Chapter 7
Detection of Music-Induced Emotion Changes by Functional Brain Networks

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ABSTRACT

This chapter discusses emotions induced by music and attempts to detect emotional states based on regional interactions within the brain. The brain network theory largely attributes statistical measures of interdependence as indicators of brain region interactions/connectivity. In this paper, the authors studied two bivariate models of brain connectivity and employed thresholding based on relative values among electrode pairs, in order to give a multivariate flavor to these models. The experimental results suggest that thresholding the brain connectivity measures based on their relative strength increase classification accuracy by approximately 10% and 8% in time domain and frequency domain respectively. The results are based on emotion recognition accuracy obtained by decision tree based linear support vector machines, considering the thresholded connectivity measures as features. The emotions were categorized as fear, happiness, sadness, and relaxation.

INTRODUCTION

The ease with which the brain completes seemingly complex tasks like pattern recognition and reasoning with words has fascinated scientists. Researchers have consistently argued that a thorough understanding of how the brain organizes computation is a necessary prerequisite of building systems which can rival brain-like computation (Körner et al., 2002, Martinez et al., 2013). This covers many aspects including synthesis and recognition of emotions.

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There has been widespread research aiming at emotion recognition from different modalities such as gestures, facial expressions, and voice (Konar et al., 2012, Kar et al., 2013). Unfortunately, these modalities cannot correctly detect the emotion of subjects as the subjects might pretend by voluntarily controlling their emotions. EEG signals contain the instantaneous electrical signature of the brain function, and carry sufficient information to recognize the true emotion of the subjects. There has been a lot of work in deciphering emotion from EEG signals (Kar et al., 2014, Petrantonakis et al., 2016), as well as to determine the dependency of brain region activities on emotional states of a person (Kroupi et al., 2011). However, deciphering neural signatures for different emotions has remained a difficult task, primarily because emotions result as a chain of interactions in the brain rather than just isolated activities of different brain regions (Horlings et al., 2008). Similarity measures of various types have been proposed to understand the relations between EEG electrode signals (Golińska, 2011, Xu et al., 2008) but most were lacking in the fundamental requirement that brain signals exhibit not only pairwise but simultaneous interdependence (Baccalá et al., 2009).

According to Davison's motivational model, the left brain is associated with positive emotions, while the right brain with negative emotions (Müller et al., 1999). However, there is not much agreement about this according to all researchers (Dennis et al., 2010, Körner et al., 2002). While earlier brain theories attempted regional mapping of different brain areas to different aspects of cognition, the more recent brain theories suggest that cognitive computation is facilitated by interaction/connectivity between different parts of the brain. The presented approach to decipher neural signatures of brain activity during emotion arousal tries to capture the multivariate nature of brain interactions. In this chapter, the authors described two techniques of decoding the neural signaling structure and outlined a simple way of extending the presented two techniques. The experiments performed by the authors suggest that considering relativity between the considered brain connectivity measures increases accuracy in classifying the emotional state of a subject. These measures are dependent on linear correlation/coherence among brain signals and are more robust than other dependency measures, primarily because both consider multiple signal relationships. The authors have compared the proposed methods with well-known similarity measures like linear correlation, correntropy (Xu et al., 2008), coherence (Golińska, 2011), and Itakuara distance (Kong et al., 1995). The proposed methods of similarity measurement have outperformed all the other four similarity measures in the domain of emotion recognition.

The first task in any physiological experiment is the design of appropriate stimuli. In this work, the authors have chosen to study the influence of music on the emotional state of a person. In order to avoid any subjective bias towards a particular language, the authors selected instrumental music as stimuli.

During stimuli selection, volunteers were asked to identify emotions carried by different instrumental music pieces. The music pieces which mostly evoked emotions of a particular class were selected as stimuli to inducing emotions of that class only. After careful stimuli selection, a new set of volunteers were asked to listen to the selected music during which their EEG was recorded. Connectivity estimates among the EEG signals were used to construct brain networks. SVM was used to classify these brain networks as representative of the following categories of emotions a) fear b) happiness c) sadness d) relaxation. Different connectivity measures were tested on their ability to indicate emotions. It was seen that considering relative values enhanced the accuracy of emotion recognition.

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