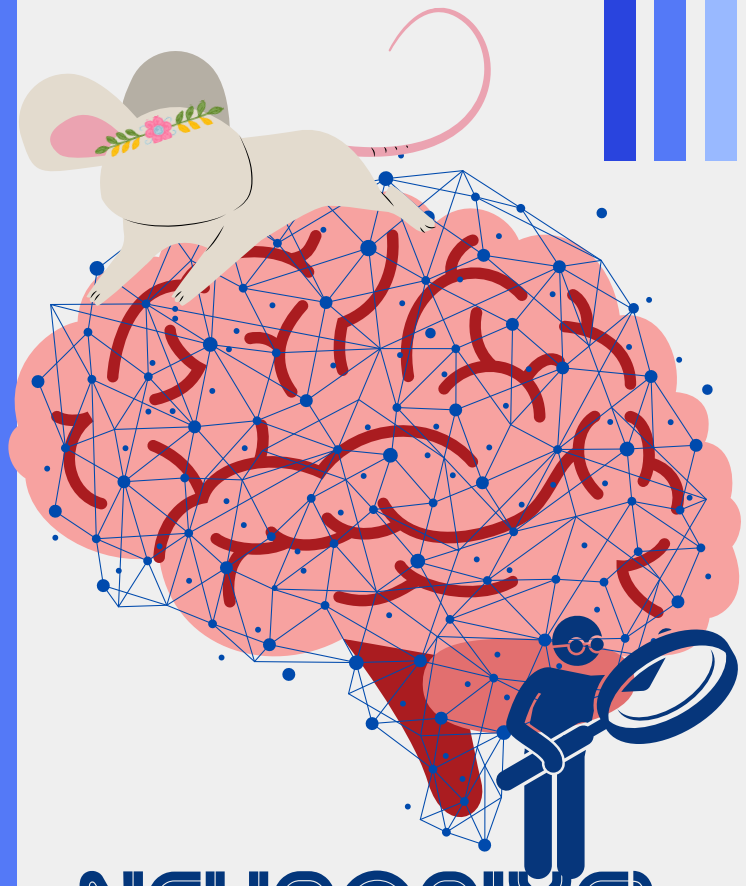

NEUROPIXEL DATA TO 3D VISUALISATION

BME 4509 Group project
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IMPERIAL

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Scan for more info from our website including our report

With heartfelt thanks to Professor Claudia Clopath and Dr. Albert Albesa Gonzalez for their support.

FUTURE POTENTIAL

1. Boost computational power for full-brain spike mapping.
2. Enable pipeline to process raw Neuropixels data.
3. Support additional modalities like calcium imaging and widefield data.
4. Integrate Allen 3D viewer with AR platforms for real-time visualization.
5. Develop AR tools for experiment planning, e.g. probe trajectory preview.

DISCUSSION

The results indicate successful mapping of neuronal spikes using spatial localisation using Euler-based methods with the AMSGRad optimiser.

It can be observed that recordings in primary motor cortex (MOp) and secondary somatosensory cortex (SSp) are largely non-selective visual and action neurons, active prior to movement onset.

Such result is expected as the regions integrate sensory and motor-related signals in movement planning and initiation.

MOTIVATION

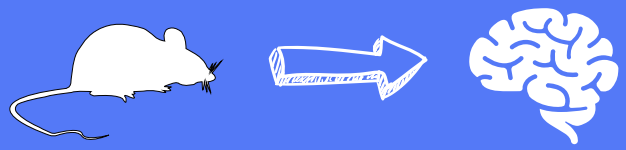
Up to now, we still don't know:

- How neural networks transform perception and thought into behaviour.
- How neurons function and communicate, and how this helps us understand brain disorders.

⊕ High-resolution of neuron architecture

⊖ Time consuming and labour intensive

Neuropixel probes capture detailed 2D data, but creating a 3D brain activity map still requires slow, manual tissue slicing, staining, and signal sorting.



Building on the framework of Steinmetz et al. and modern spike-localization methods we aimed to;

- Automatically label neurons based on what stimuli they respond to.
- Reconstruct 3D spike locations from the probe's 2D recordings
- Map those neurons onto a standard 3D mouse-brain atlas

IDLE Shell 3.11.4

</> **Session 1-Spike filtering & preprocessing**

→ Step 1: Statistical selection
Compute stimulus-response p-value
If p < threshold → mark as responsive

→ Step 2: Half-Gaussian filtering
Remove low-firing neurons and noise

>>> Output 1: Significant neuronal clusters

</> **Session 2-Neuronal classification**

→ Step 3: Build Toeplitz matrix to map spikes to functions (visual, choice, action)
→ Step 4: Use ElasticNet to assign spikes to kernels
→ Step 5: Test for significant kernel types

>>> Output 2: Identified neuronal functions

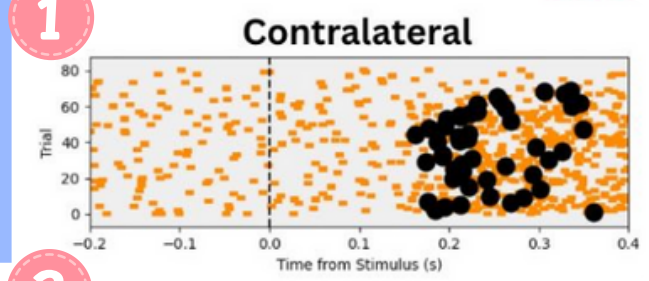
</> **Session 3-3D visualisation of spike**

→ Step 6: Map filtered significant neuronal functions from Session 2 to the dataset
→ Step 7: Extract PTP values
→ Step 8: Train the algorithm to obtain the optimised 3D global coordinates by Euler-based method equipped with AMSGrad (Adam variant) regularizer.

>>> Output 3: 3D spike visualisation in Brainrender at CCF

Python was selected as the primary software tool for its flexibility and the richness of its open-source library ecosystem.

1



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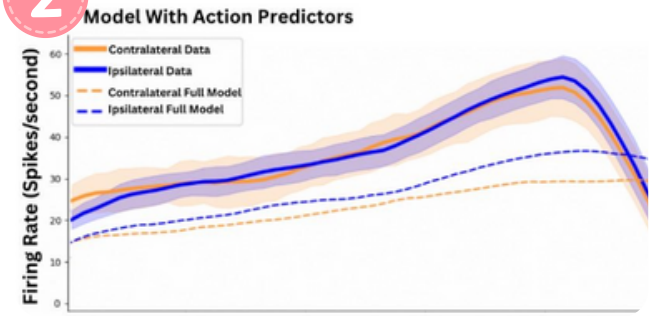

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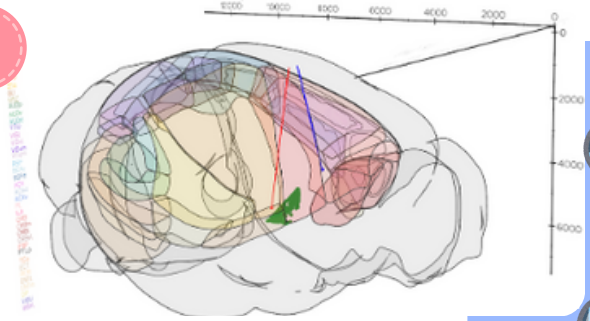

RESULTS

1. The spike activity increases around 0.2s, which suggests the neurons are involved in action execution.
2. If the variance is greater than 2%, the neuron is classified as action-selective neurons.
3. The visualisation of action and vision neurons at MOP and SSP

1 AIM

2 SPIKING DATA PIPLINE

3 VISUALIZATION OUTPUTS