A Generic Classifier for Brain-Computer Interfaces based on Steady State Visually Evoked Potentials

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Introduction: Brain-Computer Interfaces (BCI) allow a direct interaction between a subject and a computer through the interpretation of brain signals. Before starting an online BCI based on Steady State Visually Evoked Potential (SSVEP), a common user is presented to visual stimuli not to control an application, but simply to train the system classifier. This stage is essential for the proper functioning of the BCI at online mode, although it can be tiring or tedious for the subject. In order to reduce the training stage, in this study we have analyzed the use of data from other subjects in the design of the BCI classifier to verify the possibility of conceiving a generic BCI-SSVEP, which does not require a priori knowledge of the brain signals of the subject who manages it.

Materials and Methods: In this study, the brain signals of six health subjects of database described in [1] were used. There are 8 trials of 12 s for each subject, considering four visual stimuli flickering at 6, 10, 12 and 15 Hz, with a total of 32 trials per subject. The signals were acquired by electroencephalography with 16 dry electrodes and sampled at a rate of 256 Hz. Each trial of 12 s was windowed in 6 segments of 2 s and filtered by Common Average Reference. The feature extraction used the Welch method to estimate the Power Spectral Density around the evoked frequencies. The BCI employed a linear classifier based on least mean squares to discriminate between the four classes. For the training and validation of the classifier, three scenarios were considered: Scenario I - only the own data of the subject were used, 50% of the samples randomly selected were used for training and the remaining 50% of the samples were used for validation. We created 1000 random partitions of database. Scenario II - data from five subjects were used to train the classifier and the system was validated with data from a sixth subject. Scenario III - data from the five subjects and 50% of samples of the own subject were used to train the classifier and the remaining 50% of samples of the own subject was used to validate the system; also 1000 random partitions of database of subject were performed.

Results: Table 1 show the average hit rate for the six subjects in the three scenarios.

Subject	1	2	3	4	5	6	Average	Variance
Scenario I	80.95	86.05	91.80	88.33	87.58	58.53	82.20	1.47
Scenario II	59.90	59.38	62.50	55.21	67.19	40.63	57.47	0.84
Scenario III	67.77	71.90	74.30	75.14	74.42	69.72	72.21	0.09

Table 1 –BCI-SSVEP performance for three classifier training scenarios.

Discussion: The best performance of BCI is achieved when more training samples of the subject that validates the system are employed (Scenario I). However, the results indicate that it is possible to use data from other subjects to train the system, reducing the collection time for BCI-SSVEP training stage by 50%, with a performance reduction of about 10% (Scenario III).When no signals of the subject were used for training, the hit rate is around 57% (to discriminate four classes – Scenario II).

Conclusion: Results suggest that is possible to build a BCI-SSVEP system by reducing the number of samples of the own subject to train the classification system, since the hit rate is greater than 25% (random case with 4 classes). Future works include a greater database to generalize the classifier in order to improve the system accuracy.

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Reference: [1] Leite, H. M. A. (2018). Design de interação para interfaces cérebro-computador baseadas em potenciais visualmente evocados.