The Mystery of Disappearing Receptive Fields

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1. Agenda

New recording technologies may transform neuroscience.

- ➔ Simultaneous calcium imaging recordings from 19,000 neurons in mouse V1 and simultaneous behavioral videos
- ➔ Cool new algorithm for analyzing this data (it's fast too!)
- ➔ Combining data and simulations

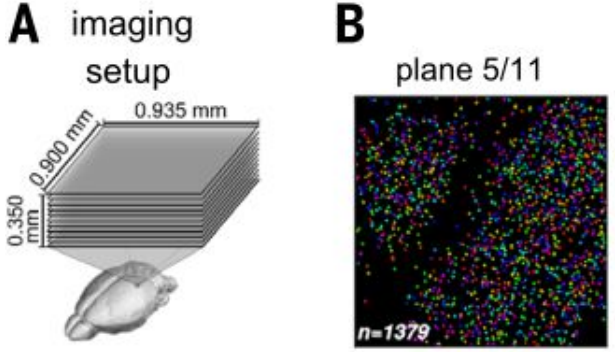
The experiment

The mice were viewing sparse noise stimuli without an explicit task or reward. Recordings were made in primary visual cortex.

Along with neural recordings, the movie of the mouse snout was recorded.

Data freely available online (google Stringer Figshare).

Preprocessing of raw data



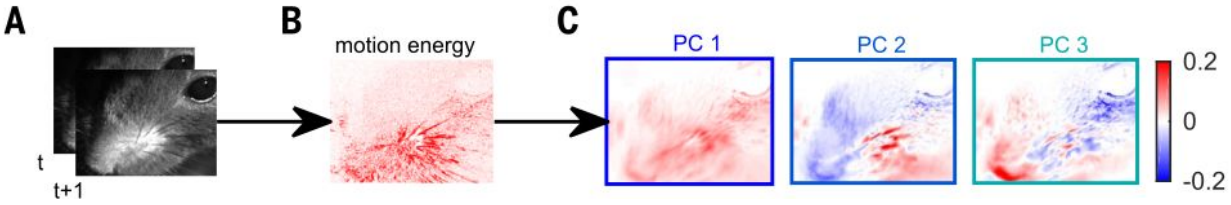
The data was recorded at 2.5 Hz (one time point is 400 ms).

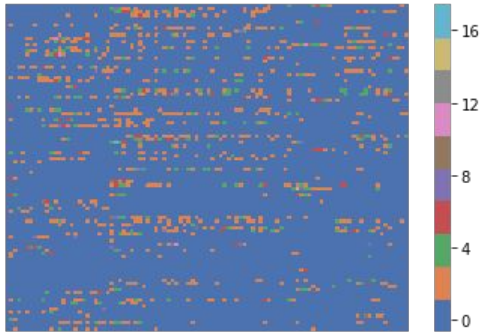
Fluorescence movie was processed using the suite2p library.

We used **deconvoloved data** (OASIS) for our analyses.

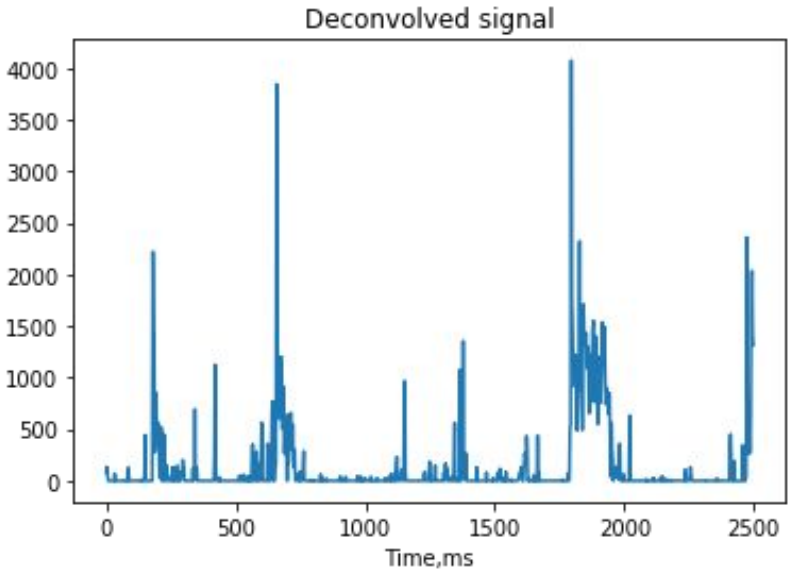
Deconvolution infers time-localized and noisy estimates of the calcium influx of the cells which is an indirect proxy for action potential firing (Stringer, Pachitariu, 2018).

We used 500 motion energy principal components from the snout movie as behavioral data.





What does the data look like?



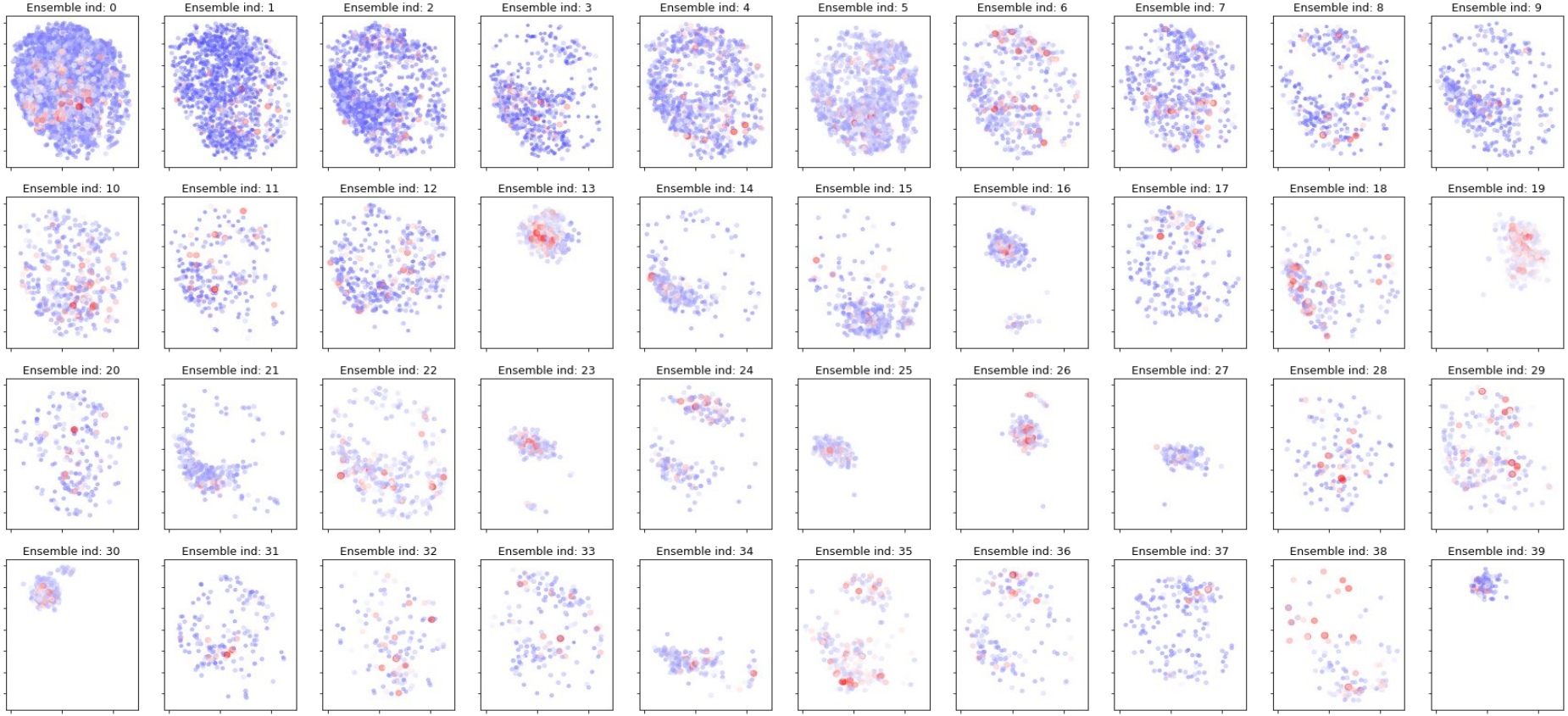
Ensemble Pursuit-- A clustering algorithm where a neuron can belong to multiple clusters

EP learns clusters of cells that tend to co-activate, e.g. form ensembles.
https://github.com/MouseLand/EnsemblePursuit

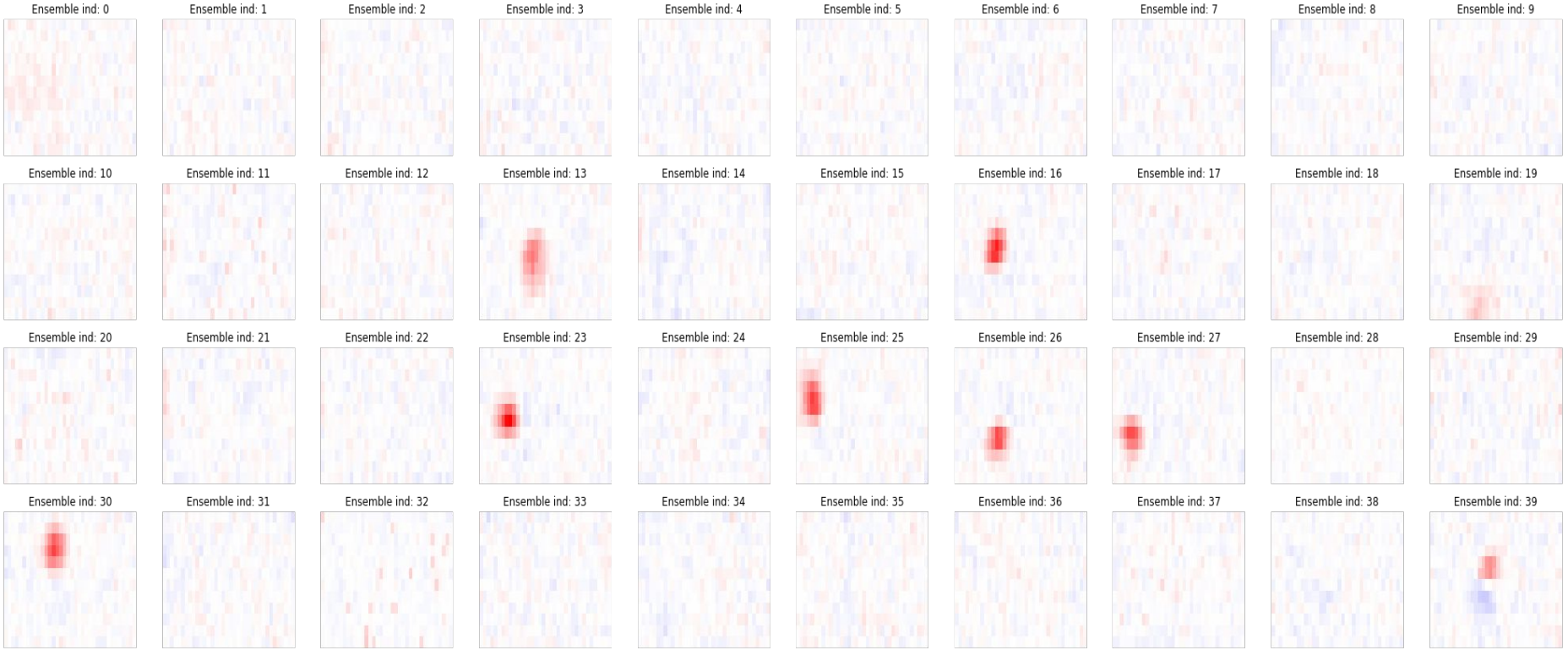
```
!pip install EnsemblePursuit
ep=EnsemblePursuit(n_components=100,lam=0.01,n_kmeans=100)
model=ep.fit(data)
V=model.components_
U=model.weights
```

Extracts 100 components of co-activating cells from 19,000 neurons x10,000 time points data in 4 minutes

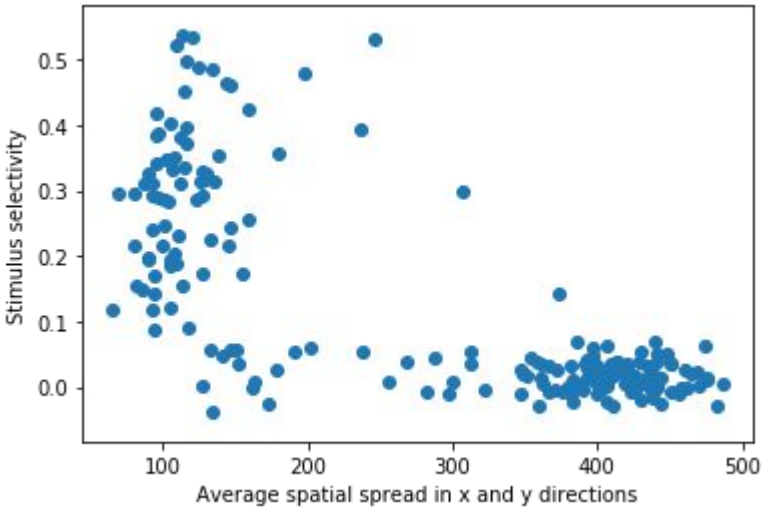
Cells in clusters

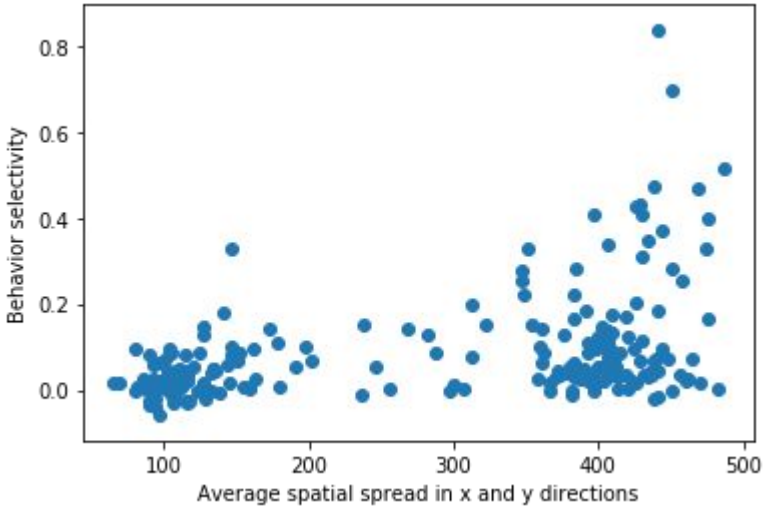


Ensemble receptive fields



‘Behavior’ ensembles are spatially spread out, ‘Stimulus’ ensembles are localized





Taylor expansion of synaptic weights

$$\frac{dw_{ij}}{dt} = F(w_{ij}; \nu_j^{pre}, \nu_j^{post})$$

BCM
Bienenstock-Munro-Cooper
(*if also include a sliding threshold for LTP and LTD)

Hebbian

$$w_{i,j} = a_0 + a_1^{pre}\nu_j^{post} + a_2^{corr}\nu_j^{pre}\nu_i^{post} + a_2^{post}(\nu_j^{pre})^2 + a_3(\nu_i^{post})^2\nu_j^{pre} + \dots$$

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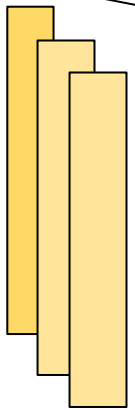
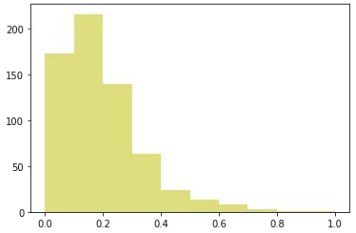
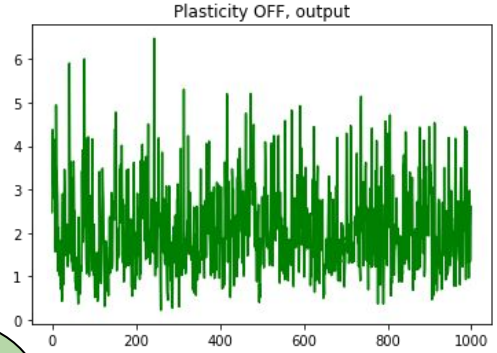
Time

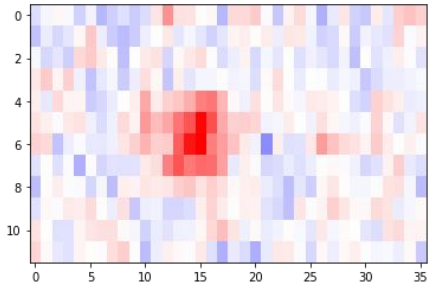
Receptive field ensemble

642 neurons







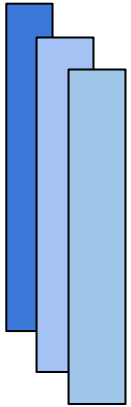


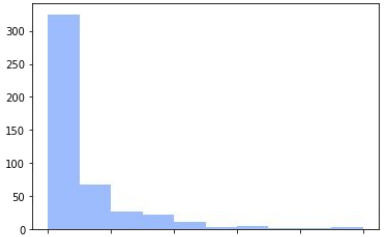
Single neuron

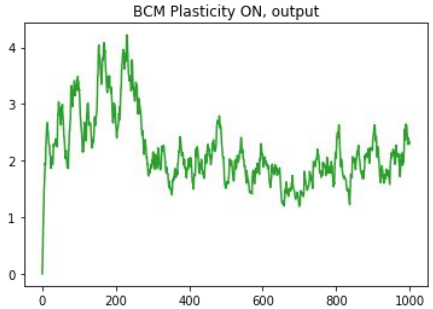
Weights
--gamma distrib.

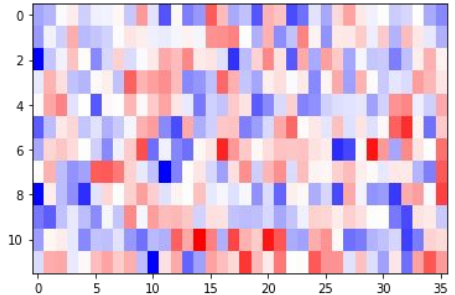
Behavior ensemble

463 neurons









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