Titre : AIoT based Neural Decoding and Neurofeedback for a Cognitive Training Acceleration

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Summary:

The main objective of this master II internship for PhD track is to design adequate tiny machine learning and pattern recognition algorithms in order to extract the relevant features and characteristics from EEG and ECG signals, implement them in microcontroller and finally design a neurofeedback system to accelerate brain training (attention or/and working memory or/and emotional intelligence) by improving efficiency and reducing training time.

Description:

Attention is a very important factor in cognitive efficiency. It allows us to notice and select a subset of information from all that is available so that we can process that information. Our attention system is needed for almost everything we do - whether it's learning, memorizing, perceiving, communicating, or solving problems, etc. it is also important for the regulation of our own emotions. Attention guides the allocation of processing resources. Efficient resource allocation means rapid availability of information for superior mental processing. Moreover, attentional guidance is crucial in tasks that require the coordination of several cognitive operations by providing the appropriate resources. All of these functions in information processing present attention as a major source of cognitive efficiency. Finally, sustained attention and rapid changes between various cognitive operations are strongly correlated with intelligence.

Working memory, another very important component of the cognitive base, emerged due to mental activities requiring the availability of several pieces of information in a limited amount of time. Such activities link multiple pieces of information together in a complex pattern. It is essential for the mental activities that are believed to be the basis of intelligence.

Because attention and working memory show a substantial relationship with intelligence, and thus a strong correlation with academic and professional success, improving attention and working memory is particularly relevant. Moreover, neuroplasticity is a remarkable feature of the brain. Indeed, neurons are able to adapt quickly to the demands imposed on them. By developing new neural networks and strengthening important connections, a cognitive training program can measurably and sustainably improve brain activity. It can also trigger the birth of new neurons. This is why the last two decades have seen an impressive effort towards the design and implementation of cognitive training programs especially with new technologies to improve general cognitive ability and slow its decline in the elderly.

This internship will not be to design a new computerized cognitive training technique, but rather to build on millennium and well-known training techniques, such as mindfulness for attention training and the method Loci or memory palaces for memory training. The main objective is to collect appropriate physiological signals including EEG and ECG, to design adequate tiny machine learning and pattern recognition algorithms to extract relevant features and finally to design a neurofeedback system to accelerate the training of attention and working memory by improving efficiency and reducing training time.

After signal acquisition, the main work consists of three main steps: feature extraction, classification, and design of the neurofeedback system. The collected signals will be analyzed both in the time domain and in the frequency domain. A nonlinear analysis will also be performed. Tiny machine learning and pattern recognition algorithms from a wearable device design perspective under limited hardware capacity constraints will be investigated for feature extraction and classification. Finally, to validate the algorithms studied, an implementation in Microcontroller will be carried out.