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A study on types of Machine learning techniques in Mental Healthcare Domain

Ela Gore
Research Scholar,Dept of Computer Engg,TCET,Mumbai

Abstract:*Mental Healthcare is a growing problem plaguing our society. It is that source of trouble which society conveniently tries to avoid it but later on faces severe brunt of its consequences affecting the person's health as well as that of the whole family.Therefore, there is an urgent need to treat basic mental health problems that prevail among people which may lead to complicated problems, if they are not treated at an early stage. The existence of sophisticated (machine learning) algorithms that can process and learn from the data helping to draw varied patterns from the patient's dataset. Psychiatrists now can have an unaccustomed opportunity to benefit from diverse patterns in brain, behavior, and genes using methods from machine learning. This will provide proof based psychiatry predictions. Several machine learning techniques have been instrumental in predicting the outcome of diseases in healthcare domain. This paper tries to review the machine learning algorithms used to predict the onset of mental illness/disorder. This research identifies the types of machine learning techniques, their accuracies, the datasets used and the task undertaken. Prediction by the professionals and prediction by the machine learning techniques would give a solid base in finding the root of mental disorders*

Keywords:*Diagnosis, Machine Learning, Mental Healthcare, Predictive Analytics, Psychiatrist*

I. Introduction

The diagnosis of mental health illness is a challenging task. Every other person goes through some mental health problems but does not admit it. They are unwilling to pay a visit to the psychiatrist and that causes delay in their diagnosis. If these mental disorders are detected on time, then it can have prognosis too through the person can resume back to his/her normal life. Wearable devices can play a major role in noting the onset of mental illness without the user knowing it by applying machine learning techniques on that data recorded from sensors of wearable devices.

There are many mental health disorders with their symptoms listed in Diagnostic and Statistical manual of mental disorders, fifth edition (DSM-5) [1]. This is a manual used by psychiatrists which has types of mental disorders and their disorders listed. The symptoms of various mental disorders are found to be much similar. Hence in the community of mental health professionals, there is a line of vulnerability of diagnosing the right mental health disorder. Machine learning techniques comes to our rescue. It can uncover the dazzled patterns and can help spot the right mental health disorder being suffered by the person. Predictive Analytics on the patient's history can be run to help the professionals in assisting the cause of illness. Prediction by the professionals and prediction by the machine learning techniques would give a solid base in finding the root of mental disorders.

As lot of similarities in symptoms of lot of mental illnesses, it is a bit tedious from the computer Engineer's community to apply the technology of AI. The thing that can be certainly done is to assign the degree of relevance of the symptoms and thereby leading to the diagnosis of particular mental illness.

The aim of this research is to take a gist of predicting basic mental health problems using machine learning techniques. Section 2 presents a review on concepts of machine learning techniques. Section 3 gives an outline of the path chosen to review the studies done in mental healthcare domain. Section 4 presents the various machine learning techniques by various authors to predict the mental health problems. Section 5 discusses the metrics used for judging performance of the model. Section 6 provides conclusion and future work.

II. Machine Learning Concepts And Techniques

Table 1 Concepts of Machine Learning techniques

Supervised Learning	Models that predict a discrete outcome (e.g., healthy group vs. control group) or continuous outcome (e.g., disease severity degrees) from measures of behavior (e.g., questionnaire), brain (e.g., neural activity), or genetics (e.g., single nucleotide polymorphisms). Data have the form: features X (n subjects 3 p variables) and target variable y (one entry for each subject). Example: Estimate patient prognosis based on genetic profile[7]
Unsupervised Learning	Models that discover structure that is coherently present in the p variables across subjects. Data have the form: features X (n subjects 3 p variables), but no target variable y. Example: Reveal biological disease subgroups in patients based on genetic profile. Ascertaining the clinical

	usefulness of discovered clusters and dimensions will often require combination with supervised predictions[7]
Support Vector Machines	A supervised model that performs prediction based on identifying observations in the data that are typical for the categories to be distinguished[7]
Neural-Network Algorithms	A supervised model that performs prediction based on a nonlinear, multilayer variant of linear regression. "Deep" neural networks are a modern version with a higher number of nonlinear processing layers[7]
Logistic Regression	Logistic regression is a classification algorithm traditionally limited to only two-class classification problems[9]
Linear Discriminant Analyser	If you have more than two classes then Linear Discriminant Analysis is the preferred linear classification technique[9]
Quadratic Discriminant Analyser	Quadratic discriminant analysis is to separate two or more classes of objects by a quadric surface, where it is assumed that the measurements from each class are normally distributed. Unlike LDA however, in QDA there is no assumption that the covariance of each of the classes is identical[10]
CK- SVM	The training of CK-SVM consists of two steps: firstly, train an SVM with a Gaussian kernel; and secondly, retrain the SVM with the conformal kernel[2]
PCA	Principal Component Analysis is a method for reducing the dimensionality of data. It can be thought of as a projection method where data with m-columns (features) is projected into a subspace with m or fewer columns, whilst retaining the essence of the original data[9]
ANFIS	ANFIS belongs to the class of rules extracting systems using a decompositional strategy, where rules are extracted at the level of individual nodes within the neural network and then aggregates these rules to form global behavior descriptions[3]
LSTM	LSTMs as allowing a neural network to operate on different scales of time at once[11]
CNN	CNN models to train and test, each input image will pass it through a series of convolution layers with filters (Kernels), Pooling, fully connected layers (FC) and apply Softmax function to classify an object with probabilistic values between 0 and 1[12]

III. Methodology Used For Reviewing

The main objective of this work is to study the efforts reported in the literature aiming to know the existing machine learning techniques to detect mental health disorders .The questions that drive my research process are

- What are the mental health disorders detected (not all but few)?
- What has been the likely prediction model used?
- What are the metrics used to assess the performance of the model?

The literature review of the papers have been done from varied years of 2013, 2014, 2016, 2017 and 2018. Six studies were chosen and examined to understand the machine learning techniques in mental healthcare.

IV. Techniques Of Machine Learning And The Mental Health Illnesses

This section summarizes the findings of the studies chosen. Chien-Te Wu et al. [2] studied that the ability to distinguish adults with Major Depressive Disorder from healthy individuals using resting-state EEG features has reached a bottleneck. To address this limitation, they collected EEG data as participants engaged with positive pictures from the International Affective Picture System; Extracted three types of relative EEG power features from different frequency bands (delta, theta, alpha, beta, and gamma) during the emotion task and resting state; Comparing CK-SVM performance with three machine learning classifiers: linear discriminant analysis (LDA), conventional SVM, and quadratic discriminant analysis. The results from the initial analyses using the LDA classifier on 55 participants (24 MDD, 31 healthy controls) showed that the participant-independent classification accuracy obtained by leave-one-participant-out cross-validation (LOPO-CV) was higher for the EEG recorded during the positive emotion induction versus the resting state for all types of relative EEG power. Furthermore, the CK-SVM classifier achieved higher LOPO-CV accuracy than the other classifiers [2].

Mallikarjun H M et al. [3] read the EEG signals using EDF browser software and the signals were loaded into Matlab to get log Power Spectral Density from EEG bands. The results obtained from Matlab are fed into neural network pattern recognition tool and ANFIS tool box which is integrated in MATLAB which are powerful tool for data classification. Relevant extracted features parameters are used as inputs to the ANFIS and nprtool. The evaluated outputs are helpful to distinguish alcoholics from controls and various sleep disorders like insomnia, narcolepsy, bruxism and nocturnal frontal lobe epilepsy. 20 samples are trained and evaluated for Alcoholism and 40 samples are trained and evaluated for 4 different sleep disorders in ANFIS tool. The evaluated ANFIS output is read as 0 for Insomnia, 1 is for No sleep disorder, 2 for Narcolepsy, 3 for NFLE, 4 for Bruxism. 240 samples for 4 different sleep disorders and 60 samples for Alcoholism/ Control are trained and classified in nprtool [3]

In this study of Tuka Alhanai et al [4] an automated depression-detection algorithm that models interviews between an individual and agent and learns from sequences of questions and answers without the need to perform explicit topic modeling of the content. They did three experiments as: i)A regularized logistic regression model without conditioning on the type of questions asked. ii) A regularized logistic regression

model with conditioning on the type of questions asked. iii) An LSTM model using the sequences of responses, and without knowledge of the type of questions that prompted the response while context-free modeling does provide some discriminative power, sequence modeling is more accurate (highest binary F1 score) and/or robust (lowest multi-class MAE,RSME)for predicting depression[4].

In this[5] study, Gregory Bramble et al. deployed a pipeline that includes moving EEG data to the cloud and getting optimal models for various classification tasks, their initial prototype has been tested only in developed world environments to-date, their intention is to test it in developing world environments in future work, they demonstrated the performance of their proposed approach using the BCI2000 EEG MMI dataset, on which it attained 63.4% accuracy for the task of classifying real vs. imaginary activity performed by the subject, which is significantly higher than what is obtained with a shallow approach such as support vector machines

This work of C. Salvatore et al. [6] aimed at assessing the feasibility of supervised ML algorithm for diagnosis of Parkinson's disease (PD) and Progressive Supranuclear Palsy (PSP), Classification accuracy of individual PSP patients was consistent with previous manual morphological metrics whereas accuracy in the detection of individual PD patients was significantly larger with the SVM method

In this study by Ms. Sumathi M.R et al. [8], the performance analysis of eight classification algorithms is carried out with a common dataset using WEKA tool. First, the classifiers were executed by including all the attributes (25) identified from the text documents and then they were executed by including only the attributes (13) selected by the feature selection algorithms of Best First Search Technique to identify five basic mental health problems of children viz., Attention problem, Academic Problem, Anxiety Problem, Attention Deficit Hyperactivity Disorder (ADHD) and Pervasive Developmental Disorder (PDD)

Table 2 Machine Learning techniques and mental health disorders

Author	Measurements/Input data	Prediction methods	Inferences
Chien-Te Wu et al.[2] (2018)	EEG signals of 55 participants (24 depressed, 31 healthy controls)	QDA(quadratic discriminant analysis), CK-VSM(conformal kernel support vector machine),LDA,SVM	CK-SVM classifier outperformed the other three classifiers, yielding an accuracy of 83.64% in classification of adults as healthy versus depressed
Tuka Alhanai et al[4] (2018)	142 individuals	Logistic regression,Long-Short Term Memory (LSTM) neural network model to detect depression	Multi-modal model yielded the best performance of F1 score of 0.77
Gregory Bramble et al.[5] (2017)	BCI2000 EEG MMI dataset having 109 subjects	CNN had 3 hidden layers: convolutional (conv) layer with 61 filters of size 5x5, a second conv layer with 69 filters of size 8x8, and a max-pooling layer (pool) with filter size 5x5 applied with a stride of 2 and learning rate of 0.001	CNN obtained best accuracy of 63.4% by choosing the optimal model after 750 iterations compared to SVM(56% accuracy) for classifying real vs imaginary activity
Ms. Sumathi M.R.[8] (2016)	The data set has 60 instances in text document format. From the documents, 25 attributes including the class label have been identified manually and checked with the psychologist.	AODEsr, Multi-Layer Perceptron (MLP), RBF Network, IB1, KStar, Multi-Class Classifier (MCC), FT, LAD Tree.	Multilayer Perceptron, Multiclass Classifier and LAD Tree produce more accurate results than the others in terms of Accuracy, Kappa statistics, ROC
Mallikarjun H M et al.[3] (2014)	EEG of 20 samples for Alcoholism and 40 samples sleep disorders	Adaptive Neuro Fuzzy Inference System (ANFIS) and Neural Network Pattern Recognition Tool (nprtool).	Accuracy rate88.32% & 91.7% respectively. Obtained results of ANFIS found to be slightly better than those of nprtool classifier
C. Salvatore et al.[6] (2013)	MRIs of 28 PD patients, 28 PSP patients, 28 Healthy subjects	Principal Component Analysis as feature extraction & SVM for classifying PD vs Healthy Controls, PSP vs Healthy Controls and PSP vs PD	PSP vs PD(88.9 accuracy) by LOO validation & 84.7 by N/2 validation

V. Discussion

Accuracy is the ratio of number of correct predictions to the totalnumber of input samples. F1 score tells how precise the classifier is (how many instances it classifies correctly), as well as how robust it is (it does not miss a significant number of instances). These are the metrics that have during the study of these papers. These cannot be comparable but classification accuracy is considered when judging the performance of a model. Table 2 lists out the types of input data, the prediction models used and the metrics of those models done by various

authors are presented. Depression, one of the mental health disorders has been extensively chosen by the authors. SVM and neural network have been used largely for the prediction models.

VI. Conclusion

A lot of work has been done in making use of machine learning techniques in prediction of mental health disorders. The future scope is to have large database and applying these techniques so as to check the levels of accuracies going up or remaining constant. There is need to apply machine learning algorithms to various other mental health problems not covered so far.

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