et al.	LINEs chatbot, SNS	Available only for LINE users , Only active users counted only in early or critical survey stage
	S. Wang et al.	Online Mental Health Service, Telemedicine	Low utilization, Unbalanced development, Excluded low and middle-income countries.
	G-D. Liu et al.	MRI, EEG, Kinesis. Bayesian Model, Logistic Regression, Decision Tree (DT), SVM and Deep Learning	No better computer configurations, Imaging process takes long time.
	R. Buettner et al.	EEG	Not well trained and tested classifier, internal validity of model was too high, inaccurate result.
	X. Chen et al.	Image Segmentation, Compressed sensing-driven MRI (csMRI), Quantitative susceptibility mapping (QSM)	No such limitation
	C. Sripada et al.	Data acquisitions, fMRI preprocessing Bayesian probabilistic PCA (BPPCA), Linear Regression with MatLab programming	No sizable signatures in the resting state, smaller effect sizes, No generalize consequence.
	A. C. Nugent et al.	Montgomery-Asberg depression rating scale, Data acquisition, MRI pre-processing (fMRI mainly), MEG data analysis with MNE- Python Pyctf toolbox, linear mixed effect	Small sample size, Missing graph analysis, Unprofessional-ism.
	G. Papanastasiou et al.	Signal Acquisition, Pre-processing, Feature Extraction, Translation Algorithm	Unsolved issues, Limited performances.
	H. Aouani et al.	SVM, Feature Extraction, Classification Model	No such limitation
	S. Lask et al.	Data coding and Analysis	Unclear conceptions, Unable dwell time score.
	Oh J et al.	Clinical Evaluation, Statistical analysis	Technical imperfections, Unclear concept
	A. A. Abd-Alrazaq et al.	Data Extraction, Data synthesis	Insufficient data, restricted studies.
	J. M. Lee et al.	Virtual reality test	No external gamepad or controller
	Z. Zhang et al.	multi-DDAE, Random Forest Fisher (FV) and paragraph vector (PV)	No such limitation
A. Priya et al.	DT, SVM, Random Forest, K-NN, Naive Bayes	No such limitation	

Year	Authors	Suggested or used AI Methods	Limitation
2019	O. Al Zoubi et al.	EEG-ms, MRI, fMRI, Average Artifact Subtraction (AAS), Agglomerative Hierarchical Clustering (AAHC)	Unclear neuro-physiological mechanism, Very heterogeneous cohort.
	Y. Wang et al.	Convolutional Neural Network (CNN), EEG, Deep Learning, Layer-wise Relevance Propagation (LRP)	No such limitation
	J.W. Ahn et al.	ECG, EEG, Validation	Small number of participants, Wet electrodes.
	N. Dusi et al.	sMRI, White Matter (WM), Gray Matter (GM)	Absence of widely shared database, Shortage and inconsistency on the outcome, Small sample size.
	L. Dai et al.	Cerebrovascular (DMN, ICA and SCA), White Matter, Gray Matter, fMRI	Low consistency, Lack of clinical specificity
	F. A. Shaqra et al.	Classification model, Neural Network, Feature Extraction	No such limitation
	A. N. Vaidyam et al.	Simple Review	Risk of harm with a conversational agent, Excessive attachment with Robo
	Bendig E. et al.	Scoping Review	Small sample size, Lack of statistical power and quality criteria.
	S.M.Jungmann et al.	Chatbot accuracy Test	Small sample size with accuracy problem
	S.Greer et al.	Test vivibot	Unable to detect cancer type or stage.
	E. G. Lattie et al.	Data extraction and synthesis	Missed relevant publications.
	A. R. Wasil et al.,	Apps Review	Unable to compare the frequency of treatment.
	S. Graham et al.	SML, UML, DL, NLP	No clinical validation
2018	D. Bzdok et al.	SVM, modern neural-network algorithms, cross-validation procedures	No such limitation.
2017	G. Cameron et al.	Review	Unable to type freely, Risk of inappropriate use.

These EEG recordings have used to diagnose the disease, know the disorder stage, or check on the progress. The recording of ECG signals is another popular neuroimaging

method. In a review [18], I see how it works together with EEG and shows the best performance with an accuracy of almost 90%.

I found in papers that they have done MRI (i.e. gray matter, and white matter) for mental health treatment. They even show how MRI identifies irregularities in the brain and measures small changes in blood flow. MRI (i.e.fMRI) used in in most cases for detecting disorders. Besides, sMRI and compressed sensing-driven MRI (csMRI) are advanced checking tools in brain imaging. Furthermore, I must mention the QSM (Quantitative Sensitivity Mapping) that was used recently. This QSM mainly detects the local distribution of magnetic reciprocity in biological tissues [[21], [22], [23] and [24]].

In treatment, MEG brain scans are not always applied alone; as I have seen in my review of MEG analysis has been linked to MRI to diagnose major mental illnesses [[26] and [27]].

The brain-computer interface or BCI has contributed a lot to neuroimaging; it is just as famous. For a long time, this AI method is working for mental health treatment by using signal processing; and machine learning [29].

Recognizing: These recognizing techniques (i.e.Speech Recognition, Emotion Recognition) are the easiest way to diagnose mental problems. As I found in research without any preparation, the problem of mental disorder is finding out by the patient's usual facial expression, speeches, movements, or tracking eye [[30], [31], [32], [33], [34] and [35]].

It is worth mentioning the use of Matlab and Python programming in my review. Besides, several AI techniques and modeling used as practical assistants in those articles are-

1) *Models:* Regression Model, Linear regression, Logistic regression, Linear mixed-effects model, Decision trees (i.e translation algorithm), Naive Bayes, K-Nearest Neighbors, Bayesian Model, Support vector machines (SVM), random forest, Convolutional Neural Network (CNN), linear mixed-effect model and Classification Model.

- 2) *Feature Extraction* (i.e.NLP, image processing)
- 3) *Data Mining* (i.e. Data synthesis, Data extraction, Data coding and Analysis)
- 4) *Virtual Reality* test
- 5) *Learning vector quantization* (LVQ) algorithm

4.2.2 Digital Mental Health

In my digital mental health-related papers, 6% from 2020 and almost 20% are from 2019; of these, three Covid-19 articles are notable as they discussed telemedicine. Especially; have to speaking of SNS and line chatbots. Because, at this time, the mental condition of the people is getting worse than usual. Besides, 6 of my 2019 papers have put chatbot or telemedicine ahead as a digital mental services assistant. It is also worth mentioning that my 2017 article also talks about chatbots while giving priority to digital counseling.

By this study I get to know about Line, Vibibot, Todaki, SNS, and AdaYour Health Guide, as well as several popular chatbots; most notably Google's Allo [69], Microsoft's Cortana [70], Amazon's Alexa [71], Apple's Siri [72]; which already provide services. Besides those some mention-able chatbot that promotes mental health is given below-

- 1) The *MYLO* chatbot manages life online; provides a self-contained program to solve user problems.
- 2) The *WOEBOT* chatbot works to reduce anxiety and frustration through a self-help program.
- 3) The *SHIM* chatbot is another self-care program; attempts to enhance mental happiness.
- 4) The *SABORI* is a nonrandomized prospective pilot study [73]; it grants a resisting self-confidence application for the betterment of psychic health.
- 5) The *GABBY* chatbot, another pilot study; but controlled randomized [[74] and [75]]. It works for behavioral variances and anxiety management; as a comprehensive self-help program.

6) The *PEACH* was another randomized and undergoing controlled [76]; to increase the personality coaching.

Although many people think Chatbot is the future of therapy [77], it still has a lot to gain. As I can mention an odd situation that found in study; one user told Chatbot that he was feeling bad and in response, a Russian chatbot [Figure 4.2.1] named Alisa responded, “No one said life means having fun” [78]. That was a very irrational answer and of course, enough to worsen the mood. Also, security measures of Chatbots are not yet so advanced; Moreover, the Chatbot can cause any problem by knowing everything the user uses. As in Europe and America, there are many data leaks which is undoubtedly a detrimental aspect. Emotional involvement is another horrible side effect since bots or conversational agents are not real people. Some services also require you to be a premier member to use the bot, which is very uncomfortable in developing countries.

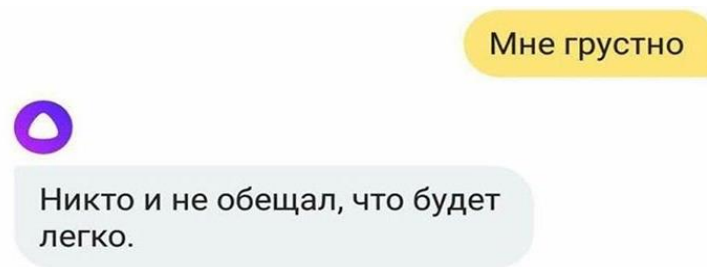


Figure 4.2.1: A conversation of the Yandex (i.e.Russian search engine) developed Russian bot Alisa

As A. A. Abd-Alrazaq explains [46], chatbots can improve mental health if performance is enhanced and provide better security. As I found, to build a powerful virtual assistant several factors to follow is- Area of use, Technical implementation, Approaches, Goal and endpoints, and Performance.

4.3 Analytical Results of Survey

Although my online survey had an aim to collect participant's info like mailing address, age, gender, occupation, and marital status, people are now more conscious about their safety indeed. So, I have to remove the mailing address from the inclusion criteria.

My survey form was open for ten days. Although I expected to collect at least 500 responses it barely able to collect 343 person's responses. Most of the participants are Male (63.2%) with 35.6% Female and 1.2% others. Although other professionals also participate in this survey, 82% of participants are students and 21-22 years old people were the most active participant as 19% of the total responses were from this age. My survey even shows that 87% of the participants are 'single' in marital status.

This survey again proved that people are still living with an insecure mentality and fear of society. My survey shows that people are not that advanced to go to psychiatrists or take any mental care for better health.

As I have found, almost 83% of participant's responses 'No' for any kind of diagnosis for mental illness and only 12% get help from a professional or psychiatrist.

As I design my question sets mainly for mentally healthy and mentally ill (e.g. anxious, depressed, or PTSD sufferers) people. So, the analytical result of this survey will show in the same sequence.

4.3.1 Mentally Healthy People:

I have selected the filtered data of healthy people with four attribute sets excluding the 'Target' cell. As with all the values in the string, I have to add the label Encoder for labeling data.

In my survey questioner, I have put some identical questions for checking a person's mental strength, positivity, confidence, and creativity. So in this section, I have attached some primary query to get a response as 'Yes'; those are including below-

- Calm and balanced or not?
- Good decision taker or not?
- What they do is it make them happy, risen the confidences or not?
- All in all, are they satisfied with this life or not?

From my survey data, I have found only 16% of people are mentally healthy; where 84% are Male with occupation student (81%) and almost 90% with marital status single and the most healthy people are in age 21(38%) and 23 (41%). According to their gender, age and status a plot figure is showing in Figure 4.3.1.

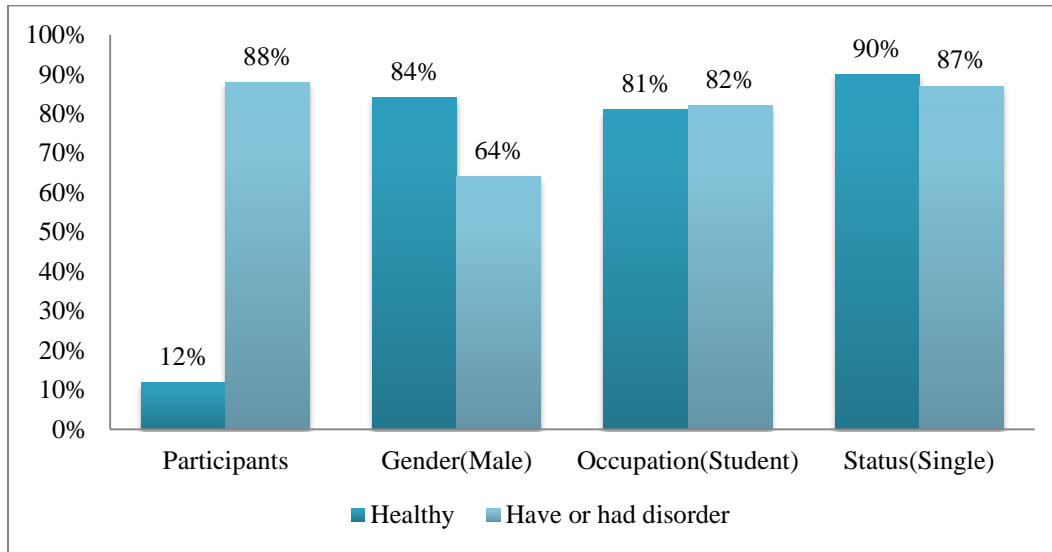


Figure 4.3.1: Healthy and Ill participants with different attributes

4.3.2 Mentally Ill People:

In Asian countries, people with disorders like anxiety, PTSD, and depression are still depriving from proper treatment. Even they don't have the facility of getting primary help. Besides, this society's stigma and fear always are lagging. For the same reason, people of this developing country like Bangladesh are suffering mostly; as their mental health section is still much poorer than others.

From my review, I have found that disorders or mental illnesses damage the mental strengths and creativity of a person. Similarly, in my survey, I have found this as a common matter. From the analytical result of survey I have found that 303 of total participants had experienced mental disorders or still suffering from and as my main concern toward this part.

As I have found that most people around the world suffer from these three common disorders- anxiety, depression, and PTSD. So, in my survey, I have included three different sets of questions for these three disorders to collect the present situations of Bangladeshi youth and found significant results of disorders. Here, some keywords of those query to get a response as ‘Completely’ for patients or ‘Sometimes’ for those who are in primary level is included below-

- **Depression-** upset, emotionally shutdown, failure, worthless, distant or cut off from people, unable to be close or do work, etc.
- **Anxiety-** hungry, tired, sleepless, sadness, bored or not enjoying, nervous, worrying too much, uncontrolled, annoyed, afraid, etc.
- **PTSD-** life threatening illness or the person or someone close, threatened by weapon, abuses or assaulted physically or sexually, harassed.

The analytical results of my survey presented in Table 4.3.1 showing the young people aged 21-22 were suffering from various mental illnesses in most cases.

Table 4.3.1: General Analytical results of the survey

Disorder	Have/Had Disorder	Age (21-22)	Gender (Male)	Occupation (Student)	Marital Status (Single)
Anxiety	98%	19%	62%	80%	85%
Depression	97%	19%	62%	80%	85%
PTSD	73%	16%	44%	66%	69%

4.4 Describe Algorithms Factors and Results

As I have mentioned before in Table 4.2.1, I have found three mostly used algorithm on mental health data and those are- Decision Tree, Random Forest, and Support Vector Machine. So, I have applied these three algorithms on just the mentally unstable participant’s data. Here, some common factors which found in all of three algorithms are-

True Positive (TP), True Negative (TN), False Positive (FP), False Negative (FN), Precision, Recall, F1-score.

Although in preprocessing I did not have to transform dataset, here I just transform my selected part of the dataset. Here, target attribute 'label' is the result of conditional check that I have performed before and now the attribute is represented as binary value where zero (0) is for 'had ill or experienced' and one (1) for 'having disorder'.

4.4.1 Decision Tree

In general, for a decision tree building there are several steps as target selection, finding target's information gain, entropy and gain of each attributes, etc. As I have already selected the target attribute so, some important terms like as information gain, entropy, Gini index of decision tree is described below-

- **Entropy:** In 'label', 234 values from total was '1' and 69 values was '0'. So, for this extend calculation entropy of label attribute is showing below-

$$E_{(label)} = -(.77 * \log_2 .77) - (.23 * \log_2 .23) = .78$$

- **Information Gain:** An information gain value calculation is attached below from one attribute of PTSD data 'Life threatening illness' denote as 'P1'

$$E_{P1}(1) = -(.72 * \log_2 .72) - (.28 * \log_2 .28) = .85$$

$$E_{P1}(0) = -(.89 * \log_2 .89) - (.11 * \log_2 .11) = .5$$

Here, the new entropy of P1 attribute is-

$$E_{P1} = \left(\left(\frac{214}{303} \right) * .85 \right) + \left(\left(\frac{89}{303} \right) * .5 \right) = .75$$

So, information gain of P1 attribute is-

$$Gain_{P1} = .78 - .75 = .03$$

- **Gain Ratio:** Before finding gain ratio I had to perform the Split Info into 'label' as I included below-

$$SplitInfo_{P1}^{(label)} = -(.29 * \log_2 .29) - (.71 * \log_2 .71) = .87$$

So, the gain ratio is, $GainRatio_{P1} = \frac{Gain_{P1}}{SplitInfo_{P1}^{(label)}} = \frac{.03}{.87} = .034$

- **Gini Index:** This Gini index is for checking the impurity of the node only with binary values. Here, the Gini index of 'label' is included-

$$Gini_{(label)} = 1 - \left(\frac{234}{303}\right)^2 - \left(\frac{69}{303}\right)^2 = .352$$

Decision Tree Result:

For the data of participants with disorders shows decision tree algorithm 74% to 80% accurate. Table 4.4.1 briefly shows the result of precision, recall, F1-score and support where this all are with the highest accuracy (80%).

Table 4.4.1: Precision Recall for Decision Tree

	Precision	Recall	F1-Score	Support
0	0.46	0.55	0.50	11
1	0.90	0.86	0.88	50
Macro avg.	0.68	0.70	0.69	61
Weighted avg.	0.82	0.80	0.81	61

Here, from confusion matrix I have found TN= 6, TP= 43, FN= 7, FP= 5.

So, Specificity= $\frac{TN}{TN+FP} = 0.55$ and False positive rate= $\frac{FP}{FP+TN} = .45\%$

4.4.2 Random Forest

As it is almost similar to decision tree without regression part which I don't included here. In random forest algorithm the highest Accuracy I have found is 85% and the lowest is 80%.

Table 4.4.2 briefly shows the result of precision, recall, F1-score and support where this all are with the highest accuracy (85%). Here, from confusion matrix I have found TN= 1, TP= 51, FN= 0, FP= 9.

So, Specificity= $\frac{TN}{TN+FP} = 0.1$ and False positive rate= $\frac{FP}{FP+TN} = 0.9\%$

Table 4.4.2: Precision Recall for Random Forest

	Precision	Recall	F1-Score	Support
0	1.0	0.10	0.18	10
1	0.85	1.0	0.92	51
Macro avg.	0.93	0.55	0.55	61
Weighted avg.	0.87	0.85	0.80	61

4.4.3 Support Vector Machine:

Applying Support Vector Machine algorithm I have found the best accuracy and the accuracy is 87% as I use 20% of the dataset as test data and the system chose it randomly.

By broke down each class and counting values the confusion matrix summarized the number of correct and incorrect predictions. Here, in Table 4.4.3 attached below showing the result-

Table 4.4.3: Confusion Matrix of Support Vector Machine

True Negative	False Positive
0	7
False Negative	True Positive
1	53

*Through column there is predicted values and actual value through row.

So,

$$\text{Specificity} = \frac{TN}{TN+FP} = 0$$

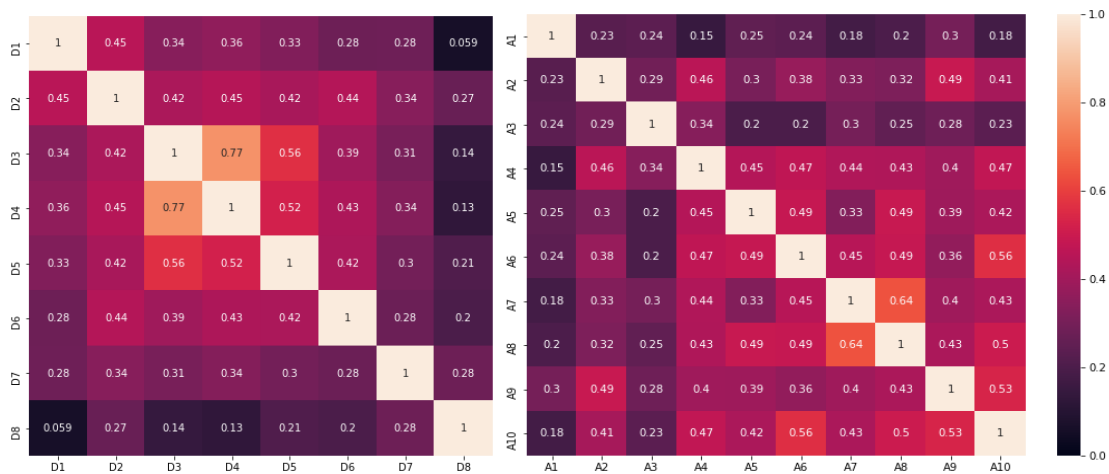
$$\text{False positive rate} = \frac{FP}{FP+TN} = 1\%$$

Table 4.4.4 briefly shows the result of precision, recall, F1-score and support where this all are with the highest accuracy (87%).

Table 4.4.4: Precision Recall for Support Vector Machine

	Precision	Recall	F1-Score	Support
0	0.00	0.00	0.00	7
1	0.88	0.98	0.93	54
Macro avg.	0.44	0.49	0.46	61
Weighted avg.	0.78	0.87	0.82	61

As data transformation of the selected set was absolutely ready to apply classification algorithm. So, I just checked the correlations between all the 10 symptoms of Anxiety and 8 symptoms of Depression and 5 symptoms of PTSD. Here, correlation of attribute set of Anxiety and Depression are showing on Figure 4.4.1.



*From the given values relations leveled with 0.77 for Depression and .64 for Anxiety.

Figure 4.4.1: Correlation between Attributes

4.4.4 Comparison of DT, RF and SVM:

In the decision tree classifier check, I have found an accuracy of 80% and random forest classifier, this accuracy is 85%. On the other hand, for the support vector machine classifier, this accuracy is 87% at most.

Thus, from this survey data analysis and analysis of papers, I found the random forest as the most versatile algorithm for regression and classification both and support vector machine for classification. Similarly, by applying these three algorithms to the different disorders data like- anxiety, depression, and PTSD, I have seen the variance of the results.

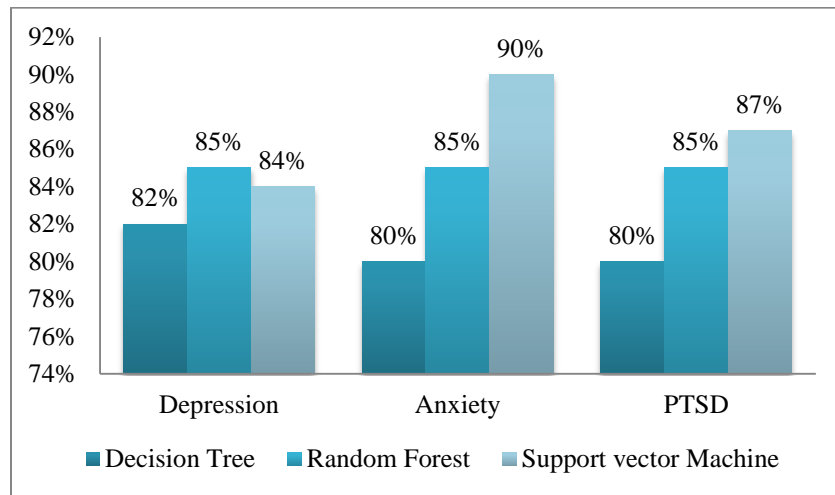


Figure 4.4.2: Algorithms accuracy on disorders

Figure 4.4.2 clearly shows that for Anxiety and PTSD, Support Vector Machine gives the best accuracy. But on Depression responses, the Random Forest algorithm is more accurate as it gives 85% over 84% of Support Vector Machine accuracy.

4.5 Overall Discussion

By destructive mentality, I mean something that will harm oneself or others in one way or, another, it may physical or mental. Here I can mention some activities that frequently happened in real-life such- self-destruction attempts (e.g., cutting or burning body parts, pulling hair), suicidal tendency, doing extra addictive activities (e.g. gambling, sports, alcohol or drugs, shopping), running away, emotions (e.g. Emotional or risky sexuality). But there are also many symptoms that no one can understand instantly but, subconsciously, they peek at others for not being smart (i.e. capable or attractive enough). Besides, sometimes people force to change themselves to please another or trying to get stuck with someone not interested, engaging in isolated or aggressive behavior (e.g.

chronic avoidance, delay). Also, like to insult another without any reason, and aggression is drowning in remorse [79]. Even the severity and type of these behaviors vary from person to person (e.g. dangerous, occasional or often, calm or restless); it is in their nature to always cause problems.

In this full review, I look at how mental disorders affect mental energy and creativity. Since the main goal of my survey was to study the mental state of people; I have been able to do a lot of that; although some imperfections were noticeable. For example, in my review, I see that about 16 percent of people say that they are mentally healthy but, after analyzing the information taken from them, I see that like 89 percent have gone or are going through some mental illness. So, this makes me think that either the participants can able to realize my questioner or, I have did not mention all possible/most common symptoms.

Even when I have started to collect responses to the survey, there were so many obstacles. A few people were interested in taking part in the survey; others continue their discouraging behavior. Besides, this Covid-19 and lockdown increased people's suffering, makes people emotionally weak, decrease their confidence level and hope. Even they get more involved in destructive thoughts and were frustrated lose their creativity. Thus the present mental conditions of people in 'Bangladesh' are increasing negatively at the same rate different psycho illnesses are coming forward.

Therefore, appropriate initiatives should take immediately to save the lives of the people and at the same time to treat the victims of mental disorders. Those all will be my satisfaction and achievement if the information from my discussion could play any role in future works toward this goal.

CHAPTER 5

IMPACT ON SOCIETY, ENVIRONMENT AND SUSTAINABILITY

5.1 Introduction

In this section impact of mental disorders and how the findings of my study impact society and the environment will be described. Besides, how the study will be sustainable will be described briefly.

5.2 Impact on Society

Nowadays the mental problem is turning into a disorder that is getting involved in everything else in the daily life of the people. In this developing country of huge population in South Asia (i.e., Bangladesh), although recently some work has started like the Roshni Project, 'Kan Pate Roi', online psychiatry. However, none of these were accepted by the common people in that way. The reason I can say is the fear of security or disclosure of identity; in some cases, the cost.

It is worth mentioning that although AI has been used a lot in the medical system of this country, it has not made much progress in the treatment of mental illness. In my review, I have discussed the most commonly used AI treatments, their importance or how to benefit from using them, or the work that has been done using them at different times. So I hope that it will come to the notice of the appropriate authorities on the use of AI in a new way and the wise can find a way to solve the mental problems at least a little. So I can say that this review will play a role in showing new ways for the well-being of the people in the society. Thus it grows a positive impact on society.

5.3 Impact on Environment

And if I have to talk about environmental conditions, then I must say that social conditions affect the environment. In that case, naturally, when people become interested in this mental health issue and start working on various steps towards these goals,

naturally, there will be an impact on the environment. This review will thus play an important role in developing a productive environment of a hardworking, healthy mindset. Thus this works impact society and eventually on the environment.

5.4 Ethical Aspect

From the moral aspects of this study, we all know how the present situation of our society. So, in this restless, alarming condition improvement of mental health is most important. As we believe a balanced society can lead to a better environment. So, the first impact of my study will be the more people read this, the more will aware of these sensitive issues. Besides, new initiatives will arise by this study. Most importantly, this must be a great starting for this developing country as there was no such research work in recent times.

5.5 Sustainability

As this study analyzes the consequences of all AI technologies and all about them, it will open up new hopes, including the perfect opportunity for leading work in the mental health sector. Moreover, I think it will be a timely initiative that can strengthen the prevention and treatment of the mental disorder.

CHAPTER 6

SUMMARY, CONCLUSION, RECOMMENDATION AND IMPLICATION FOR FUTURE RESEARCH

6.1 Summary of the study

Primarily, this review intended to analyze the most commonly used AI applications or methods used in the mental health sector. I have reviewed and come up with some digital and realistic mental service applications. In which role of a conversational agent or chatbot digital assistant is providing quite a good service with the realistic service assistants, I saw more use of neuroimaging and recognizing techniques.

Secondly and most importantly, my study's goal was to observe the mental state of Bangladeshi youth. So I conducted the survey and collected general people data with an age range of 19 to 29. I did analyze the dataset mostly, the anxiety, depression, and PTSD parts. On this analysis, I have got an alarming result. As it shows that almost 89% of participants had experienced any disorder or still have any.

Here, I must mention the machine learning algorithms- decision tree, random forest, and support vector machine that I have applied for checking the disorder dataset, classification, accuracy. Those three algorithms are mainly founded from the review as they are used many times in mental health analysis.

6.2 Conclusion

In this review, I try to disclose what I have seen; how fast the whole world is going forward using AI in the mental health sector. However, this South Asian developing country Bangladesh is still stuck with our negative thoughts, stigma, and fear of what people will say. So, we should follow those methods or methods for our benefit, for the sake of a healthy future, and create opportunities to use them to prevent or reduce mental illness in people.

In the present situation, it will be a perfect combination if we can combine chatbot, voice and visualization checkups, and neuroimage checking at the same time with psychiatrist

treatment. For surviving strongly in today's world, we should be more careful and sincere about these mental health problems. Otherwise, it will soon turn into a terrible mental illness or disorder.

As my survey results show that almost 89% of participants had or has mental issues. So it is high time to be alert and take the necessary steps like use technologies. Especially during this COVID-19, we should be more careful and positive about mental well-being.

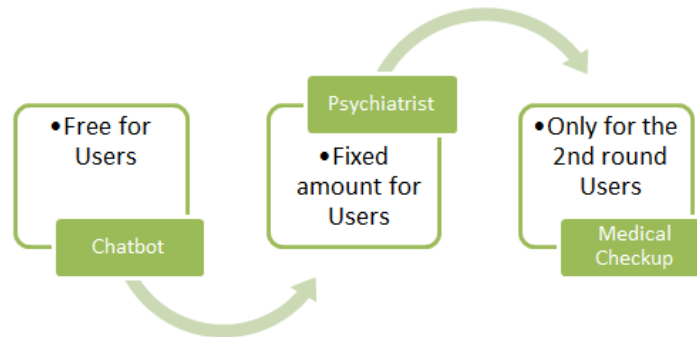


Figure 6.4.1: Propose Model for future work

6.3 Limitations

Like any other research, this study has some limitations and those are included below-

- In the review, there was less paper of 2017-2018 (2017-digital mental care and 2018-practical application of AI.)
- I choose only 31 papers where maybe any relevant publication is missing.
- Worldwide data has been used in my review as no suitable work on mental illness in Bangladesh has founded.
- Although, the present study is a systematic review in nature but my plan was to collect Face-to-face interview or primary data from patient. But, for COVID situations and all, a face-to-face interview or primary data is missing here.
- The survey that I included in this work has a notable limitation as I was asking questions in 'English' and many people cannot realize the exact meaning of the questions. Thus, they skip this survey or respond unknowingly. For this reason, I have got many in consist answer in the survey.

- There was also an inconsistency between the responses. Since, analytical results showed that 10% are healthy, but by peoples answer 'yes' to direct health questions, get 16% healthy.

6.4 Recommendations and Implication for further study

- 1) Chatbots could use for clinical psychology and psychotherapy soon.
- 2) Conversational agents or chatbots will be a new edition with foster mental health for users with a suicidal tendency or destructive mentality.
- 3) Decreasing the treatment expenses of realistic technologies (e.g. MRI, EEG, etc.).
- 4) A mental healthcare can be built with the combination of virtual and realistic AI technologies; using the concept of the conversational agent (i.e.chatbot) for the primary user, psychiatric help for the secondary user, and neuroimaging and recognizing technologies for advanced treatment [Figure 6.4.1].

APPENDICES

1. What grows the destructive behavior & suicidal tendency of people?

My literature review study found that, in the last few years such problems have been increasing among people where a destructive thought gives birth to other mental illnesses. Although, now it doesn't matter if you ever have a mental illness, or not anyone of any age can become destructive to the detriment of themselves or others. In particular, teens and young adults are more engaged in physical self-injury [29] in recent days.

According to this research, destructive mentality can occur for various reasons. The most well-known causes include neglect (i.e. abandonment), mental or physical abuse, childhood trauma, self-esteem, grief, trauma or shock, social isolation, alcohol or drug use, and traumatic events.

As I get to know from this study, depression plays a big role in suicide. Although many more probable causes besides family history are scan through this survey [80]. For now, I found, there are several risks such as health, historical and environmental factors for growing suicidal tendencies. Here are some of those factors are mentioning below-

- 1) Historical: childhood experiences (e.g. abused, traumatized, neglected), history of suicide (e.g. family, close ones, own, acquaintances), etc.
- 2) Environmental or External influences: misfortunes, including divorce, chronic stress (e.g. mobbing, harassment, or personal relationship difficulties), financial hardships, access to lethal objects, unexpected life changes, the experience of anyone suicide, or witnessing distressing suicide descriptions.
- 3) Health-related: mental disorders (e.g. depression, schizophrenia, anxiety, bipolar, contact), aggressive behavior, difficulty in health conditions, mood swings, difficulty maintaining relationships, problems with substance use, severe physical health conditions (i.e. pain, traumatic brain injury), etc.

For one or more of these reasons, people become destructive and think of their loss or suicide. In the end, these are the main reasons for the increase in baneful behavior and suicidal tendencies.

I have found the same result from my survey. Where it shows clearly people's destructive behaviors are mostly increased because of an anxious or depressed mentality or PTSD.

2. How did mental disorders reduce the creativity & mental strength of people?

As we all know, people are most creative in a positive mood. But disorders change moods, thoughts, behaviors. It turns people's thoughts and behavior into negative ones. As a result, they can no longer think creatively; because they do not have that mental strength. Moreover, the number of people sufferings from mental illness has increased in recent years. Due to mental illness, several obstacles in relationships, family conflicts, social isolation, unhappiness, decreased enjoyment of life, legal and financial problems, addictive problems (i.e. tobacco, alcohol, and other drugs) grow [81].

From one of my papers on mental illness, I found that stress (30%), anxiety (22%), and depression (14%) are the obstacles to the creativity of college and university students. Their mental strength is also decreasing due to failure career [82]. Teenagers have also lost energy due to mental illness, optimism, lack of attention, and even addictive behavior in many. In this way, many are missing classes or work, some stop reading; Study, career all give up. Gradually their mental strength and creativity diminished and turned into an opposite mentality. Thus mental disorders push people's mental energy towards destruction and reduce creativity.

Here I must mention, I have found only 16% of participants with no mental disorder in my survey analysis; but, surprisingly in between them 6% just pretending as healthy or did not get the proper questionnaire. From survey I have also found some common characteristics that were in all healthy participants like as: calm, balanced, good decision taker, do enjoyable things only, satisfied with life, etc. But, a mental disorder changes those behaviors inversely and reduced mental strengths and creativity.

3. What were the most effective AI strategies for motivating people?

From the discussion, it is clear that the recent Covid-19 situation had worsened human mental health. In that situation, telemedicine or online mental health services was the safest and easiest method to help in mental disorder patient. Even in ordinary days, it will be the same; although, south Asians are still in the trap of fear of criticism and superstitions.

Besides, in realistic strategies, neuroimaging and recognizing techniques were very popular throughout those all studies related to real-life AI technologies; although, most of them are expensive. Here, I must mention psychiatric therapy which was another technique to motivate people with mental disorders with several talk therapy, behavioral therapy, addiction counseling, anger management, meditation, stress management, etc. Even in the United States and other neighboring countries, many advanced treatments have started for mentally ill peoples. They even have a separate treatment for each type of disease, such as the hot-line for people prone to suicide [83].

My survey shows that most people's problems are still in their infancy and, there is a chance to these can be solved only by talking. As most suffering people start to suffer from loneliness and other mental illnesses it is possible to fix these by talking to a bot or a virtual agent since they just need someone to talk to. And those who are no longer in the early stages of mental illness must go to a psychiatrist. This is because many patients have returned to a healthy life with 'skin touch' and face-to-face talking. Because the word of the doctor, comfort, reassuring hand touches, sincere hugs are very effective for these mentally unstable people. This method also appropriates for the initial stages of psychiatric treatment, but it has a cost issue that makes people go further. Those peoples who are in the worst condition have to treat on different scales because it is not possible to get anything out of them by normal talking. AI has many famous applications for such patients to record their voice and eye movements. Many developed countries have already used those technologies extensively. So, for all these reasons, I have planned to work on this sector in the future and most probably go forward with the proposed model I have mentioned in future scopes.

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