A Review on Application of Machine Learning to Detect Depression from EEG signals

Ayushi Sharma[1], Arun Kumar Jharpate[2]
[1]M.Tech Scholar, Sagar Institute of Research and Technology, Bhopal, India
[2]Professor, Sagar Institute of Research and Technology, Bhopal, India
[1]aayushi.sharma1800@gmail.com

* Corresponding Author: Ayushi Sharma

Abstract: Brain is the main functional unit of a human body. It is essential to have proper functioning of nerve cells to have perfect working in human body but in today's era of high competition, high expectations, desires and curiosity, brain cells are affecting in various ways like hypertension, epilepsy, seizures and depression. Depression is one of the major brain disorder that affect people of almost all age group whether a student, working person, Owners or even old age people and it may lead in deteriorating of human conditions physically and mentally both. The Growth rate states that it will become the second most happening disease by 2020.Therefore for maintenance and for a fit and healthy body it is essential to diagnose depression in person at its early stage so that suggestive steps should be taken. One of the method to diagnose the same is electroencephalogram (EEG).The aim of this paper is to provide a kind of literature survey on various uses of EEG in depression detection. It also shows the growth and significance of EEG in depression detection. How does the output and value is changed by using different algorithms like Genetic Search (GS), Greedy Stepwise (GSW), K-Nearest Neighbor (KNN), Linear Forward Selection (LFS), Random forest (RF) and Correlation Feature Selection (CFS). The paper also aims to provide the growth of EEG in identifying brain disorders at low cost and at easy maintenance.

Keywords: Depression, Electroencephalogram (EEG), Magnetic resonance imagining (MRI), mental disorder

I. Introduction

Depression is a common brain disorder that has already affected more than 335 million people worldwide in all age group. It causes sadness, loneliness, loss of interest in normal physical or regular activities of human being and mood swings. Depression may cause severe health issues in human being if not treated on time and ignored. Sometimes person may take deadliest step and commit suicide. Latest survey done in various countries shows that depression in human beings is increased by 5.8% from 2.1% in year 2020. It is also stated that depression affects women more than men. The reason of depression in females are more due to pregnancy and menopause [8]. This pandemic COVID-19 has affected every individual worldwide and being also a reason for increase in this percentage. Survey also states that most of the colleges, school going Students are affected by depression and they are unaware of it, their reason may differs like exam stress, academic grades, high competition, career and scope but depression is affecting the youth and future generation of countries badly. It is predicted to be the world's second most affecting brain disorder in 2020. To avoid such deadliest steps to be taken by individuals and especially these students, it is imperative to have a proper diagnosing system at its early stage so that necessary steps should be taken care. The current methods of depression detection are not very affective as it is based on doctor's experience and are human intensive. Therefore a serious urge is there to have a way for proper and accurate diagnosis of depression. Electroencephalogram (EEG) is one the powerful tool. It analyzes the functional activity of brain and generates a detail assessment in the form of wave signals which provide crucial information of parameters that depicts the mental state of a person and helps in identification of various mental disorders like seizures, depression, schizophrenia, anxiety and mental fatigue. EEG is very powerful tool because of its noninvasive technique, low-cost and easy setup and installation [1]. As compared to magnetic resonance imagining (MRI) that captures the changes of blood flowing in brain within a particular period of time (seconds or minute), an EEG is more effective in diagnosis of mental disorder as it records the brain's electrical activity over a period of time. Also MRI is quite expensive than EEG. Identification of brain disorder or illness is nowadays a major interest for scholars therefore various studies have been done on application of EEG signals in brain functioning.

II. Clinical Depression

Major depressive disorder (MDD), or depression for short, is one of the most widely recognized mental issues across the world[9,10]. As depicted in the World Health Organization [11] Global Action Plan 2013-2020 for mental health, depression has affected more than 300 million individuals overall the world and also became a significant reason for disability, particularly among ladies. At present, depression records 4.3% of the worldwide weight of disease and it will probably become the main root of diseases in high-income countries by 2030 [12].

The following points mentioned below include the signs and symptoms of clinical depression in a person:

- During the time when a person is depressed, it is difficult for them to take proper sleep. They also feel insomniac and sometimes they were taking too much sleep.
- A person may feel tearful, sad, alone, and hopeless because of many scenarios running in his life.
- Some people feel anxious, agitated and restless all the time whereas some people feel worthless or guilty, fixating on past failures or self-blame.
- A person gets very angry, irritable or frustrated even at very small issues.
- Suicidal thoughts, suicide attempts and suicide were very frequent during these periods.
- They feel tired all the time due to which small tasks took lot of time and effort.
- A person undergoing depression loses interest and pleasure in many normal activities like sex, sports, hobbies, family gatherings etc.
- Their thinking, speaking and body movements is slowed.
- A person can suffer from unexplained physical problems like back pain and headaches while dealing with depression.
- Some people feel anxious, agitated and restless all the time whereas some people feel worthless or guilty, fixating on past failures or self-blame
- Trouble in thinking, concentrating, making decisions and remembering things is also slowed by person dealing with depression.

III. Related Work

Depression is defined as the mental illness of a person that has influenced more than 350 million individuals all over the world till now. This illness is not only affecting one person but it also includes families of person suffering from depression. The World Health Organization (WHO) has declared that depression will be the second foremost reason of further disease by the year 2020. On the other hand, appraisal strategies for diagnosing depression were based on clinical and patient reports of relentlessness of a person. Apparent drawbacks associated with patient rejection, low sensitivity, subjective bias and inaccuracies were common to have in current diagnostic technique. Finding a target, exact and useful strategy for recognizing depression stays a challenge. In introductory stages when depression is in its mild form, early discovery of depression in a person is helpful for both the individual as well as society.

Among all biological signals, EEG (Electroencephalogram) is most adaptive way that can reflect actual mental state. EEG signals are generated by nervous system when any external stimulus occurs which can be used to correctly diagnosis of mental health of an individual. Many existing researchers are exploring their knowledge to show the efficiency of EEG as a reliable mode for detecting depression.

From more than 12 years, EEG has been used for diagnosing various mental disorders. Acharya et.al [1] in his study presented a screening based on EEG signals for depression detection using an approach of deep learning known as convolutional neural network (CNN). The proposed algorithm automatically learns differentiation among depressed and normal subjects from EEG signals in adaptive manner [1]. The algorithm provides 93.5 % accuracy in left hemisphere and 96% accuracy in right hemisphere. Acharya with some other authors have done a long study on the same concept from year 2012 to 2017 and have given a detail about algorithms and conclusion along with results in [1]. Evaluation is done on 18 subjects. This study has discovered that an EEG signal from right hemisphere gives better result and optimal performance in terms of specificity, sensitivity and accuracy.

Xiaowei Li et.al [2] attempts to study the EEG signals in order to diagnose depression. The experiment is done on more than 200 undergraduate's students in various universities. The experiment shows variation in EEG signals of normal brain students and depressed students. During the experiment the time given, No of questions, screen distance is same for every participant. The entire process works on frequency bands. Feature extractors were used to extract three frequency bands namely theta, alpha and beta [2] and confirmed to have major differences in produced EEG signals. A combination five feature selection and five classification algorithm is taken and author concluded that GSW based on CFS and KNN had the optimal performance [2]. The study shows 92% accuracy especially with beta frequency band and thus helps in diagnosing Mild depression.

Subha et al. [4] have attempted to classify the EEG signals in order to identify the normal brain and affected brain by depression. The paper provides a well-established technique using Relative Wavelet energy (RWE) and artificial feed forward network (ANN)for signal classification [4]. The evaluation is done on the basis of various parameters like sensitivity, specificity and classification accuracy in ANN-based technique. The evaluation is done on 160 records [4]. The results conclude that waveform generated by EEG when processed with RWE and ANN shows differentiation in signals of normal healthy brain and depressed brain. Moreover ANN-based technique gives an overall accuracy of 98.11% [4].

Bachmann et. al [5] has compared the two methods of EEG for depression detection namely spectral asymmetry index (SASI) and Higuchi's fractal dimension (HFD). Experiment is done on 17 depressive patients and 17 mentally fit person. Various calculative parameters were evaluated in various regions of Brain like frontal FP1 and FP2, temporal T3 and T4, parietal P3 and P4, and occipital O1 and O2. Both methods shows remarkable result identification and proves to be correct in 85% cases in either method. The study concludes that linear SASI method and non-linear HFD method generates optimal results in a single channel EEG [5]. Linear SASI gives true detection rate of 88% whereas HFD gives a rate of 94%.

Muhammad Umar saeed et. al [6] research studied the classification of long term stress with machine learning algorithms. Long term stress is a better predictor of symptoms that shows depression and is considered to be a major risk factor such as cardiovascular diseases [6]. In paper two methods were used for long term classification using EEG signals and experimental results are evidence that proves that Support vector machine (SVM) and logistic regression (LR) generates highest accuracy i.e 85.20%. The study concludes that alpha symmetry can be used as potential bio marker for classification via SVM. The result evaluated in the experiment is done on the basis of perceived stress scale score and expert evaluation and this consideration of expert advice is not done earlier.

Chien Te Wu et.al [7] has proposed a method to overcome the limitation of distinguishing EEG features which has reached a bottleneck. The research is done by extracting three types of EEG power features and a comparison is generated among healthy and depressed images. A novel classifier is also applied for enhancing the generalization performance called as conformal kernel support vector machine (CK-SVM) [7]. The study proved that inducing positive emotion images for cleaving information from EET signals that leads in classification of healthy and depressed signals. The result in one of the three method stated in [7] generates an accuracy of 83.64%.

Acharya et.al [8] focused on recent efforts on computer aided design (CAD) of depression via EEG signals. The consideration was majorly done for Non-linear methods as it exhibits huge dynamical variation as compared to linear method [8]. The paper reviewed various linear and non linear methods and concluded that a CAD system is user friendly and accurately confirmed the result of EEG signals which results in depression diagnosis.

Hinrikus et. al [9] aims to distinguish the EEG signals in female depression. The experimental values are evaluated on two groups of 18 females. One group is for healthy females and another for depressed females. Spectral asymmetry (SA) is taken as parameter for evaluation. Experimental results are generated on various frequency bands like beta and theta. The results of the study are better than other authors as it showed positive values of SA and generated negative value of SA for depressed case [9]. Although the results for 4 subjects are deviated, this is a small variation on a given set of input. [9].

Problem Identification

One of the most worldwide problem is depression or anxiety disorders that are highly prevalent worldwide and causes harm not only to an individual but also their nearby people, family and society. As discussed above researchers focused their work to diagnose depression effectively by using machine learning approach. Following problems are identified in existing systems:

- Depression is considered to be the most frequent mental illness, and it is among the main causes of disability.
- Depression is a mood disorder that produces feelings of sadness, loss, anger, and frustration for a long time, interfering with daily life.
- Precision rate is low in visual and audio depression detection system.
- System should be gender independent.
- Most of the existing models are unimodal. So, their accuracy rate is low.
- Most of the unimodal models are based on textual, audio or visual.
- There is a need of multi-modal systems to analyze the symptoms and work on the data sets for accurate and timely prediction of mental state of a person.
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IV. CONCLUSION

The paper has presented a review on various work done on EEG signals in the field of depression detection. Various algorithms from various fields like CNN, RWE, SA, CAD and SVM are applied for analysis of EEG signals so that the information that can be used to classify the depressed and normal subjects of a person can be gathered. The research has considered various frequency bands for experimental evaluation among which the result obtained in most of the research is from beta band as it provides more accuracy as compared to theta, alpha and other bands. One of the study also concluded that EEG signals from right hemisphere of the brain yields better performance in classification.
Finally, the given review can be extended to see how EEG signals can help in identifying various stages of depression, severity of depression. Moreover, to have better and best result in all cases, larger database can be taken as results in few of the research work are little deviated..

REFERENCES

[1] Hanshu Cai,1 Jiashuo Han,1 Yunfei Chen,1 Xiaocong Sha,1 Ziyang Wang,1 Bin Hu , 1,2,3 Jing Yang,4 Lei Feng,5 Zhijie Ding,6 Yiqiang Chen,7 and Jürg Gutknecht8 "A Pervasive Approach to EEG-Based Depression Detection" 6 February 2018; https://doi.org/10.1155/2018/5238028

[2] Xiaowei Li, Bin Hu *, Shuting Sun, Hanshu Cai "EEG-based mild depressive detection using feature selection methods and classifiers" 6 August 2016; http://dx.doi.org/10.1016/j.cmpb.2016.08.010

[3] U Rajendra Acharya , Shu Lih Oh , Yuki Hagiwara , Jen Hong Tan , Hojjat Adeli , D P Subha "Automated EEG-based Screening of Depression Using Deep Convolutional Neural Network" 17 April 2018

[4] DOI: 10.1016/j.cmpb.2018.04.012

[5] Subha d. Puthankattil and paul k. Joseph "classification of eeg signals in normal and depression conditions by ANN using RWE and signal entropy" 3 August 2012 DOI: 10.1142/S0219519412400192

[6] Maie Bachmann, Jaanus Lass, Anna Suhhova, and Hiie Hinrikus "Spectral Asymmetry and Higuchi's Fractal Dimension Measures of Depression Electroencephalogram" 6 September 2013 http://dx.doi.org/10.1155/2013/251638

[7] Sanay Muhammad Umar Saeed 1 , Syed Muhammad Anwar 2,3,*, Humaira Khalid 4 , Muhammad Majid 1 and Ulas Bagci 3 "EEG Based Classification of Long-Term Stress Using Psychological Labeling" 29 March 2020; doi:10.3390/s20071886

[8] Chien-Te Wu 1,2,†, Daniel G. Dillon 3,4,† ID , Hao-Chun Hsu 5 , Shiuan Huang 5 , Elyssa Barrick 3 and Yi-Hung Liu 5 "Depression Detection Using Relative EEG Power Induced by Emotionally Positive Images and a Conformal Kernel Support Vector Machine" 27 July 2018 ; doi:10.3390/app8081244

[9] U. Rajendra Acharya a–c Vidya K. Sudarshan a Hojjat Adeli d, e Jayasree Santhosh c Joel E.W. Koh a Amir Adeli d "Computer-Aided Diagnosis of Depression Using EEG Signals" May 14, 2015 ; DOI: 10.1159/000381950

[10] Hiie Hinrikus1,*, Anna Suhhova1 , Maie Bachmann1 , Kaire Aadamsoo2 , U¨ lle Vo˜hma2 , Hannes Pehlak3 and Jaanus Lass1 "Spectral features of EEG in depression", 2010; DOI 10.1515/BMT.2010.011

[11] Esther L. Meerwijka,⁎, Judith M. Fordb,c, Sandra J. Weiss a, "Resting-state EEG delta power is associated with psychological pain in adults with a history of depression", 2015, http://dx.doi.org/10.1016/j.biopsycho.2015.01.003 0301