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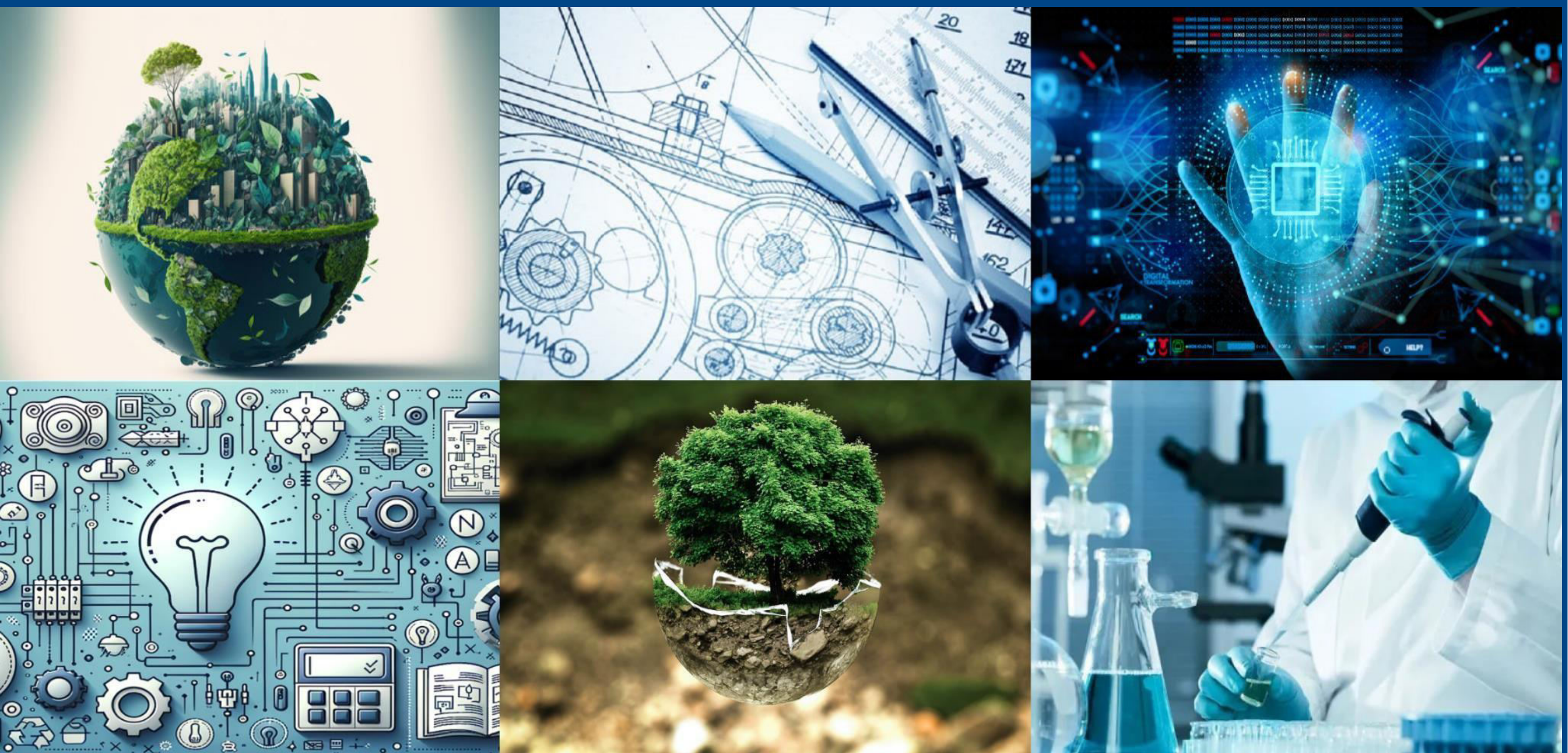

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# A DEEP NEURAL APPROACH TO EEG-BASED AFFECTIVE STATE RECOGNITION

**Dr. Vidya Pol, Sinchana H C**

Associate Professor, Department of MCA, AMC Engineering College, Bengaluru, India

Student, Department of MCA, AMC Engineering College, Bengaluru, India

**ABSTRACT:** This paper focuses on leveraging electroencephalography (EEG) data to predict human emotional states using machine learning techniques. This project aims to recognize these patterns by processing raw EEG signals, extracting significant features, & applying machine learning models to classify emotional states accurately. Emotions such as happiness, sadness, anger, & calmness produce distinct patterns in brainwave data, which can be analyzed & categorized. The features which are extracted will be trained on a machine learning model which recognize & categorize the patterns using labelled data. Emotions recognition based on EEG data has different applications in the areas like mental health monitoring, human computer interaction which responds to user data. For instance, real- time emotion detection system can be embedded to different systems to enhance gaming or virtual reality experiences by adapting to the user's emotional state, & provide personalized user experiences in various interactive applications.

***KEYWORDS:*** EEG, Emotional States, Patterns, Labelled data.

## I. INTRODUCTION

Emotions play a significant role in shaping human interactions, decision-making processes, & overall well-being. The ability to detect and interpret emotions accurately has reached to various fields, including mental health, education, human-computer interaction, & entertainment. The EEG data is represented in the form of brainwaves, which vary in frequency & amplitude depending on an individual's cognitive & emotional state. Brainwave Patterns are categorized Into different frequency bands , such as delta , theta , alpha, beta, & gamma waves , each associated with various states of alertness & mental processes For example, high levels of beta activity may indicate anxiety or stress, while increased alpha waves are often associated with relaxation. Using the collected EEG data the goal is to build a machine learning model that can predict emotions states. The EEG data is preprocessed to remove noise & artifacts Features extraction techniques are applied to gain some characteristics of the emotions states. Multiple algorithms are applied to determine the effective model for predicting emotions state based on EEG data. The model will also predict the emotions based on the text given by the user. The selected machine learning algorithms are trained on large datasets with diverse emotional labels to ensure that the model can perform consistently across varied inputs. Ultimately, this project seeks to bridge the gap between human emotions & technology, contributing to the development of emotionally responsive systems that can better serve users' needs & improve overall well-being.

## II. LITERATURE SURVEY

Fahim Hanzum, Marina L. Gavrilova[1] Focused on micro-blog data & text-based Emotion detection. An advanced approach based on Genetic Algorithm (GA) is used to construct the input representation which is composed of stylistic, sentiment, and linguistic features extracted from tweets. Each sample is labeled with those six classes: sadness, happiness, love, anger, fear, & surprise. They achieved the highest levels of precision (96.49%), recall (96.49%), F1-score (96.49%), and accuracy.

In [2] Emotion recognition based on EEG signals is proposed, utilizing two approaches: spectral analysis and statistical analysis. Generated feature vectors that is related with the help of several classification algorithms, bringing the accurate of emotion detection up to 85%.To facilitates the implementation of these analytics, through software Interface (API) that provides all the required technical functionalities was designed.

In [3] Sara Bagherzadeh et al. Proposed a method to develop a novel emotion recognition system from electroencephalogram (EEG) signals using effective Connectivity & deep learning methods. Estimated a fused

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image from these methods for each five-second window of 32- channel EEG signals. They applied six pre- trained CNNs to classify the images into four emotion classes based on the two- dimensional valence-arousal model. They used the leave-one-subject-out cross- validation strategy to evaluate the classification results.

Qi Li et al.[4] introduced Fast Fourier Transform (FFT) and Continuous Wavelet Transform (CWT) are used to extract the features of EEG signals on the DEAP data set and build two CNN models for emotion recognition. The results show that the proposed algorithm is effective for EEG signal emotion recognition. The average recognition accuracy of emotion valence can reach 75.9%; the arousal can reach 79.3%; the like/dislike can reach 80.7%.

Rayhan Habib Jibon & Md. Maniruzzaman.[5] investigates the EEG signals are changed with eight different classes of emotions , naming as joy, relax, sad, fear, sleepy , calm, happy & excited The The raw data is preprocessed, then some features are extracted using PCA technique & finally, these features are used for classification purposes using CNN , SVM , KNN , AdaBoost, NB , & RF classifiers for different emotional states. An average accuracy of 99.84%, 98.06%, 98.98% for valence, and 99.53%, 97.89%, 98.51% for arousal states are respectively obtained for CNN, SVM, and RF classifiers. Among all the mentioned classifiers CNN provides a better classification accuracy on an average of 99.68% comparing with SVM and RF in valence and arousal states.

EXISTING STYSTEM

Current approaches to emotion detection largely rely on traditional methods such as facial expression analysis, voice modulation, and physiological signals like heart rate or skin conductance. The current systems as limitations in accuracy and reliability. For example facial expressions and vocal cues can be influenced by external factors, making it difficult to consistently interpret true emotional states. Physiological responses like heart rate variability or skin conductance can indicate arousal but do not always specify the exact emotion being experienced. Due to these limitations, there is a growing interest in EEG-based emotion detection, which directly measures brainwave activity, offering a more objective & nuanced understanding of emotions.

PROPOSED SYSTEM

The proposed system aims to develop emotional detection methods by leveraging EEG signals, which provide direct insight into brain activity patterns associated with specific emotional states. Advanced signal processing techniques are used to extract meaningful features from these signals, such as frequency & time-domain characteristics that are known to correlate with emotional responses. The system takes the input as text from the users & it predicts the emotion state & gives recommendations based on their emotions. The features are fed into different machine learning algorithms including models such as support vector machines (SVM) & neural networks, to classified the EEG data into different emotional states. This approach allows for a more precise & reliable prediction of emotions. Additionally, the system can be integrated into human-computer interaction (HCI) platforms to create emotionally adaptive systems that respond to users' moods, there by enhancing user experience & engagement.

## III. SYSTEM ARCHITECTURE

The system architecture is based on a modular approach, divided into five main layers, each with specific roles. The architecture is designed for flexibility, scalability, & ease of updates or integration with other systems. The Data Acquisition Layer handles the connection and data capture from EEG devices. Data Preprocessing Layer Responsible for cleaning and filtering raw EEG data, removing noise, and segmenting data to ensure consistency. Features are extracted such as frequency bands and statistical attributes for relating to emotional states. Classify the emotions by applying different deep learning algorithms. Finally display the emotions to the user and give the recommendation to the users according to the emotions.

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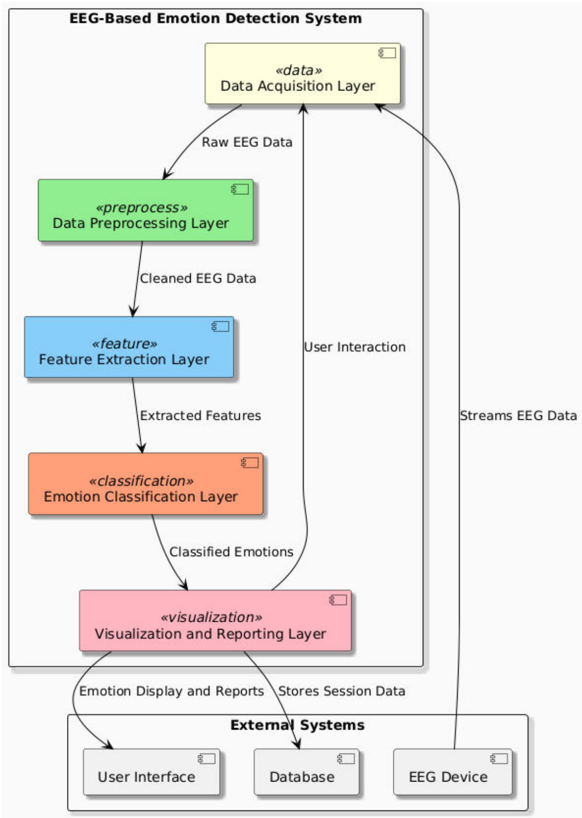


Fig 3.1 System Design

## IV. METHODOLOGY

The methodology adopted in this study for EEG-based emotion detection involves a structured pipeline consisting of data acquisition, preprocessing, feature extraction, emotion classification, result visualization, & reporting. EEG signals were obtained using compatible multi- channel devices capable of capturing brainwave activity in real time or from pre-recorded datasets, ensuring high-resolution data collection. The raw EEG data underwent preprocessing to enhance signal quality by removing noise and physiological artifacts such as eye blinks & muscle movements. Signal normalization & segmentation were also performed to ensure uniformity across all input samples. Subsequently, key features were extracted from the preprocessed signals, including frequency-domain characteristics (alpha, beta, theta, gamma bands) & time-domain metrics (such as amplitude and variance). A customizable feature selection process was implemented to optimize input features based on target emotional categories. These features were then input into machine learning & deep learning models, which classified them into predefined emotional states such as happy, sad, angry, or neutral. The system was designed to operate in real time, delivering rapid & accurate classification results.

## V. DESIGN AND IMPLEMENTATION

The design of the EEG-based emotion detection system follows a modular and layered architecture to facilitate secure access, efficient processing, and accurate classification. The first component is the user authentication module, which ensures secure access through a registration and login system. Users register with a username, email, & password, which is hashed using bcrypt or werkzeug security for security. Sessions are maintained using Flask's session cookies, enabling authenticated access throughout the user's interaction with the platform. Once authenticated, users can upload EEG data files, typically in .csv or .txt format, via a web interface. The EEG data upload module handles the uploaded files using Flask's request files, storing them temporarily or in a user-specific directory. EEG signals are filtered using a bandpass filter (0.5–45 Hz) to remove low-frequency drift & high- frequency noise. Features include band power across frequency bands (Delta, Theta, Alpha, Beta, Gamma), statistical metrics (mean, variance, skewness,



EEG-Based Emotion Detection - System Design

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kurtosis), entropy measures (sample entropy, approximate entropy), & frequency-domain characteristics are extracted. The resulting feature vectors are then fed into the emotion classification module, which employs machine learning algorithms such as Random Forest, Support Vector Machines (SVM), & K-Nearest Neighbors (KNN). The classifier outputs a predicted emotion label—categorized as Positive, Neutral, or Negative—along with a confidence score. Finally, the results visualization module presents the outcome to the user through an intuitive web dashboard giving the emotions state.

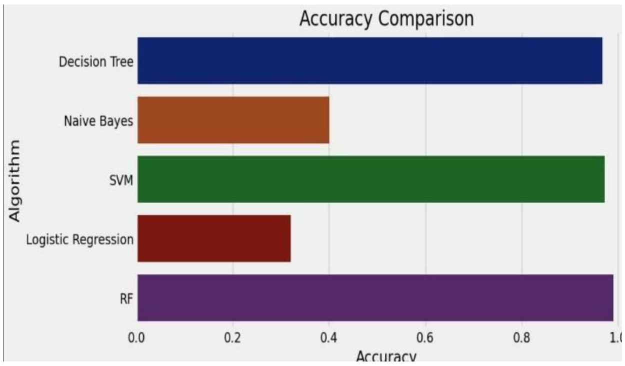
## VI. OUTCOME OF RESEARCH

The outcome of this research project highlights the successful development and implementation of an EEG-based emotion prediction system that leverages machine learning to classify human emotional states with high accuracy. By collecting EEG signals and applying advanced preprocessing techniques—such as noise filtering, artifact removal, & signal normalization—the system effectively enhances data quality, ensuring reliable inputs for analysis. Through the extraction of both time-domain and frequency-domain features, the system identifies distinct patterns associated with different emotional states, such as happiness, sadness, calmness, & anger. Various machine learning models, including support vector machines, neural networks, & k-nearest neighbors, were evaluated and optimized, resulting in a robust & generalizable classification framework capable of performing across different individuals and datasets. Notably, the system demonstrated the capability for real- time emotion detection, enabling adaptive responses in applications like mental health monitoring, virtual reality, and emotionally intelligent interfaces.

## VII. RESULT AND DISCUSSION

In this paper using a publicly available EEG dataset that included multiple emotional states recorded from several participants. EEG signals were collected across multiple channels with a standard sampling rate & then preprocessed using bandpass filtering and artifact removal techniques to ensure clean and reliable data. After preprocessing, features were extracted from the EEG signals using statistical & frequency-domain methods, focusing primarily on power spectral density within different brainwave bands (delta, theta, alpha, beta, and gamma). These features were then used to train various machine learning models, including Support Vector Machines (SVM), k-Nearest Neighbors (KNN), & a Multi-Layer Perceptron (MLP) neural network. The model can predict emotions based on the eeg signals accurately. Even the text given by the user using that text the model can predict the emotions present in the text. Multiple algorithms are evaluated to identify the most effective one for emotion prediction, ensuring high accuracy & reliability.

| Algorithm | Accuracy |
|---|---|
| Decision Tree | 96.72 % |
| Naive Bayes | 40.05% |
| Logistic Regression | 38.05% |
| Random Forest | 99.06% |



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## VIII. CONCLUSION

This project titled "A Deep Neural Approach to EEG-Based Affective State Recognition" had successfully demonstrates the integration of biomedical signal processing, artificial intelligence, & web-based applications for real-world emotion recognition through EEG signals. By collecting EEG signal data and applying that signal on advanced machine learning algorithms, the system is capable of accurately classify human emotions such as happiness, sadness, anger, & neutral. The implementation of this system using the Flask web framework ensures a user-friendly interface where users can register, log in, upload EEG CSV files, through this websites and receive emotion prediction results in real-time. The blend of SQLite3 allows lightweight, secure, & efficient data store for managing user credentials and prediction history. This project holds great potential in areas like mental health monitoring, personalized healthcare, and human-computer interaction. By analyzing neurological data non-invasively, & it opens up possibilities for developing emotion- aware systems.

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