Neuroimaging Conjunction with Machine Learning for Applications of fNIRS for Human Pain

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Abstract

Pain diagnosis for nonverbal patients represents a big challenge in clinical settings. However, neuroimaging methods such as functional magnetic resonance imaging and functional near-infrared spectroscopy (fNIRS), have shown some promising results to assess neuronal function in response to nociception and pain. Recent studies strongly suggest that neuroimaging in conjunction with machine learning models can be used to not only facilitate but also predict different cognitive tasks on this challenge. The aim of this research is to expand our previous studies by exploring the classification of fNIRS signals (oxyhaemoglobin) according to temperature level (cold and hot) and corresponding pain intensity (low and high) using machine learning models. In our research, we defined and used the quantitative sensory testing to determine pain threshold and pain tolerance to cold and heat in 18 healthy subjects (three females), with, mean age _ standard deviation, being 31.9 _ 5.5. The classification model is based on the bag-of-words approach, a histogram representation used in document classification based on the frequencies of extracted words and adapted for time series; two learning algorithms were used separately, K-nearest neighbor (K-NN) and support vector machines (SVM). A comparison between two sets of fNIRS channels was also made in the classification task, all 24 channels and 8 channels from the somatosensory region defined as our region of interest. The results showed that K-NN obtained slightly better results (92.08%) than SVM (91.25%) using the 24 channels; however, the performance slightly dropped using only channels from the region of interest with K-NN (91.53%) and SVM (90.83%).

These research results indicate potential applications of fNIRS in the development of a physiologically based diagnosis of human pain that would benefit vulnerable patients who cannot self-report pain including in clinical settings.

Keywords: pain, near-infrared spectroscopy (NIRS), biomarker, machine learning, *k*-means, BoW, K-NN, SVM.