Spike Sorting

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Agenda

- Feature extraction
- Clustering
- Methodology
- Noisy spike sorting
- Results
- Work in progress
- Questions

Feature extraction

The goal is to select features that best separate the different spike classes.

- **Derivative**
  - Reduces low frequency noise and amplifies high frequency component.
  - Recorded waveforms from neurons with similar ion channel populations may have localized variations (high frequency) making it difficult to examine in time domain.
  - Derivation amplifies these localized variations. *

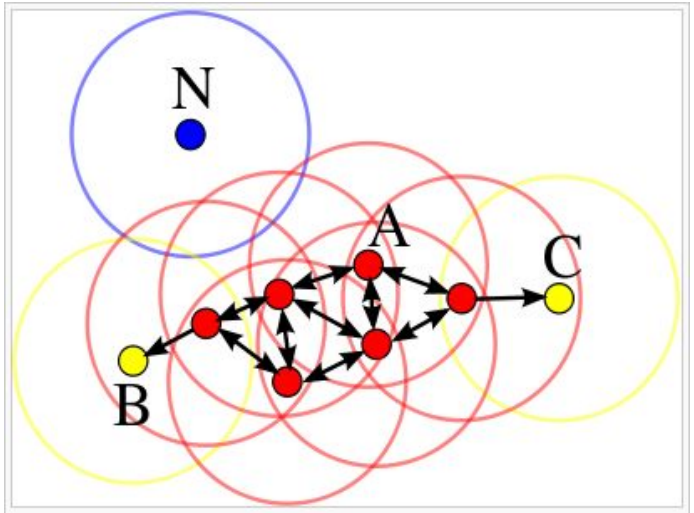
- **Wavelet**
  - Use wavelet transform to calculate the coefficients for each spike.
  - Select the wavelet coefficients using Kolmogorov Smirnov test for Normality.
  - Our implementation uses the first 10 coefficients with the largest deviation from normality.
  - Wavelet coefficients provides a compressed representation of the spike features that serves as the input to the clustering algorithm.

- **PCA**
  - The first 3 features are considered.

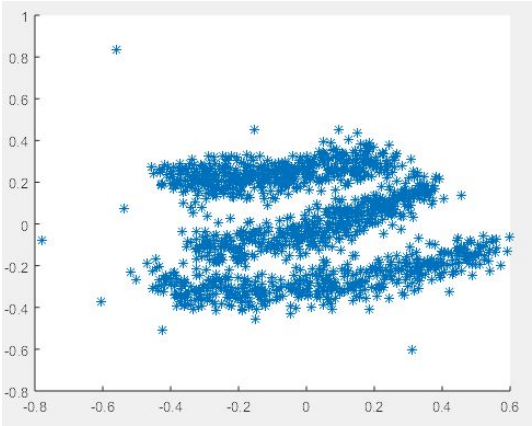
*Ref:Spike Feature Extraction Using Informative Samples. Zhi Yang, et al.

Clustering

- DBSCAN
  - It is a density based clustering algorithm.
  - A cluster satisfies two points.
    - → All points within the cluster are mutually density-connected.
    - → If a point is density-reachable from any of the cluster, it is a part of the cluster as well
  - The border points which are treated as noise by DBSCAN are sorted separately.



Methodology

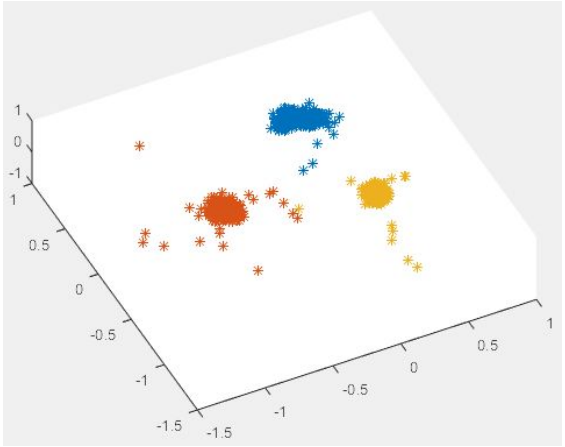


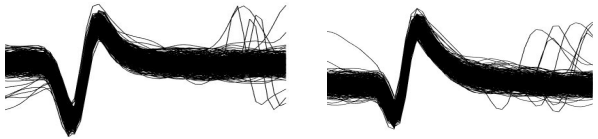
Perform derivative on the given data set

Feature Extraction: PCA / wavelet

Clustering: DBSCAN

Noisy Spike Sorting: kNN / Correlation



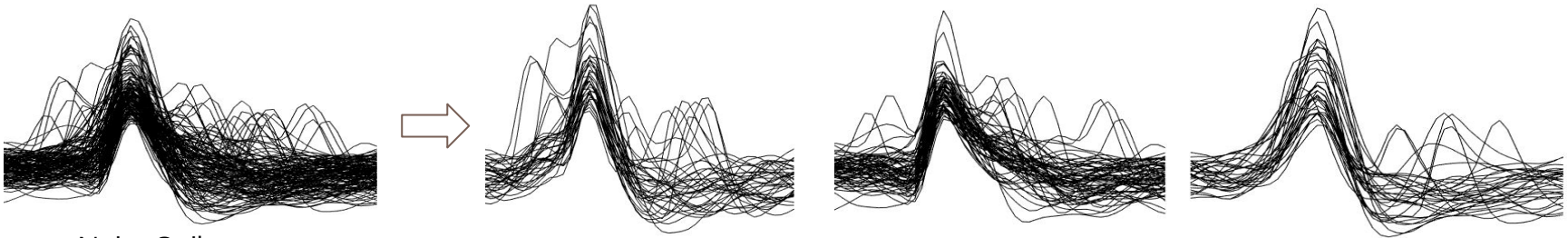


Approaches with limited success

- PCA with k-means (worked for Sample_data 1)
- Wavelet with k-means (worked for Sample_data 1 and 2)
- Mapping waveforms to higher dimensions(improvement was insignificant)
  - Clusters the irregular spikes.
- Template matching
  - Needs centroid spike.
  - Will be good for sorting the outliers after clustering.
- Derivative of spikes followed by PCA / wavelet and DBSCAN for clustering works well.

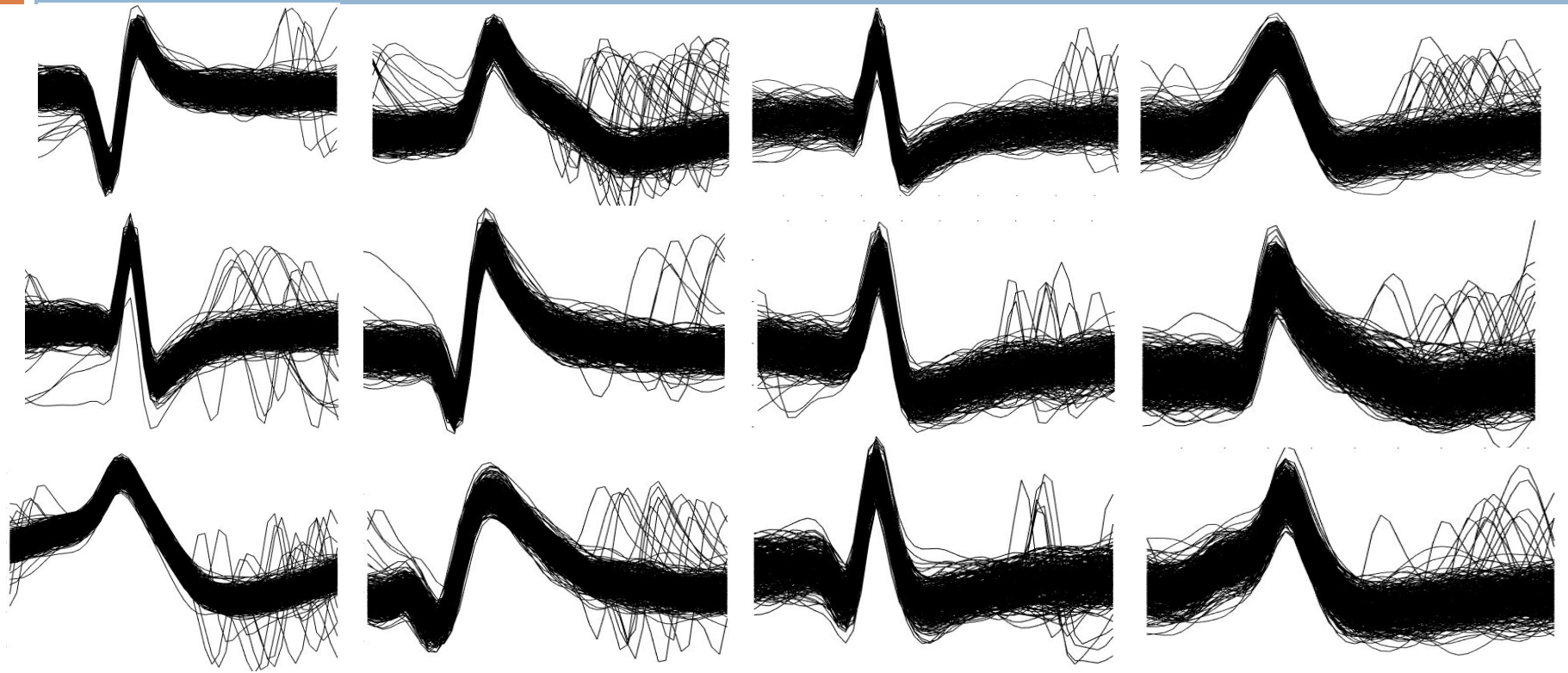
Approach for Noisy spike sorting

- knn - classification
  - Noisy spike is assigned to the nearest cluster.
- Correlation
  - Find a spike that shows high correlation with other spikes in the cluster.
  - Compare the correlation coefficient of each noisy spike with the above spike.



Noisy Spikes

Results



Sample data 1 Sample data 2 Sample data 3 Sample data 4

Work in progress

- Automatic selection of ε for DBSCAN
  - k-Nearest Neighbour graph.
  - Use HINTS :)
    - For example, there cannot be more than 6 clusters.

Thank You

Questions?