Identifying the Depression in Patients through EEG-Based Classification Using Spatial Information

Rishika Yadav,
Asst. Professor, Department of Comp. Sc. & Info. Tech., Graphic Era Hill University, Dehradun, Uttarakhand India 248002

Abstract
Depression is a mental illness that is associated with feelings of sadness and hopelessness. A person's mental and physical health are also impacted. Also, it is challenging to identify depression since there are currently no established diagnostic procedures for the condition that may yield definitive results. Many depressed individuals are completely ignorant of their condition. The electrochemical potential of the brain may be changed, and this change can be detected by electroencephalographic (EEG) data. The automatic categorization of the normal as well as depressive EEG signals is the foundation of the current study. In order to retrieve hidden information from the EEG data, signal processing techniques are required. In this study, the pre-processing, feature extraction, along with classification procedures are used to distinguish between normal and depressive EEG data. The system's main goal is to increase the precision of patient monitoring systems, remove variations in EEG signals, and enhance process accuracy.

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1. INTRODUCTION
An enabling technology known as "signal processing" includes applications, techniques, and implementations that support the underlying idea for processing or conveying data that is stored in a variety of physical, symbolic, or abstract representations. It involves mathematical, statistical, computational, heuristic, as well as linguistic representations, formalisms, including methods for representation, modelling, analysis, synthesis, discovery, recovery, sensing, acquisition, extraction, learning, security, or forensics methodologies. Audio processing, also known as audio signal processing, is the deliberate modification of audio signals, sometimes using an audio effect or effects unit. Whereas digital processors use mathematics to manipulate the signal's digital representation, analogue processors work with the actual electrical signal directly. The physical modification of the continuous signal by analogue signal processing (ASP) entails modifying the voltage, current, or charge using different electrical techniques. Digital signal processing has taken over as the go-to technique ever since the invention of digital technology.

Engineers are always working on an essential topic called digital signal processing (DSP). This study focuses on the underlying technology and practical applications of DSP for acoustic signal detection. Active noise control is one of the most well-known uses of detecting acoustic signals. It employs a microphone to feed ambient noise data to an analog-to-digital converter, where a DSP processor turns it into an inverse signal, which is then outputted through a secondary speaker, producing destructive interference with the ambient noise. Several commercial applications, including speech recognition and security systems, employ acoustic signal detection. One company that creates speech recognition software that enables users to narrate documents and issue voice commands is Microsoft.

An analog-to-digital converter is required to transform analogue acoustic signals into digital form, which is then delivered to an integrated DSP processor or PC running DSP software. The DSP programme must then separate the intended signal from background noise and produce the right output for the input signal.

The electrophysiological monitoring technique of electroencephalography is a device intended to capture brain electrical activity. Although invasive electrodes are occasionally employed in particular applications, it is mainly non-invasive. The sort of...
cerebral oscillations (often referred to as "brain waves") that may be seen in EEG signals are the focus of diagnostic applications, which concentrate on the spectrum content of EEG. EEG is most frequently used to identify epilepsy, but it can also identify comas, encephalopathies, sleep problems, and brain death. The two main categories of abnormal activity—epileptiform and non-epileptiform—can be generally divided into focused and diffuse. When millisecond-range temporal resolution is needed for study or diagnosis—something that is impossible with CT or MRI—EEG is a useful tool.

The electroencephalogram (EEG) is a recording made from the scalp of the brain’s electrical activity. It is possible to distinguish and discretize artefacts from severe neurological events like epilepsy and others using intracortical electroencephalogram electrodes and subdural electrodes. Recently, more sophisticated measurements of aberrant EEG patterns have drawn interest as potential biomarkers for other illnesses including Alzheimer’s disease. Microvolts, the unit used to measure EEG activity (mV). Theta, Delta, and Alpha are the three primary frequencies of human EEG waves.

In newborns up to one year olds and in stages 3 and 4 of sleep, the delta rhythm—which has the biggest amplitude and the slowest waves—is typical as the dominating rhythm. Theta is categorised as “slow” activity and has a frequency range of 3.5 to 7.5 Hz. The posterior areas of the skull on both sides exhibit alpha, which has a frequency between 7.5 and 13 Hz and is more pronounced on the dominant side. It is the primary rhythm observed in typically content people and is present for the majority of life, especially after the age of thirteen.

The electrophysiological monitoring technique of electroencephalography (EEG) to be recorded the electrical activity of the brain. It is used to diagnose epilepsy, sleep problems, comas, encephalopathies, and brain death. Often non-invasive, electrodes are implanted across the scalp. The sort of cerebral oscillations (often referred to as "brain waves") that may be seen in EEG signals are the focus of diagnostic applications, which concentrate on the spectrum content of EEG. Magnetic resonance imaging along with computed tomography are two examples of high-resolution anatomical imaging methods that have been developed. EEG's usage has declined for the identification of tumours, strokes, and other localised brain illnesses (CT). Regardless of the low spatial resolution, EEG is still a valuable technique for study and diagnosis, particularly when millisecond-range temporal resolution is needed (which is impossible with CT or MRI).

The EEG approach has other derivatives, such as event-related potentials (ERP) that require averaging the EEG activity time-locked to the presentation of a stimulus of certain type (visual, somatosensory, or auditory), with evoked potentials (EP), which need this (ERPs). Cognitive science, cognitive psychology, as well as psychophysiological studies all use ERPs.

2. LITERATURE SURVEY

Alzheimer’s illness The Neuroimaging Initiative (ADNI) is a multicenter, continuing, longitudinal research that aims to create biomarkers for Alzheimer’s disease that may be used for early identification and monitoring (AD). 400 participants with early moderate cognitive impairment (MCI), 200 participants with early Alzheimer’s disease, and 200 healthy control participants were planned for the study. The creation of standardised techniques for clinical examinations, magnetic resonance imaging (MRI), positron emission tomography (PET), and cerebrospinal fluid (CSF) biomarkers in a multicenter environment, as well as the explanation of the patterns but also rates of change in imaging as well as CSF biomarker tests in control participants, have been among ADNI's major accomplishments. Patients with MCI and AD, evaluation of alternative diagnostic categorization methods, increased clinical trial efficiency, confirmation of the AD risk loci CLU, CR1, and PICALM, discovery of novel candidate risk loci, global impact through the establishment of ADNI-like programmes in Europe, Asia, and Australia, and integration of the biology and pathobiology of healthy ageing, MCI, and AD are just a few of the areas that this research will focus on [1].

In this study, a methodological framework known as multi-modal imaging and multi-level characteristics with multi-classifier was introduced to help identify patients with AD from healthy controls (M3). The research included data analysis from two imaging modalities, structural MRI and resting-state functional MRI. This method's efficacy was evaluated using leave-one-out cross-validation. According to the findings, the classification was accurate to within 89.47%, sensitive to within 87.50%, and specific to within 90.91%. The default-mode, occipital ( fusiform gyrus, inferior and middle occipital gyrus), subcortical (amygdala and pallidum of lenticular nucleus), as well as occipital (posterior cingulate gyrus, hippocampus, along with parahippocampal gyrus) regions were most significantly impacted by the most discriminative features for classification. This method could improve the evaluation of AD treatment and clinical diagnosis [2].

Alzheimer’s disease (AD) individuals had slower EEGs and less complicated than that of age-matched healthy participants, according to medical research. Using two different EEG datasets, this study examines the possibility that EEG slowdown...
and loss of complexity might serve as early signs of AD. Comparing MCI and MiAD patients to age-matched control participants, relative power and complexity assessments are utilised as characteristics to categorise the patients. 83% (MCI) and 98% (MiAD) classification rates are obtained when paired with two synchronisation measurements. The classification rates are marginally higher when the compression ratios are included as features compared to just using relative power and synchrony measurements [3].

This study examines current developments in the electroencephalogram (EEG)-based diagnosis of Alzheimer's disease (AD) (EEG). There have been three main changes in the EEG associated with AD: a slowing of the EEG, a reduction in the complexity of the EEG signals, and disturbances in EEG synchronisation. To find these small changes in AD patients' EEGs, a range of advanced computational methods have been presented recently. The study first discusses techniques for identifying EEG slowness. The paper then discusses several EEG complexity measurements and describes how these measures have been applied to research EEG complexity variations in AD patients. The context of diagnosing AD is therefore taken into account while looking at various EEG synchrony metrics. Moreover, a brief discussion of EEG pre-processing is included. It is required to eliminate artefacts caused by things like head and eye motion or interference from electronic equipment before one may study EEG. Pre-processing of EEG has drawn a lot of interest recently. This study describes a number of cutting-edge pre-processing methods, such as blind source separation and various non-linear filtering paradigms. The research also discusses the benefits and drawbacks of computational methods for AD diagnosis based on EEG. Finally, current issues and upcoming difficulties are examined [4].

AD is a neuro-degenerative condition that includes the most prevalent kind of dementia. It is the most expensive illness in contemporary civilization and is defined by behavioural, cognitive, and intellectual dysfunction. As a result, early illness detection is crucial since it enables patients and their families to take preventative actions. EEG is a commonly used diagnostic test for Alzheimer's disease. The EEG signals of Alzheimer's disease patients exhibit a number of anomalies. So, it is necessary to create a method for detecting dementia in its early stages, with mild cognitive impairment as its first stage (MCI). In recent decades, the role of EEG in the diagnosis and clinical study of Alzheimer's disease has grown in importance. The identification of AD by diagnostic and early preclinical stage detection are currently the most crucial tasks. The EEG signal's diagnostic accuracy has to be increased. The concepts for improving the signal's accuracy by utilising various techniques are presented in the study. Essentially, slowing of the signals, shift of power spectrum to low frequencies, etc. are characteristics of anomalies in the EEG signals. EEG can be used in this way to aid in the early detection of Alzheimer disease [5].

3. PROPOSED SYSTEM

In existing work, the classification techniques for designing Brain Computer Interface (BCI) systems based on Electroencephalograms are discussed (EEG). It rates their effectiveness against one another and offers recommendations for selecting the best classification algorithm(s) for a certain BCI. Since it is noninvasive, consistent, and simple to do at home using wireless body area networks, electroencephalography is one of the primary techniques used to diagnose Alzheimer's disease. Moreover, it is a therapeutically useful indicator of brain activity that is used to track mental activity. Non-linear analysis of the collected EEG data has demonstrated the distinctive properties to disclose the diagnosis of neurological illnesses as Parkinson's, epilepsy, and Alzheimer's. The main drawbacks of the current system are its poor classification rate, large complexity, low relative power, and low accuracy. An efficient electroencephalogram-based detection approach for depression categorization utilising geographical information is proposed in this procedure. Twenty participants—some of whom were depressed patients and others were healthy controls—were given the face-in-the-crowd test, which included emotive facial expressions in both the positive and negative range. For feature extraction and selection, a support vector machine and the genetic algorithm were utilised, also a support vector machine was employed to classify. Prior to feature extraction, a task-related common spatial pattern (TCSP) was suggested to improve the spatial disparities.

![Fig 1: System Architecture](image-url)
The following benefits of the suggested strategy are listed:

- Peak signal that can be accurately recovered from an EEG signal, even one that is extremely noisy.
- Our EEG simulator's key benefits include time savings and the elimination of risks while recording the EEG using non-invasive techniques.

Social demands
- Depression is simple to diagnose.
- Because it does not require an external device, it can be detected early in the preclinical stage.
- It is trustworthy to utilise.

![Fig 2: Flow Diagram](image)

The processes involved in implementing the suggested strategy are explained in the part below this:

1. **Input Signal**

An electrophysiological monitoring technique used to measure the electrical activity of the brain is called electroencephalography (EEG). It is used to identify brain death, coma, encephalopathies, sleep disorders, epilepsy, and sleep disorders. Applications for diagnosing neurological conditions concentrate on the spectrum content of EEG, which is the kind of brain oscillations seen in EEG data. With the development of high-resolution anatomical imaging tools like MRI and CT, the use of EEG as the initial technique for cancer, stroke, as well as other conditions’ diagnosis localised brain illnesses has diminished.

2. **Preprocessing**

The pre-processing of the EEG signal includes artefact removal, filtering, and signal amplification. Many methods, like Blind Source Separation (BSS) and Independent Component Analysis (ICA), are employed to generate an EEG signal that is more improved (ICA). Assuming the statistical independence of the subcomponents and non-Gaussianity of the signals from one another, ICA is a computer technique for decomposing a multivariate signal into additive subcomponents. A mixed signal separated by blind ICA produces excellent results.

3. **Feature Extraction**

With a starting set of measured data, feature extraction creates derived values (features) that are meant to be useful and non-redundant, aiding learning and generalisation procedures. Mean value refers to the average value of a signal, whereas low-level feature extraction focuses on low- and high-level picture characteristics. The difference between the standard deviation and the average deviation is that power is averaged rather than amplitude. Any a discrete spectral density estimate or a limited collection of values like a parametric vector, or a specific section of a digital signal, can be used to calculate entropy.

4. **Classification**

Support Vector Machines (SVMs) assess data used for classification and regression analysis. SVMs are supervised learning models with related learning methods. Based on the idea of decision planes that specify choice limits, they are. In order to distinguish between different objects inside an image, classification of remotely sensed data is utilised to assign matching levels with regard to groups with homogenous features. An SVM model is a mapping of the instances as points in space with as much space between the examples of the various categories as feasible. By implicitly converting their inputs into high-dimensional feature spaces, or the “kernel trick,” SVMs may successfully carry out a non-linear classification.

4. **RESULTS**

This study suggests an efficient electroencephalogram-based detection approach for classifying depression depending on location. The experiment had 20 volunteers, some of whom were depressed patients and others of whom were healthy controls. For feature extraction and selection, the genetic algorithm was applied, and a support vector machine was employed to perform classification. Prior to feature extraction, a task-related common spatial pattern (TCSP) was suggested to improve the spatial disparities. The following screenshots demonstrate the dramatic improvement in classification performance and demonstrate how the TCSP may increase spatial differences prior to feature extraction. We'll keep emphasising correlation research in the future to get more in-depth data.
5. CONCLUSION
Depression is a mental disorder that is impacting more and more people. With the use of a face-in-the-crowd task stimulus experiment that used frequency information filtering, temporal information feature extraction, along with spatial information feature selection, we refined an EEG-based feature classification approach that uses spatial information and is beneficial for the identification of depressed individuals. The classification performance was greatly enhanced by using the TCSP, indicating that the TCSP can increase the spatial differences prior to feature extraction. Yet, We ought to careful of the datasets’ limitations. We’ll keep emphasising correlation research in the future to get more in-depth data.

REFERENCE