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Modulation of Neural Cross Frequency Coupling analysis in VLSI Architecture

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ABSTRACT

Cross-frequency coupling (CFC) is a key mechanism in neuronal computation, communication, and learning in the brain. Abnormal CFC has been implicated in pathological brain states such as epilepsy and Parkinson's disease. A reduction in excessive coupling has been shown ineffective neuromodulation treatments, suggesting that CFC may be a useful feedback measure in closed-loop neural stimulation devices. However, processing latency limits the responsiveness of such systems. VLSI architecture is presented which implements the phase locking value of CFC to enable the application specific trade-off between low-latency and high-accuracy processing.

KEYWORDS: *Cross Frequency Coupling, Low Latency, High Accuracy*

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INTRODUCTION

Now a day's simulation plays a major role that wise cross-frequency coupling (CFC) is a key mechanism of neuronal computation and communication of the brain states. With the help of cross- frequency coupling (CFC) captured the abnormal pathological brain signals. Cross- frequency coupling (CFC) used as feedback in closed loop neural simulation. Importantly, while high-frequency brain activity reflects local domains of cortical processing, low-frequency brain rhythms are dynamically entrained across distributed brain regions by both external sensory input and internal cognitive events. Cross- frequency coupling (CFC) may thus serve as a mechanism to transfer information from large-scale brain networks operating at behavioral timescales to the fast, local cortical processing required for effective computation and synaptic modification, thus integrating functional systems across multiple spatiotemporal scales.

The neuronal simulation environment is designed for modeling individual neurons and networks of neurons, and is widely used by experimental and theoretical neuroscientists. It provides tools for conveniently building, managing, and using models that are numerically sound and computationally efficient. The Neuron is particularly well-suited to problems that are closely linked to experimental data, especially those that involve cells with complex anatomical and biophysical properties.

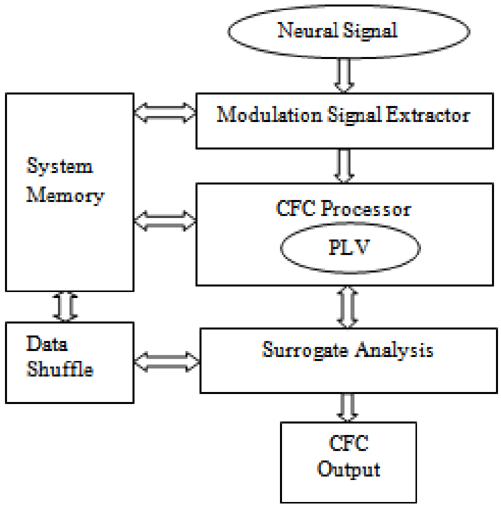
Phase-amplitude coupling (PAC) a form of cross-frequency coupling where the amplitude of a high-frequency signal is modulated by the phase of low-frequency oscillations. The existing methods for assessing PAC have some limitations including limited frequency resolution and sensitivity to noise, data length, and sampling rate due to the inherent dependence on bandpass filtering. Cross- frequency coupling (CFC) have Phase-amplitude coupling (PAC) is one of the most common representations of the cross- frequency coupling (CFC). PAC reflects the coupling of the phase of oscillations in a specific frequency band to the amplitude of oscillations in another frequency band. In a normal brain, PAC accompanies multi-item working memory in the hippocampus, and changes in PAC have been associated with diseases such as schizophrenia, obsessive-compulsive disorder (OCD), Alzheimer's disease (AD), epilepsy, and Parkinson's disease (PD).

Depending on the reference paper, we altered the CFC processor of Phase Locking Value (PLV) with the help of Hilbert transform. The feedback of closed-loop processing based on CFC, low latency has quickly recognized the parameters and states of the brain. Also, the architecture is versatile and increased the latency, power consumption to find the signals with the help of surrogate analysis.

METHODOLY

Phase-amplitude coupling is build to study cognitive processes in electroencephalography (EEG) and magneto encephalography (MEG) and various signals could be measured. Phase- locking value (PLV), mean vector length (MVL), modulation indexes (MI) are the generalized linear modelling of cross-frequency coupling (GLM- CFC). In that, Phase locking value (PLV) placed the major part of this project. The Cross-Frequency Phase Locking Value (CF-PLV) has been proposed to detect the cross-frequency synchrony between a low-frequency phase and a high-frequency envelope phase. So we could detect easily the extraction of signals. This method will be implemented in VLSI and detail discussed in the below sections.

BLOCK DIAGRAM



In Block Diagram, Neural signal passes to the modulator. The modulators extracted the samples and send them to the CFC processor. Cross frequency coupling analysis has Phase locking value (PLV) to decrease the period. A system resource has Hilbert filter and Multiplier and counting the data.

I. CFC PROCESSOR

A. Cross-Frequency Phase Locking Value (CF-PLV)

The goal of the CF-PLV algorithm is to detect the cross-frequency Synchrony between the phase of the low frequency modulating signal ($\varphi fp(t)$), and the phase of the envelope extracted from the high frequency modulated signal ($\varphi fA(t)$). The phase difference between both signals is calculated as

$$\Delta\varphi\ (t) = \varphi fA(t) - \varphi fp(t)$$

II. SURROGATE ANALYSIS

To consider the level of statistical significance of the estimated CFC metrics, a surrogate distribution is formed by repeating the computation of either MVL-MI or CF-PLV with shuffled versions of the amplitude signal, fA(t). This process is accelerated using a random access circular sample buffer which is used for inter-sample memory storage. The random selection of the start point in each shuffle iteration is performed using a linear feedback shift register (LFSR) is a pseudorandom number generator. This acts as a memory address generator to access a random start points in the circular buffer, from which the surrogate is generated. The mean, μ, and variance (Mean Absolute Deviation) are calculated across the set of values from each surrogate iteration, which is used to assess the significance of the CFC metric. 50 permutations can be sufficient. However, this can be increased dynamically, depending on the required accuracy.

CONCLUSION

In this paper, Cross Frequency Coupling has modified with the help of Hilbert transform. The phase-locking value is programmed with a high ratio so collect the result of the EEG signals. The simulation could be useful to get signals of normal and abnormal EEG.

For better time resolution and precision, CF-PLV has been demonstrated. However, this measurement comes at the expense of increased latency. The architecture implements these measures with power efficiency suitable for implantable devices, enabling responsive closed-loop in vivo experiments involving CFC.

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