**Time-Frequency-Topography (TFT) analysis for continuous wave functional near infared spectroscopy (CW-fNIRS)**

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**Area**: Data analysis and signal processing.

*Aim*: To implement a tool for conducting TFT analysis and apply this analysis to a CW-fNIRS dataset from surgical neuroergonomics.

*Background*: Time-Frequency-Topography (TFT) analysis [1] is a highly expressive yet often unexplored data visualization approach in which a dataset can be observed in three major domain representations, i.e. time, frequency and space, all at once permitting a fast yet detailed appreciation of major underlying driving mechanics of the phenomenon being observed. TFT analysis is popular in some neuroimaging modalities such as EEG, but it has never been employed in CW-fNIRS perhaps because of the inherent bivariate nature of the fNIRS signal which at any location can measure both oxy- and deoxygenated haemoglobin.

Methods: You will be provided with a neuroimaging dataset collected using continuous-wave functional near infrared spectroscopy (CW-fNIRS) by our colleagues at Imperial College studying surgical neuroergonomics [2]. In this dataset, brain haemodynamics of the surgeons whilst executing a simulated surgical task was collected to understand surgical skill acquisition and performance in a cohort of surgeons of different expertise under some stress condition. This project requires you to:

1. Get a thorough understanding of TFT analysis (at mathematical level so that you can later modify it to suit CW-fNIRS particularities).
2. Replicate the implementation of an existing univariate TFT analysis available for EEG in Matlab
3. Modify the above TFT analysis to support bivariate analysis
4. To design and apply a reconstruction and processing pipeline to the provided fNIRS dataset to clean the raw data from major artefacts and prepare it for analysis. Existing software tools such as Homer 3, MNE-NIRS, ICNNA or NIRS toolbox may be of use for this task.
5. To conduct a TFT analysis on the dataset and report the consequent findings.
6. Validate findings against standard task-baseline statistical analysis.

*Expected outcome*: Segregational statistics regarding active brain regions under different experimental condition and validation against standard task-baseline statistical

analysis.

*Related literature*:

[1] Marroquin, JL et al (2004). Exploratory EEG data analysis for psychophysiological experiments. NeuroImage 21 (2004) 991–999

[2] Goble, M et al (2023). Optical neuroimaging and neurostimulation in surgical training and assessment: A state-of-the-art review, Front. Neuroergon. 4:1142182. doi: 10.3389/fnrgo.2023.1142182