International Journal of Engineering, Technology, and Natural Sciences
ISSN: 2685 – 3191 (online)
Vol. 1, No. 2, 2019

Emotion Classification by EEG Signal Generated by Brain using Discrete Wavelet Transform and Artificial Neural Network Backpropagation with Classical Music Stimulus

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Abstract
People feel different emotions when listening to music on certain levels. Such feelings occur because the music stimuli causing reduced or increased brain activity and producing brainwave with specific characteristics. Results of research indicated that classical piano music can influence one's emotional intelligent. By using Electroenchephalography (EEG) as a brainwave recording instrument, we can assess the effect of stimulation on the emotions generated through brain activity. This study aimed at developing a method that defines the effect of sound to brain activity using an EEG signal that can be used to identify one's emotion based on classical piano music stimulus reaction. Based on its frequency, this signal was the classified using DWT. To train Artificial Neural Network, some features were taken from the signal. This ANN research was carried out using the process of backpropagation.
Keywords : EEG, emotion, Discrete Wavelet Transform, Artificial Neural Network, backpropagation

INTRODUCTION

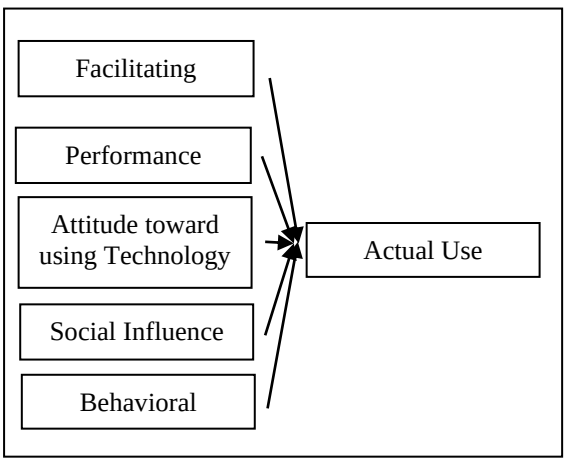
In certain frequencies, when listening to music, the brain can respond and generate brainwave that can influence one's emotion. Electroenchephalography (EEG) is a device used to monitor brainwave caused by neuronal activity in the brain of humans. Most researchers use it primarily to evaluate brain activity and predict the generated emotion. By using EEG, we can find out how the brain reacts to actions that are carried out and identify the emotional condition. Discrete Wavelete Transform is used as feature extraction of characteristics of the EEG signal, and Artificial Neural Network (ANN) is used as a classifier. They are used to develop an emotion classification system based on a brain-generated EEG signal and to know how the system works, whether it can be used or not.

PROBLEM FORMULATION

1. Can ANN be used to classify emotion as a result of classical piano music stimulus through the EEG signal generated by the brain?
2. Can brain activity affect but not determine one's emotional intelligence?
3. How is ANN classification performance when certain parameters are used such as features, number of epochs, learning rate, and number of neurons in each layer?
4. Is it possible to determine one's dimension and also type by ANN classification?

Data collection was carried out by distributing questionnaires containing 18 item statements as follows :

1. Performance Expectancy (PE) : 4 statement points
2. Attitude toward using Technology (AT) : 4 statement points
3. Social Influence (SI) : 4 points statement
4. Facilitating Condition (FC) : 1 points statement
5. Behavioral Intention (BI) : 3 statement pointsActual Use: 2 statement points



The proposed hypotheses are as follows:
Hypothesis 1: Facilitating conditions will have a significant impact on actual use using QMS
Hypothesis 2: Performance expectancy will have a significant impact on actual use using QMS
Hypothesis 3: Attitude toward using technology will have a significant impact on actual use using QMS
Hypothesis 4: Social influence will have a significant impact on actual use using QMS
Hypothesis 5: Behavioral intention will have a significant impact on actual use using QMS

OBJECTIVE

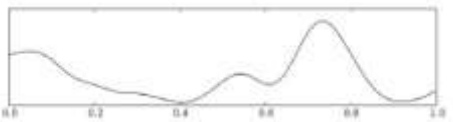
1. To know whether ANN can be used to classify emotion as a result of classical piano music stimulus through the EEG signal generated by the brain.
2. To know whether brain activity can be used to determine one's emotional intelligence.
3. To know the effectiveness of ANN classification performance.

THEORITICAL FRAMEWORK

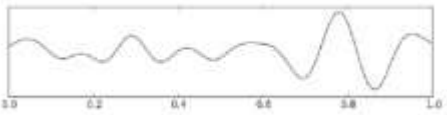
1. Brainwaves

Brainwaves are any of fluctuations in the brain when people do activity. Important frequency range which is clinnically connected is divided into four major groups, alpha, betha, theta and delta. The frequency range of brainwaves that can be detected starts at 0.5 to 500Hz. While the frequency range from EEG measurement starts with amplitude ranging from 10Hz to 100 microvolts from 1 to 80Hz. The frequency ranges of brainwaves are Beta (14-30 Hz), Alpha (8-13.9 Hz), Theta (4-7.9 Hz), Delta (1-3.9 Hz), and Gamma (> 30Hz).

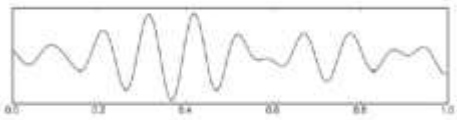
i) Delta (∂) has a frequency of 4Hz or below. It is a deep sleep frequency



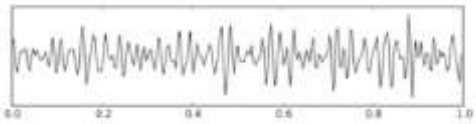
ii) Theta (θ) has a frequency between 4-8 Hz. This frequency is associated with vivid imagery, dream and first stage of sleep.



iii.) Alpha (∝) has a frequency between 8 Hz- 12 Hz. This condition is associated with relaxation without focus and concentration.



iv.) Beta (β) has a frequency between 12 dan 30 Hz.It is presented in a happy state when we are alert with full mental activity.



2. Emotion

Emotion is a mental state expressed with agreeable or disagreeable formed in limbic system of mammalian brain. Emotion arises as a result of the increased or decreased brain activity level. In emotion prediction, there are two coverages of emotion measurement:

i) Discrete
Discrete emotion measurement is used when standard definition about emotion state has been done and with stimulus.

ii) Continue
It indicates measurement from a stimulus, like picture, music, etc that is given in certain level of experiment. It is usually visualized with valence and arousal axis.

3. Personality Typologies

Personality typology or kinds of personality is a concept developed to classify personality into several categories. Personality typology compares eight difference in personality type into each personality dimension: extroversion (E), neuroticism (N) and conscientiousness (C). From those personality dimensions, the method is classified into eight personality

types: spectator (E –, N –, C –), insecure (E –, N +,C –), sceptic (E –, N –, C +), brooder (E –, N +, C +), hedonist (E +, N –, C –), impulsive (E +, N +, C –), entrepreneur (E +, N –, C +), and complicated (E +, N +, C +).

4. Sound and Music

The brain can produce different responses and EEG signals with different characteristics when listening to sound at certain frequencies. Sudirman et al. also claimed that the brain would produce different brain signals when listening to sound in different frequencies. Some studies also revealed that it would generate EEG with different frequency range while listening to certain songs.

5. Electroenchephalography

Electroenchephalography (EEG) is an activity that records spontaneous electrical activity within a certain period of time from the brain. EEG utilizes neuronal electrical activity in the brain. Electroenchapalogram(EEG) is the instrument used to record EEG.

6. Discrete Wavelet Transform (DWT)

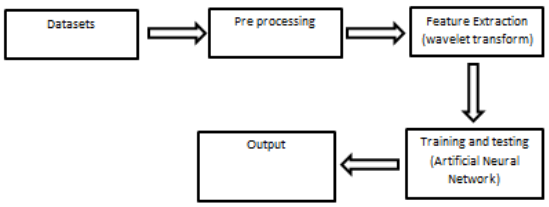
Wavelet is one of the method of extraction of features used in signaling. It is used for analyzing single and multidimensional signals, especially when each time the signal has different information.

7. Artificial Neural Network (ANN)

Wavelet representation is **mutiscale** from signal decomposition that we can find as a tree where each level in particular resolution saves signal projection into the basic function or in other words the value of wavelet changes into some coefficient. Wavelet time-frequency representation is achieved by filtering the signal using a filter pair that will split the middle frequency domain

SYSTEM DESIGN

Generally, the system was designed as the following chart:



1. Dataset

DEAP Dataset: A Database for Emotion Analysis using Physiological Signals was used in this study. It used continue emotion measurement. Participants were asked to give their rating score on a scale of 1-9 points in each trial or experiment. This leveling was called self-assessment (SAM). To evaluate whether or not self-evaluation EEG data could be used as an indicator, an experiment was conducted by comparing the EEG correlation with the ranking. Based on the results of the experiment, it could be concluded that in the context of classical piano music stimulus, the ranking was a valid indicator of the emotional condition.

2. Preprocessing

DEAP Dataset includes a pre-process EEG dataset. It was aimed at reducing the noise of raw data from the EEG.

3. Feature Extraction

This feature extraction was done using Discrete Wavelet Transform (DWT) using db4 wavelet and wavelet level 4. In this research, the features extracted were as follow:

1. One feature (power) in each sub-band frequency so that the total was 4 features.
2. Five features (minimum, maximum, average and standard deviation) in each sub-band frequency so that the total feature used was 20.

4. Artificial Neural Network

The number of neurons in the input layer was set based on the number of features used. The output layer consists

of two neurons, i.e. valence and arousal prediction. The system would clarify the influence of stimulus on the emotion given based on the prediction. It was built in three layers for the hidden layer, whereas each neuron layer would be configured based on the specified test scenario. On the following illustration, the process of data distribution and development of ANN could be seen. There were two phases on the growth of the ANN network, i.e. training and testing.

TESTING AND CONCLUSION

The aim of this test is to see if ANN can be applied to the emotion classification system and to know how the system is accurate and efficient when using network configuration according to the testing scenario used. For the test scenario, the parameter of the network configuration that will be modified for the EEG testing process is the number of neurons in each layer, the period, the rate of learning and the features used.

1. Conclusion

It is difficult to determine the best network configuration based on the average performance of the outcome of classifications. The highest average of 20 features was 34.03 % during the preparatory phase of testing. It can therefore be concluded that it is not very easy to classify. This is because the proper feature to do emotion classification using EEG is difficult to determine or characterize, especially if there are too many subjects.

Furthermore, when 20 features are used, the level of accuracy at the test stage improves compared to when 4 features are used. It can be seen from the disparity in higher tests where the test result with 4 features shows 24.6% accuracy while a test with 20 features shows 35.9% accuracy.

2. Recommendation

Other researchers are recommended to use other methods or collaborative methods that can produce better accuracy with not too many subjects using the EEG dataset and choose better extraction of features.

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