 DOI: 10.3217/978-3-85125-467-9-162

2-D analog like control of a cursor by means of SSVEP acquired with two dry electrodes and elicited by 4 LEDs

R. Ferrante[1*], G. Di Lorenzo[2], L. Bianchi[1]

[1] *DICII Tor Vergata University of Rome, Italy;*

[2] *Laboratory of Psychophysiology, Systems Medicine Dept. Tor Vergata University of Rome, Italy;*

* E-mail: raffaeleferrante1988@gmail.com

Introduction: In this study we propose a new SSVEP-based BCI approach [1] for 2D cursor control. Our goal is to allow a subject to gaze at a point on a PC screen and move a cursor on it, not fixing a flickering LED but gazing between 4 LEDs. The result is a dependent BCI which provides a mean ITR of 21 bit/min (SD: 3 bit/min). Data were collected using a wireless electroencephalograph with just two dry electrodes (O1, O2) and analyses were performed offline.

Material, Methods and Results: This study included 12 subjects (5f, 7m). We used 4 white flickering LEDs whose frequencies have been set, using Arduino UNO board, to 8.5 Hz – 9.5 Hz – 10.5 Hz – 11.5 Hz (see Fig. 1). Every subject had to gaze at 64 different target locations (red circles, fig. 1), while every trial was divided into 3 epochs: Inter-Trial Interval (1s), Cue (2s), during which the subject was instructed to the target location to gaze, and Performance (4s) during which the subject had to fixate the previously requested site. Targets were displayed on a PC screen within a square whose side was 21.7cm and whose vertices were populated by the four LEDs (Fig. 1) that were mounted on a fixed frame positioned on top of the PC screen. Subjects were positioned at a distance of 80cm from the center of the screen. Two EEG signals (O1, O2) were recorded by means of dry electrodes using a Bluetooth wireless communication electroencephalograph (NE StarStim).

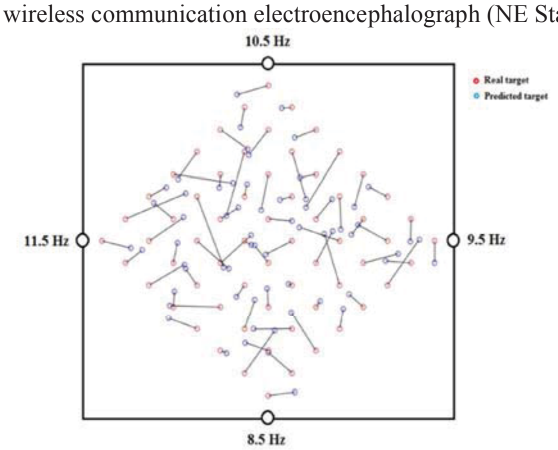

Fig 1. *LEDs position and errors for the best performing subject. Each segment represents the distance between the real (red) and estimated (blue) target.*

Spectral features (amplitudes and phases) were computed during the performance epoch of each trial by means of FFTs computed over 4s, thus obtaining a resolution of 0.25Hz. Those in the [5-99Hz] band were used to built 8 linear models, two for each LED, that linked spectral features with polar coordinates of the targets, centered at each LED location, after a pre-selection procedure which reduced the available features from 1504 to 48. Thus, from each LED, a model pair was built, one for the modulus and one for the phase, that identified in polar coordinates the location of the targets. A total of 4 models pairs, one for each LED, were then built. It should be noted that the same trial was then modeled by 4 different model pairs, thus according to 4 different polar systems.

For each of the 8 models, the choice of the best one (and so of the features set that composed it) was carried out according to Akaike AICc coefficients, computed iteratively 48 times while removing at each iteration the least significant spectral feature. We tested, using a leave-one-out approach, the proposed method by predicting each target location by estimating it from the 4 different models pair and after averaging across them.

The average error, computed as the difference between real and estimated target location, from all the targets and for all the subjects was 2.3cm (mean bit-rate 21±3 bits/min). For the best performing subject we obtained an average error of 1.8cm, and a theoretical bit rate of 27 bits/min.

Discussion: The results show that it could be possible to have an analog-like control of a cursor in 2D and with just 4 flickering LEDs. This can be obtained by building a model that relates spectral features of the elicited SSVEPs signal with the polar coordinates of a target having as origin a flickering LED. The BCI system we propose is particularly practical and comfortable, thanks to the use of only two dry electrodes. The stimulation is minimally annoying for the user, who can use the interface without directly gazing at a flickering LED.

[1] Zhu D, et. al. A survey of stimulation methods used in SSVEP-based BCIs. Comput Intell Neurosci. 2010:702357