Real-time assessment of mental workload with Near Infrared Spectroscopy: Potential for human-computer interaction

Introduction: Human computer interaction (HCI) is an interdisciplinary field that involves the study and development of user interfaces for computers. One challenge of HCI is the collection of quantitative information on human computer users, which is fundamental for evaluation purposes and real-time input [1]. The collection of neurophysiological data of cognitive workload has been proposed using multivariate electroencephalography (EEG) [2] and also functional near infrared spectroscopy (NIRS) [3]. In this work we propose to use machine learning algorithms for the analysis of near-infrared data, and apply this approach to process data collected on the forehead of human subjects while they perform tasks of increasing cognitive workload levels. The purpose is to develop a tool for quantitative and real-time assessment of cognitive workload to provide continuous feedback to a dynamic human-computer interface.

Methods and results: The experimental apparatus and the protocol are shown in the section on top. In the central section are shown the relative change of intensity (left side) and some folding average results for λ[Hb] and λ[HbO] (right side) obtained with modified Beer-Lambert law. The folding average results were obtained after a moving average band-pass filter in the range of 0.01-0.1 Hz. One period of activation/rest lasts about 85 sec. From the graphs of intensity change we can already see clear activations at all the source-detector distances. The trends of λ[HbO] and λ[Hb] shown in the folding average results are opposite of those usually expected for cerebral activation during finger tapping. However, in the literature these inverted trends during mental tasks were already reported [4]. In the section on the bottom are shown the results of the classification of three workloads according to two machine learning algorithms, namely the dynamic time warping (DTW) and the symbolic aggregate approximation (SAX). In the tables are shown the details and percentage of successful classifications.

Conclusion and future work: Machine learning algorithms applied to NIRS data show good potential for distinguishing different levels of mental workload. This is the first step towards the development of interactive human-computer interfaces. Future work will be directed for finding more efficient and systematic ways to choose the right instances (period of activations) from which we can get the best classification of the workloads.

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References:

Machine learning algorithms (DTW, SAX)

DTW

Subjects 1 2 3 4 5
Percentage 83.3% 77.8% 88.9% 77.8% 94.4%
Neighbors 2 1 1 1

SAX

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Dynamic Time Warping (DTW)

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RESULTS OF CLASSIFICATION OF WORKLOADS 0, 2, 4

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