Universidad de Alcalá

25th Annual Meeting of the European Charcot Foundation
25 Years of Fundamental Milestones in MS
25th anniversary
30 November - 2 December 2017
Grand Hotel Dino Baveno, Italy

Departamento de Electrónica

# APPLICABILITY OF AUTOMATIC CLASSIFICATION OF mfVEP SIGNALS in MS ASSESSMENT

*L.de Santiago[1], L.Boquete[1]*

*(1) Department of Electronics, Universidad de Alcalá, Spain*

## INTRODUCTION. Motivation and Goal

•Previous works found significance difference between controls and Multiple Sclerosis (MS) definitive subjects using amplitud and latencies from mfVEP (1,4).

•Appropriate preprocessing of biomedical signals improves the patient diagnosis based on the results of signal classification.

•The goal of automatic classification is to predict labels for new test examples based on previous relations label-example.

• This work studies the performance of automatic classification applied to mfVEP signals using a k-nearest neighbor's algorithm.

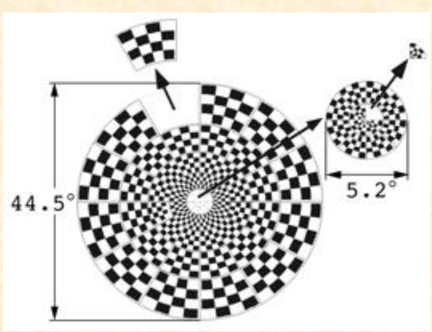
## INTRODUCTION. The mfVEP

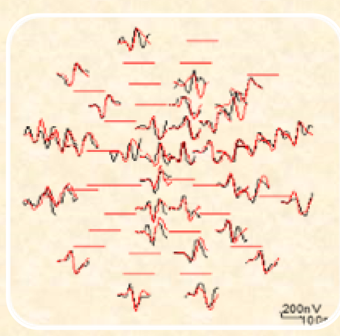
•The mfVEP test, measures the potentials obtained by stimulating the visual field divided in sectors using a flash or checkerboard visual stimuli.

•The mfVEP allows practitioners to analyze the topographical features of different segments of the visual field represented in the primary visual cortex. It is a valid tool for assessment of visual function in patients with pathologies that affect the visual pathway.

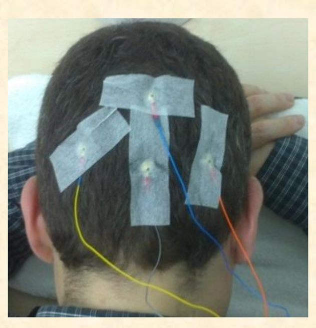
## The recordings and analysis

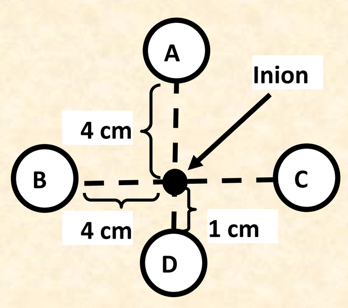
•Monocular mfVEP recordings are obtained using VERIS software 5.9 (Electro-Diagnostic Imaging. San Mateo. USA). The stimulus was a scaled dartboard with a diameter of 44.5, containing 60 sectors, each with 16 checks, (8 white / 8 black).

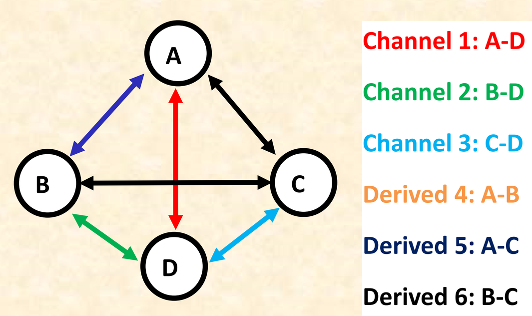


•Three channels of continuous mfVEP recordings are obtained using gold cup electrodes. Three others channels derived are obtained by substracting.





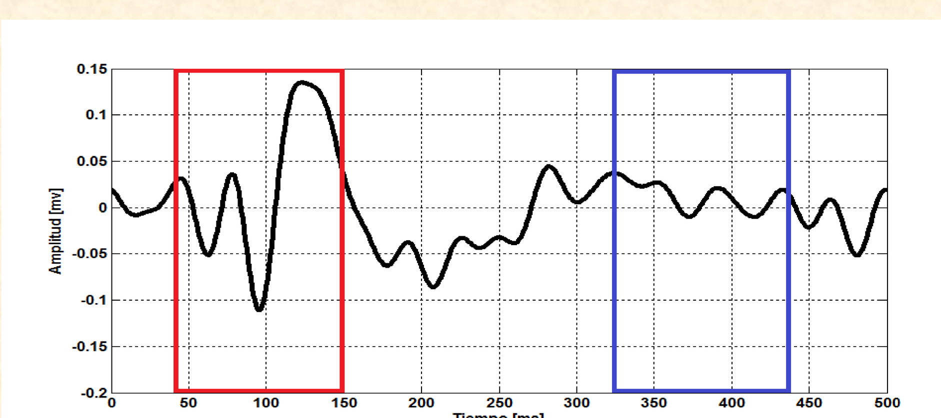




•The records are amplified with the low and high frequency cut-offs set at 3 and 100 Hz, and sampled at 1200 Hz. Impedance was <2 KΩ for all electrodes. The length of each record is 500 ms.

## METHOD. Amplitude measurements

•The signal to noise ratio (SNR) is the parameter used to quantify the quality of the mfVEP recordings (2,3).

•The recordings are divided in: signal window (45-150 ms) and noise window (325-450 ms). The SNR is computed as the Root Mean Square (RMS) of the signal windows divided by the RMS of the noise window mean of the 60 sectors.




$$SNR_S = \frac{RMS_S}{RMS_N}$$

$$SNR_N = \frac{RMS_N}{RMS_N}$$

## METHOD. Latency measurements

•Latency was measured as the temporal shift producing the best cross-correlation value between:

-Each individual and a template constructed by averaging responses from a control database (Monocular Latency =Mo_La)

-The corresponding responses of each eye (Interocular Latency =In_La)

## METHOD. Features vector

•For each subject, a features vector is constructed with the information of SNR, Mo_La and In_La of each sector:

| Sector 1 | Sector 1 | Sector 1 | Sector 2 | Sector 2 | Sector 2 | … | Sector 60 | Sector 60 | Sector 60 |
|---|---|---|---|---|---|---|---|---|---|
| SNR | Mo_La | In_La | SNR | Mo_La | In_La | … | SNR | Mo_La | In_La |

## METHOD. Subjects Database

22 right eyes from control subjects (Control label)

33 right eyes from patients with MS (MS label)

The eyes of MS subjects were also divided in Optic Neuritis affected (ON label) and no affected (noON label).

## METHOD. K-nearest neighbor's algorithm

The nearest-neighbor method is a simple algorithms for predicting the class of a test example.

The training step: store every eye features vector with its label.

| Subject | Features vector | Label 1 | Label 2 |
|---|---|---|---|
| *Control 1_OD* | *FV(Control 1_OD)* | *CON* | *--* |
| *Control 2_OD* | *FV(Control 2_OD)* | *CON* | *--* |
| … | … | … | … |
| *MS_01_OD* | *FV(MS_01_OD)* | *MS* | *ON* |
| *MS_02_OD* | *FV(MS_02_OD)* | *MS* | *noON* |
| … | … | … | … |

To make a prediction for a test eye:

•Compute its Euclidean distance to every eye features vector.

$$d(F_1,F_2) = ||F_1 - F_2|| = \sqrt{(F_1 - F_2)\cdot(F_1 - F_2)} = \left(\sum_{se=1}^{se=60\times 3} \left(F_{1_{se}} - F_{2_{se}}\right)^2\right)^{1/2}$$

•Keep the k closest features vectors, where k ≥ 1 is a fixed integer.

•Look for the label that is most common among these eyes. This label is the prediction for this test example.

## RESULTS

Confusion matrix for each classification:

| | Control | MS | % |
|---|---|---|---|
| Control | 32 | 2 | 94.11<br>5.88 |
| MS | 1 | 20 | 91.00<br>9.00 |
| % | 96.97<br>3.03 | 95.24<br>4.76 | 95.8<br>4.2 |

| MS | ON | noON | % |
|---|---|---|---|
| ON | 12 | 7 | 63.16<br>36.84 |
| noON | 3 | 11 | 61.12<br>38.88 |
| % | 80.00<br>20.00 | 21.40<br>78.60 | 71.1<br>29.9 |

•The global accuracy obtained for Control-MS classification is 95.8%.

•The global accuracy obtained for MS eyes: ON-noON is 71.1%.

•The best values were obtained for K=1

•Pool computation was used to reduced computing time to 1.87 and 1.18 seconds in each case.

## DISCUSSION

•Good classification accuracy results were obtained between control and patients.

•Moderate classification accuracy for ON-noON due to subclinical affection.

•Our results suggest that automatic classifier as k-NN used in combination with the actual techniques (MRI, OCT) could improve multiple sclerosis diagnosis.

•Proposed future works:

- use more sofisticated automatic classifier: neural networks.
- comparison between different comercial register equipment (example: VERIS vs. ROLAND).
- Study MS-risk patients.

## LITERATURE


- 1. Blanco R, Perez-Rico C, Puertas-Munoz I, Ayuso-Peralta L, Boquete L, Arevalo-Serrano J. Functional assessment of the visual pathway with multifocal visual evoked potentials, and their relationship with disability in patients with multiple sclerosis. Mult Scler J. 2014;20: 183–191.
- 2. De Santiago L, Ortiz del Castillo M, Blanco R, Barea R, Rodríguez-Ascariz JM, Miguel-Jiménez JM, et al. A signal-to-noise-ratio-based analysis of multifocal visual-evoked potentials in multiple sclerosis risk assessment. Clin Neurophysiol. 2016;127: 1574–1580.
- 3. Hood DC, Greenstein VC, Odel JG, Zhang X, Ritch R, Liebmann JM, et al. Visual field defects and mfVEP: evidence of a linear relationship. Arch Ophthalmol (Chicago, Ill 1960). 2002;120: 1672–81.
- 4. Van der Walt A, Kolbe S, Mitchell P, Wang Y, Butzkueven H, Egan G, et al. Parallel Changes in Structural and Functional Measures of Optic Nerve Myelination after Optic Neuritis. Frishman L, editor. PLoS One. Elsevier Academic Press; 2015;10: e0121084.


## Acknowledgements

This research was partially supported by Universidad de Alcalá grant: "Diagnóstico precoz de neuropatías ópticas mediante análisis de registros de potenciales evocados visuales multifocales" UAH GC2016-004 and ISCIII grant RETICS RD16/0008/0020.