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RESEARCH ARTICLE

Wavelet based Extraction of Features from EEG Signals and Classification of Novel Emotion Recognition Using SVM and HMM Classifier and to Measure its Accuracy

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A B S T R A C T

Aim: The study aims to extract features from EEG signals and classify emotion using Support Vector Machine (SVM) and Hidden Markov Model (HMM) classifier. **Materials and methods:** The study was conducted using the Support Vector Machine (SVM) and Hidden Markov Model (HMM) programs to analyze and compare the recognition of emotions classified under EEG signals. The results were computed using the MATLAB algorithm. For each group, ten samples were used to compare the efficiency of SVM and HMM classifiers. **Result:** The study's performance exhibits the HMM classifier's accuracy over the SVM classifier and the emotion detection from EEG signals computed. The mean value of the HMM classifier is 52.2, and the SVM classifier is 22.4. The accuracy rate of 35% with the data features is found in HMM classifier. **Conclusion:** This study shows a higher accuracy level of 35% for the HMM classifier when compared with the SVM classifier. In the detection of emotions using the EEG signal. This result shows that the HMM classifier has a higher significant value of P=.001 < P=.005 than the SVM classifier.

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Introduction

Emotions play a significant role in our everyday lives and will continue to do so. Most potential applications will depend on the brain-computer interface, critical (Badicu and Udrea 2019). To comprehend human feelings or perceptions, significant works of art involving brain-machine software Neuromarketing, market research, medicine, and security are only a few examples as the demand for such services grows (Hosseini 2017). The study's importance is to analyze the various components under EEG signals used to detect the emotions using the SVM and HMM classifiers to compare other classifiers based on their efficiency (Chaurasiya, Shukla, and Sahu 2019).

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This study's application is to comprehend the working of SVM and HMM classifiers that would detect and measure the physiological signals with higher precision(Daimary et al. 2018).

The previous literature mentioned that "SVM classifier in emotions detection" EEG may be a reliable predictor of the subject's emotional state. To distinguish EEG signals into seven distinct emotions, we used Independent Component Analysis (ICA) (Bhardwaj et al. 2015). The key finding from this study explains rice disease, which an SVM classifier can detect, and it gives the accuracy of disease. The best study in this research, "wavelet analysis based classification of emotion from EEG signal," the study is based upon the wavelet-based and emotion classification (Islam and Ahmad 2019). The EEG signals were retrieved from an available dataset collected from EEG (Barakat and Gadallah 2010). The collected signals can be classified based on their principal component. There is an involvement of the recognition method in detecting emotions, whether they are happy, sad and angry (Ravindran and Malathi Ravindran 2014; Edla et al. 2018)).

Previously our team has a rich experience in working on various research projects across multiple disciplines (Sathish and Karthick 2020; Varghese, Ramesh, and Veeraiyan 2019; S. R. Samuel, Acharya, and Rao 2020; Venu, Raju, and Subramani 2019; M. S. Samuel et al. 2019; Venu, Subramani, and Raju 2019; Mehta et al. 2019; Sharma et al. 2019; Malli Sureshbabu et al. 2019; Krishnaswamy et al. 2020; Muthukrishnan et al. 2020; Gheena and Ezhilarasan 2019; Vignesh et al. 2019; Ke et al. 2019; Vijayakumar Jain et al. 2019; Jose, Ajitha, and Subbaiyan 2020). Now the growing trend in this area motivated us to pursue this project.

Lacunae existing in the study states the lack of precision in the tools used in the diagnostic instruments. Our study's aim was based on emotion detection, classified by the support vector machine and extraction of features from EEG signals and classifying emotion using SVM and HMM classifiers.

Materials and Methods

In this study, two groups are involved for emotion recognition. The sample used in this study is 30. The required samples for this study are tested using G power calculation. The minimum power for this study is fixed as 1.0 and maximum accepted error is fixed as 0.5. The study setting was done in the DSP lab of Saveetha School of Engineering. In this section, there is only the use of software tools and no use of hardware. The research was conducted using algorithms such as MATLAB software using Windows 8 in the English language and SPSS (Statistical Package for the Social Sciences) to study the various features under EEG signals and to understand their characteristics. The study did not use any live samples; hence ethical approval is not necessary. The samples used in this study are classified as three groups and the total number of samples used under this study is 30.

The MATLAB software (version R2018a) was used to predict the recognition of characters. The algorithm was implemented in the editor box, and the output waveform is obtained from the command window. The process was done with both the classifier SVM as well as the HMM classifier. The SVM and HMM were used to extract different signal features in this analysis. If the wavelet coefficient characteristics are very similar to the wavelet function characteristics, better feature extraction efficiency can be easily achieved. Under step one, the waveform is detected, analyzed and it is applied in the Matlab software; the input of the file is mentioned and RUN the program, and the output is displayed.

The character recognition results are implemented from the SPSS software to compare results like mean, Std. Deviation standard error Mean significance t-test for equality of means and graphs are plotted. Independent sample tests and group statistics have been taken for the results. Results obtained were satisfactory, particularly once input characters were near to printed letters. It's important to achieve a high level of accuracy so that applications can be designed around it. The research's statistical analysis was analyzed and tested using MatLab software, SPSS and independent test variable tests.

Results

Electroencephalogram has been recorded for various samples and shown in Fig. 1. After finalizing the emotional parameters/factors like happy, angry and sad for each sample and uploaded it to the algorithm. (Table 1). Group statistics for HMM and SVM have been recorded (Table 2). Independent 't' test has been calculated between HMM and SVM classifiers and shown in table 3. In comparison, HMM classifier showed significant results than the SVM classifier in high mean value and low standard deviation (Table 3). The comparison of accurate values for HMM and SVM classifier is shown in table 4.

Table 1. The accuracy rate of the SVM and HMM classifier

S.NO	ACCURACY RATE	
	SVM	HMM
1.	177.00	64.70
2.	286.00	111.00
3.	347.00	49.40
4.	155.00	85.50
5.	155.00	85.50
6.	347.00	49.40
7.	430.00	83.70
8.	1.00	22.30
9.	32.80	1.25
10.	32.80	1.25
11.	234.00	22.30
12.	294.00	147.00
13.	187.00	46.60
14.	189.00	6.69
15.	294.00	6.89

Table 2. Comparison in Accuracy between HMM (35%) classifier and SVM classifier (29%).

	Accuracy (%)	Sensitivity (%)	Specificity (%)	Precision (%)
HMM classifier	35.00	0.31	0.37	0.17
Support vector machine	29.00	1.00	0.00	0.29

Table 3. Group statistics of EEG signals. The mean value of HMM (52.218) and SVM (20.470)

ACCURACY	GROUP STATISTICS				
	GROUP	N	MEAN	Std. Deviation	Std. Error Mean
	1	15	20.4707	12.49093	3.22515
	2	15	52.2187	43.89919	11.33472

Table 4. Comparison of Independent sample test for SVM and HMM classifiers:

ACCURACY	INDEPENDENT TEST									
	Equal variance assumed	LEVENE'S TEST FOR EQUALITY OF VARIANCE		T-test for equality of Means					95% confidence interval of the difference	
		F	Sig	t	df	Sig	Mean Difference	Std.error difference	Lower	Upper
	Equal variance not assumed	14.059	<0.001	-2.694	28	0.12	-31.74800	11.78463	-55.88772	-7.60828
				-2.694	16.252	.016	-31.74800	11.78463	-56.69883	ccc

From Table 1, it was observed that the SVM and HMM classifiers are compared and tested based on their accuracy rates. From Table 2, it was observed that the SVM classifier has an accuracy of 29%, and HMM classifier has an accuracy of 35%. Comparatively, it can be concluded that HMM results in higher accuracy. From table 3, it was observed that the mean value of HMM was 52.218 and the standard deviation to be 43.8. The mean value of SVM is to be 20.470 and the standard deviation to be 12.490. From table 4, it was observed that the significant value of HMM classifier accuracy to be < 0.01. In comparison with the standard significance value of < 0.05.

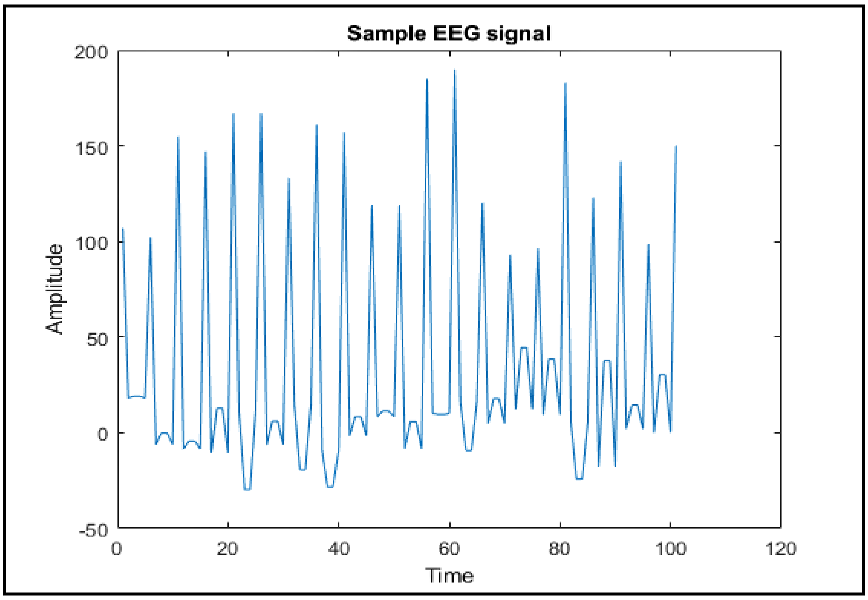

Fig.1. The sampled waveform of an EEG signal which is denoted by its amplitude and time

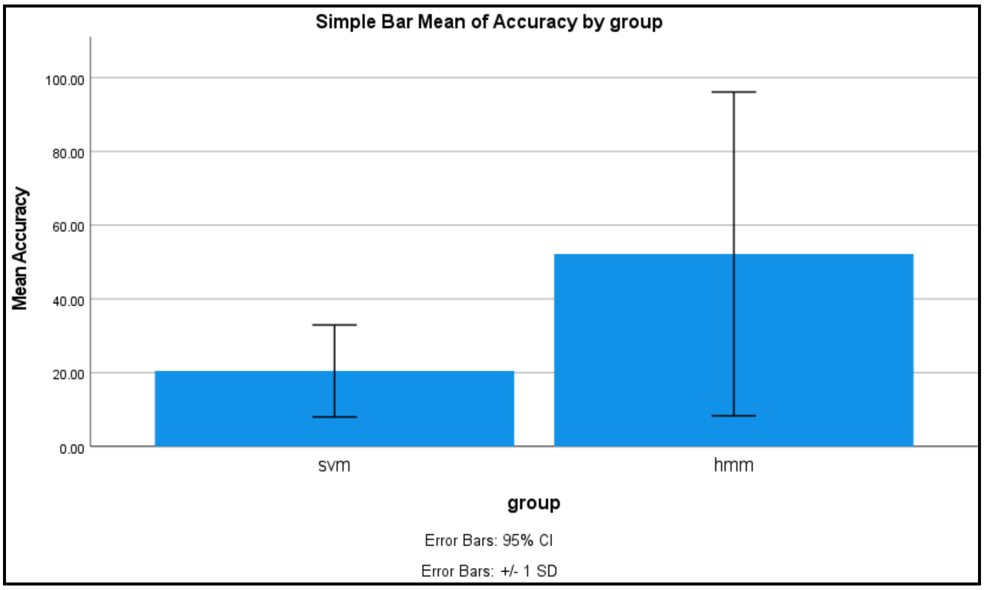

Fig. 2. The simple bar graph compares the mean accuracy values of SVM and HMM classifiers. Based on the mean accuracy, it is said that HMM classifier is more efficient when compared to SVM classifier. The mean accuracy of SVM is denoted as 20.470, and the mean accuracy of HMM is denoted as 52.218. X- axis: HMM vs SVM classifiers. Y-axis: Mean accuracy of detection +/_ SD.

From fig. 1, The sampled waveform of an EEG signal which is denoted by its amplitude and time. From fig. 2, The simple bar graph compares the mean accuracy values of SVM and HMM classifiers. Based on the mean accuracy, it is said that HMM classifier is more efficient when compared to SVM classifier. The mean accuracy of SVM is denoted as 20.470, and the mean accuracy of HMM is denoted as 52.218.

While performing the statistical analysis for 10 samples from the both HMM and SVM classifiers, HMM classifier obtained 43.8 standard deviation with 11.3 standard mean error. However, the SVM classifier obtained 12.4 standard deviation with 3.2 standard mean error (Table). The significance value of P=0.001 which is lower than the P=0.005 showed that our work holds significantly good.

Independent t-test was used to compare the accuracy levels for both HMM and SVM classifiers and a statistically significant difference was noticed P=0.001 < 0.005. The HMM classifier obtained 52% accuracy (Figure 2). When compared with the other algorithms, the performance of the proposed HMM technique achieved better performance than SVM classifier novel emotion recognition.

Discussion

In this study, two methods were used to recognize emotional factors from EEG signals, namely the HMM classifier and SVM classifier. The HMM classifier is better than the SVM classifier with HMM values (P=0.001; P<0.005) with 42.8 standard mean value, 11.2 standard mean error with the 43.8 standard deviation value, 11.3 standard mean error and the accuracy level of 52% has obtained. That the classification's outcome is purely empirical, and the precision of this method cannot be measured in terms of numbers (Jude Hemanth 2019). Based on the analysis, it was observed that HMM classifier had an accuracy of 52%, and SVM had an accuracy of 20%. Comparatively, it can be concluded that HMM classifiers' efficiency is better than SVM classifiers and would analyze the EEG waveforms effectively.

Similar literature describes "Using wavelet transform for feature extraction from EEG signal," The classical technique of extracting EEG signal features based on frequency characteristics only extracts the energy features of each channel and ignores the correlation information between channels (Jude Hemanth 2019; "USING WAVELET TRANSFORM FOR FEATURE EXTRACTION FROM EEG SIGNAL" 2008; Feng, Hao, and Nuo 2019)). "Feature extraction algorithm based on CSP and wavelet packet for motor imagery EEG signals" (Feng, Hao, and Nuo 2019; Djamal, Suprijanto, and Arif 2014)) feature extraction of EEG signals using wavelet transform. The results obtained from our study concludes that HMM classifier is effective for analyzing EEG signals in comparison with the previous database. Based on the literature, there wasn't any evident finding which opposes the research of the study.

Our institution is passionate about high quality evidence based research and has excelled in various fields ((Vijayashree Priyadharsini 2019; Ezhilarasan, Apoorva, and Ashok Vardhan 2019; Ramesh et al. 2018; Mathew et al. 2020; Sridharan et al. 2019; Pc, Marimuthu, and Devadoss 2018; Ramadurai et al. 2019). We hope this study adds to this rich legacy.

This study's limiting factor is that the HMM needs a larger sample than simple Markov models and must be trained on a set of sample sequences. It also requires a repeated number of iterations.

The study's future scope is detecting and analyzing physiological signals using SVM and HMM classifiers and determining their efficiency.

Conclusion

This study shows a higher accuracy level of the classifiers, and its accuracy is detected to give significant information on the EEG signal. HMM, the classifier, is comparatively said to be more significant than SVM classifier.

Declarations

Conflict of Interests

No conflict of interest in this manuscript.

Authors Contributions

Author MM was involved in data collection, data analysis and manuscript writing. Author VV was involved in data validation and critical review of manuscript.

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