NOVA I4H – Thesis Proposal

Title:

Deep Learning for Biosignals Classification applied to Functional Near Infrared Spectroscopy

Objectives:
Deep Learning is a machine learning technique which uses optimization to automatically extract features. It has been successful in many different fields, including machine translation, molecular biology and autonomous driving. By automatically extracting features, it will be possible to recognize patterns in brain activity.

Monitoring physiological mechanisms via instrumentation of physical measures in the electrical, mechanical and optical dimensions have provided an increased number of biosignals to use in many biomedical applications. Functional near-infrared spectroscopy sensing has appeared as a novel instrument to extract information from physiological mechanisms. This sensing technique started to be used in sports performance tasks to evaluate the local oxygenation of the muscles and on cognitive psychology and neurology research tasks to evaluate the cognitive process in the brain. More recently, this technique has been used for the detection of disease-related events, such as epileptic seizures.

In order to use fNIRS to analyze the human brain, subtle patterns in neural activity can be identified by extracting features from these signals and finding correlations or causes between activity centers. However, these features are not easily discovered by human analysts.

In this context, this thesis will focus on the development of signal processing and classification methods for multi-channel fNIRS signals, with the objective of obtaining knowledge about the human brain and using it to help doctors and psychologists. For this purpose, novel deep learning and signal processing methods will be studied and applied to multi-channel fNIRS.

The challenges with signal processing of fNIRS physiological changes, coming from light interference, placement difficulty, among other problems will request models with a high degree of robustness to noise. Deep learning classification techniques will be applied to multi-signal time series and must have the ability to model spatial relations.

Use cases will be created in the areas of sports performance, cognitive psychology and medical diagnosis to demonstrate and document novel applications of fNIRS. The developed algorithms for the application scenarios will be shared with the scientific community via mature publications and by placing the code and documentation in open source repositories.

Framework:

Established in 2007, PLUX creates innovative products for industry, clinicians and researchers, by developing advanced biosignals monitoring platforms that integrates wearable body sensors combined with wireless connectivity, algorithms and software applications. PLUX has a strong background on research collaboration with Universidade Nova de Lisboa. In the context of this thesis, the research on novel algorithms for fNIRS analysis will enable the extraction of useful knowledge about the human brain and its application to psychology, sports and medicine.

This project will be developed in collaboration with the laboratory of Biomedical Instrumentation Lab – LIBPhys of Universidade Nova de Lisboa and will be will be supported by a company/faculty PhD grant assigned by FCT.

Tasks:
The candidate should investigate the current state of the art deep learning techniques applied to multimodal time series. The core developments will be on the processing and classification of multi-channel fNIRS data, with all the development documentation and open source repositories. The algorithms will be validated by comparison with other research results. The intermediate results of the PhD should be presented in conferences and published in journals with known impact factor, on the areas of biomedical engineering and machine learning. During the innovation process, careful attention should be given to identify ideas that can be part of intellectual property protection.

Venue:
This project will take place in the Biomedical Instrumentation Lab of FCT/UNL, as well as in PLUX Wireless Biosignals.

Candidate profile:

Considering that this project focuses heavily in signal processing and machine learning, the candidate should have expertise on biomedical engineering, electrical engineering or physics engineering. The candidate should have experience in implementing deep learning and analog/digital signal processing algorithms.

The capacity to innovate, and develop new techniques for sensing systems along with the physical design devices, as well as the necessary critical aptitude towards all the procedures that he/she might be involved.

In addition, since this collaboration is between a faculty and an enterprise, the candidate must be prepared to develop his/her activity in an industrial environment, when necessary.

Supervisor

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