EEG and Face Feature Fusion based Depression Detection using Convolution Auto Encoder

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Abstract: *Depression is a mood disorder with symptoms that affect a person's thoughts, feelings, behavior, and daily functioning. In some severe cases, it can also lead to thoughts of death or attempts at self-harm or suicide. According to the World Health Organization, clinical depression has affected approximately 300 million people globally. While forms of depression are more common among females (5.1%) than males (3.6%) and prevalence differs between regions of the world, it occurs in any age group and is not limited to any specific life situation. Previous studies have shown that depression also has an effect on language usage and that many depressed individuals use social media platforms or the internet in general to get information or discuss their problems. The main aim of the research is to develop an objective and convenient method which is helpful to assist depression detection using facial features as well as neurological (EEG) features.*

Keywords: *EEG, Face, Feature Extraction, Depression Detection, Auto Encoder.*

I. Introduction

Depression is a mood disorder with symptoms that affect a person's thoughts, feelings, behavior, and daily functioning. In some severe cases, it can also lead to thoughts of death or attempts at self-harm or suicide. According to the World Health Organization, clinical depression has affected approximately 300 million people globally. Which equals about 4.4% of the global population? While forms of depression are more common among females (5.1%) than males (3.6%) and prevalence differs between regions of the world, it occurs in any age group and is not limited to any specific life situation [1]. Depression is ranked as the largest contributor to global disability and is also a major reason for suicide. Still, many individuals suffering from forms of depression are not treated for various reasons. Previous studies have shown that depression also has an effect on language usage and that many depressed individuals use social media platforms or the internet in general to get information or discuss their problems. It becomes more commonplace in society, the timely and effective detection of the signs of depression for its prevention and early treatment becomes more important. The term “being depressed” has become frequently used in everyday language. In general, depression can be described to lead to an altered mood and may also be accompanied, for example, by a negative self-image, wishes to escape or hide, vegetative changes, and a lowered overall activity level [2][3]. The symptoms experienced by depressed individuals severely impact their ability to cope with any situation in daily life and therefore differ drastically from normal mood variations that anyone experiences [4].

It can be caused due to a combination of several factors that include—genetic factors, life events, and stress [5]-[7]. Some causes are—

- Psychiatric disorders: Depression can coexist as a part of undiagnosed psychiatric disorders, such as obsessive-compulsive disorder (OCD), social phobia, schizophrenia. A detailed assessment by a mental health expert is recommended in such cases.
- Life stressors: Common life stressors—like problems relating to work, interpersonal relationships, finances—can contribute to depression.
- Physical health problems: Distress experienced by a person because of a physical illness that is hard to cope with can lead to showing signs of depression. It is important to consult a medical professional in such cases.

The following criteria is followed while diagnosing depression:

- Medical history: Usually, an expert records your medical history to rule out other illnesses that may be causing the symptoms. For example, vitamin D deficiency or other hormonal imbalances can cause depression.
- Psychological evaluation: A mental health expert uses different psychometric assessments to collect information about the person's symptoms; thoughts; feelings; behavioral patterns. The expert will also evaluate the duration of symptoms, how and when they started, their severity, and how these symptoms have affected the person's thoughts and behavior.

- Depression is diagnosed only if there are five or more symptoms of depression during most times of the day, over a period of two weeks. These symptoms must be severe enough to disrupt a person's daily activities either at work, home or other areas of functioning they are usually involved in.

II. LITERATURE REVIEW

Prajakta Bhalchandra Kulkarni et al. [6] For implementation of a depression detection method, two algorithms were used named as Fisher vector algorithm and LTrP. Fisher vector is used for representation and description of an image. It uses Gaussian mixture model (GMM). Efficiency of fisher vector encoding is great for a computation. It gives a best result even with the linear classifier. We have applied this algorithm on a face. For the feature extraction LTrP is applied. Local tetra pattern uses a central pixel as a reference pixel with its neighbourhood pixel with respect to dimensions and then gives a magnitude as well as tetra pattern. for a better and accurate classification result fisher vector encoding is computed. Fisher vector encoding left the demerits of Bow that is bag of words. And LTrP left the demerits of Local binary pattern and gives the better results. This method gives the classification result in 'Depressed' or 'Not depressed' form.

Le Yang et al. [8] In this work, we propose several novel approaches towards multi-modal depression detection and estimation. Our previous studies mainly explored the multi-modal features and multi-modal fusion strategies, experimental results showed that the proposed hybrid depression classification and estimation multi-modal fusion framework obtains promising performance. The current work contains two parts: 1) In order to mitigate the impact of lack of data on training depression deep models, we utilize Generative Adversarial Network (GAN) to augment depression audio features, so as to improve depression severity estimation performance. 2) We propose a novel FACS3DNet to integrate 3D and 2D convolution network for facial Action Unit (AU) detection. As far as we know, this is the first work to apply 3D CNN to the problem of AU detection. Our future work will 1) focus on combining depression estimation with dimensional affective analysis through the proposed FACS3DNet, and 2) collect Chinese depression database. When completed, these studies will compose the author's dissertation.

Yan Guo et al. [9] This paper describes a mild depression detection method based on the EEG. Firstly, we present a comprehensible function to categorize volunteers by linear discriminant analysis (LDA). Then, a novel multi-objective particle swarm optimization (MOPSO) for depression detection is proposed, minimum the number of misclassifications, minimize the internal distance and maximize the external distance are all included in the objectives of our model. Finally, the results of the experiment with 6 volunteers indicate that accuracies achieve 100%, and our method maybe good candidates for usage in portable systems for mild depression detection.

Mandar Deshpande et al. [10] Depression is a leading cause of mental ill health, which has been found to increase risk of early death. Moreover, it is a major cause of suicidal ideation and leads to significant impairment in daily life. Emotion artificial intelligence is a field of ongoing research in emotion detection, specifically in the field of text mining. The advent of internet-based media sources has resulted in significant user data being available for sentiment analysis of text and images. This paper aims to apply natural language processing on Twitter feeds for conducting emotion analysis focusing on depression. Individual tweets are classified as neutral or negative, based on a curated word-list to detect depression tendencies. In the process of class prediction, support vector machine and Naive-Bayes classifier have been used. The results have been presented using the primary classification metrics including F1-score, accuracy and confusion matrix.

III. METHODOLOGY

Depression and anxiety disorders are distinctive, however human beings with depression frequently revel in signs and symptoms similar to those of an anxiety disease, including nervousness, irritability, and issues napping and concentrating. However every disease has its personal causes and its personal emotional and behavioral symptoms. Many those who increase melancholy have a record of an anxiety disorder in advance in life. There may be no evidence one ailment causes the other, however there's clean proof that many human beings suffer from each disorders. In proposed method, hybrid neurological as well as facial features are used to stumble on depression degree in a man or woman. Anxiety and depression abnormalities are distinguishable but people with depression often experience signs and symptoms of nervousness, irritability, and napping and concentration. Depression and anxiety disorders are similar. But all diseases have their own personal causes, emotional and comportemental symptoms. A record of a trouble in life is recorded by many people who increase melancholy. Although there is no proof that one illness causes the other, there is clear evidence that many people suffer from both.

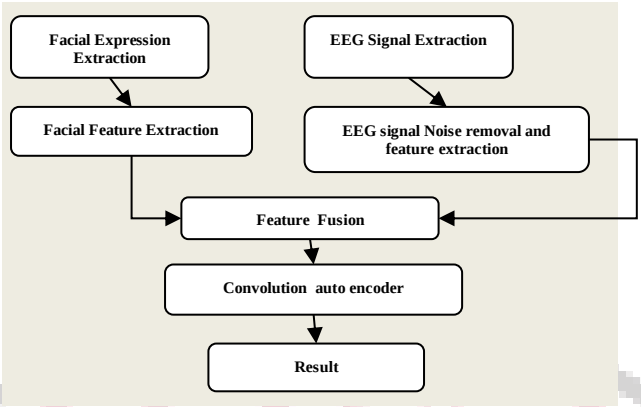

Figure 1: Proposed Framework

EEG signals and facial expressions are used in the suggested approach to diagnose depression. To determine whether or not a person is sad, deep biological feature fusion and a Convolutional auto encoder network are utilized. The BCI project is utilized to create a dataset using EEG signal and frontal face data in order to simulate the proposed methodology. The ECG may contain noise, necessitating the use of a noise extraction technology. Filtration is achieved through the use of filters 8 and 25Hz that are used for the removal of unwanted artifacts to filter a band pass filter using the Butterworth movable. The filtration of the band pass is achieved by combining a high-pass filter with a low-pass filter, which finally allows pre-ordered frequency to transfer through it. For each of the higher and lower frequencies, designated f and fl, the cutoff factors for the decisive cancellation of frequencies are computed. The clear and right hole must be defined between the two cutoff points, so that frequencies cannot be intermixed. In conjunction with the required gap between the 2 levels, the general voltage advantage was characterized by the amplifier. The procedure of identifying depression in a human is done out by observing the individual's bodily motions, which include mouth movement, particularly of the corners, time , frequency at which the person's eyes blink, eyebrow movement and eye ball rotation. The method of feature extraction is the changing of input data based on their features to generate a set of features classification. It was found to be successful in reducing the length of the statistics chosen for treatment by extracting key selective characteristics from the data package and converting them into a function vector with the necessary compression and the reduction of redundancy. The feature removal approach is conducted using Discrete Wavelet transformation technology using a set of data accessible that is pursued via low and high passing stages just after filtration process. The approximation together with the detail coefficients are discovered to be the progressive continuation of the wavelet coefficients.

$$Mean = \frac{1}{N\sum_{i=1}^{n} x_i}$$

$$Variance = \sum_{i=1}^{n} \frac{(x_i - \mu)^2}{N-1}$$

$$Standard\ Deviation = \sqrt{\sum \frac{(x_i - \mu)^2}{N}}$$

$$skewness = E[(X - \mu\sigma)^3$$

Kurtosis: It represents the data distribution about the peak of the signal generated as compared to normal distribution. It is mathematically represented as in ewn (v):

$$kurtosis = \mu 4 \frac{}{\sigma^4}$$

Both biological features extracted in above step are combined together and fed into Convolutional auto encoder for classification.

A Convolutional auto encoder (CAE) is a neural network that is trained to reproduce its input image in the output layer. An image is passed through an encoder, which is a ConvNet that produces a low-dimensional representation of the image. The decoder, which is another sample ConvNet, takes this compressed image and reconstructs the original image.

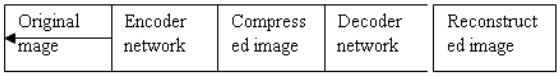

Figure 2: Convolutional auto encoder network

Proposed Algorithm
Input: Input image (X={x_1, x_2,…..x_n}), EEG Signals (Y ={ y_1, y_2,…..y_n }), Iteration (itr)
Output: Output Result, Dep_{res} , (Depressed or Nondepressed)
Procedure: Multi-modal Depression Detection
start
for epochs 1:N
for iteration 1:itr
Facial features ← X; (Extracted Feature Vectors, FV_1)
EEG features ←Y ; (Extracted Feature Vectors, FV_2)
FV_1+FV_2← Feature Fusion (FV_{fusion})
CAE←FV_{fusion}; (FV_1+FV_2)
end for
end for
Return → Dep_{res}exit

The simulation of proposed methodology is performed on MATLAB platform using deep learning tool. The simulation is performed by using facial as well as EEG dataset. Their individual performance is also stated along with fused result. For training and testing different datasets are taken as input.

IV. RESULTS

Performance evaluation of methodology proposed in this work is represented in table 1. As depression detection in this work is evaluated by using biological feature fusion such as EEG features as well as facial features and classified using CAE. The performance are evaluated on the basis of accuracy, precision, recall and f_measure. Different testsets are taken to illustrated the effectiveness of the model.

Table 1: Performance Evaluation

	Feature Fusion
Accuracy	96
Recall	98
Precision	98
F_Measure	98

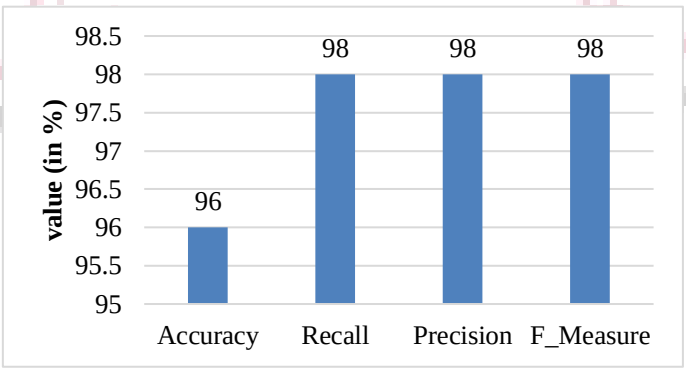

Figure 3: Feature Fusion Performance Evaluation

Table 2: Comparative Accuracy Evaluation

Models	Feature	Accuracy
Li et al. (2019)	Neurological	98
Proposed	Neurological	99.2
	Facial	92
	Feature Fusion	95.6

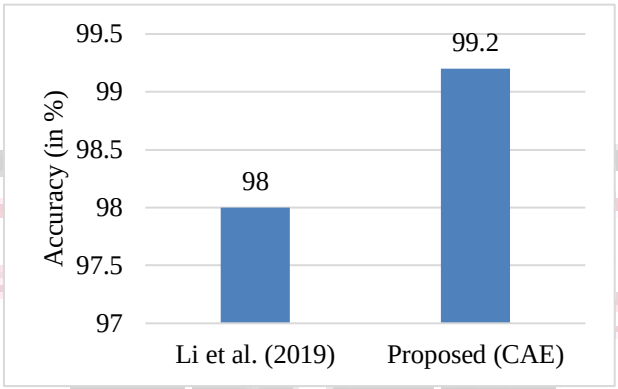

Figure 4: Comparative Accuracy Evaluation

The performance is evaluated on the basis of accuracy and it was observed that proposed system outperformed better as compared to existing work.

V. CONCLUSION

The main aim of the research is to develop an objective and convenient method which is helpful to assist depression detection using facial features as well as neurological features. The performance is evaluated on the basis of accuracy and it was observed that proposed system outperformed better as compared to existing work.

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