Prediction of Anxiety Disorders using Machine Learning Techniques

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***Abstract*— Anxiety disorders have seen an elevating number since the Covid-19 pandemic. This paper aims at identifying more about the various anxiety disorders using machine learning Techniques. Further, symptoms of the types of anxiety disorders: Generalized Anxiety Disorder, Panic Disorder, Post-Traumatic Stress Disorder, Obsessive-Compulsive Disorder and Social Anxiety Disorder are also discussed. The datasets used in the paper are collected by researchers from hospitals/organizations/educational institutions mainly through questionnaires and surveys. Some of the many Machine Learning techniques used for prediction of these anxiety disorders include Random Forest, Linear Regression, Support Vector Machine among others. Lastly, the performance metric for the techniques is presented here and henceforth, the result is drawn from this available data followed by the conclusion.**

Keywords—Machine Learning, Anxiety Disorders, Anxiety, Mental Health

I. INTRODUCTION

Mental Health is one of the most pressing issues globally. As per latest studies, one in every seven individual is said to be facing mental health illness.

World Health Organisation (WHO) has defined anxiety disorders (AD) as the mental disorders which are caused by feelings of anxiety and fear. These include Generalised Anxiety Disorder (GAD), Panic Disorder (PD), phobias, Post-Traumatic Stress Disorder (PTSD), Obsessive-Compulsive Disorder (OCD) and Social Anxiety Disorder (SAD) [1]. In 2020, the Covid-19 pandemic led to a significant increase of around 25.6 % in the number of people suffering from anxiety disorders [2].

Machine learning (ML) algorithms help in creating systems that uses inputs in the form of training data, graphs, etc. to acquaint itself just like we as humans learn through books, videos, etc. Based on the values of various features and the result about presence or absence of anxiety disorder, the algorithm is trained to classify the disease. After the training, the algorithm can predict whether the patient with new data is suffering from anxiety disorder or not. It is a useful tool to help in identifying mental health [3]. There are many different types of ML techniques which can be used for prediction of the disease:

1. Supervised Learning (SL)- In this type of learning method, labelled dataset is used to train the machine and then the machine predicts the output on test data. The output can further be classified into classification and regression [Figure 1]. In classification, the output variable is yes/no variable. ML techniques for these are Decision Tree (DT), Logistic Regression (LR), Naïve Bayes (NB) and Random Forest (RF) etc. In regression, linear relation between input and output variables is provided. The examples of regression techniques are Decision Tree (DT), simple linear regression (SLR), multivariate regression, support vector machine (SVM), etc.

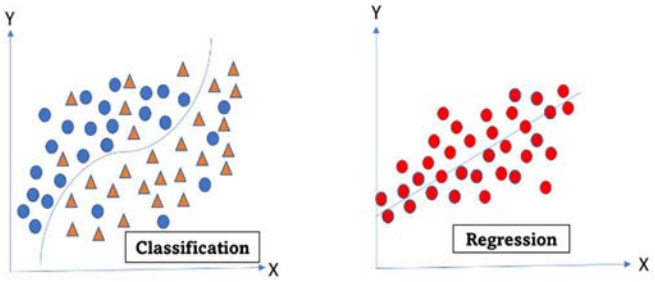

Figure 1: Classification and Regression

2. Unsupervised Learning (USL)- In unsupervised learning techniques, no labelled dataset is provided to the machine for learning. The machine predicts the output without any supervision. USL can be further classified into clustering and association. In clustering [Figure 2], clusters of objects with similar characteristics are formed as a cluster such that a cluster has fewer or no similarities with the other one. Output is the cluster to which the current data point belongs to. ML techniques used for clustering are K-Means Clustering, mean- shift, DBSCAN, etc. In association, dependency of one data item on another is found and mapping is performed to gain maximum profit. ML techniques for association are FP-Growth, Apriori, Eclat, etc.

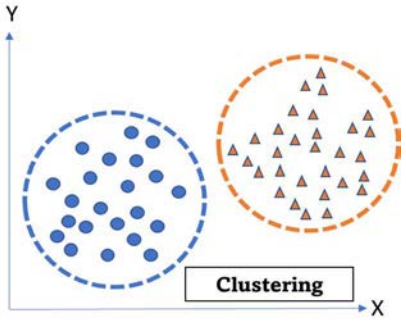

Figure 2: Clustering

3. Semi-Supervised Learning (SSL)- This type of ML technique uses a mix of both labelled and unlabelled dataset for training and so, is said to be on the middle ground of SL and USL.
4. Reinforcement Learning (RL)- This type of ML technique has AI agents that interact with the environment to gain experience, act, and improve their

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performance. There is reward for correct response and punishment for incorrect response.

Figure 3 represents a flow chart of the above discussed Machine Learning Techniques:

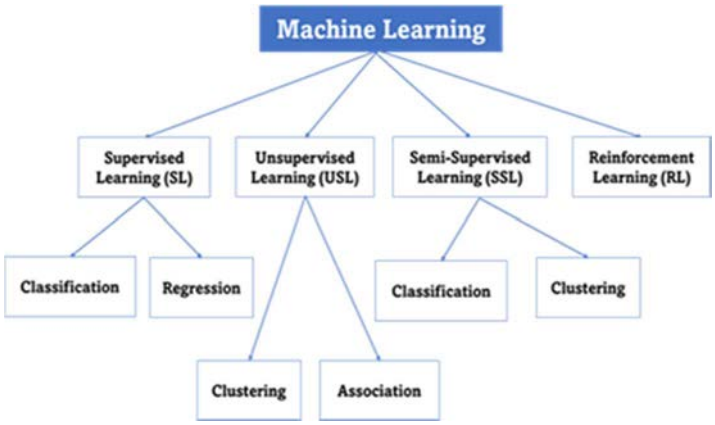

Figure 3: Types of Machine Learning Techniques

With the help of ML techniques, AD can be predicted, its level can be figured out, and the response to the treatment can also be predicted. Data can be collected from various resources that is through surveys, questionnaires, health records and through certain wearable devices that are now available in the market along with a number of other ways. This data can be used as training set and the required information/features can be selected by using a feature selection algorithm. Further, the classification can be done using available algorithms and models. Figure 4 represents the task of model training followed by the evaluation.

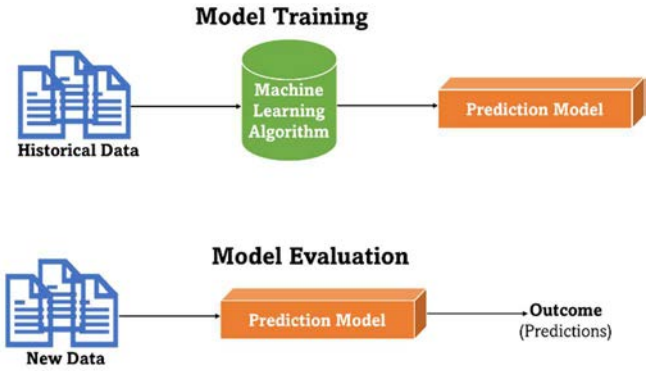

Figure 4: Model Training and Evaluation

This paper presents a review on how ML techniques can be used to determine and treat AD. There are many different types of anxiety disorders like PD, GAD, OCD, SAD, and PTSD. The focus of the research is to identify various ML techniques for different types of AD. A number of such ML algorithms is discussed in the paper. A brief about these is provided below:

1. Support Vector Machine (SVM)- Used for both Classification and Regression, the objective of SVM is to find a hyperplane (whose dimensions depend on number of features) to distinctly classify data points in N-dimensional space. This algorithm can be used for Image classification, face identification, etc.

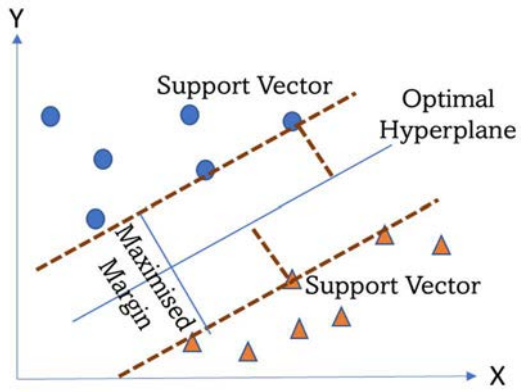

Figure 5: Maximum hyperplane distance (for SVM)

2. Logistic Regression (LR)- Used for solving classification problems, LR predicts the output of a categorical dependent variable using a given set of independent variables. In this, there exist a 'S' shaped logistic (sigmoid) function that predicts two values (0 or 1).

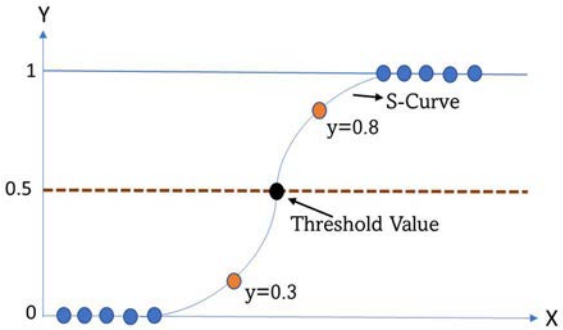

Figure 6: Logistic Regression (LR)

3. Decision Tree (DT)- It is a classifier in the structure of a tree wherein the features of the dataset are represented by the internal nodes, decision rules by the branches and outcome by each of the leaf nodes. In order to build a tree, we use the Classification and Regression Tree (CART) algorithm.

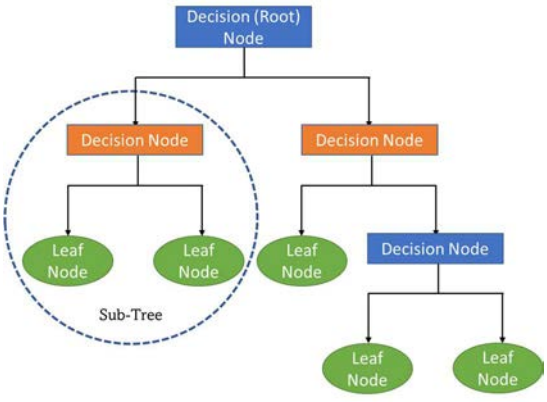

Figure 7: Decision Tree (DT)

4. Random Forest (RF)- As the name suggest, RF is a classifier that consists of a number of decision trees taken from the dataset, the values are further averaged

to improve the predictive accuracy of the dataset. The greater the number of trees, the higher the accuracy.

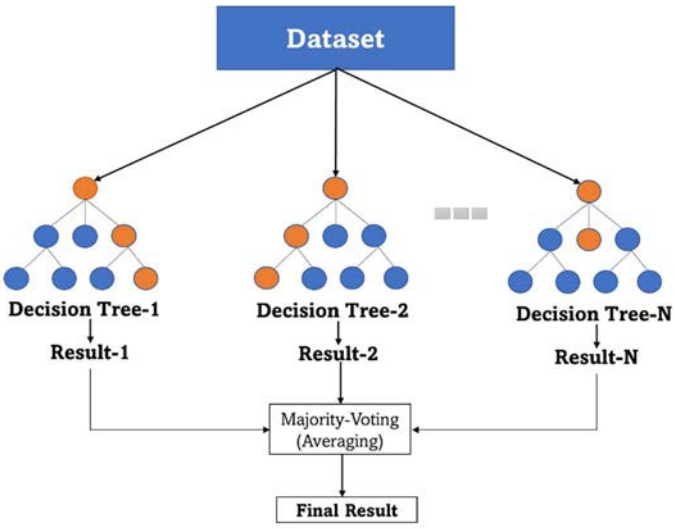

Figure 8: Random Forest (RF)

5. Neural Network (NN)- They perform tasks without any specific rules by using datasets and examples. In other works, the systems should identify characteristics from the data without them being programmed about that dataset.

6. Multi-Layer Perceptron (MLP)- A NN with multiple layers, MLP is dense connected layers that is used to transform any layer to desired form. It consists of an input layer, a node (neuron) for each input, an output layer, a node for each output and hidden layers with any number of nodes.

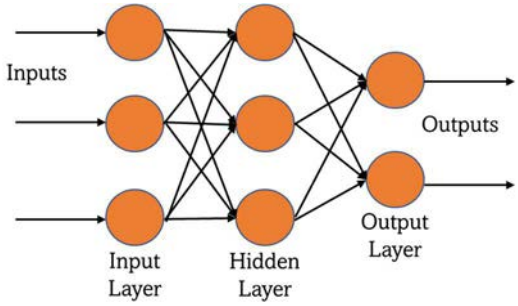

Figure 9: Multi-Layer Perceptron

7. Ensemble algorithm with Multiple Parcellations for Schizophrenia prediction (EMPaSchiz)- An AI- based software with increased accuracy used for examining brain scans from patients diagnosed with Schizophrenia.

Related work on AD is covered in section II. The findings of the review are presented in section III. Conclusion and future scope are given in section IV.

II. RELATED WORK

There are several existing studies made to determine the role of ML in identifying AD. In one of the papers, the authors interviewed 460 seafarers at Haldia Dock Complex. The study used 14 features and five ML classifiers to determine the level of anxiety/depression among the seafarers. On the test dataset, CatBoost outperformed the other classifiers with an accuracy of 89.3% followed by LR with 87.5%, SVM and NB both with 82.1% and RF with 78.6% accuracy [4]. The anxiety disorders can broadly be categorized into five types. Their common symptoms are shown in Figure 10:

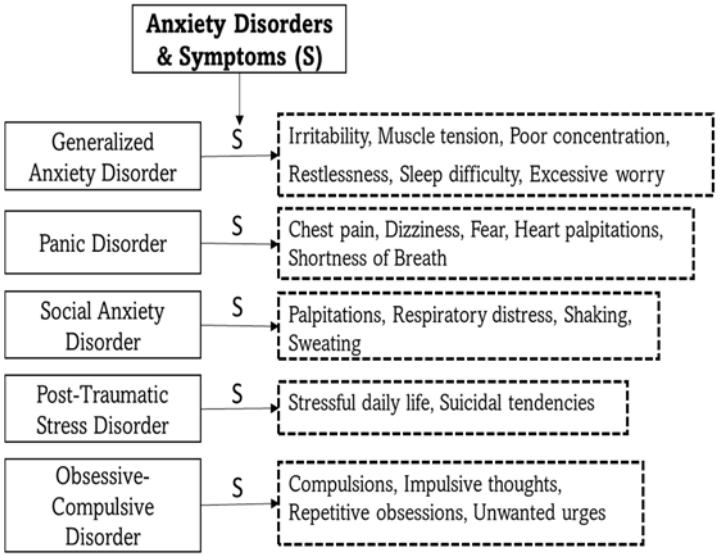

Figure 10: Types of Anxiety Disorders and their Symptoms

A. Generalised Anixety Disorder (GAD)

GAD is the most common mental disorders which is diagnosed by symptoms like irritability, muscle tension, poor concentration, restlessness, sleep difficulty, excessive and uncontrollable worry [5]. Sribala collected 66 samples from the data obtained from patients using DSM IV standard questionnaire [6]. A Neural Network (NN) based model was generated for GAD using 14 features. The process was divided into 3 stages, first was Data Collection & pre-processing followed by using artificial NN for obtaining prediction models in the second stage and producing the result analyzes in the third stage. The accuracy came out to be 90.323% without sensitivity analysis while it was 96.429% with sensitivity analysis. Albagmi et al. used data collected from 3017 participants in Saudi Arabia to predict anxiety among patients during the Covid-19 pandemic to classify two-class and three-class anxiety problems early using 10 features [7]. The authors used SVM, and J48 Decision Tree followed by feature selection. The results were promising as SVM outperformed J48 Decision Tree with a classification accuracy of 100%.

Pre-treatment functional magnetic resonance imaging (fMRI) data was taken into consideration from individuals with GAD and PD from a total of 48 adult in [8]. These included 25 GAD and 23 PD patients. Three models were studied, the fMRI-based model got 79% accuracy, and a sensitivity of 0.86 using

RF, clinical and demographic variables with an accuracy of 69% with sensitivity 0.79 and a combined model with accuracy 73%. Biometric markers and characteristics of 4184 undergraduate students were collected using Electronic Health Records for detecting GAD and major depressive disorder (MDD) by Nemesure et al. [9]. 59 biomedical and demographic features were used for model training by collecting these from a health survey and a set of engineered features. An accuracy of 73% (sensitivity: 0.66, specificity: 0.7) for GAD and accuracy of 67% (sensitivity: 0.55, specificity: 0.7) for MDD was achieved. Additionally, the paper used Shapley Additive exPlanations (SHAP values) to identify features having the greatest impact on prediction of GAD and MDD.

B. Panic Disorder (PD)

Frequently occurring, unexpected panic attacks identify the presence of PD [10]. Some of its symptoms include intense fear accompanied with dizziness, chest pain, heart palpitations and shortness of breath.

Kyoung-Sae et al. conducted a study to differentiate panic disorder from other anxiety disorder [11]. 60 subjects were diagnosed to be suffering from panic disorder while 61 were found to be suffering from with anxiety disorder. Five algorithms Artificial Neural Network (ANN), Gradient Boosting machine, LR, RF and SVM were used where LR outperformed with an accuracy of 78.5% and F1 -score of 0.790. Tsai et al. collected data from various sources- physiological data from wearable devices (Smartwatch, etc.), Environmental Protection Administration's Environmental Open Data Platform while the questionnaire data from the survey conducted [12]. For predicting panic attacks, the ML classifiers Adaptive Boosting (AdaBoost), DT, Extreme Gradient Boosting (XGBoost), Linear Discriminant Analysis (LDA), RF and Regularized Greedy Forests (RGFs) were used. The result was drawn for seven days panic attack prediction and RF produced the best rate of prediction.

Sundermann et al. assessed whether multivariate pattern analysis when applied to a fMRI, can predict response to cognitive behavioral therapy (CBT) in PD with agoraphobia (PD/AG) or not [13]. SVM classification based
on an interoception paradigm wasn't really able to predict individual response to CBT. Jang et al. used 71 patients in a study to differentiate PD patients from HCs using k-nearest neighbor (KNN), LR, multilayer perceptron (MLP), RF and SVM with radial basis function kernel [14]. Analysis was done on 39 HCs and 32 patients with panic disorder. MLP with all 33 features had the highest accuracy of 75.61 % while LR had the highest sensitivity of 0.715.

C. Social Anxiety Disorder (SAD)

SAD comprises of excessive self-consciousness and overwhelming anxiety in front of a large gathering or crowd. It includes symptoms such as palpitations, respiratory distress, shaking and sweating. SAD is commonly occurring in 13% of the population [15]. Two groups- SAD and HC group with 48 and 46 patients respectively were analyzed using the SVM model that relied on the response of the brain to threat (vs Happy) faces, threat faces (vs shapes) and threat/happy faces (vs shapes) with 90 ROIs [16]. A satisfactory result was achieved for the first one with cross-validated accuracy of 69.99 % and the sensitivity 0.71 while the one with shapes resulted in less optimal classification. Al-Ezzi et al. included 88 participants (66 with SAD and 22 HCs) in the age group 18-25 in a study to classify the severity of SAD (severe, moderate, mild and control) and used KNN, LDA, NB, DT and SVM. The comparison of the average accuracies and standard deviations was drawn using Partial Directed Coherence (PDC) values alone as well as using PDC and graph theory values (GT). Highest accuracy of 92.78% was achieved for GT+PDC features using SVM in the alpha band [17].

Månsson et al. assessed neural predictors of long-term treatment outcome of SAD patients, one year after the completion of Internet-delivered CBT (iCBT) [18]. 26 SAD patients underwent iCBT and Internet-delivered attention bias modification (ABM). SVM was used to differentiate between treatment responders and non-responders based on blood oxygen level-dependent (BOLD) responses to self-referential criticism. The study successfully predicted SAD treatment successfully using multivariate SVM–fMRI. Hoogendoorn et al. focused on writing of 69 patient's (use of words, topics written on, sentiments of the message and the writing style) to predict SAD [19]. LR, DT and RF were used to build the predictive model. Using Logistic Regression, the area under the curve (AUC) of 0.83 was reported halfway through the therapy. With complete date, a precision of 0.78 was achieved. It was thus concluded that texts do help in predicting therapeutic outcome.

D. Post-Traumatic Stress Disorder (PTSD)

PTSD can develop after a terrifying event such as a violent crime, serious accident, personal assault, etc. that caused/ could have caused physical harm to an individual. The disorder can be severe and may lead to suicidal tendencies of the patients [20]. Wshah et al. conducted a test on 90 individuals to categorize PTSD and non-PTSD cases using SVM, RF, LR, NB and ensembles of all of these [21]. SVM along with a Gaussian Kernel outperformed with an accuracy of 84.6%. Saxe et al. discussed how childhood PTSD could be predicted using SVM, RF and Lasso (Regularized Regression (RR)) techniques [22]. The data set consisted of 163 children in the age group 7-18.

Papini et al. predicted PTSD screening status, three months after an injury using ensemble ML algorithm using gradient boosted decision trees and 271 patients (age>= 18) with an accuracy of 85.95% [23]. AdaBoost (AB), Bayesian binary regression (BBR), Kernel ridge regression (KRR), RF, and SVM were used to predict the PTSD status of 957 trauma survivors after fifteen months. These were implemented on a combination of emergency room features and post event features after 10 days [24]. 16 of these were classified as potential predictors with an accuracy of 78% using SVM.

E. Obsessive-Compulsive Disorder (OCD)

The presence of obsessions along with compulsions indicate OCD. Obsessions may be repetitive in nature and may occur in the form of unwanted persistent images, impulses, thoughts, or urges associated with anxiety. Compulsions are mental acts or behaviors in response to an

obsession [25]. A sample of 188 patients was collected from the OCD Clinic of Nimhans, India [26]. EMPaSchiz system was used for the model and fivefold balanced cross-validation was performed in five iterations. The algorithm predicted OCD with 80.3% accuracy while the sensitivity of the model was 0.82.

Tubío-Fungueiriño et al. conducted a study to measure the impact of Covid-19 pandemic on OCD patients [27]. Data of 127 patients in the age group 18-65 were considered based on questionaries and telephonic interview. The paper used LDA for classification, multivariate Linear Regression Model for regression. SVM with radial basis function (RBF) kernel and Support Vector Regressor (SVR) were also used. The study generated a 100% reliable Y-BOCS score prediction model at a score threshold of ± 6. The best results were achieved by SVM and SVR which predicted how sociodemographic and clinical data can be useful for OCD detection. To identify predictors of remission in OCD patients using ML techniques, Askland et al. collected a sample of 296 adults was considered and Random Forests algorithm was used [28]. 25 high priority features were identified using RF and the participants were successfully distinguished based on binary remission outcomes with an error rate= 24.6% (95% bootstrap).

III. Findings of the Review

The findings of the review are summarized in Table 1 below:

Table 1: Summary of findings of ML in AD

Disease	Paper	ML Algorithm	Best Accuracy
GAD	[6]	NN	96.429 %
	[7]	SVM/ J48 DT	SVM= 100%
	[8]	RF	79%
	[9]	Ensemble	73%
PD	[11]	LR	78.5%
	[12]	RF	81%
	[13]	SVM	NA
	[14]	MLP	75.61%
SAD	[16]	SVM	69.99
	[17]	KNN/LDA/NB/DT/ SVM	SVM= 92.7%
	[18]	SVM	92%
	[19]	LR/DR/RF	AUC (Halfway)=83%
PTSD	[21]	SVM/RF/LR/NB	SVM= 84.6%
	[22]	SVM/RF/RR	AUC=79%
	[23]	GB DT	85%
	[24]	SVM/RF/AB/KRR/BB R	78%
OCD	[26]	EMPaSchiz	80.3%
	[27]	SVM/SVR	94%
	[28]	RF	95%

The highest accuracy achieved for is 100% for GAD using SVM, 81% for PD using RF, 92.7% for SAD using SVM, 85% for PTSD using GB DT and 95% for OCD using RF.

IV. Conclusion and Future Scope

The study here aims at identifying details about various anxiety disorders. A brief about the types of anxiety disorders: Generalised Anxiety Disorder, Obsessive-Compulsive Disorder, Panic Disorder, Post-Traumatic, Social Anxiety Disorder and Stress Disorder is discussed. Further, the use of different Machine learning techniques (SVM, NN, KNN, LR, RF, etc.) in dealing with these disorders is explained with the help of datasets collected from hospitals/organizations/educational institutions through questionnaires. Based on the given data, the conclusion drawn is that SVM has the highest accuracy for GAD and SAD while it was left behind by a margin of just 0.4% by GB DT for PTSD and by 1% for OCD by RF which also achieved the best accuracy for PD.

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