Using convex feature selection to improve offline movement decoding

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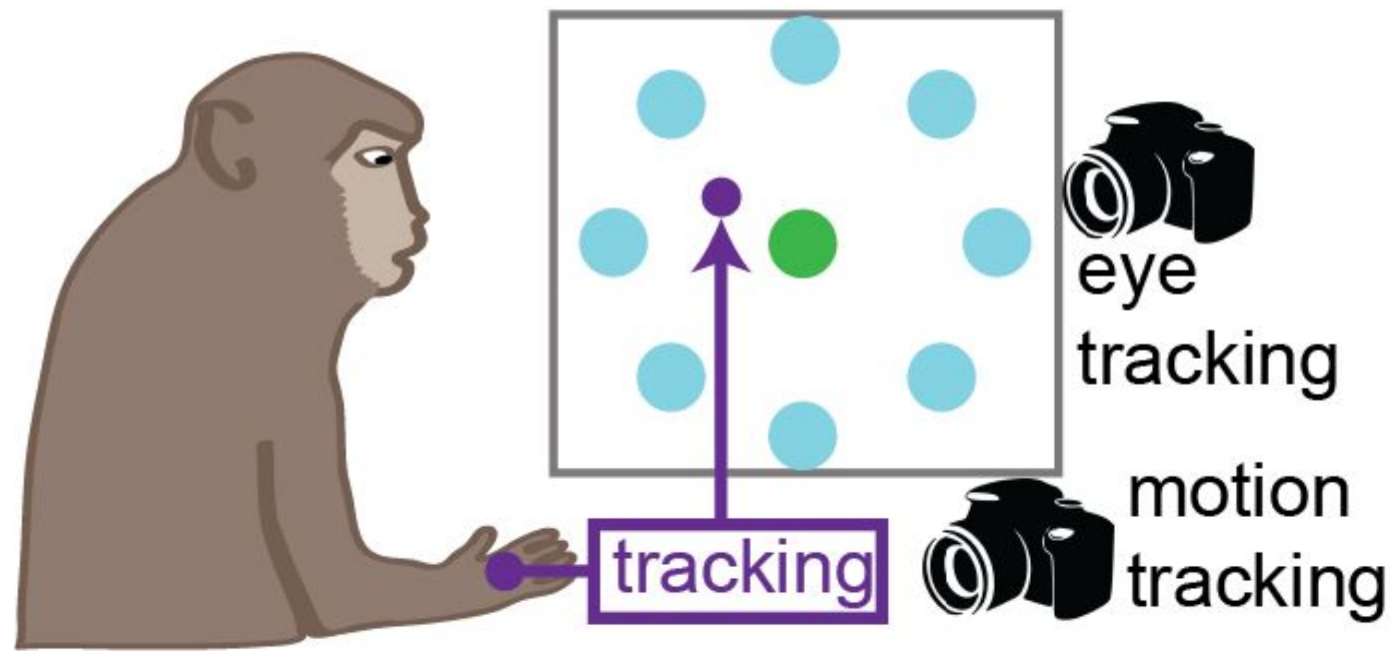
MOTIVATION

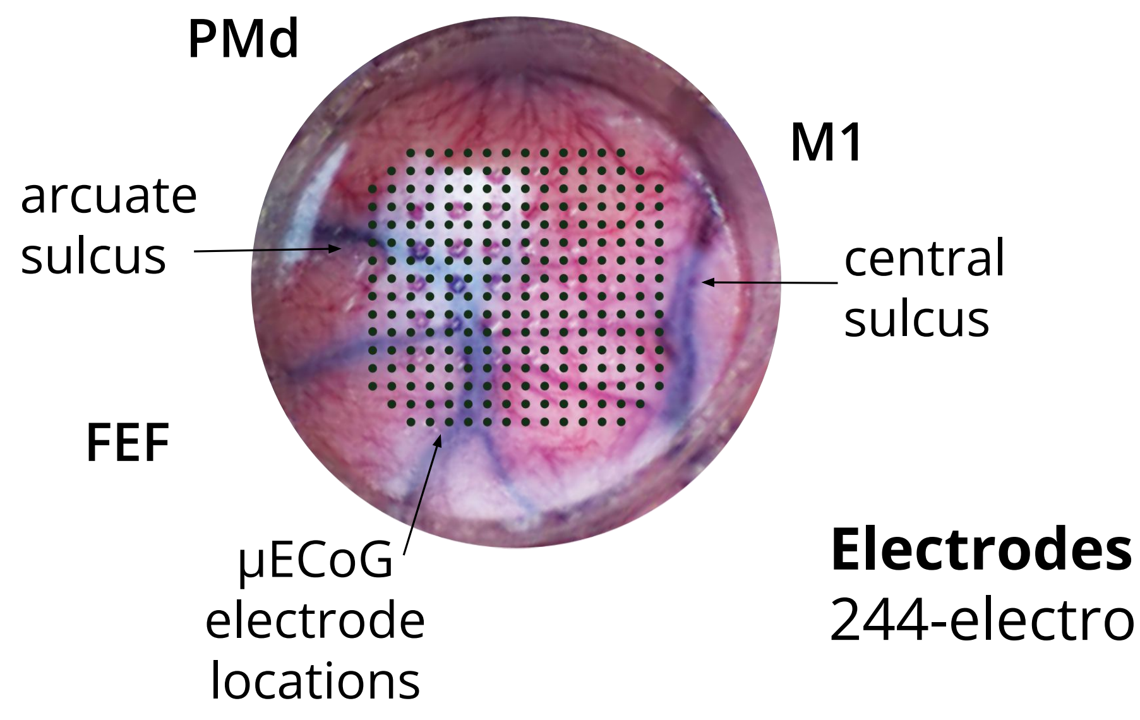
- Can use brain electrical activity to control brain-computer interfaces
- Want to reduce the computational power by removing redundant features from data
- How do we account for:
  - relevance
  - sparsity
  - smoothness
- **Goal:** implement a convex optimization algorithm with recorded data and evaluate its accuracy

METHODS

1. Start with neural, cursor data
2. Train a kalman filter
3. Run convex optimization algorithm
4. Use reduced feature set, predict cursor position
5. Compare predicted cursor position to actual cursor position

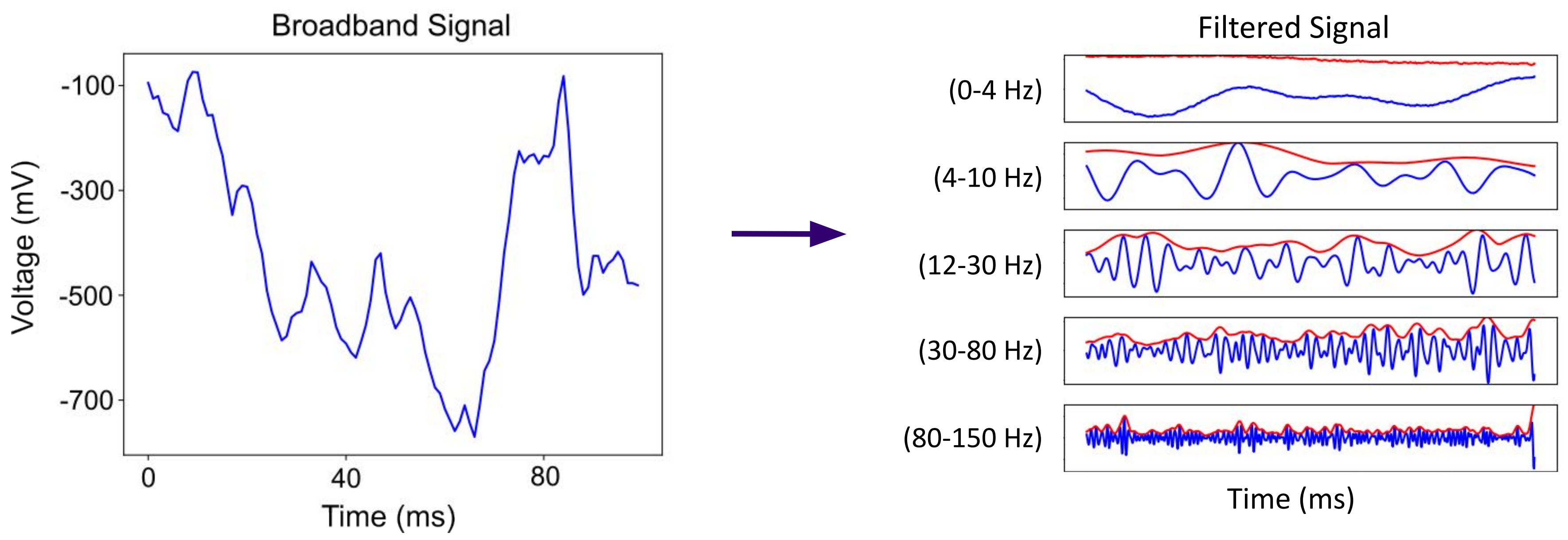
MOVEMENT TASK





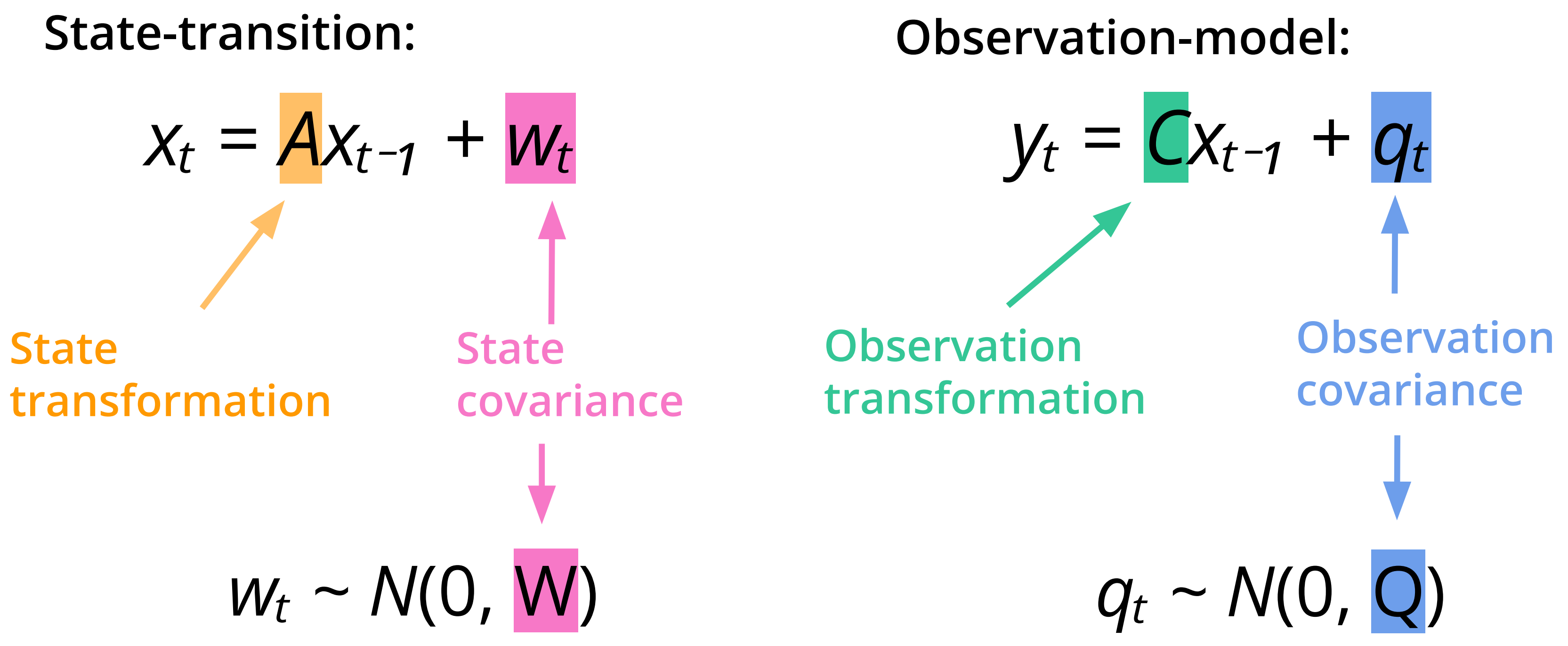
Electrodes
244-electrode µECoG array

ECoG HAS MANY FEATURES



236 electrodes x 5 frequency bands = 1180 features

KALMAN FILTER



State-transition:

$$x_t = A x_{t-1} + w_t$$

State transformation

State covariance

$$w_t \sim N(0, W)$$

Observation-model:

$$y_t = C x_{t-1} + q_t$$

Observation transformation

Observation covariance

$$q_t \sim N(0, Q)$$

Kalman filters (map) internal states (neural activity) to observed behavior (cursor position)

CONVEX FEATURE SELECTION

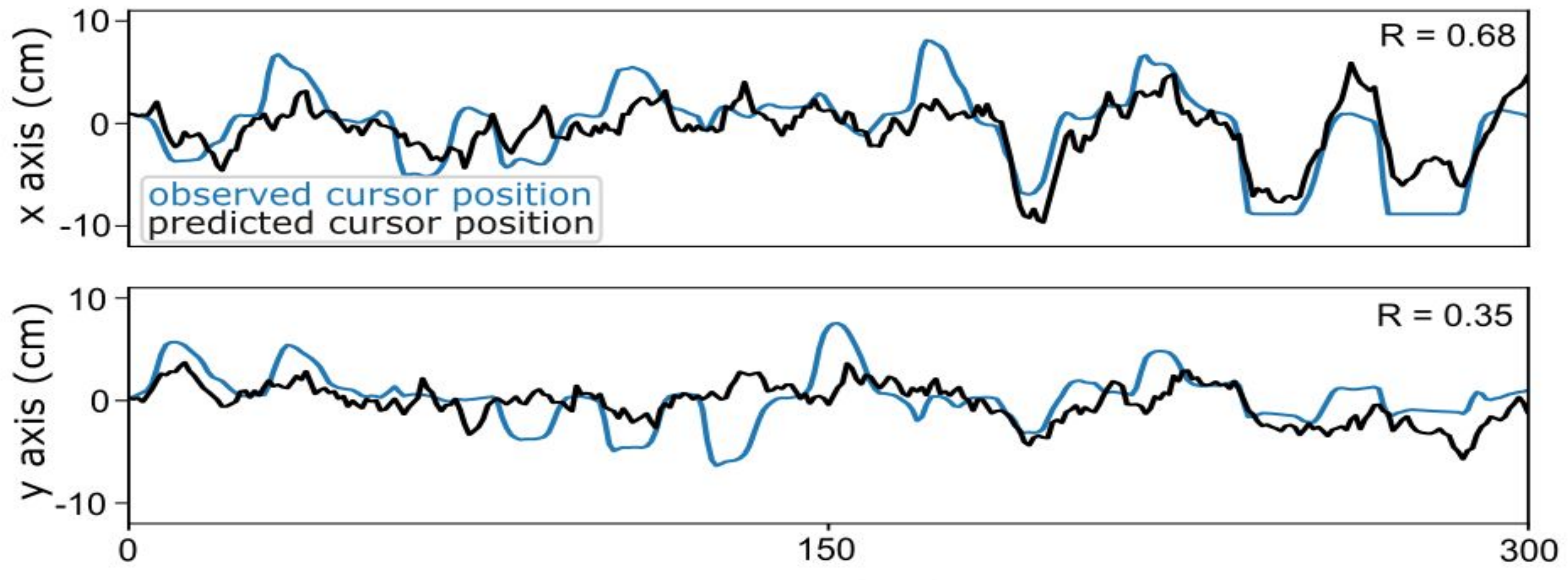
$$\min_{\theta_i} \; -\mathbf{logdet}(C_i^T Q^{-1} \Theta_i C_i) + \lambda \theta_i^T \mathbf{1} - \mu \theta_i^T [\, \theta_{i-1} \ldots \theta_{i-k} \,][\, p \ldots p^k \,]^T$$

s.t. $0 \leq \theta_i \leq 1$

Convex optimization selects features for relevance, sparsity, and smoothness

RESULTS

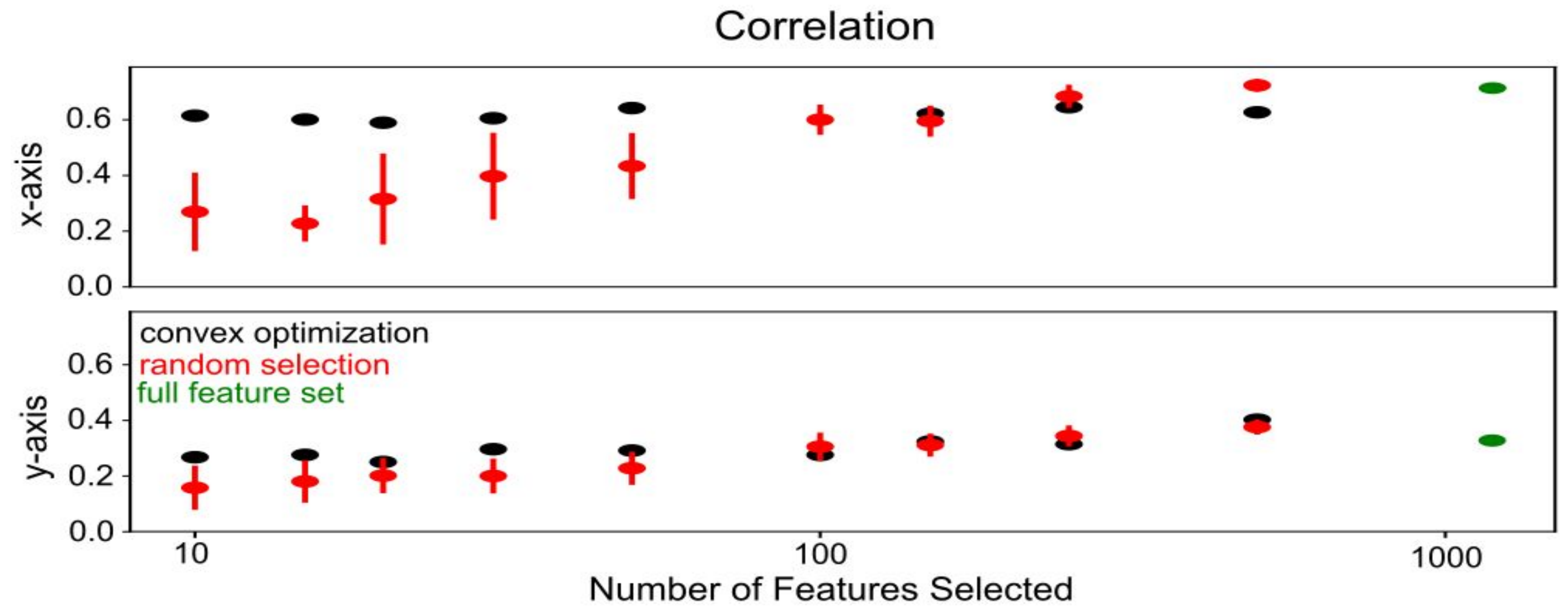
Correlation Comparison Between Actual and Predicted Cursor Position



Time (ms)

N = 250 Features

CONVEX FEATURE SELECTION HAS HIGHER PERFORMANCE AT LOWER THRESHOLDS



FUTURE WORK

We will apply the convex optimization algorithm to neuropixels and then apply it to online brain movement decoding.

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