Machine Learning Approach for Emotion Recognition using EEG Signals

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Abstract - *The relationship between human emotion and brain activities is far from clear. Current brain state can be recorded as electroencephalograph (EEG) to discover the links between emotional states and brain activity. Recognition of emotions from EEG signals have benefit of being more passive and less intrusive for human than facial expressions or vocal intonation. Various machine learning techniques can be used on the recorded EEG data to classify different emotional states. The proposed system will be able to recognize human emotions using EEG signals.*

***Key Words*: Real-time emotion recognition, KNN, EEG, SVM, Machine learning.**

1. INTRODUCTION

Human emotion is a complex phenomenon which comes from human brain while there is no clear knowledge on its generation mechanism. Psychologist and computer scientist have tried to study it for long time. Brain is significant part of human body which control entire parts of human body. Brain can be viewed as collection of neurons which decides human behavior.

Many methods for recognizing human emotion have been proposed in the past. The conventional methods basically utilize audio, visual attributes to model human emotional responses, such as voice, facial expressions, and body gestures. More recently, accessing physiological responses has gained increasing attention in characterizing the emotional states [1]. Bio signals used in these studies were recorded from autonomic nervous system (ANS) in the periphery, such as ECG, skin conductance (SC), electromyography (EMG), respiration, pulse, etc. Compared to audio and/or visual-based methods, the responses of bio signals tend to provide more detailed and complex information as an indicator for estimating emotional states [2].

The ongoing brain activity which is recorded using EEG provides non-invasive measurement with temporal resolution in milliseconds. In cognitive neuroscience, EEG has been used to investigate the regulation and processing of emotion for the past decades. In various distinct frequency bands, power spectra of the EEG were assessed, such as alpha (α: 8–13 Hz), beta (β: 14–30 Hz), delta (δ: 1–3 Hz), theta (θ: 4–7 Hz), and gamma (γ: 31–50 Hz) [3], to examine their relationship with the emotional states.

Using EEG to assess emotional states is still a new concept, compared to other works which use audio–visual based methods. The objective of this study is to systematically uncover the association between the EEG dynamics and emotions by 1) searching motion-specific features of the EEG and 2) testing the efficiency of different classifiers.

1.1 Related Work

Presently, there are number of techniques existing, which are used in the field of emotion recognition. Different techniques are used for emotion recognition, such as, emotion recognition through text, speech, facial expressions or gestures as stimuli. Most of these techniques mentioned, have a lower accuracy rate and also have a higher percentage of error. Emotion recognition using EEG signals is a more robust technique, which recognizes emotions from the brain waves of human, thus being more passive and less intrusive than facial expressions or vocal intonation. The need along with importance of the automatic emotion recognition from EEG signals has grown with increasing role of brain computer interface applications and development of new forms of human-centric and human-driven interaction with digital media.

The system discussed in [4] propose an idea of machine learning methods which are used to model relationship from EEG recordings in the publicly available dataset DEAP (Database for Emotional Analysis using Physiological Signals). Different features are extracted from raw EEG recordings. Maximum Relevance Minimum Redundancy (mRMR) was used for feature selection. These features are fed into machine learning methods to build the prediction models to extract the emotion information from EEG signals.

Another study to predict emotional state with the help of brain waves is done by [5] in an ITS (Intelligent Tutoring System), in the case of disabled, taciturn or impassive learners. This experimentation allowed to comprise a large dataset. It appears that there are significant relationships between brainwaves and emotional states experienced during learning.

In [6], the research work aims to detect stress for students based on EEG as EEG displays a good correlation with stress. The EEG signal is pre-processed to remove artefacts and relevant time-frequency features are extracted using Hilbert-Huang Transform (HHT). The extracted features are manipulated to detect stress level using hierarchical Support Vector Machine (SVM) classifier.

In [7], a systematic EEG feature extraction and classification was conducted in order to assess the association between EEG dynamics and music-induced emotional states. The results of this study showed that DASM12, a spectral power asymmetry across multiple frequency bands, was a sensitive metric for characterizing brain dynamics in response to emotional states (joy, anger, sadness, and pleasure).

A very high level of performance is achieved in [8], the proposed system is a novel general EEG-enabled music therapy algorithm which implemented an adaptive music therapy system that could be used by the user without any help from a music therapist.

Traffic sign detection system in [9] the paper proposes emotion recognition using electroencephalography (EEG) techniques. This paper is based on the calculations of the EEG signals and recognize the emotions from the human brain activity.

2. PROPOSED SYSTEM

In this paper, we propose an emotion recognition system from the brain-waves information acquired by a simple electroencephalograph. A simple electro-encephalograph is used for this purpose. Input data of this system is the EEG signals data of several feeling states acquired using the simple electroencephalograph. The output of the system would be one of the emotional states associated with a certain feeling state as shown in Fig. 1.

This system has two stages, a feature extraction stage and an emotion classification stage. At the former stage, we

Algorithms	Strengths	Weakness	Scope
Support vector machine	Insensitive to over fitting problems -High generalization and accuracy with smaller training samples	-Isn't suited for larger datasets. -Less effective on noisier datasets with overlapping classes.	Performance can be improved by evaluating specific link between EEG signals and emotional responses.
Random Forest	-Insensitive to over fitting problems. - Able to deal with unhinged and missing data. - Works well on large datasets.	- Cannot predict beyond range in dataset. - Overfitting in case of noisy data. - Hyper-parameters need good tuning for high accuracy.	With the addition of more features into the system, the performance of emotion detection from EEG recordings can be improved.
K-Nearest Neighbour	- Robust to noisy training data - No need for tuning complex parameters to build a model.	- Need to determine value of parameter K. - Distance based learning is not clear. - Computation cost is high.	Feature selection can improve the performance by removing some irrelevant feature vectors.
Gaussian Naïve Bayes	-Perform multiclass prediction -Performs well in case of categorial input variables compared to o numerical input variables.	- Naïve Bayes is also known as bad estimator. - Naïve Bayes is the assumption of independent predictors.	By applying better feature selection and denoising techniques, signal-to-noise ratio can be improved and thereby increase in performance.

Table -1: Comparison of Different Algorithms

use principal component analysis for reduction of input dimension after wavelet transform. Moreover, the average and the variance of the amplitude of brain waves, and the power spectrums of alpha, beta, and gamma wave are also adopted as features at this stage.

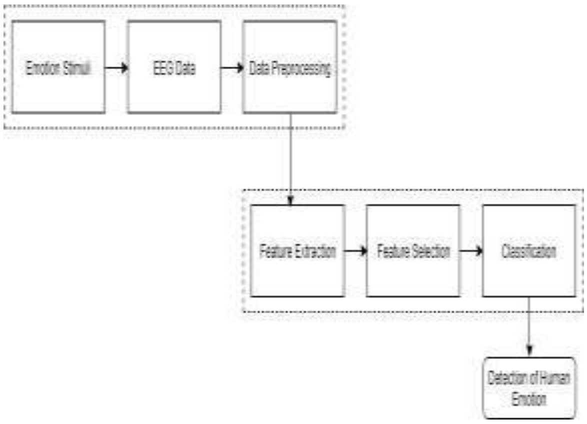

Fig -1: Proposed system for emotion recognition using EEG signals

2.1 Dataset Description

DEAP dataset is a multimodal dataset for analysis of human affective states. EEG data to study different emotional states of a person using different machine learning methods can be collected from a publicly available dataset DEAP (Database for Emotional Analysis using Physiological Signals). Evaluation of various features is done with the help of various machine learning methods applied on the above dataset. DEAP dataset contains four categories of emotions: low valence, high arousal; low valence, low arousal.

2.2 Feature Extraction

The purpose of this stage is to map EEG into the consequent emotional state. The recorded EEG data will be first pre-processed to remove serious and obvious motion artefacts through visual inspection. The resultant spectral time series will be averaged into five frequency bands, including delta, theta, alpha, beta and gamma. Different feature extraction methods like Fast Fourier Transform (FFT), Wavelet Transform (WT), Continuous Wavelet Transform (CWT) can be used for feature extraction.

2.3 Feature Classification

Feature classification is the process of organizing data into categories/groups in such a way that data objects of same group are similar. Classification algorithm assigns each and every instance to a particular class such that classification error will be small. It is used to extract model that accurately define important data classes within the given dataset. Classification techniques can handle processing of large volume of data. It can predict categorical class labels and classifies the data based on model built by using training set and associated class labels, then can be used for classifying newly available test data.

2.4 Feature Selection

Feature selection is a necessary process before performing any data classification and clustering. The main objective of feature selection is to extract a subset of features by removing redundant features and maintaining the features which are informative. The feature selection seems particularly important not only to improve the computational efficiency, but also for expanding the applicability of EEG-based human-centered system in real-world applications.

3. CONCLUSION

Thus, the proposed system will be a generic model which will take EEG signals as input and will recognize the emotions depending upon the input EEG signals. The neuro signals recorded can be highly useful means to systematically classify the human emotional states which can be further useful in various application domains. There are significant relationships between brainwaves and emotional states experienced during learning. Further understanding of the different stages of how the brain processes a particular information will make an impact on realization of novel EEG inspired multimedia applications, where the contents of multimedia will be meaningfully inspired by feedback given by users.

REFERENCES

[1] J.Kim and E.Andre, “Emotion recognition using physiological and speech signal in short-term observation,” in Proc. Percept. Interactive Technol., 2006, vol. 4021, pp. 53–64. M. Young, The Technical Writer’s Handbook. Mill Valley, CA: University Science, 1989.

[2] Yuan Pin-Lin,“Chin Hong wang,Tzyy, ”EEG-Based emotion recognition in Music Listening,” Pattern recognition, Volume 48, Issue 4, IEEE(2010), Pages 1039-1049. K. Elissa, “Title of paper if known,” unpublished.

[3] S. Valenzi, T. Islam, P. Jurica and A. Cichocki, "Individual classification of emotions using EEG,” Journal of Biomedical Science and Engineering, vol. 7, pp. 604, 2014.

[4] S. Koelstra, C. Mühl, M. Soleymani, J. Lee, A. Yazdani, T. Ebrahimi, T. Pun, A. Nijholt and I. Patras, "Deap: A database for emotion analysis; using physiological signals," Affective Computing, IEEE Transactions On, vol. 3, pp. 18-31, 2012.

[5] Alicia Heraz,Ryad Razaki,Claude Frasson , " Using machine learning to predict learner emotional state from brainwaves .," international Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 5 Issue IV, April 2007.

[6] Vanitha V, Krishnan P, "Real time stress detection system based on EEG signals", IEEE 2016.

[7] Murray W. R. (1998). "A practical approach to Bayesian student modeling" In B. P. Goettl, H. M. Halff.

[8] Olga Sourin,Yisi Liu, " Real-time EEG-based emotion recognition for music therapy " in Proc. IROS, Sendai, Japan, 2012, pp. 70–75.

[9] C. L. Redfield, and V. J. Shute, editors, Intelligence Tutoring System (Proc. 4th Int'l Conf. ITS'98).