The III Meeting of PhD Students
June 30, 2016

Multimodal Fusion Methods for Medical Diagnosis Based on EEG and ECG Signals.

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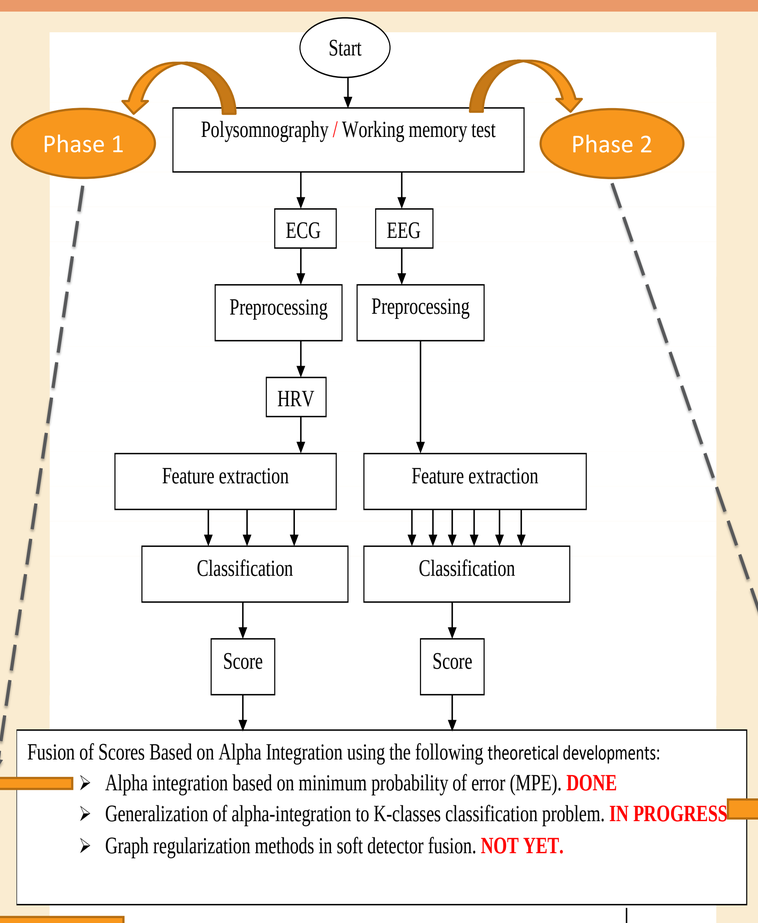
01 Objectives

There are many situations where the combination of different detectors leads to significant improvements in their individual performance. The general aim of this thesis will be to investigate the use of adapted α-integration, in order to verify the possible improvement in automatic detection and/or classification problems related to medical diagnosis.

On the other hand, our specific objectives behind the proposition of new methods based on α-integration are:

- Improving the individual performances of detectors /classifiers.
- To reproduce the manual detections given by the medical expert of microarousals during sleeping using automatic analysis of electroencephalogram and electrocardiogram, as much as possible.
- Improvement of the detection changes in stress condition in healthy humans during concurrent working memory tasks (the data are collected from subjects at the GTS lab (Grupo de Tratamiento de Señal, ITEAM, Universidad Politécnica de Valencia).

02 Research Methodology



The α-integration for d different detectors working on the same hypotheses and that everyone contributes with a scores s_i is given by:

$$s_\alpha(s=[S_1 \dots S_d]^T) = \begin{cases} \left\{\sum_{i=1}^{d} w_i . s_i(x)^{\frac{1-\alpha}{2}}\right\}^{\frac{2}{1-\alpha}}, & \alpha \neq 1. \\ \exp\left\{\sum_{i=1}^{d} w_i . log\,(s_i)\right\}, & \alpha = 1. \end{cases}$$

Where α and w_i are the α-integration parameters

The proposed Cost Function:

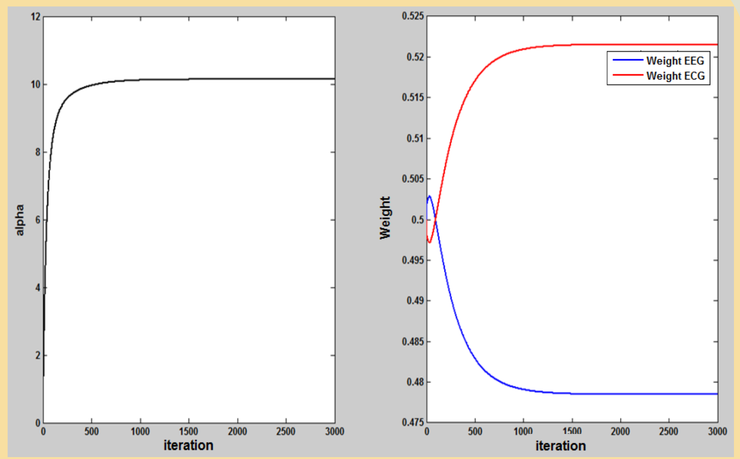
$$-lnP_c = -\sum_{j=1}^{N} y_j ln\left(s_\alpha(S^j)\right) + (1-y_j)\, ln\left(1-s_\alpha(S^j)\right)$$

Where: P_c is the probability of making correct decisions
y_j is is the known binary decision

03 Results

Phase 1 : Alpha integration based on minimum probability of error (MPE).

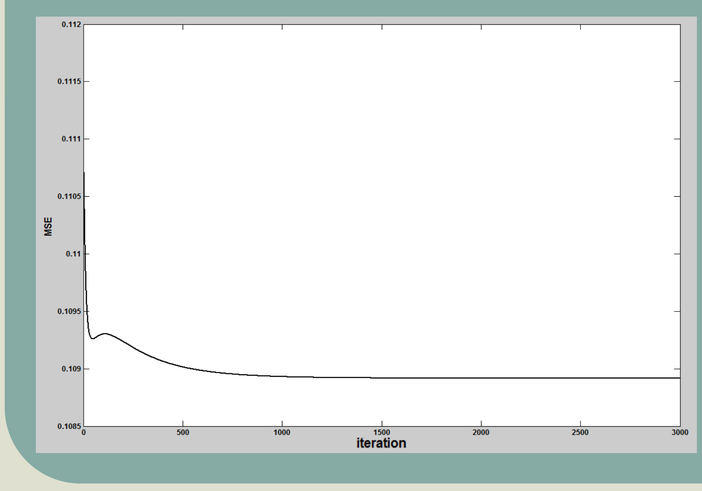
Patient	Sample size for learning (Number of epochs of 30 seconds			Sample size for testing (Number of epochs of 30 seconds)		
	Class 1	Class 2	Sum	Class 1	Class 2	Sum
Subject 1	302	133	435	292	142	434
Subject 2	313	85	398	290	108	398
Subject 3	418	65	483	451	32	483
Subject 4	416	29	445	405	40	445



01.Classification Features

02.Learning Parameters α and w_i

03.The MSE between the binary score and the decision of the expert



4.Percentage of Decisions Coincident with the Expert Decisions

Patient	Precision % EEG	Precision % VRC	Precision % α-Intégration	Parameters		
				Alpha (α)	Weights (w_i)	
					EEG	HRV
Subject 1	78.60	80.55	84.93	10.1383	0.4785	0.5215
Subject 2	77.39	74.37	77.51	17.0254	0.5552	0.4448
Subject 3	89.13	90.48	91.72	10.158	0.5786	0.4214
Subject 4	80.45	93.93	93.93	96.0269	0.2009	0.7991

04 Conclusion and Expected Results.

Using MPE, a new cost function is defined that is the negative of the log probability of correct answers. A real data case have been considered. The method has been applied in the fusion of two scores, respectively obtained from EEG and ECG records. The problem was the automatic detection of arousals during sleeping, which the medical expert currently does manually. Experiments in four subjects have illustrated the potential interest of MPE α-integration in these kinds of problems.

In addition, we expect when employing all the proposed α-integration algorithms adapted to the detection context to fuse scores corresponding to different detectors/classifiers will result in both higher accuracy and more improvement of the individual detector/classifier performance.

Main references

1. Choi, H., Choi, S., & Choe, Y. (2013). Parameter learning for alpha integration. Neural Computation, 25, 1585–1604.
2. Khaleghi, B., Khamis, A., Karray, F. O., & Razavi, S. N. (2013). Multisensor data fusion: A review of the state of the art. Information Fusion, 14 (1), 28–44.

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