2023 A3D3 Workshop Hackathon
DadarlatLab Dataset

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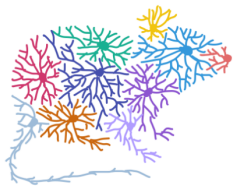
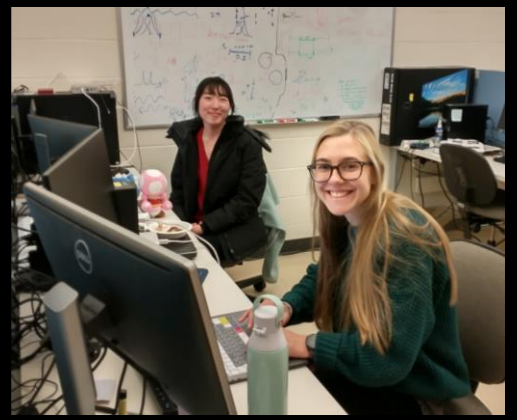


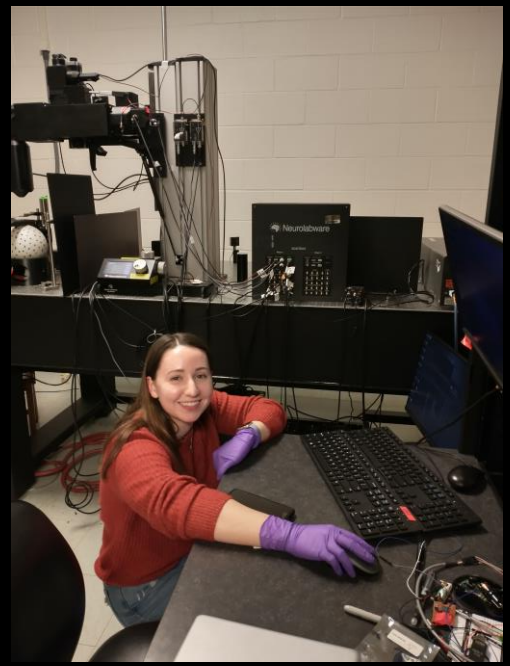
DADARLAT LAB

DADARLAT LAB

https://engineering.purdue.edu/DadarlatLab

The Dadarlat Lab has two main areas of study:
(1) to understand how sensory information is processed in the visual and somatosensory systems
(2) to apply these insights towards the development of artificial sensation.
To address these questions, we use a combination of animal behavior, in-vivo electrophysiology, 2-photon-imaging, and electrical stimulation.





Dr. Maria Dadarlat-Makin

Megan Lipton

Seungbin Park

Elizabeth Frazier

Samuel Senneka

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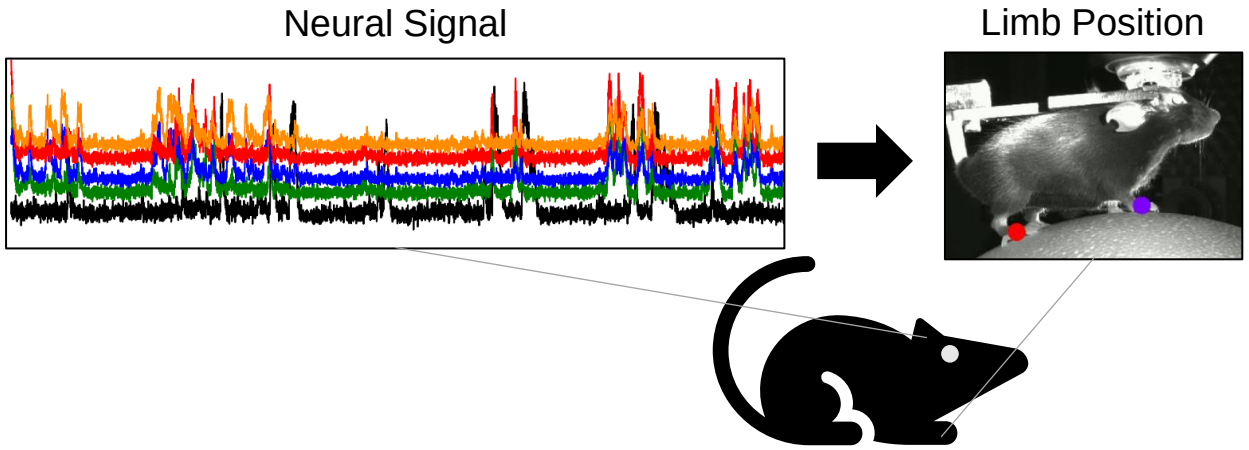
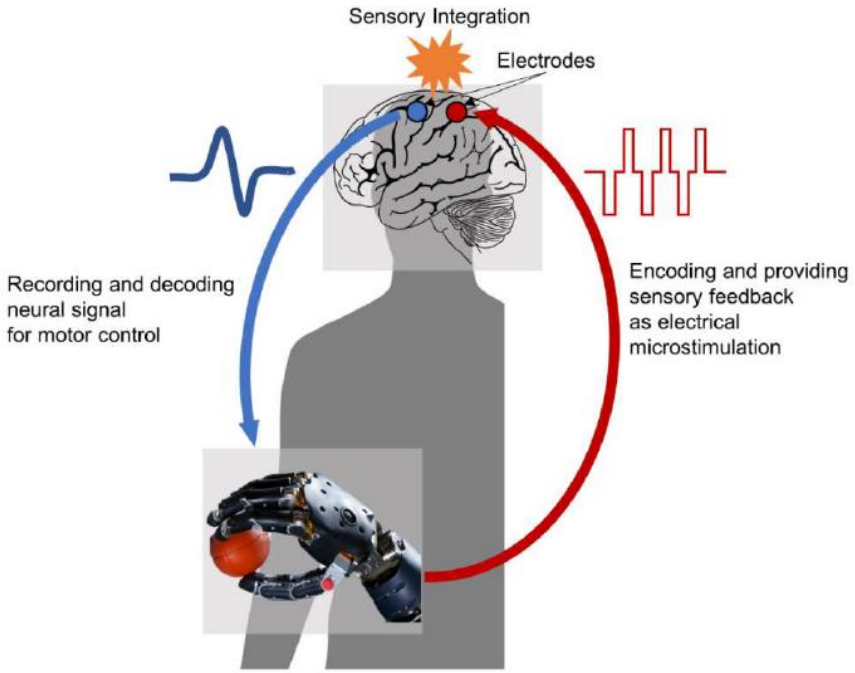
Neural Decoding

: Neural Signal → Behavior

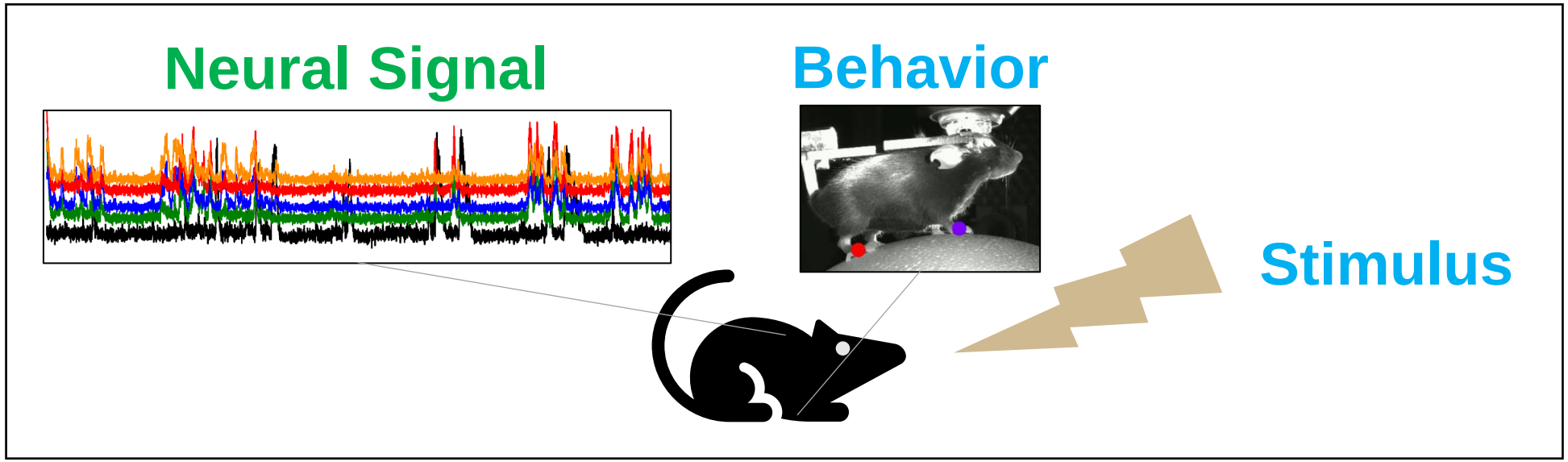




(1) To develop technology to aid patients suffering from neurological injury and disease

ex) Brain-machine interface, Artificial sensation by electrical stimulation

(2) To understand the function of the brain



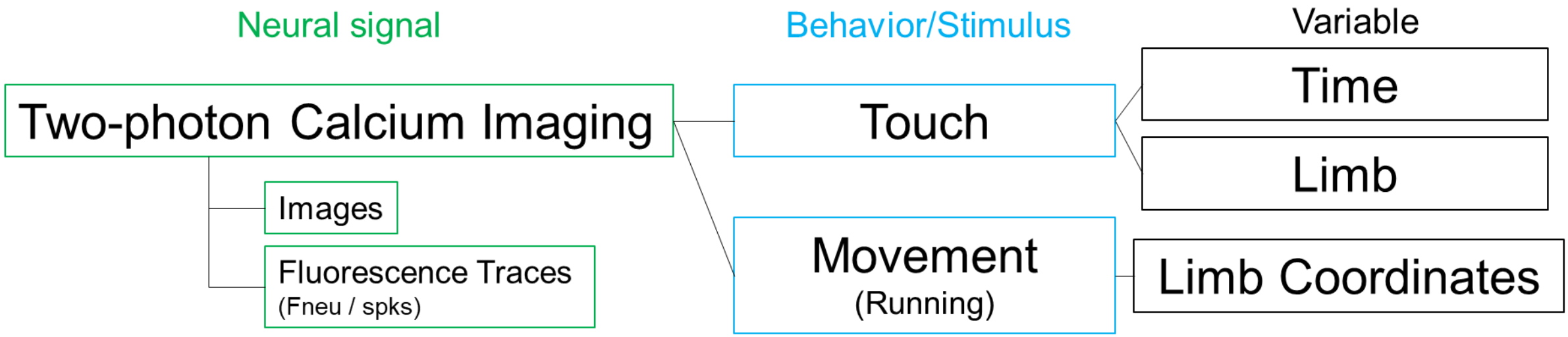
Neural signal

Behavior/Stimulus

Variable

- Two-photon Calcium Imaging
  - Images
  - Fluorescence Traces (Fneu / spks)
- Touch
  - Time
  - Limb
- Movement (Running)
  - Limb Coordinates

Possible Hackathon Projects



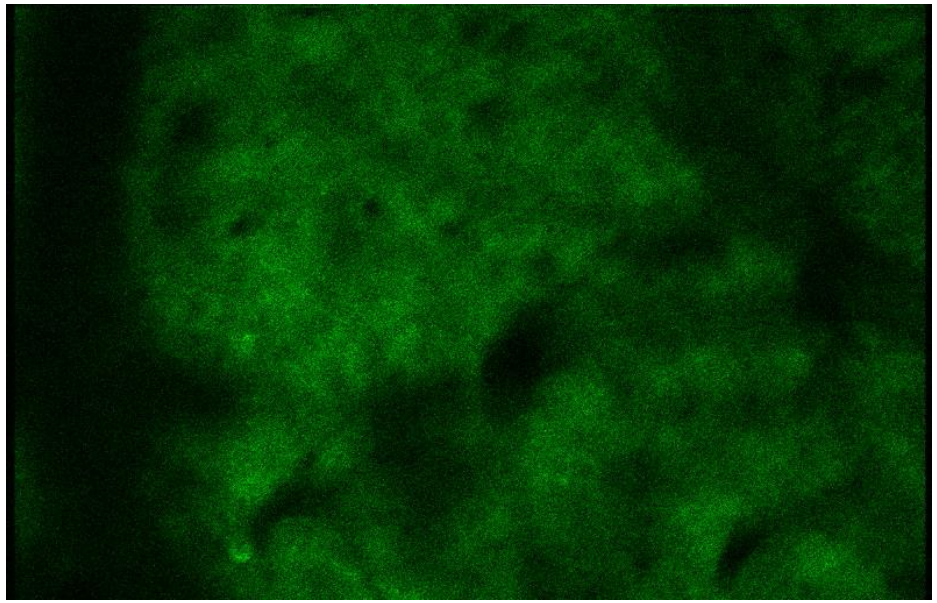
- Main goal: To explore the datasets

- 2P+Touch
  - (Classification) Decoding the time when the touch stimulus was given from 2P calcium images
  - (Classification) Decoding the limb in which the touch stimulus was given from 2P calcium images
- 2P+Running
  - (Regression) Decoding continuous limb trajectories of a running mouse from 2P calcium images

- Reconstruction
- Anithing you want

Two-Photon Calcium Imaging

: a promising technique for recording large populations of neurons



When neurons fire action potentials, intracellular calcium levels rise. Two-Phton calcium imaging measures neural activity by detecting fluorescence from fluorescent molecules that bind to calcium.

Challenges in Decoding Two-Photon Calcium Imaging

(1) Indirect and non-linear relation to action potentials
(2) Slow kinetics with a long decay time
(3) Time variance between neural activities in a frame
(4) Low sampling rate

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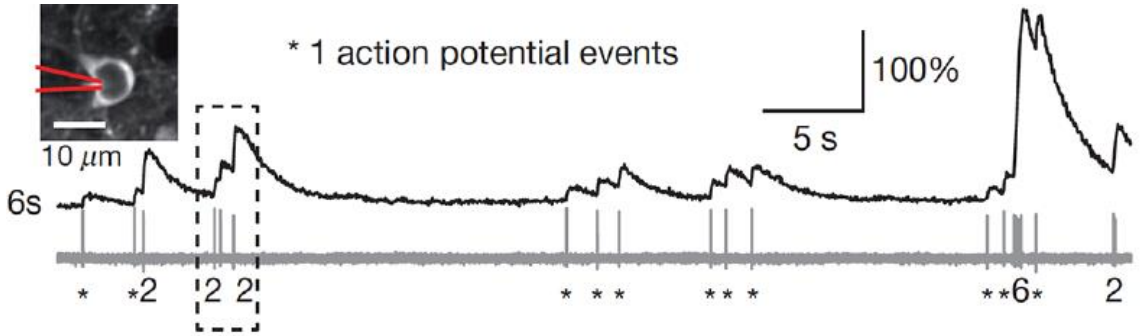

Rapid rise time, much longer decay time
Duration of calcium elevation >> action potential

Ali et al., 2020

Challenges in Decoding Two-Photon Calcium Imaging

(1) Indirect and non-linear relation to action potentials
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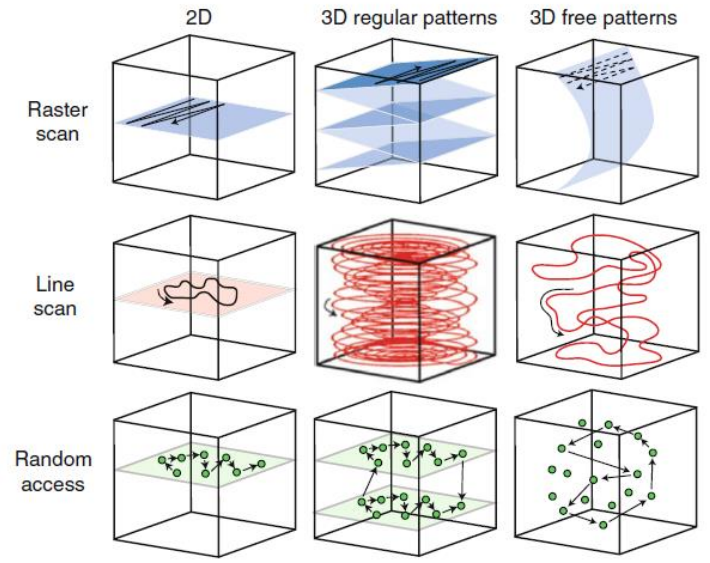

Weber et al., 2014

Challenges in Decoding Two-Photon Calcium Imaging

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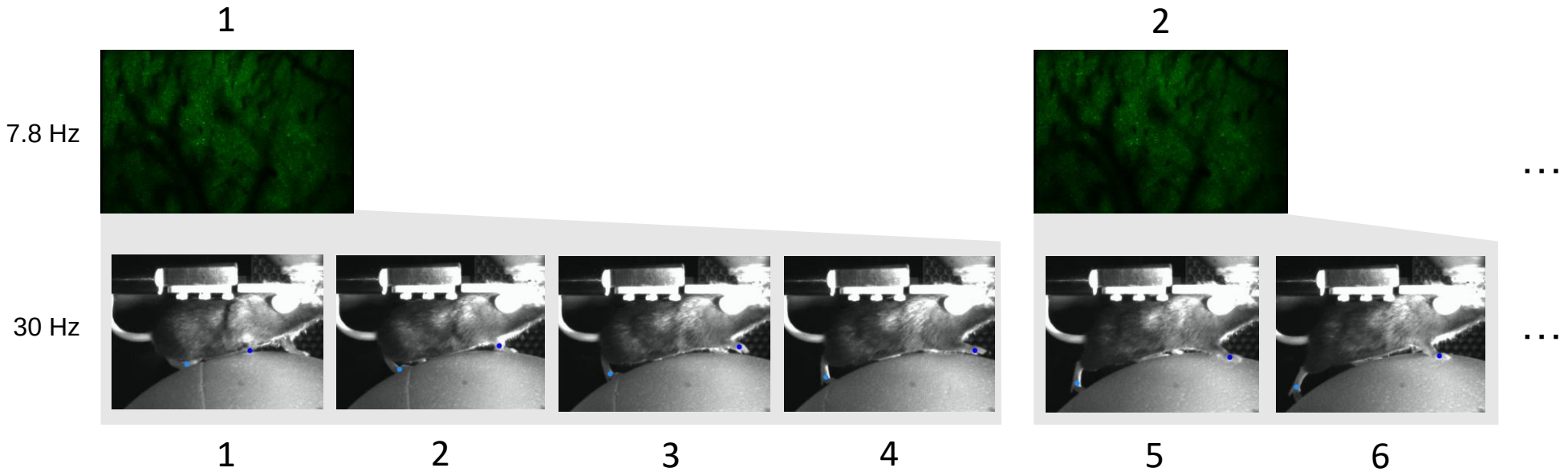
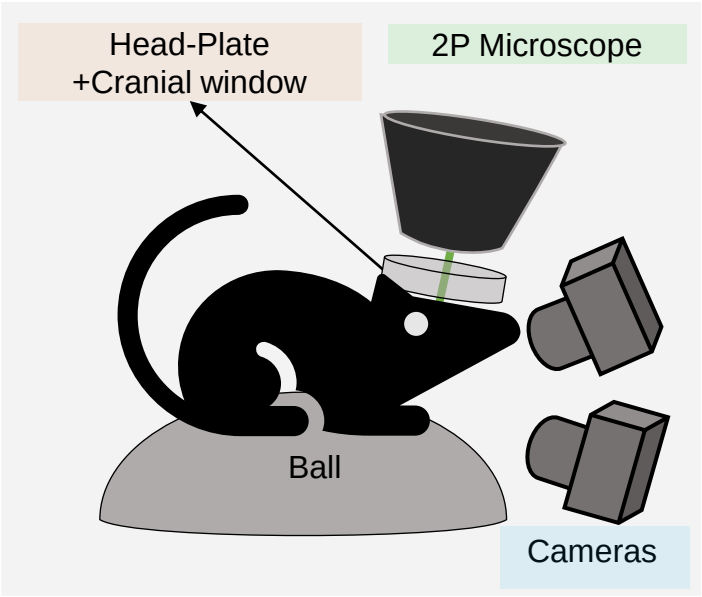
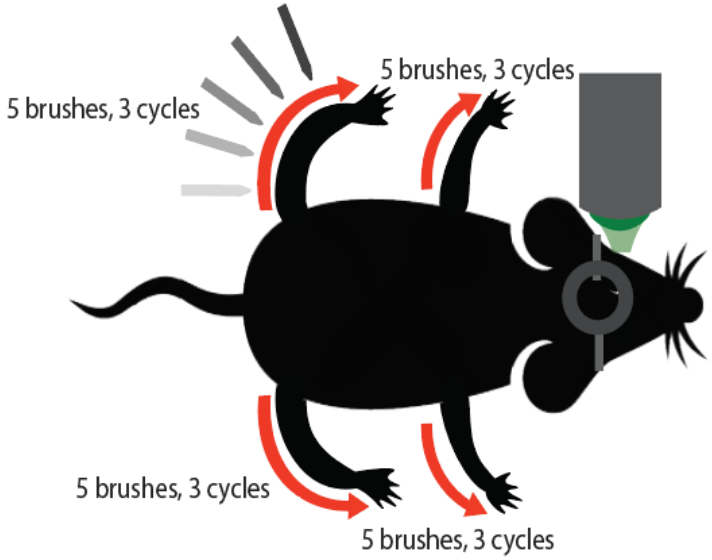
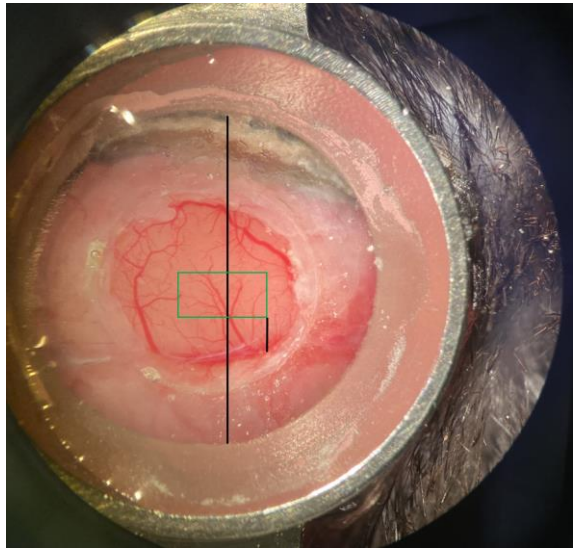


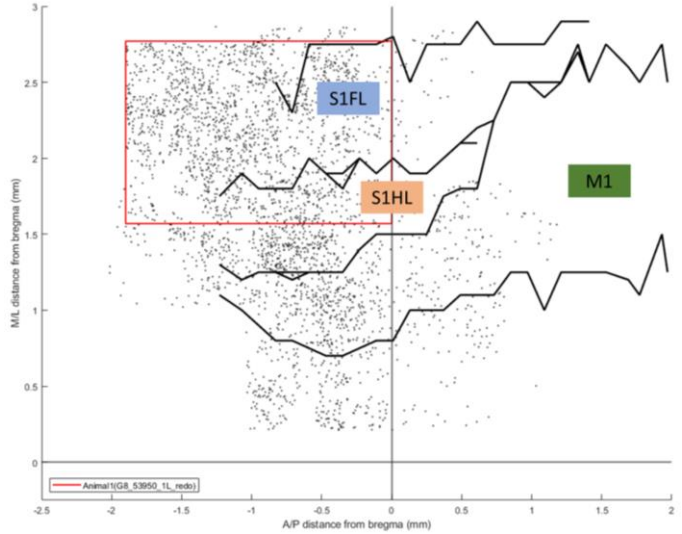
Experiments



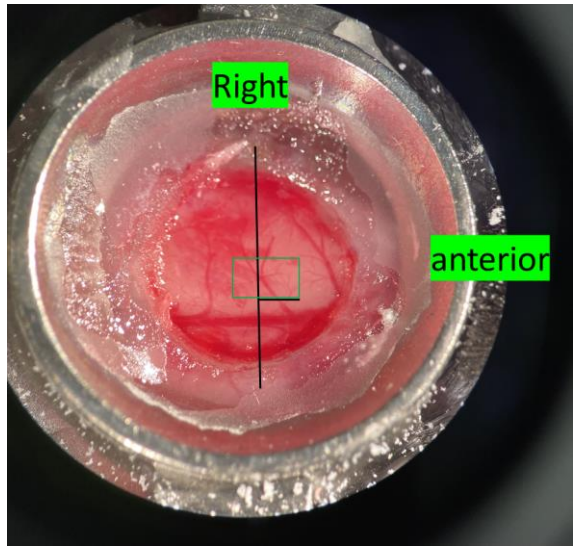


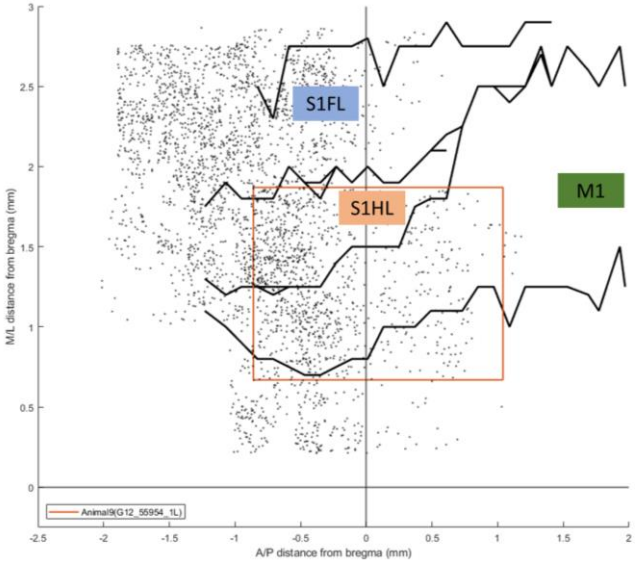
Animal 1



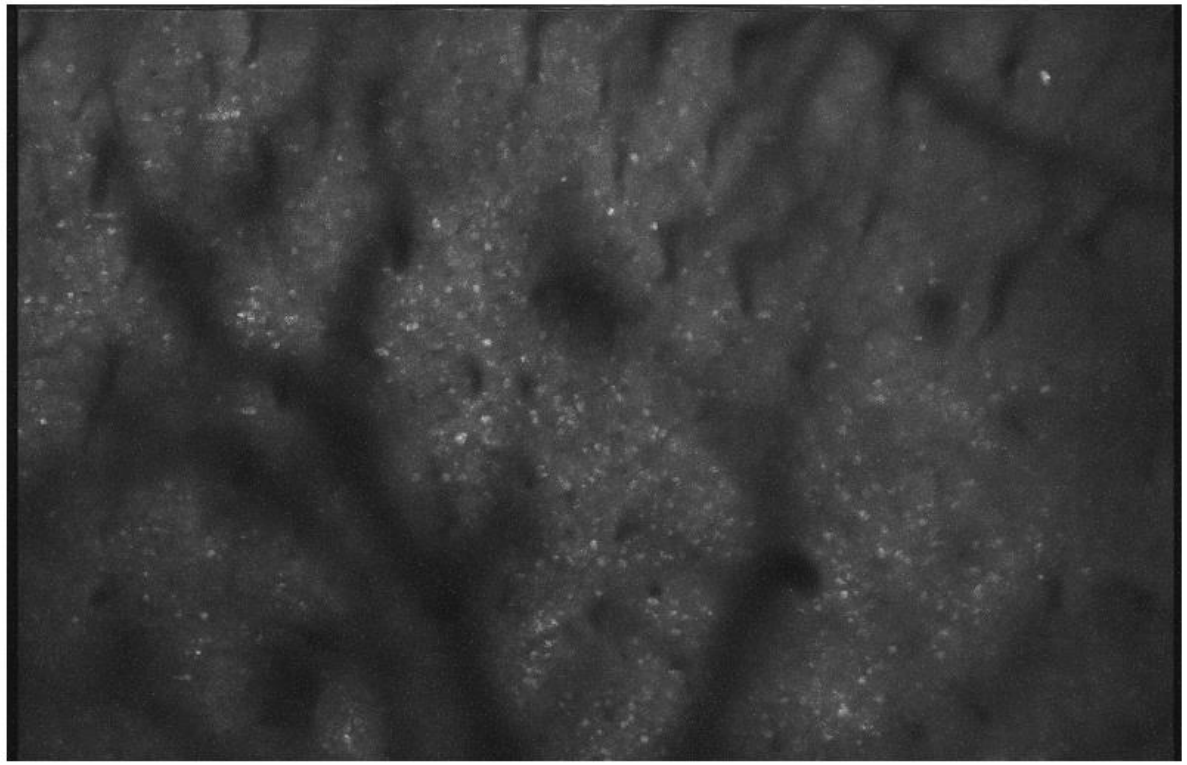


Animal 2

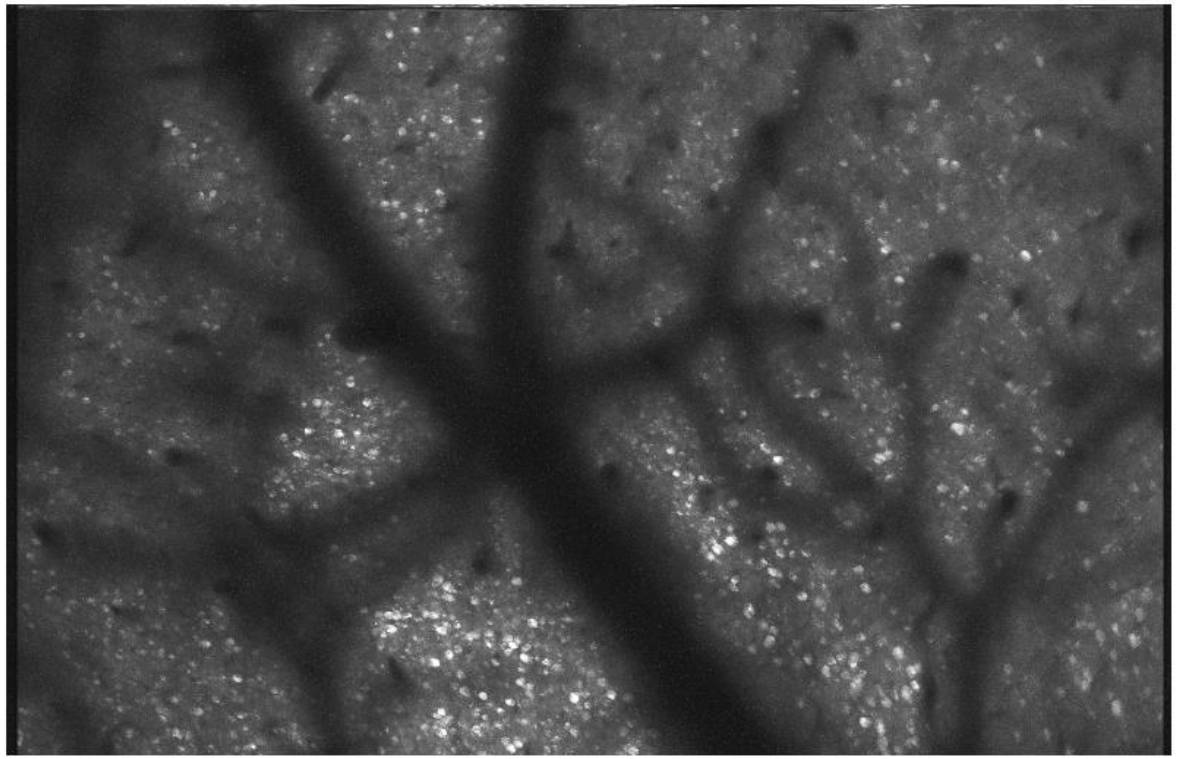




Animal 1

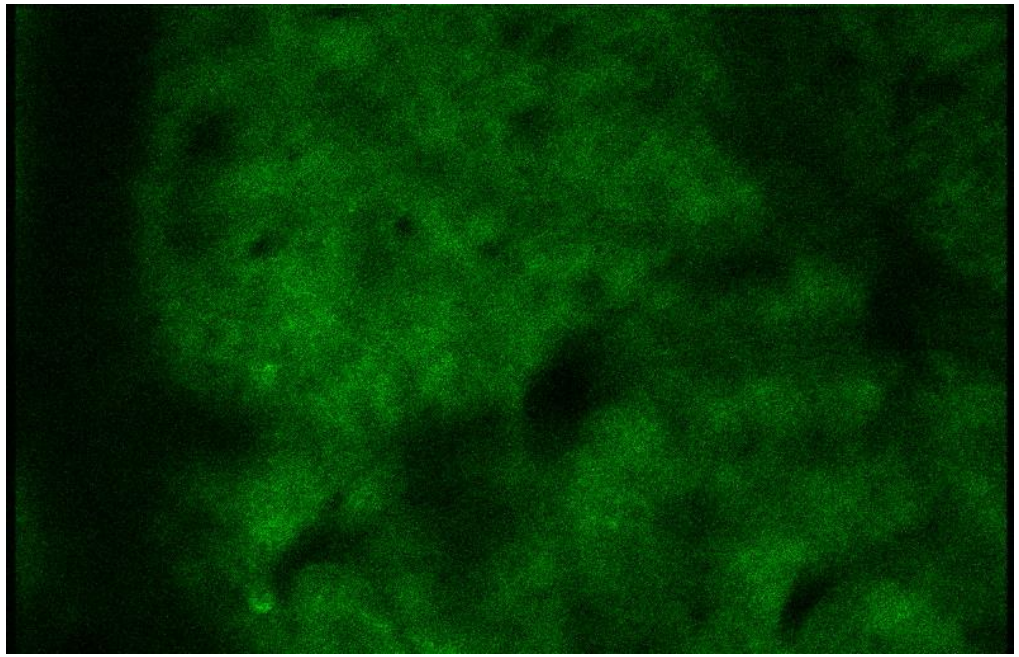


Animal 2



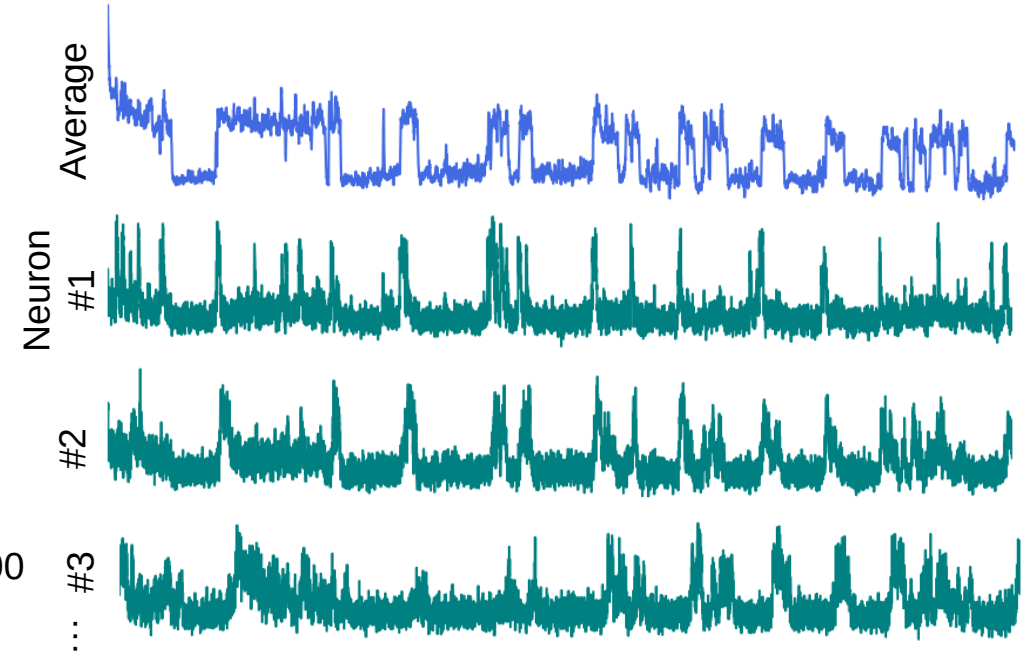
Fluorescence Traces

2P Calcium Imaging

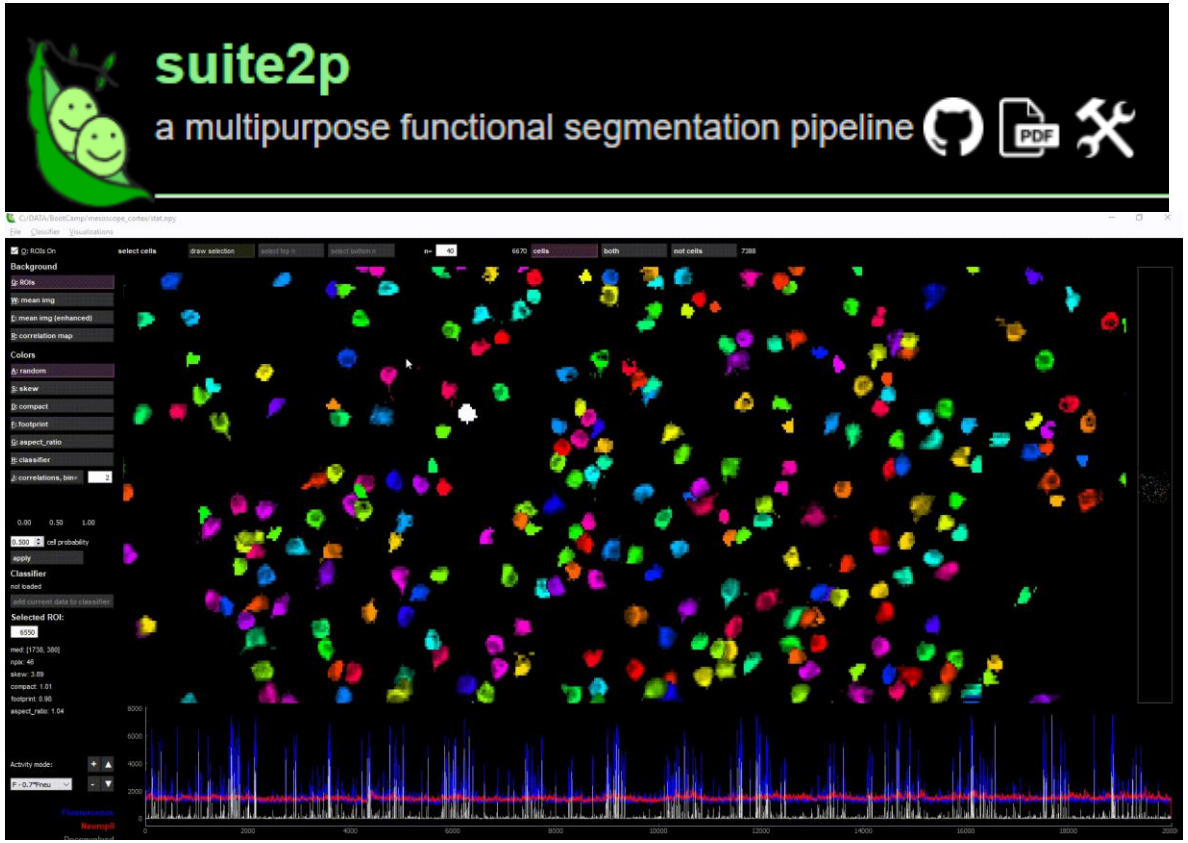


100 ~ 3000 Neurons

Fluorescence Traces



- Neurolabware
- Layers: L2/3
- Field of view: 1.9 mm x 1.2 mm; Laser: 920 nm
- Frame rate: 7.8 Hz
- Preprocessing: suite2p, Normalization



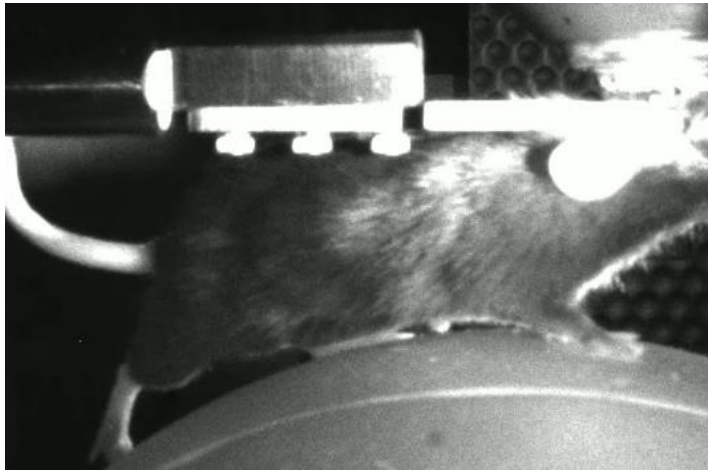
Registration
Cell Detection
Signal extraction
Spike deconvolution

https://www.suite2p.org/

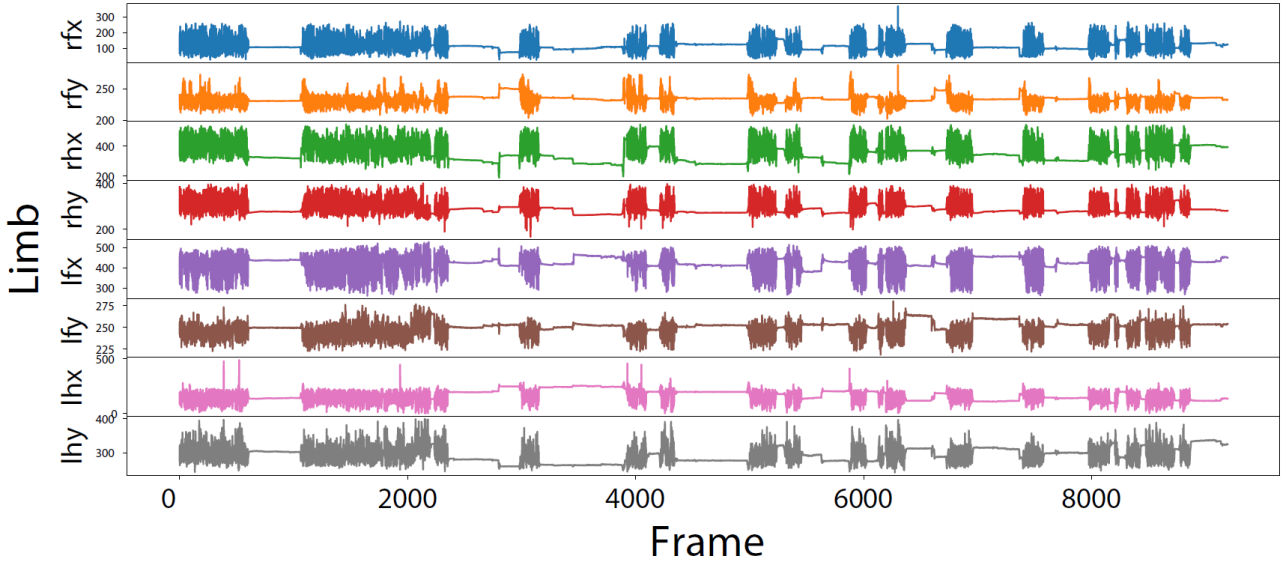
Doc on Outputs:https://suite2p.readthedocs.io/en/latest/outputs.html

Limb Coordinates from a Running Mouse

Behavior Video



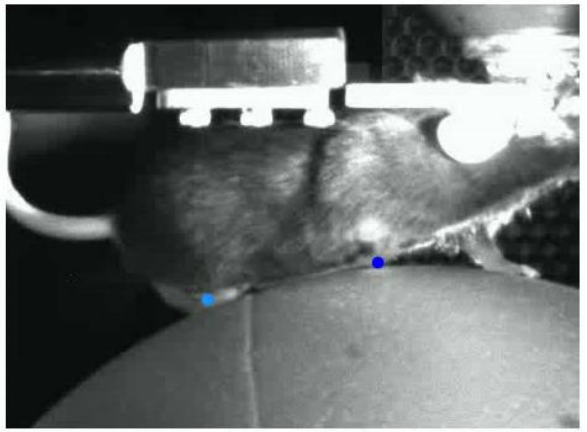
Limb Coordinates



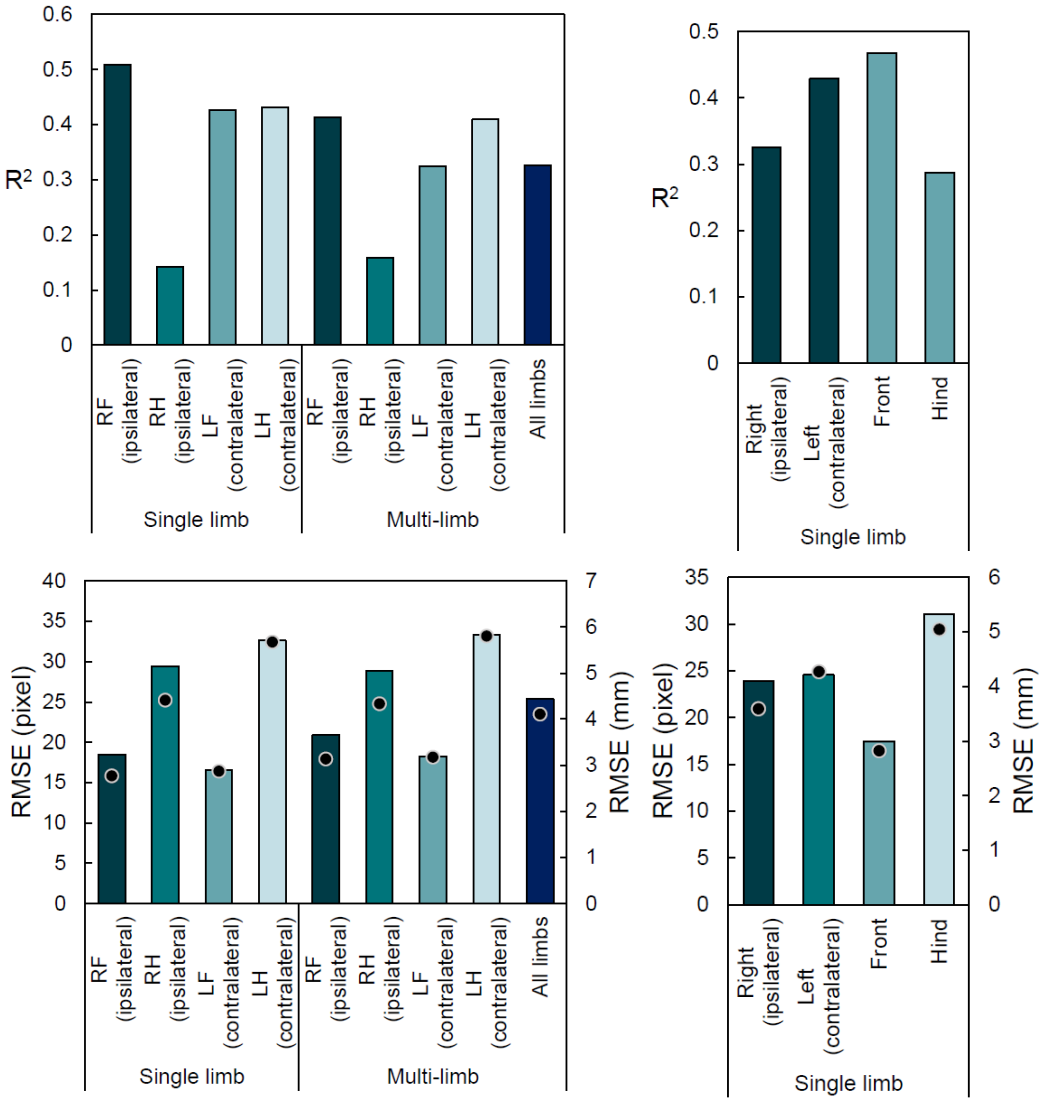
- Freely running on the ball.
- Trained for 4 days, 1 hour per day.
- Frame rate: 30 Hz
- Preprocessing: Deeplabcut, Normalization

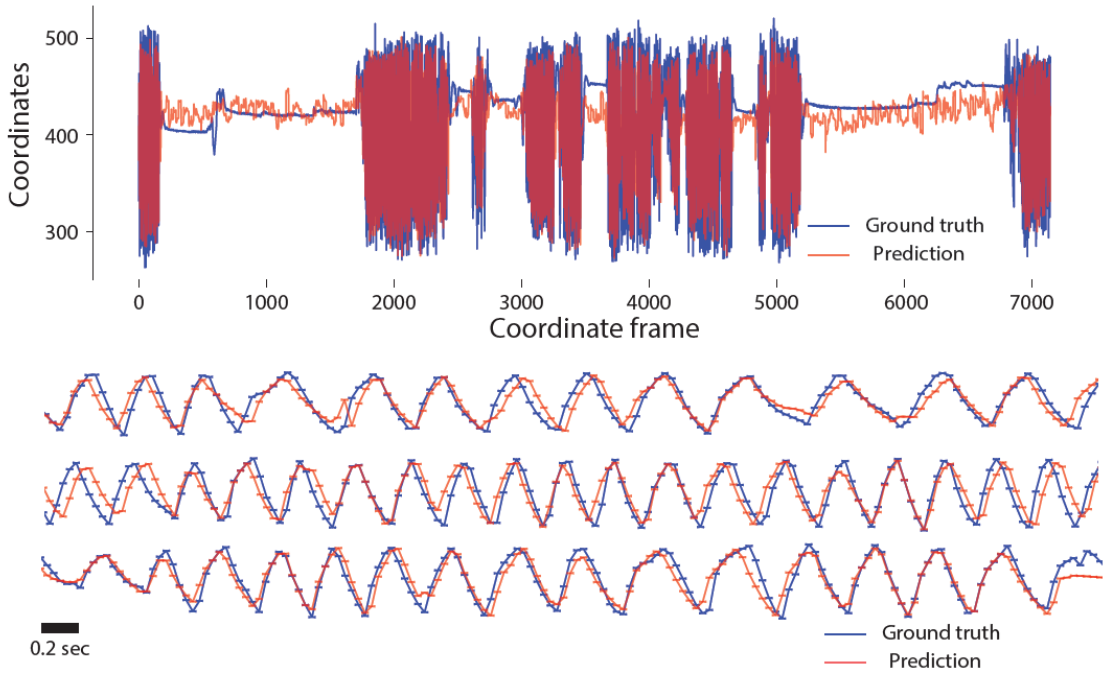
DeepLabCut™: a software package for animal pose estimation

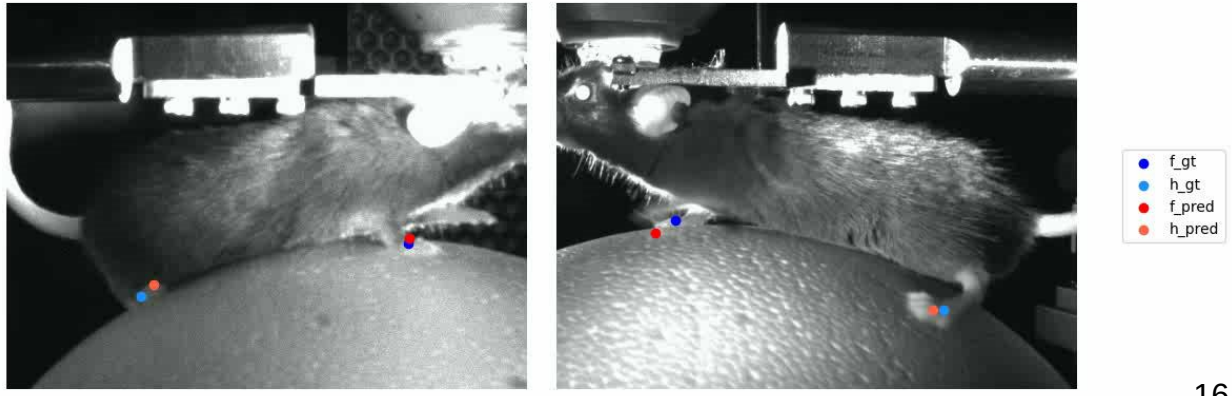
http://www.mackenziemathislab.org/deeplabcut



All limbs(contralateral/ipsilateral, front/hind) could be decoded both simultaneously and separately from a single cortical hemisphere.







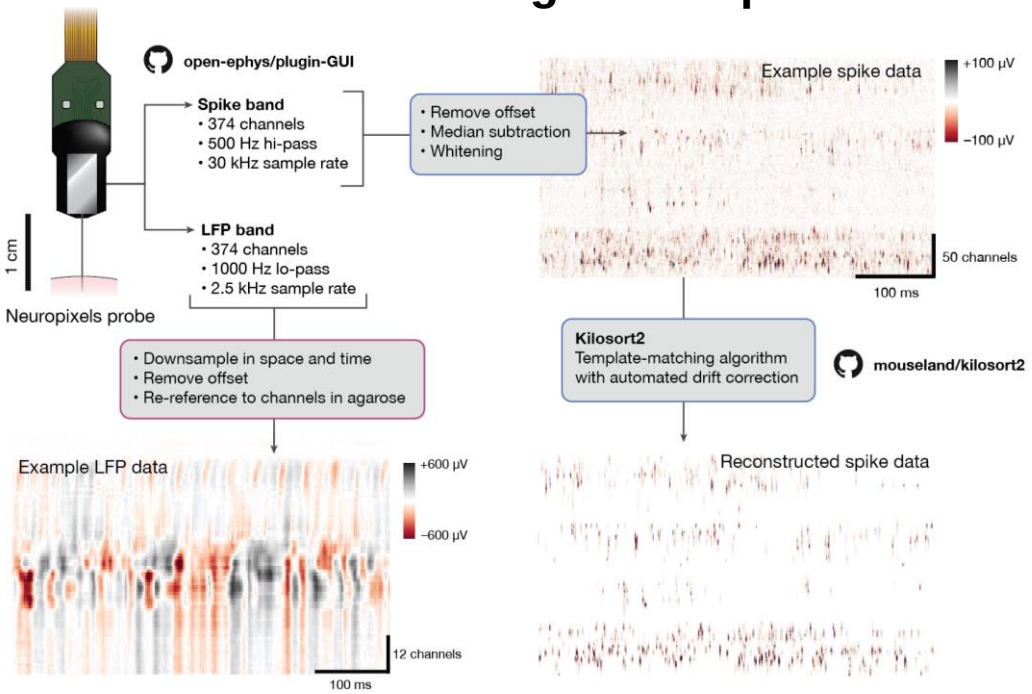
Animal 1, Multi-limb: R^2=0.326, RMSE=25.35 (4.11 mm)

Examples of Open Datasets

Allen Brain Map
https://portal.brain-map.org/

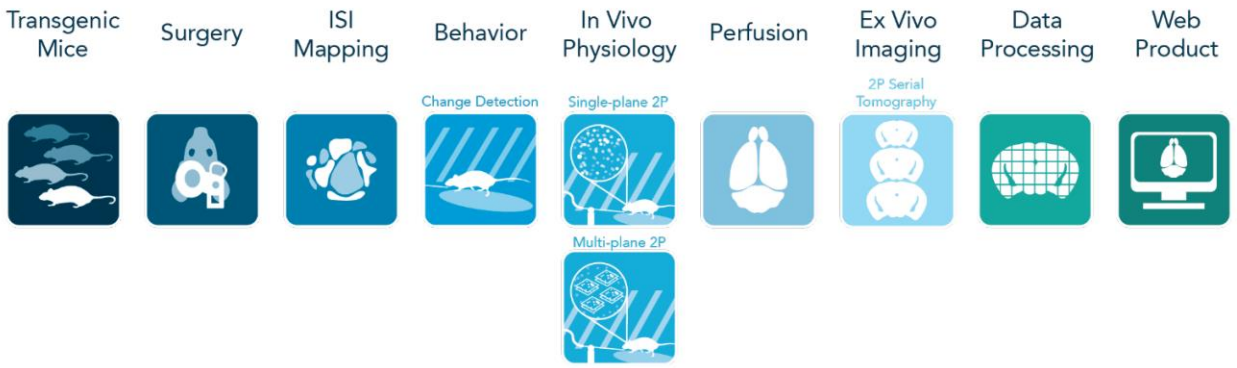
Neurodata Without Borders
https://www.nwb.org/example-datasets/

Visual Coding - Neuropixels

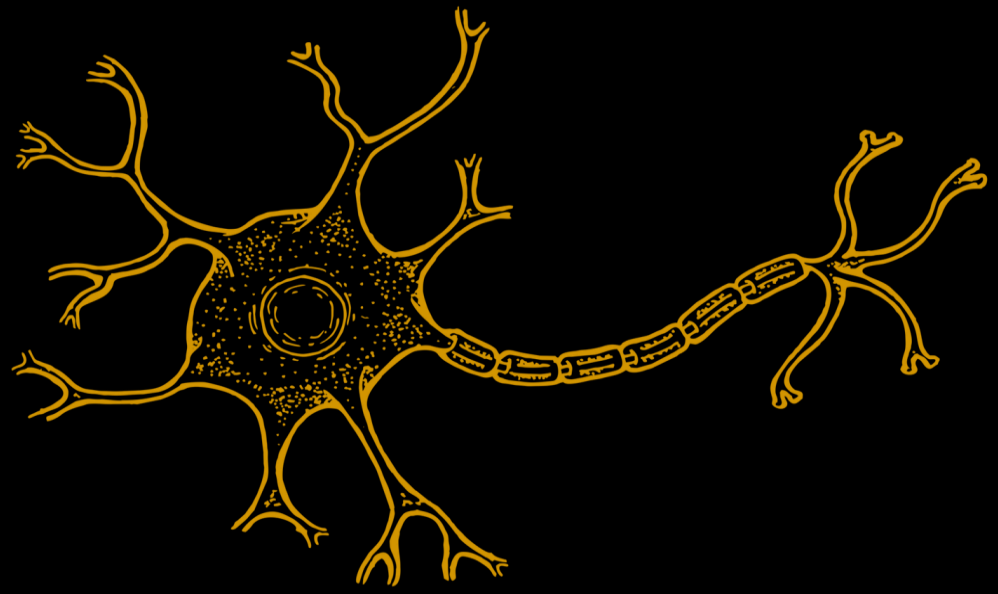


https://allensdk.readthedocs.io/en/latest/visual_coding_neuropixels.html

Visual Behavior – 2P



https://portal.brain-map.org/explore/circuits/visual-behavior-2p



Documentation

These datasets are not validated yet.
We are currently working on them.

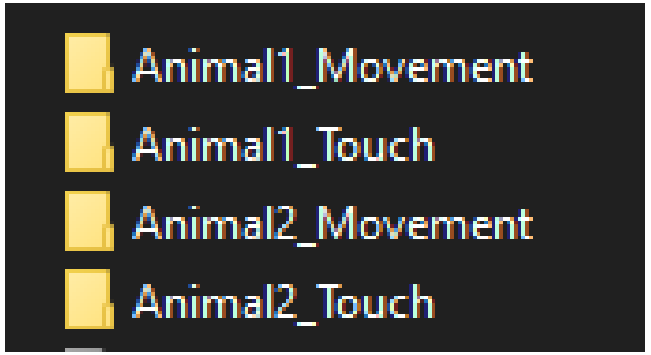
Guidelines:

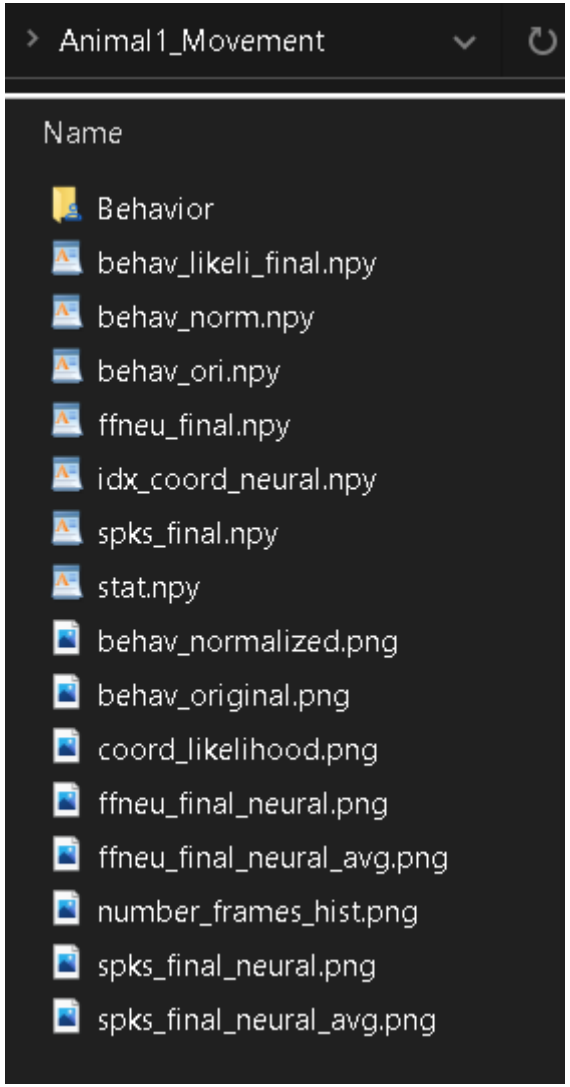
- All raw data are available.
- Considering the limited time, preprocessed data is being provided.
  It was preprocessed and synchronized, so you can just start to use them right away.
- Choose one behavior between touch (classification) and movement (regression).
  Recommend trying classification first because it is simpler.
- Try Animal 1 first. And validate more with Animal 2 if Animal 1 worked.

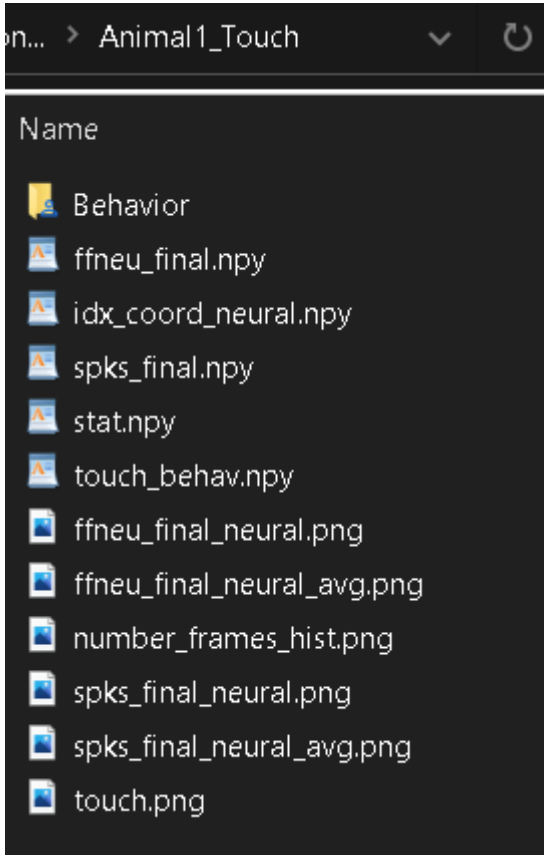
- Research ideas
  - It is usual to use deconvolved fluorescence traces.
    But related studies suggest using raw 2P microscope images or fluorescence traces that are not deconvolved as future plans, because they might include more information.
  - If you want to try to use raw 2P microscope images or unprocessed original fluorescence traces, please feel free to go explore and have fun.
  - Consider the characteristics of the datasets – 2P images and behaviors.
    ex) Latency, GNN using spatial information, Denoising …
  - LFADs on 2P: https://www.nature.com/articles/s41593-022-01189-0

- Even though you don't get the final results, focus on exploring data & we would love to hear about research ideas on the datasets or collaborations.

- Data: https://drive.google.com/drive/folders/1kFaLNqckbXtQ8RgJwPDjKW_PoX5e_Kyi?usp=sharing


Animal1_Movement
Animal1_Touch
Animal2_Movement
Animal2_Touch


Animal1_Movement
Name
Behavior
behav_likeli_final.npy
behav_norm.npy
behav_ori.npy
ffneu_final.npy
idx_coord_neural.npy
spks_final.npy
stat.npy
behav_normalized.png
behav_original.png
coord_likelihood.png
ffneu_final_neural.png
ffneu_final_neural_avg.png
number_frames_hist.png
spks_final_neural.png
spks_final_neural_avg.png


Animal1_Touch
Name
Behavior
ffneu_final.npy
idx_coord_neural.npy
spks_final.npy
stat.npy
touch_behav.npy
ffneu_final_neural.png
ffneu_final_neural_avg.png
number_frames_hist.png
spks_final_neural.png
spks_final_neural_avg.png
touch.png

Preprocessed		
File name	**Description**	**Shape**
Neural Signal		
ffneu_final.npy	ffneu=F-0.7*Fneu(Neuropil) Normalized, Synchronized	(n_neuron, seq_neuron)
spks_final.npy	Deconvolved Normalized, Synchronized	(n_neuron, seq_neuron)
idx_coord_neural.npy	Array that tells neural frame number for each behavior frame.	(seq_behav,)
calcium_final.npy	Raw calcium images	(512, 796, seq_neuron)
stat.npy	Information about neuron positions Docs on suite2p website	(n_neuron,)
Movement		
behav_ori.npy	(Movement) Original limb coordinates	(8, seq_behav)
behav_norm.npy	(Movement) Processed limb coordinates. Normalized, Synchronized	(8, seq_behav)
behav_likely_final.npy	(Movement) Likelihood of predicted pixel from Deeplabcut	(4, seq_behav)
Touch		
touch_behave.npy	(Touch) Original touch stimulus loaded from cvs Start behavior frame, End behavior frame, limb(1=front rignt, 2=Hind right, 3=Front left, 4=Hind left)	(n_stimuli, 3)

```
im = np.zeros((ops_data['Ly'], ops_data['Lx']))
    for n in range(stat.shape[0]):
        ypix = stat[n]['ypix'][~stat[n]['overlap']]
        xpix = stat[n]['xpix'][~stat[n]['overlap']]
        im[ypix,xpix] = importance[n]#n+1
```

Behavior, Movement	
File name	**Description**
limb1.avi limb2.avi	Behavior videos. Limb1: Right, Limb2: Left
limb1.csv limb2.csv	FL: Front Left, HL: Hind Left x,y: x and y coordinates of a limb likelihood: Likelihood of pixel prediction from Deeplabcut

Behavior, Touch	
File name	**Description**
limb1.avi limb2.avi	Behavior videos. Limb1: Right, Limb2: Left
touch_timestamps.csv	start, end: behavior frame of start/end of stimulus limb: 1=front rignt, 2=Hind right, 3=Front left, 4=Hind left

Synchronization