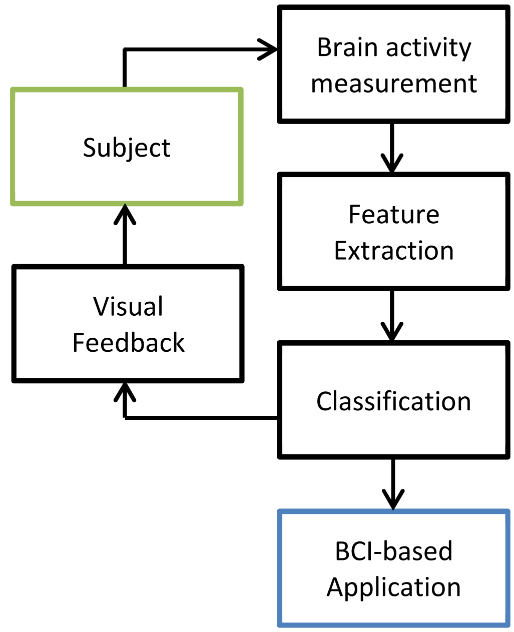
BCI and Neurofeedback

1. BRAIN-COMPUTER INTERFACE

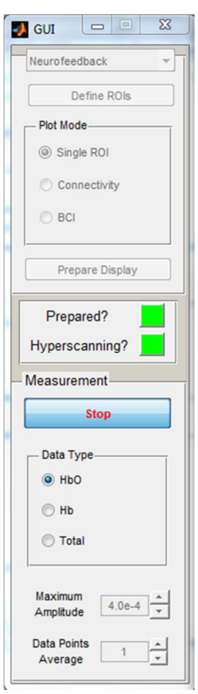


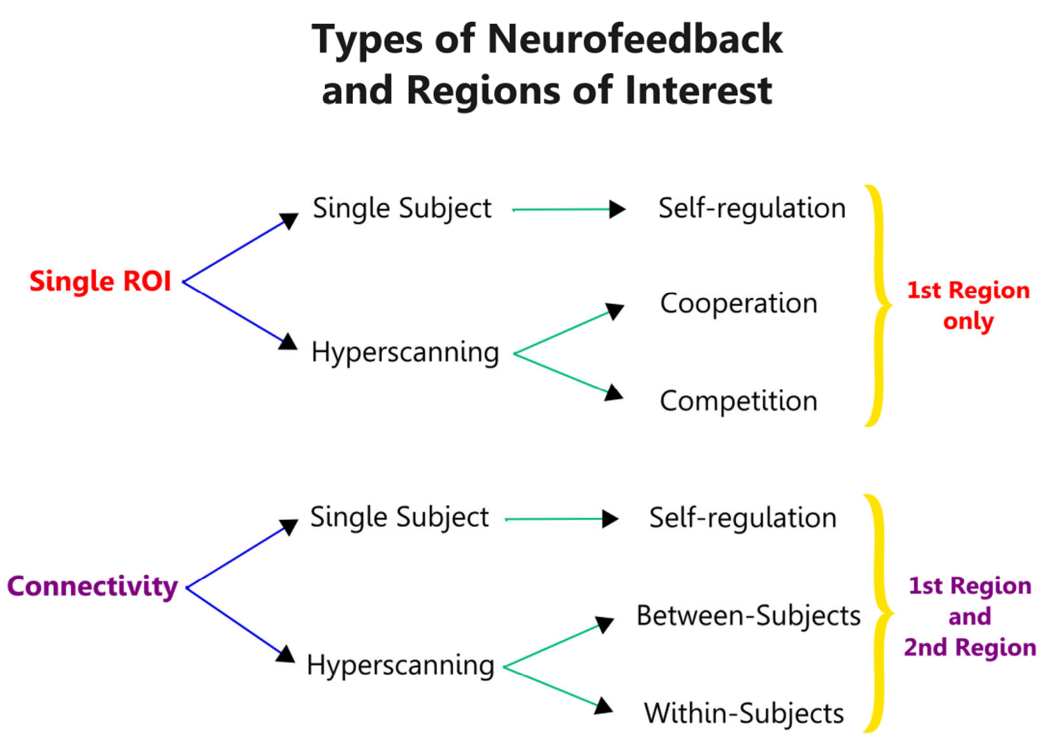
Brain-Computer Interface (BCI) represents the communication between the brain and a computer that may be used to interpret the real-time activity of the brain through signal processing and machine learning. Such communication offers a great gamma of possibilities for the medical focused research, for example the development of prosthetics controlled by motor imagery, calibration of cochlear implants and communication improvement of patients with amyotrophic lateral sclerosis.

Given its great performance in the presence of muscles movements, the system portability and its ease of application, fNIRS presents itself as an optimal candidate to acquire the cortical brain signals as reliable and representative inputs for a Brain-Computer Interface investigation.

2. NEUROFEEDBACK

Yet another whole field to be explored is based on neurofeedback, i.e. the feedback obtained from the online brain activity that may be used for the subject's self-regulation. With the advent of fNIRS and its capability of measuring two or more subjects at the same time on realistic environments, the neurofeedback possibilities based on hemodynamic states have been widely expanded, as depicted on the schematic below. Research fields that may strongly benefit from that are social interaction, stroke rehabilitation and emotions regulation.

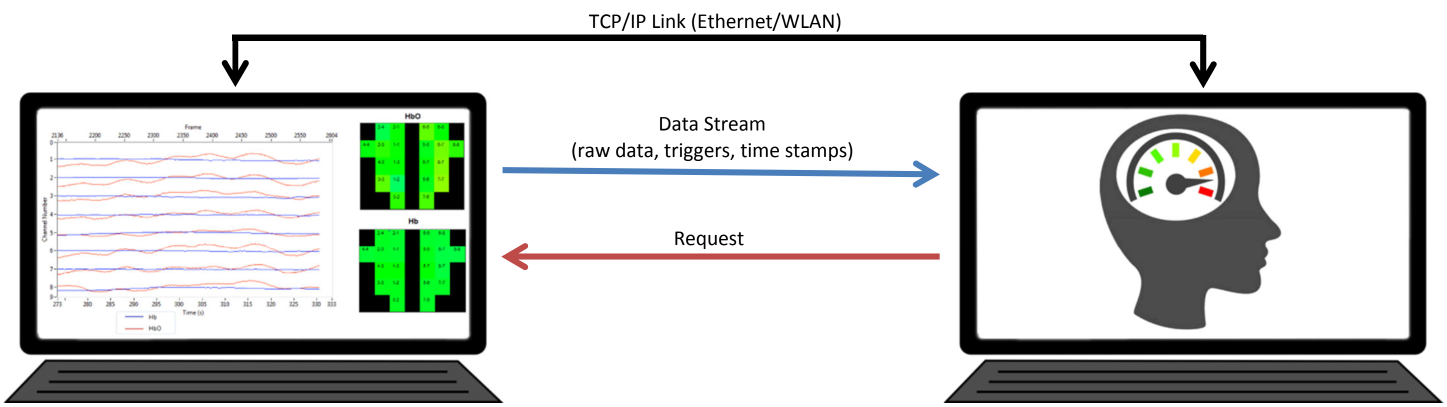




BCI and Neurofeedback

3. DATA STREAMING

A key process for both BCI and Neurofeedback is the possibility of streaming the raw data along with the trigger markers from the acquisition computer (server) to the presentation computer (client). This allows for real-time processing of the raw data, which is essential for feature extraction for BCI as well as convertion to hemodynamic states to be used as input for the Neurofeedback module. A general schematic is shown below.



The real-time data stream, as depicted above, can be easily achieved with the NIRx Software Development Kit (SDK), which provides a dynamic library that allows the user to communicate with the acquisition software. *Users without programming knowledge may also easily benefit from SDK with the several examples available.

4. USE CASES

Two examples of results recently published by NIRx users focusing on feature extraction and discrimination of different tasks are shown below. These illustrate how hemodynamic states are robust for signal classification.

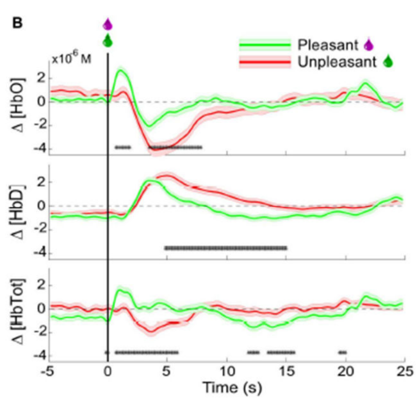


Fig. 1. Hemodynamic changes after unexpected delivery of pleasant and unpleasant liquids. **[1]**

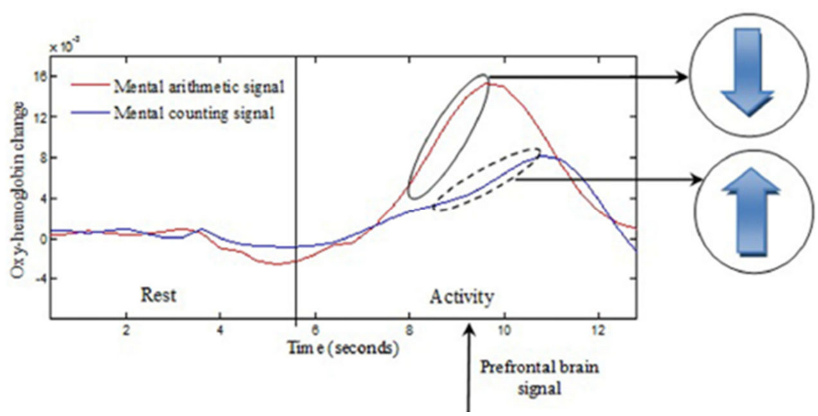


Fig. 2. Features from mental arithmetic and mental counting signals are extracted and decoded for a hybrid brain-computer interface. **[2]**

[1] DiStasio, M.M., and Francis, J.T., "*Use of frontal lobe hemodynamics as reinforcement signals to an adaptive controller*", PLoS ONE 8(7), e69541, doi:10.1371/journal.pone.0069541 (2013).

[2] Khan, M.J., Hong, M.J., and Hong, K.-S., "*Decoding of four movement directions using hybrid NIRS-EEG brain-computer interface.*" Frontiers in human neuroscience 8(244), 1, doi:10.3389/fnhum.2014.00244 (2014).