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## P246 A Computational Pipeline for Simulating Mouse Visual Cortex Microcircuits with Spiking Neural Networks

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### Introduction

To integrate in vitro methodologies with in silico techniques, to investigate brain development and neural circuit interactions, we are preparing a computational pipeline to recreate Brain-on-Chip [1] systems with spiking neural networks. We leveraged the MICrONs dataset [2], which provides detailed reconstructions of neurons and astrocytes, with their connections, in a cubic millimeter of mouse visual cortex. The dataset presents significant challenges for computational modeling, particularly regarding quality and quantity of the automatically identified synapses. In this work, we establish a pipeline for transforming raw data into functional spiking neural networks that accurately represent cortical microcircuits.

### Methods

The MICrONs dataset showed critical limitations: insufficient synapses and incorrect morphological attributions. Two solutions were implemented: Synapse enhancement through cloning, generating a cluster of synapses placed in a sphere centered on the original synapse. The new synapses are validated through layer densities analyses [3]. Improve synapse attribution using proofread astrocytes to establish connectivity patterns for non-proofread cells. For neurons, templates from proofread synapses will serve as models for non-proofread neurons. The framework incorporates layer-specific connectivity with bidirectional astrocyte-neuron interactions. Comparisons were made with networks having the same neurons but different connectivity [4].

### Results

Our synapse enhancement method generated clusters of 10 synapses placed in spheres with 10 µm radius, centered on original synapses. This successfully increased the overall synapses count while maintaining layer-specific patterns. A geometric approach was developed that defines minimum ellipsoidal domains containing all synapses belonging to each proofread astrocyte [5]. These ellipsoid representations served as spatial patterns for non-proofread astrocytes. For neurons, template-based attribution from proofread synapses increased the accuracy of connection identification. Layer-specific connectivity analysis demonstrated that our reconstructed network successfully preserved the characteristic connection patterns across cortical layers (Fig1).

### Discussion

This work addresses the identified limitations in using the MICrONs dataset. The developed methods correct connectivity data, enabling more accurate modeling of cortical microcircuits. The approach preserves connections and layer-specific organization unique to the MICrONs dataset. This network is then imported and simulated as a spiking neural model to generate biologically realistic activity. This framework also allows testing alternative network architectures (e.g., random, small-world, etc) compared to the accurate structural connectivity. Future work will refine astrocyte-neuron interaction models. These methodologies could then be applied to BoC experimental data, further validating the computational approaches.

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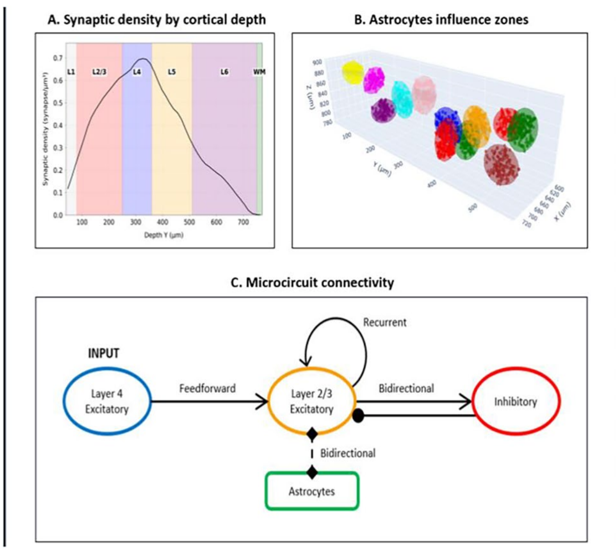


**Figure 1:** A. Enhanced synaptic density distribution across cortical depth. B. Astrocyte influence zones represented as ellipsoidal regions, each containing associated synapses. C. Functional connectivity diagram of the reconstructed microcircuit showing layer-specific connections and bidirectional signaling with astrocytes.

## P247 Basic organization of spinal locomotor network derived from hindlimb design and locomotor demands

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### Introduction

One of the core principles of sensorimotor physiology is that the musculoskeletal system and its neural control have coevolved to satisfy behavioural demands. Therefore, it may be possible to derive the organization of the neural control of a motor behaviour (e.g., locomotion) from its mechanical demands and properties of the musculoskeletal system. The goals of this study were to (1) determine activity patterns of cat hindlimb muscles from locomotor demands of walking, (2) determine muscle synergies from the predicted and recorded muscle activity patterns and (3) propose a spinal locomotor network organization based on the derived muscle synergies.

### Methods

We defined locomotor demands as patterns of resultant moments of force at hindlimb joints generating walking kinematics. To determine the locomotor demands, we computed the resultant muscle moments (using motion capture and methods of inverse dynamics) and muscle activations producing the moments and minimizing muscle fatigue using optimization. We then derived muscle synergies using the non-negative matrix factorization from the computed and recorded activities. We constructed a rhythm generation and pattern formation network of a spinal central pattern generator (CPG) from the derived muscle synergies and incorporated it into our neuromechanical model of spinal hindlimb locomotion.

### Results

Locomotor activity patterns of hindlimb muscles obtained from hindlimb musculoskeletal properties and locomotor demands demonstrated a close agreement with the recorded activity patterns. Muscle synergies and their activation patterns derived from the predicted and measured hindlimb muscle activations were similar and consisted of two flexor and three extensor synergies. We used the revealed muscle synergies to construct a spinal CPG and incorporated it into a neuromechanical model of cat hindlimb locomotion. Computer simulations of locomotion demonstrated realistic locomotor mechanics and activity patterns.

### Discussion

We demonstrated that hindlimb musculoskeletal properties and locomotor demands (desired resultant joint moments and minimization of muscle fatigue) can predict hindlimb muscle activation patterns, muscle synergies and a general organization of the CPG. The predicted and recorded muscle activations had the following features: (i) reciprocal activation of antagonists,