Multi-Electrode Motor Cortex Data Project

Data from the laboratory of Dr. John Donoghue

In this dataset, neural spikes from the primary motor cortex were recorded using a chronically implanted multi-electode array (96-channel Utah array), while a non-human primate performed a center-out reaching task.

Task:
In each trial, the monkey has to first touch and hold its hand at the center of screen (“center acquired"), and wait for the onset of a target which appears in one of the eight directions (0º, 45º, … 315º), and the once the go cue appears (“go cue onset"), the monkey can move his hand and reach the target (“target acquired") to get the reward. This data set contains 17×8 trials, only correct trials are included here. The time stamps (in seconds) of the go cue onset, the start of movement and the finish of movement are recorded.

The timeline of one trial:
| start of trial — center acquired — target onset — go cue onset — start of movement — outer target acquired — reward and trial finish |

Electrophysiological Recording:
The spikes have already been detected and sorted. The timestamps (but not the waveforms) of spikes are stored. There are 62 units in total, some are from the same channel (electrode). The channel placements within the electrode array are also provided.

Data format:
The table below shows you how the data are stored. You can access the data as follows:

```
data = np.load('motor_dataset.npy')[()]
```

and then run commands like:

```
len(data['spk_times'][10])
```

to see how many spike times were recorded for unit 10.

There is a lot of data in here. You have all the trial information, all the spike information, and the location of the recording electrode (channels) where the neurons (units) were recorded. More than one unit can be recorded from the same channel.

Name	Description	Datatype	Real Units	Size
trial_angle	Direction of movement	int32	degrees	1 per trial
trial_go	Time of go cue signal for each trial	float32 (real)	seconds	1 per trial
trial_move	Start of movement for each trial	float32 (real)	seconds	1 per trial
trial_acq	Time the target location reached	float32 (real)	seconds	1 per trial
spk_times	List of arrays of spike times for each unit in dataset	List of numpy float32 arrays	time, in seconds, of each spike for each unit	variable number of spikes per unit (62 units)
spk_channels	Actual channel the spike data were taken from	int32	index (starting at 0)	1 for each array of spk_times (62)
spk_templates	Average spike waveform for each channel	List of numpy float32 arrays	A/D units	For each channel in spk_channels array is 48 vaues (array is 0 length for unused channels)
channel_map	Actually mapping of channel locations across recording array	2d list of int32s (integer)	Channel index	10x10 array, with -1s denoting no recording electrode

Choosing a question:

In this final project, you can explore the multi-channel neurophysiology data. You can do many types of analyses with it! Here are just two possibilities here:

- Can you decode the movement direction based on neural activity? (Recall the idea of a "population code" from Dr. Donoghue's interview. Try considering the "vector average" of the population of neural activity. See vector average information below for more hints.)

- Are there properties other than the firing rate that contains information related to the animal's behavior? (Like spike timing?)

- Is there a relationship between electrode recording location and the preferred direction of motion of the recorded neurons?

Exploring This Data:

There are many possible avenues to explore with this data set. Feel free to incorporate any or all of these into your project:

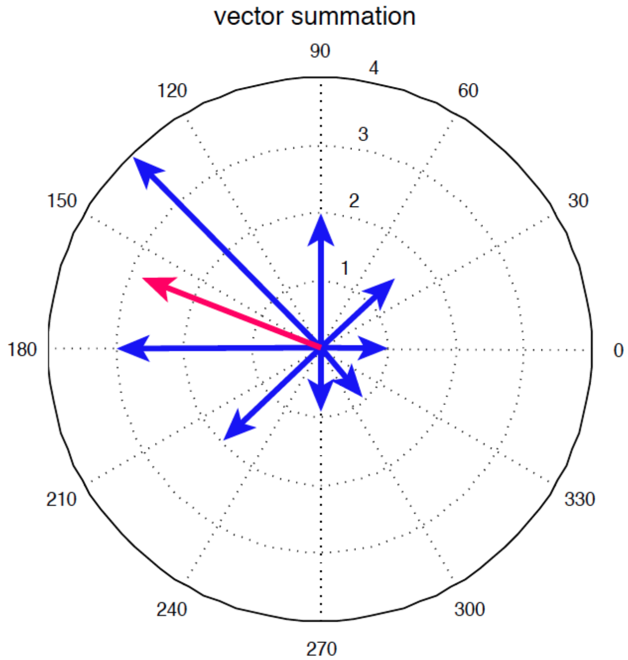
- Create a decoder to determine movement direction based on neural activity.
    - Is it best to include all the neurons in your decoder or just some of them?
    - Should you decoder be based on firing rate or some other property of the spiking pattern?
    - Does your decoder work best for certain directions of motion?
- How can your results be visualized? What does this tell us about the functions of motor cortex?

You could work on these questions, but we also encourage you to ask your own question and explore the dataset. As long you have a complete story and make your point (positive or negative) with your analysis, it will be a great project. Good luck exploring and don't hesitate to share your exiting discoveries!

Supplementary Information

Vector Average as a basic method to decode the movement direction of population code

There are a lot of advanced methods to decode the neural activity. Here we demonstrate a simple and classical method: vector average.



Here we assume that each recorded neuron has a preferred reaching direction, that is, one prefers upper left and another prefers upper right, etc. When coding moment direction as a population, each neuron "votes" for its preferred direction by its activity level. Therefore, the more spikes a neuron fires, the more weight it puts to its preferred direction.

Figure: vector summation, where the length of each blue arrow represents the response (firing rate) of a neuron preferring the pointed direction (here show 8 neurons). The average vector is shown as the red arrow, whose direction is a decoded moving direction of this population activity.

You can try to decode the neural activity by this method and evaluate the decoding performance. Does it work well? What could go wrong with this method? How can you improve it?