Spinal Circuits for the Control of Dexterous Movement
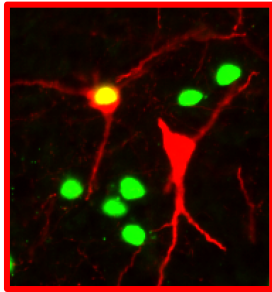
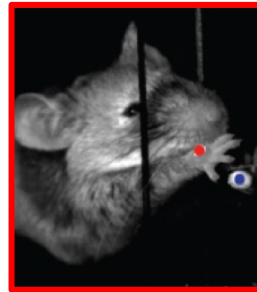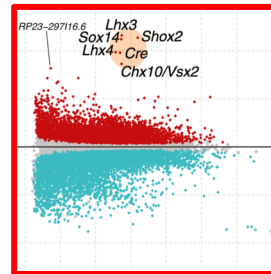**Modeling**
Golomb/Sharpee

Cell Phenotyping
Pfaff

Web Portal
to Reference Atlas
and annotated data

DataCore
Sharpee
MetaCell
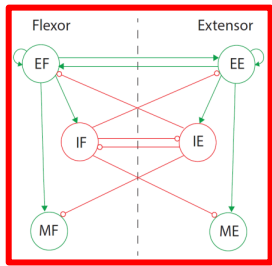
Connectivity
Goulding

Behavior/Activity
Azim/Nimmerjahn
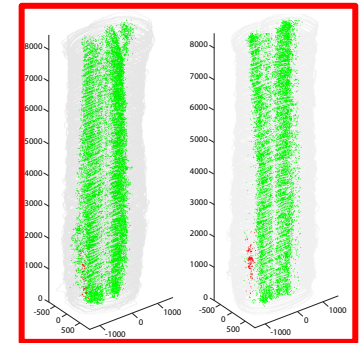
1. Model MNs and muscle recruitment during motor behaviors

Flexor

Extensor
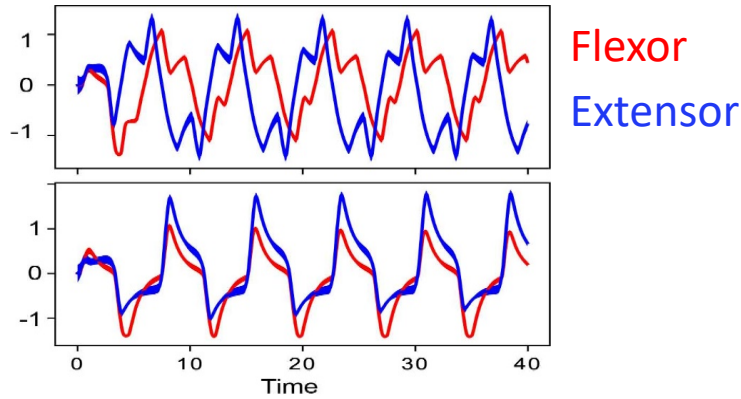
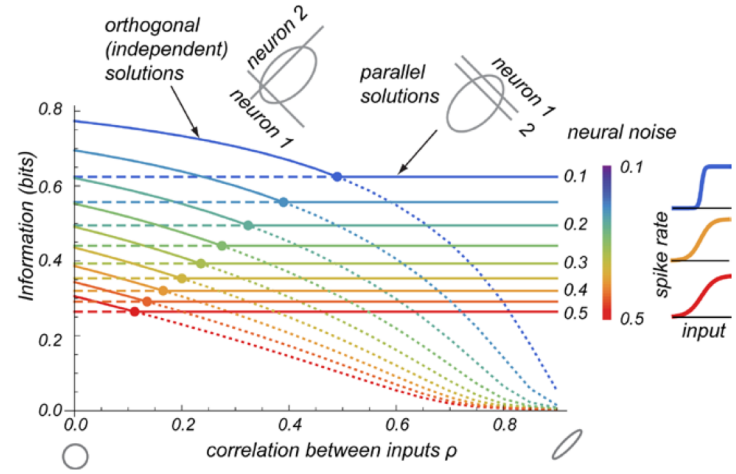Conductance-based model $\quad C\dfrac{dV}{dt} = -\sum_{\text{ions}} I_{\text{ions}} - \sum_{\text{syn}} I_{\text{syn}}$
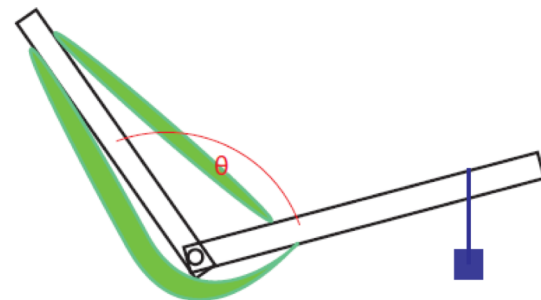
2. Model optimal circuit configurations
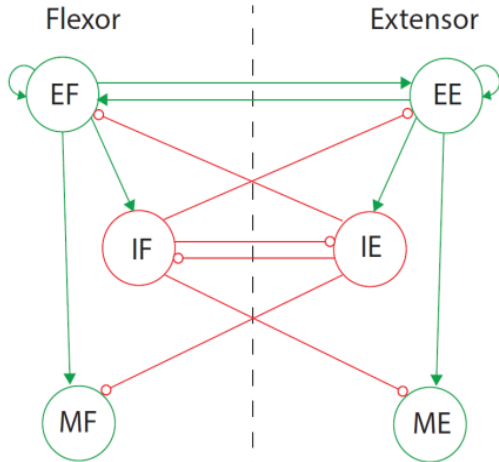
Rate model $\quad \dfrac{ds}{dt} = -\dfrac{s}{\tau_s} M \quad M = \beta\left[\sum_{\alpha} J_{\alpha} s_{\alpha} - a - \theta\right]_+$

3. Predict cell types

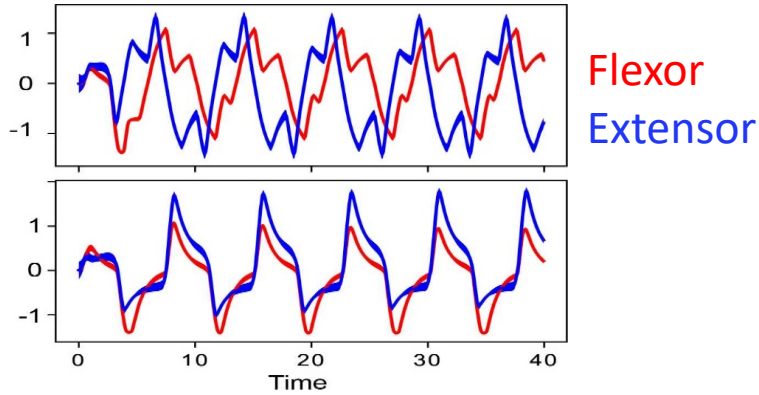Control theory, Information theory

4. Model mechanical forelimb responses
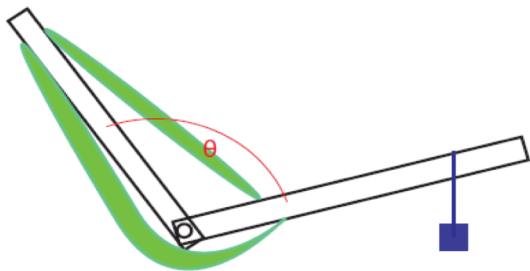

Newtonian mechanics, model for muscle contraction

Modeling Approach

Model MNs and muscle recruitment during motor behaviors

Flexor
Extensor

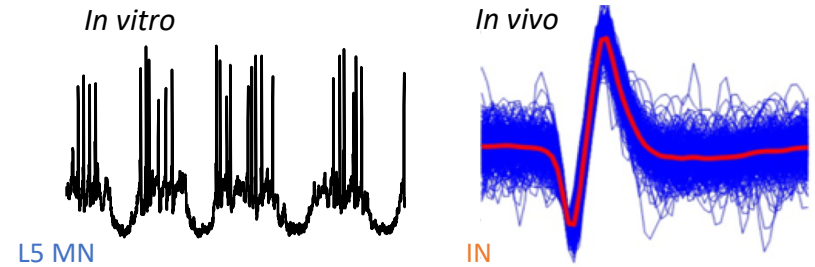Conductance-based model $C\dfrac{dV}{dt} = -\sum_{ions} I_{ions} - \sum_{syn} I_{syn}$

Model mechanical forelimb responses

θ

Newtonian mechanics, model for muscle contraction

Experimental Data

MNs and INs recording

In vitro

In vivo

L5 MN

IN

Bulk EMG Recordings during behavior

Walking

1 mV

Biceps

1 mV

Triceps

Reaching

0.5 mV

0.4 mV

0.1 sec

0.1 sec

Single Unit Recordings

1 µV

Triceps

0.5 sec

Modeling Approach

Model MNs and muscle recruitment during motor behaviors

Flexor
Extensor

Conductance-based model $\quad C\dfrac{dV}{dt} = -\sum_{\text{ions}} I_{\text{ions}} - \sum_{\text{syn}} I_{\text{syn}}$
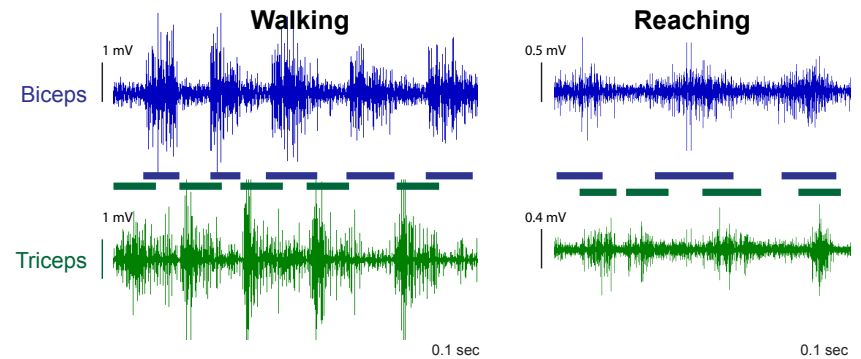
Model mechanical forelimb responses

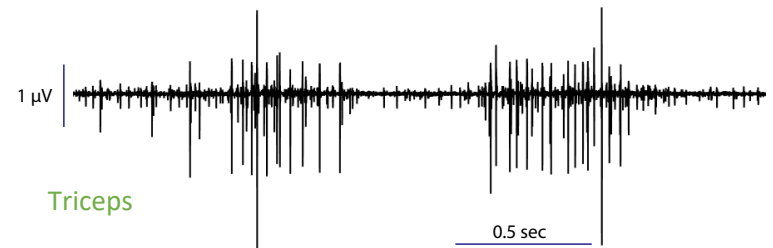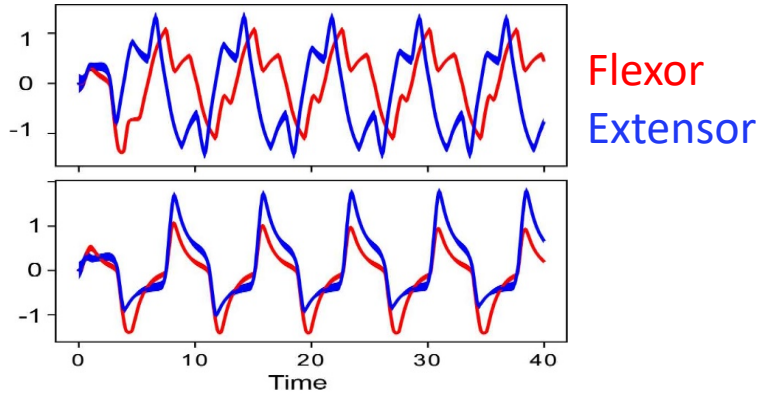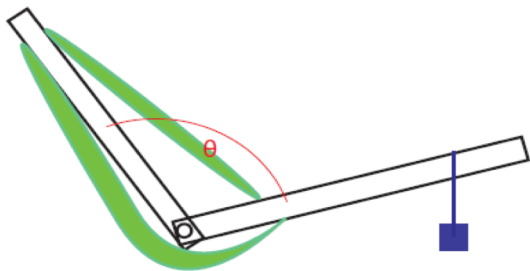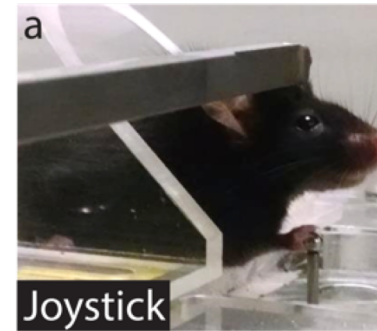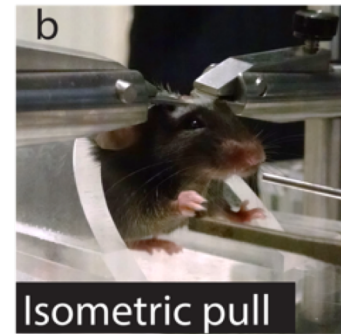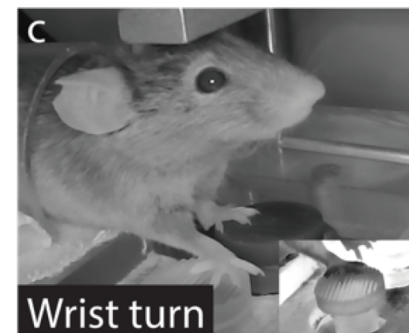Newtonian mechanics, model for muscle contraction

Experimental Data
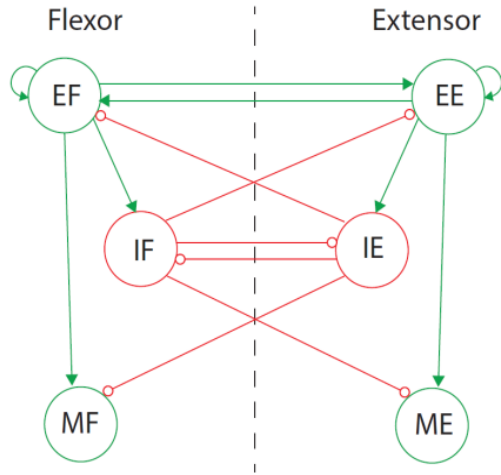
Elbow flexion/extension Behavior

a

Joystick

Elbow isometric contraction

b

Isometric pull

Wrist abductor/adduction

c

Wrist turn

Modeling Approach

Experimental Data

2. Model optimal circuit configurations
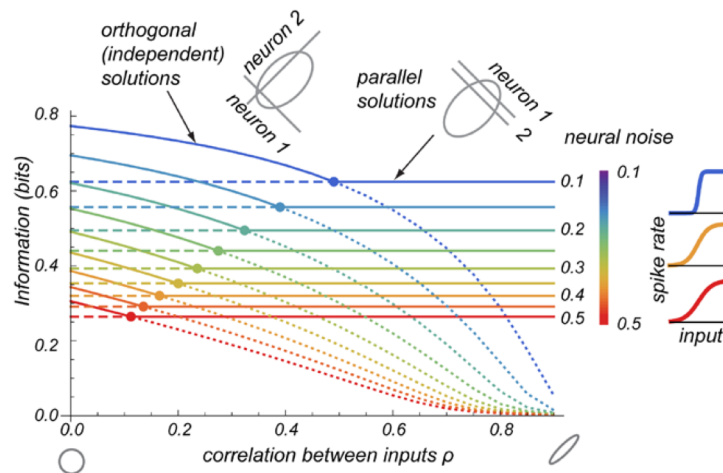
Molecular Heterogeneity

3. Predict cell types
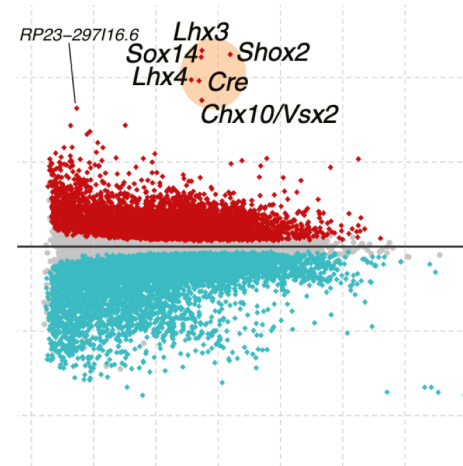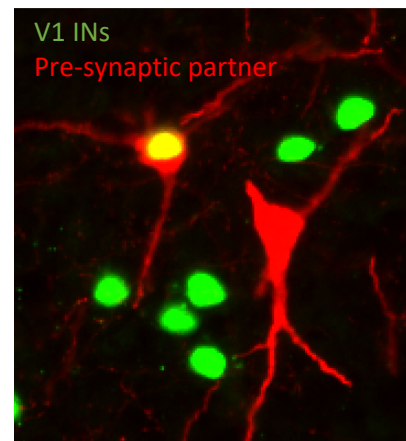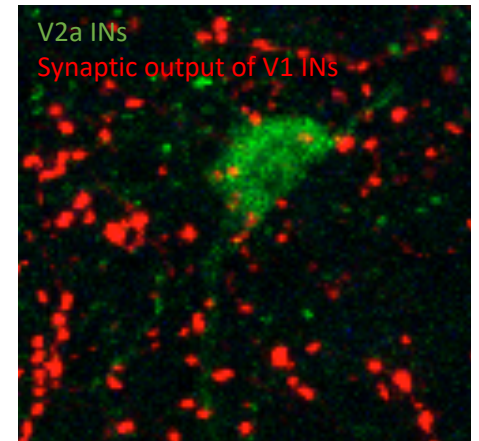

Connectivity

Rabies tracings for pre-synaptic input

Viral tracings for post-synaptic output