BITS Pilani
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Dept. of Computer Science and Information Systems

CS F433: COMPUTATIONAL NEUROSCIENCE

Spatial Spread of the Local Field Potential and its Laminar Variation in Visual Cortex

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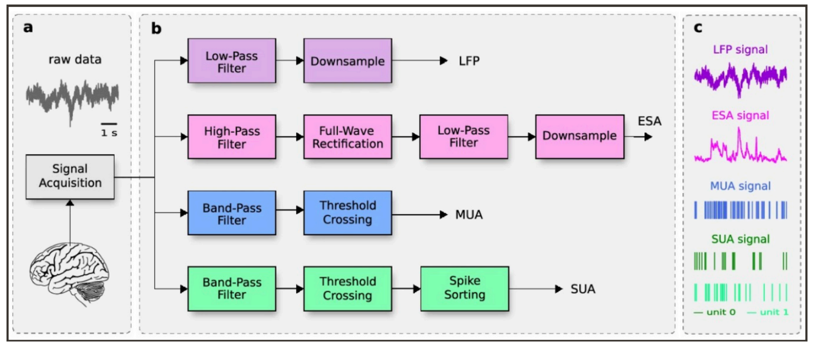
ABSTRACT

The cortical processing of visual information is fundamental in understanding how the brain interprets complex stimuli. This study investigates the spatial spread of the Local Field Potential (LFP) and its laminar variation in the visual cortex, providing insights into the synaptic and neural network mechanisms underlying visual processing.

The small cortical spread of LFP signals, the LFP and multi-unit activity (MUA) recorded simultaneously had similar visual field maps. Therefore, the LFP is a good index of **local circuit activity**.

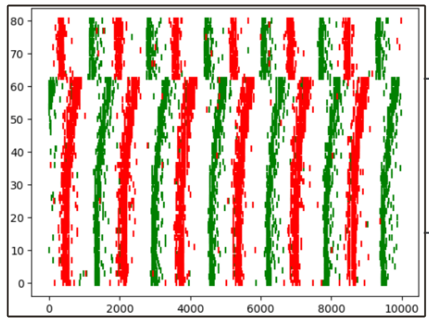
TYPES OF SIGNALS

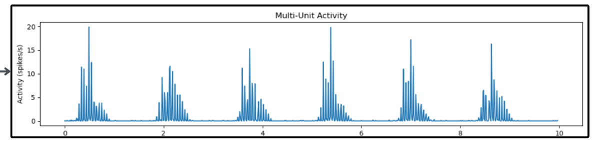


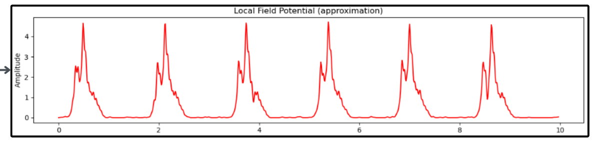
METHODOLOGY

Retinal responses to moving vertical bars were recorded via a multi-electrode array, capturing the neural activity across an 81-unit grid. Event timestamps, reflecting 'ON' (increase in light intensity) and 'OFF' (decrease in light intensity) stimuli responses, were extracted and stored in a structured dataset for analysis.

DATA EXTRACTION

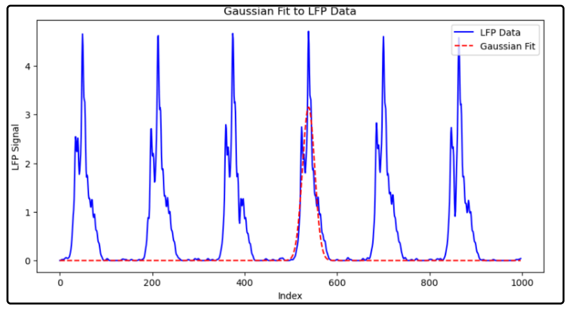






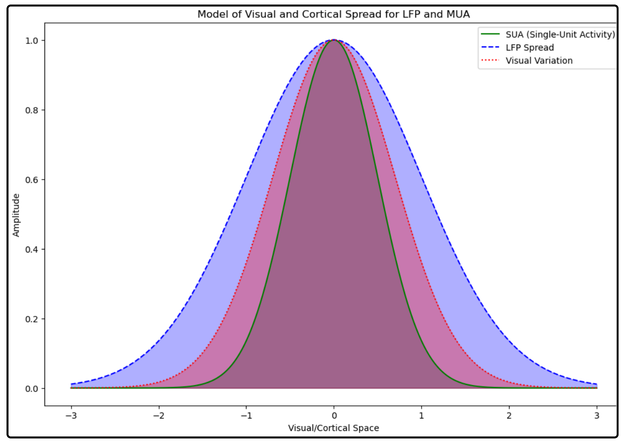
Computes Multi-Unit Activity (MUA) from neuronal spike events and simulates the Local Field Potential (LFP) using Gaussian smoothing.

GAUSSIAN FITTING



To characterize the temporal profile of the MUA signal, a Gaussian fitting procedure was applied. Using initial parameter estimates, the curve_fit algorithm optimized a Gaussian function to fit the MUA data, providing amplitude, mean, and standard deviation of the activity peak.

MODEL SIMULATION



$$VS_{MUA}(y) = \sum_i g_{cMUA}(MF \cdot (y - y_i)) \cdot VS_{SUA}(y_i)$$

$$VS_{LFP}(y) = \sum_i g_{cLFP}(MF \cdot (y - y_i)) \cdot VS_{SUA}(y_i),$$

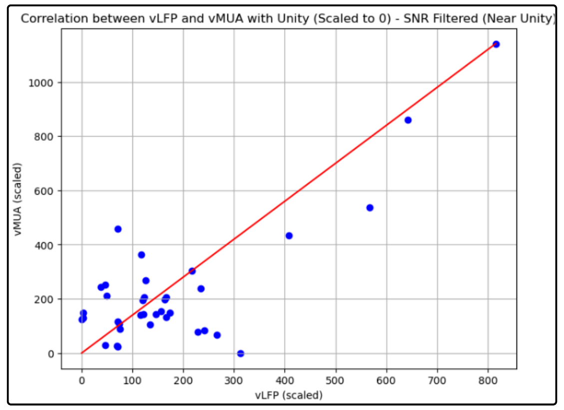
$$\sigma_{cLFP} = \sqrt{MF^2\,\sigma_{vLFP}^2 - MF^2\,\sigma_{vMUA}^2 + \sigma_{cMUA}^2}.$$

Signal Summation: The model for spatial summation in Multi-Unit Activity (MUA) and Local Field Potential (LFP) is grounded on the notion that each signal comprises the collective electrical activity of a group of neurons.

Retinoptic scatter: The variability or "scatter" in the mapping of the visual field onto the retinotopic map within the visual cortex. Ideally, this mapping would be precise, but due to natural variations in the nervous system, it is not perfect.

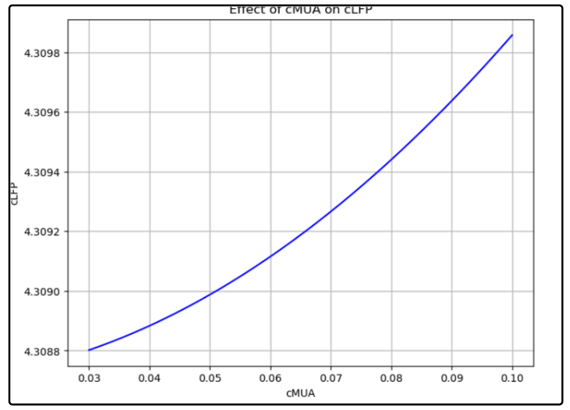
RESULTS

CORRELATION OF vMUA & vLFP



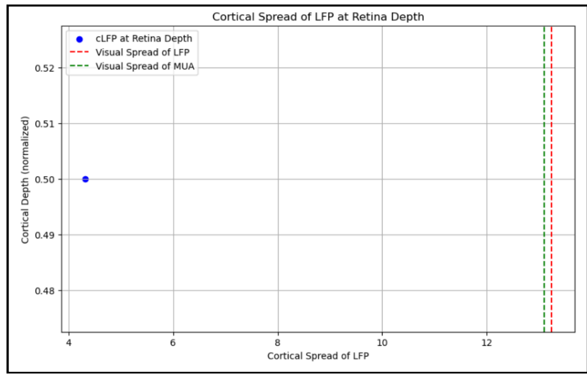
This plot shows that the visual spread of MUA and LFP are highly correlated with each other.

CORRELATION OF cMUA & cLFP

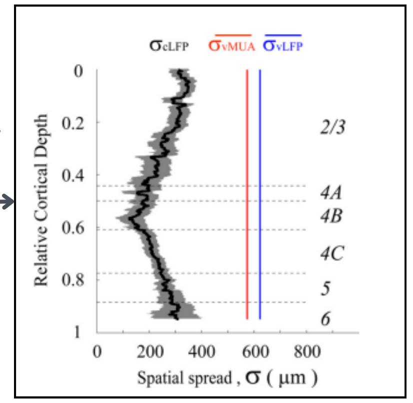


This plot shows that cMUA does not effect the cortical spread of LFP.

Relation of cLFP, vMUA, vLFP with cortical depth at single site



If simulated for multiple layers



This plot shows that how cortical spread of LFP is very small in comparison to vLFP and vMUA.

This plot shows that how cortical spread of LFP varies in different cortical layers

CONCLUSIONS

- The visual spreads of MUA and LFP were similar , visual spread of MUA being slightly less than LFP
- Varying MUA spread within 30μm to 100μm range had no notable impact on their estimation of Local Field Potential (LFP) cortical spread.
- The relatively small value of cortical spread is one important reason why the visual spreads of MUA and LFP are so similar.

REFERENCES

Xing D., Yeh C., & Shapley R. (2009). Spatial Spread of the Local Field Potential and its Laminar Variation in Visual Cortex. The Journal of Neuroscience, 29(37), 11540–11549. https://doi.org/10.1523/jneurosci.2573-09.2009

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