Data driven analysis

Giuseppe Torrisi

King's College, London

Abstract

The Haemodynamic responce of different brain regions during mental arithmetic tasks is investigated.

Contents

1. Introduction

Brain computer interface (BCI). are devices that aim to interpret brain activity and produce digital signal that can be read by a machine. The main challenge is to online classify the brain signal in a stable and reliable way. In particular the key point for the development in BCI is to find patterns of brain activity associated to specific tasks.

In this report I analyse the hemodynamic response to metal arithmetic operation.

1.1. Measurement mechanism

Haemoglobin (Hb) is a protein found on red cells, it binds up to four O_2 molecules, making it the main Oxygen carrier in blood. The Hb shows structural changes when bound with oxygen. In this case oxy-Hb rather than deoxy-Hb is formed. Oxy-Hb and deoxy-Hb have different absorption

spectra. Since biological tissure is relatively transparent to light in the near-infrared range between 700 nm to 1000 nm [1], near-infrared spectroscopy (NIRS) is suitable to estimate Oxy-Hb and deoxy-Hb concentration [2].

The analysis of hemodynamic response can be used to measure the activity in different areas of brain [3]. Measurement at the brain tissue level [4] have suggested that in case of higher brain activity more O_2 is required, which causes the decrease of oxy-Hb. However, the blood flow rises to satisfy the higher need of oxygen. In conclusion, after the early decrease of oxy-Hb, the long term effect is the increases of haemoglobin oxygenation. The latter effect is exploited in NIRS to asses brain activity during the performance of specific tasks, *e.g.* cognitive[5], visual [6], and motor [7]. However, the temporal resolution of hemodynamic response spans over several seconds, making any analysis of NIRS challenging and problematic in the case of BCI.

1.2. Protocol

Data have been recorded from 8 University students (three males and five females, all right-handed aged 26.0 ± 2.8 years. They were asked to perform one digit subtraction from a two digit number (*e.g.* $93 - 5$). The protocol consists in performing as many mental operation in 12 second, then a 28 s rest is given. During rest person is asked to relax and not to move. This protocol is repeated 6 times. 3 or 4 run of this protocol is measured per participant.

The device records 52 channel with a sampling rate of 10 Hz

1.3. Data selection

The same dataset has already been used in [8, 9] to find pattern in the brain response to mental arithmetic tasks. They identify 3 regions of interest (ROI) each containing 3 channel, called ROI-1,ROI-2, and ROI-3 (see Table 1).They show that a antagonistic activation patterns occurs, consisting in the rise of oxy-Hb in ROI-2 and ROI-3 and decrease of oxy-Hb in ROI-1. Therefore in the following only the channels corresponding to ROI-1,ROI-2, and ROI-3 are considered. The authors point out that oxy-Hb concentration provides stronger and less noisy signal compared to deoxy-Hb concentration. Therefore in this report it has been chosen to consider the oxy-Hb concentration only.

Table 1: Channels belonging to the three Region of Interest as defined in [8]. In this report we examine the following 9 channels only.

ROI-1	46	47	48
ROI-2	18	28	29
ROI-3	13	23	24

2. Cusum

Cusum

[1] F. F. Jobsis, Noninvasive, infrared monitoring of cerebral and myocardial oxygen sufficiency and circulatory parameters, Science 198 (1977) 1264–1267.

[2] A. Villringer, B. Chance, Non-invasive optical spectroscopy and imaging of human brain function, Trends in neurosciences 20 (1997) 435–442.

[3] R. B. Buxton, K. Uludağ, D. J. Dubowitz, T. T. Liu, Modeling the hemodynamic response to brain activation, Neuroimage 23 (2004) S220–S233.

[4] D. Malonek, A. Grinvald, Interactions between electrical activity and cortical microcirculation revealed by imaging spectroscopy: implications for functional brain mapping, Science 272 (1996) 551–554.

[5] M. A. Franceschini, S. Fantini, J. H. Thompson, J. P. Culver, D. A. Boas, Hemodynamic evoked response of the sensorimotor cortex measured noninvasively with near-infrared optical imaging, Psychophysiology 40 (2003) 548–560.

[6] M. Herrmann, A.-C. Ehlis, A. Wagener, C. Jacob, A. Fallgatter, Near-infrared optical topography to assess activation of the parietal cortex during a visuo-spatial task, Neuropsychologia 43 (2005) 1713–1720.

[7] S. Wriessnegger, J. Kurzmann, C. Neuper, Spatio-temporal differences in brain oxygenation between movement execution and imagery: a multichannel near-infrared spectroscopy study, International Journal of Psychophysiology 67 (2008) 54–63.

[8] G. Bauernfeind, R. Scherer, G. Pfurtscheller, C. Neuper, Single-trial classification of antagonistic oxyhemoglobin responses during mental arithmetic, Medical & biological engineering & computing 49 (2011) 979.

[9] G. Pfurtscheller, G. Bauernfeind, S. C. Wriessnegger, C. Neuper, Focal frontal (de) oxyhemoglobin responses during simple arithmetic, International Journal of Psychophysiology 76 (2010) 186–192.