Chapter 8

EEG Analysis to Decode Tactile Sensory Perception Using Neural Techniques

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ABSTRACT

This chapter introduces a novel approach to examine the scope of tactile sensory perception as a possible modality of treatment of patients suffering from certain mental disorder using a Support Vector Machines with kernelized neural network. Experiments are designed to understand the perceptual difference of schizophrenic patients from normal and healthy subjects with respect to three different touch classes, including soft touch, rubbing, massaging and embracing and their three typical subjective responses. Experiments undertaken indicate that for normal subjects and schizophrenic patients, the average percentage accuracy in classification of all the three classes: pleasant/acceptable/unpleasant is comparable with their respective oral responses. In addition, for schizophrenic patients, the percentage accuracy for acceptable class is very poor of the order of below 12%, which for normal subjects is quite high (42%). Performance analysis reveals that the proposed classifier outperforms its competitors with respect to classification accuracy in all the above three classes.

INTRODUCTION

Touch refers to physical contact of a person’s skin with any non-living substance or living organisms. Perceiving touch usually depends largely on the subjective experience of people. For example, a baby of two months old can recognize his mother by the way she holds the baby. In this way, touch perception can be considered as one of the most important modality during his development stages.
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al., 2010; Gallace & Spence, 2010; McGlone, 2014). The sense of touch is perceived by various tactile receptors, which in general, utilizes A-beta fibers to transmit tactile information with extremely rapid speed. In addition, relatively slower A-delta and even slower C fibers are also used for signal transmission by free nerve endings (Schore, 2005). Receptors gather tactile information during various touch nourishments including soft touch, rubbing or massaging from a relatively larger area of the skin, which causes ambiguity in locating the source of the stimulus. Tactile information (sensation) for each touch nourishments are fed to the spine from the receptors by the nerve endings and then ascend to the brain using the spino-thalamic pathway.

This chapter aims at classifying distinctive touch patterns commonly used in hospitals/health centers to treat physio- and psycho-therapeutic patients from their acquired electro-encephalographic (EEG) signals. It refers to the electrical response of the brain to external stimuli or memory based incidental thought/activity. EEG is usually acquired by specialized electrodes placed on the scalp of human subjects/animals. The acquired signals are pre-processed, filtered and analyzed to decode/classify cognitive tasks undertaken by the subjects. Pre-processing refers to filtering and artifact (noise) removal technique for electroencephalographic (EEG) signals that require a suitable band-pass filter and computational strategies. Artifacts are unwanted spurious pick-ups in signal amplitude, especially due to un-volunteered movements of eye-blinking and/or muscle activation, which appears as noise in the main signal.

Experiments have been performed with both normal (healthy) subjects and schizophrenic patients to determine their level of pleasure in three different types of (non-sexual) touch-nourishments offered by nurses or inmates of the subjects from their cortical responses. The cortical response also shows the variation in blood concentration near the active regions for different types of touch nourishment. Later the degree of nourishment perceived is matched with the oral response of the subject to test the validity of the experimental results obtained from cortical responses.

The fundamental contribution of the present work lies in developing a data-point as well as feature selection algorithm by determining skewness of a hyperplane-based neural network (NN) classifier to classify detected touch modality into levels of pleasure (unpleasant, acceptable and pleasant). Since, like any other patterns, an EEG signal too is described by its features, feature extraction and selection, therefore are considered as the important steps in touch perception. Here, authors select well-known EEG features such as time- (Hjorth parameters (Vourkas et al., 2000), Adaptive autoregressive parameters (Schlögl et al., 1997), frequency- (Power spectral density, or in short PSD (Stoica & Moses, 1997), and time-frequency (Discrete wavelet transform, or in short DWT (Panda et al., 2010). Approximate entropy (Srinivasan et al., 2007) domain to extract features from acquired EEG signal depending on the touch nourishments provided. It is important to mention here that classifying tactile information has always been a serious pattern classification problem, and sometimes, computationally complex feature generates a very high dimensional feature space which may contain both relevant and redundant features. The presence of redundant features adversely affects the performance of the classifier in terms of accuracy and time complexity. Feature selection hence aims at reducing the dimension of the feature set by retaining only the most relevant features and rejecting the rest.

Besides classifier, other important coverage of the chapter includes defining degree of pleasure perceived (DPP) (Saha et al., 2015) by a subject based on the EEG feature estimates, and comparing the measured DPP with subjective assignments by the patients. Moreover, DPP measure for pleasant touch, as perceived by the subjects, is used to select the best-performing and hence most appropriate nurse to
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