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Brain-Activity-Driven Real-Time Music Emotive Control

S. Giraldo[1], R. Ramirez[1]
[1]*Music Technology Group, Pompeu Fabra University, Spain*

Correspondence: S. Giraldo, Pompeu Fabra University, Roc Boronat, 138, 08018 Barcelona, Spain.
E-mail: sergio.giraldo@upf.edu

Abstract. Active music listening has emerged as a study field that aims to enable listeners to interactively control music. Most of these systems aim to control music aspects such as playback, equalization, browsing, and retrieval, but few of them aim to control expressive aspects of music to convey emotions. In this study our aim is to enrich the music listening experience by allowing listeners to control expressive parameters in music performances using their perceived emotional state, as detected from their brain activity. We obtain EEG data using a low cost EEG device and then map this information into a coordinate in the emotional arousal-valence plane. The resulting coordinate is used to apply expressive transformations to music performances in real time by tuning different performance parameters in the *KTH Director Musices* rule system. Initial results show that the emotional state of a person can be used to trigger meaningful expressive music performance transformations.

Keywords: EEG, Emotion Detection, Expressive Music Performance

1. Introduction

In recent years, active music listening has emerged as a study field that aims to enable listeners to interactively control music. While most of the work in this area has focused on control music aspects such as playback, equalization, browsing and retrieval, there has been few attempts to controlling expressive aspects of music performance. On the other hand, electroencephalogram (EEG) systems provide useful information about human brain activity and are becoming increasingly available outside the medical domain. Similarly to the information provided by other physiological sensors, Brain-Computer Interfaces (BCI) information can be used as a source for interpreting a persons emotions and intentions.

In this paper we present an approach to enrich the music listening experience by allowing listeners to control expressive parameters in music performances using their perceived emotional state, as detected by a bran-computer interface. We obtain brain activity data using a low cost EEG device and map this information into a coordinate in the emotional arousal-valence plane. The resulting coordinate is used to apply expressive transformations to music performances in real time by tuning different performance parameters in the *KTH Director Musices* rule system [Friberg et al., 2006].

2. Material and Methods

Our proposed method is depicted in Fig. 1. The process begins with detection of emotion based on the approach by Ramirez and Vamvakousis [Ramirez and Vamvakousis, 2012]. For the data extraction we used the Emotiv EPOCH head set. First we measure the EEG signal from the AF3, AF4, F3, and F4 electrodes. Using band pass filtering i, the signal is split up in order to get the frequencies of interest, which are in the range of 8–12 Hz for alpha waves, and 12–30 Hz for beta waves. Alpha waves are dominant in a relaxed awake mind state, whereas beta waves are indicator of an excited state of mind. The arousal value is computed from the beta/alpha ratio as:

$$arousal = \frac{a_{F3}+a_{F4}}{b_{F3}+b_{F4}} \tag{1}$$

Left frontal inactivation is linked to a negative emotion, whereas right frontal inactivation may be associated to positive emotions. Thus valence is calculated as:

$$valence = \frac{a_{F4}}{b_{F4}} - \frac{a_{F3}}{b_{F3}} \tag{2}$$

As depicted in Fig. 1, each quadrant of the arousal valence plane correspond to one of the studied emotions as follows: high arousal and high valence correspond to happy state, high arousal and low valence correspond to angry state, low arousal and high valence correspond to relax state, and finally low arousal and low valence correspond to sad

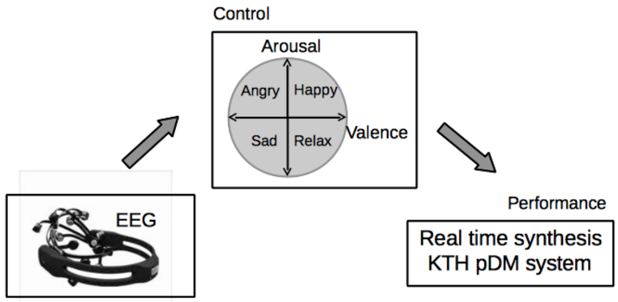

Figure 1: *Theoretical frame work for expressive music control based on EEG arousal - valence detection.*

state. As arousal and valence values are not absolute and vary among subjects, we normalize the values by computing the mean of a 5 second window over the last 20 second window maximum and minimum of the signal. This way we obtain values that range between minus one and one for both arousal and valence values.

For synthesis we have used a real-time based implementation of the KTH group, pDM (Pure Data implementation of Director Musices Profram) [Friberg, 2006]. Thus, the coordinate on the arousal-valence space is mapped as an input for the pDM activity-valence space expressive control. In our implementation, this control is adapted in the pDM program, so the coordinates are rotated to fit the ones of the arousal valence space. Then the transformation of each of the seven the expressive rules takes place by interpolating 11 expressive parameters between four extreme emotional expression values (Bressin and Fridberg, 2000) .

Two types of experiments were performed:a first one listening and the other listening while playing (improvising) with a musical instrument. In both we aim to evaluate if the intended expression of the synthesized song (and the user performance when playing) is reflected in the incoming signal of the listeners brain activity, in a passive listening scenario. The expression of the performance is dynamically changed between to extreme values (happy and sad). A 2-class classification task is performed for both experiments. Features are obtained from the signal by taking four seconds time intervals, and sliding each of this windows every quarter of a second.

3. Results

Two classifiers, Linear Discriminant Analysis and Support Vector Machines, are evaluated to classify the intended emotions, using 10-fold cross-validation. Initial results are obtained using the LDA and SVM implementations of the Open Vibe library. For happy-versus-sad classification we obtained a 76.41 % for passive listening with out playing, and 65.86 % for passive listening when playing an instrument (improvising) along the expressive track using SVM with radial basis kernel function.

4. Discussion

Initial results suggests that the EEG signals contain sufficient information to classify the expressive intention between happy and sad classes. However, the accuracy decrease, as expected, when playing an instrument. This may be due to the fact that the action of playing requires attention, thus, the alpha activity may remain low and beta may remain high.

5. Conclusion

In this paper we have explored an approach to active music listening, implementing a system to control in real time the expressive aspects of a musical piece, by means of the emotional state detected by an EEG device. We have used machine learning techniques (LDA and SVM) to perform a two class classification task between two emotional states (happy and sad). Initial results suggests that EEG data contains sufficient information to distinguish between the two classes.

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