PHD PROPOSAL IN ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

ROBUST HUMAN OPERATOR MONITORING THROUGH SIGNAL PROCESSING AND MACHINE LEARNING APPLIED TO PHYSIOLOGICAL FEATURES

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Net salary: 2096€ per month with some teaching (64 hours per year on average)

Duration: 36 months

DESCRIPTION

Context: Although research on brain-computer interfaces (BCIs) has been increasing dramatically these recent years, passive BCIs, systems that implicitly adapt to the operator based on his/her psychophysiological state, are still far from optimal in terms of accuracy. Yet they provide a means to perform operators' online monitoring in risky settings (e.g. aeronautical context) which is not feasible with subjective and behavioral measurements. Moreover, they enable engineers to build closed-loop systems that not only monitor but take into account this psychophysiological state to modify the interaction and/or the task in order to increase both safety and performance. The implementation of effective BCIs faces several issues including the following ones: i) The very nature of the signals makes this problem particularly complex. Indeed, the signal-to-noise ratio is very low for physiological signals such as cerebral ones. Also, they are non-stationary and fluctuate over participants, time and experiments; ii) Mental states can interact/overlap, and physiological features too (1; 2); iii) The size of the datasets used for learning is limited since they come from time and money-consuming experiments that involve humans. Therefore, a need for specific and robust classification pipelines exist, one that would be robust to mental states interaction, features' overlap, settings, participants and sessions. Many promising avenues have emerged to overcome these issues (3). For instance, adaptive classifiers (4) update learning using new data, which improves accuracy when the distribution of data changes over time. Transfer-learning (5) can also be a good solution when available datasets are not close enough to the actual considered data. The improvement of the BCIs has also been made possible by the use of techniques from Riemannian geometry (6), particularly in very noisy contexts (7). Other examples of solutions are control-inspired monitoring (8), dataset improvement with data generation (9; 10), deep learning (11) etc.

Content and Outline: This PhD topic addresses the issue of developing a pipeline to process physiological data in an online manner which would be robust to noise, to the work context and the operator, and which would enable to monitor mental states relevant in risky settings such as workload, fatigue, stress, and error detection. The physiological data of interest would mainly consist of cardiac and oculomotor measures recorded using ECG and eye-tracking devices, but also cerebral measures recorded by electroencephalography (EEG). The PhD would not include any experimental campaigns since the analyses would chiefly be performed on already acquired datasets and publicly available ones.

PhD outline:

• First year: literature review, databases identification and selection, development of state-of-the-art pipelines.

• Second year: benchmarking of signal processing and machine learning methods, proposal of a new pipeline, first scientific publication/proceeding.

• Third year: last comparisons and developments, thesis writing, second scientific publication/proceeding.

The main libraries that will be used:

• Scikit-learn – https://scikit-learn.org/stable/

• MNE-python – https://martinos.org/mne/stable/index.html

• Pytorch – https://pytorch.org/

• EEGLab – https://sccn.ucsd.edu/eeglab/index.php

• Gumpy – http://gumpy.org/

• PyRiemann – https://github.com/alexandrebarachant/pyRiemann

PhD candidate’s profile:

• Applied Mathematics, Artifical Intelligence, Signal Processing or Biomedical Engineering background;

• Strong programming skills;

• Autonomous, hard-working, problem-solver;

• Interested in Neuroscience and Cognitive Science.

Collaborators: ANITI Chair holder Professor Frédéric Dehais, as well as Dr Caroline Ponzoni Carvalho Chanel and Dr Fabien Lotte (INRIA Bordeaux).

References:

[1] R. N. Roy, S. Bonnet, S. Charbonnier, and A. Campagne, “Mental fatigue and working memory load estimation: interaction and implications for EEG-based passive bci,” in 2013 35th annual international conference of the IEEE Engineering in Medicine and Biology Society (EMBC), pp. 6607–6610, 2013.

[2] R. N. Roy and J. Frey, “Neurophysiological markers for passive brain–computer interfaces,” Brain–Computer Interfaces 1: Foundations and Methods, pp. 85–100, 2016.

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[11] R. T. Schirrmeister, J. T. Springenberg, L. D. J. Fiederer, M. Glasstetter, K. Eggensperger, M. Tangermann, F. Hutter, W. Burgard, and T. Ball, "Deep learning with convolutional neural networks for EEG decoding and visualization," Human brain mapping, vol. 38, no. 11, pp. 5391–5420, 2017.

APPLICATION PROCEDURE

Formal applications should include detailed cv, a motivation letter and transcripts of bachelors' degrees.
Samples of published research by the candidate and reference letters will be a plus.
> applications should be sent by email to: advisor email
More information about ANITI: https://aniti.univ-toulouse.fr/