

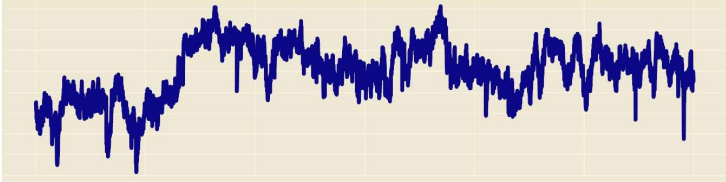
Event Detection & Classification

Mohini Bariya
UC Berkeley

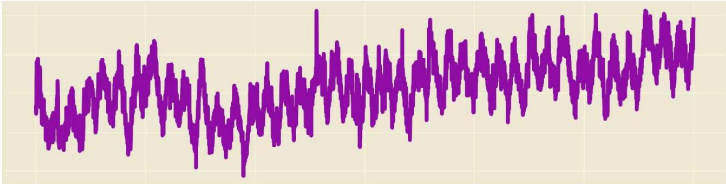
Outline

- Motivation
- Event Detection
- Event Classification & Analysis

Phasor Measurement Data



Voltage magnitude



Current magnitude

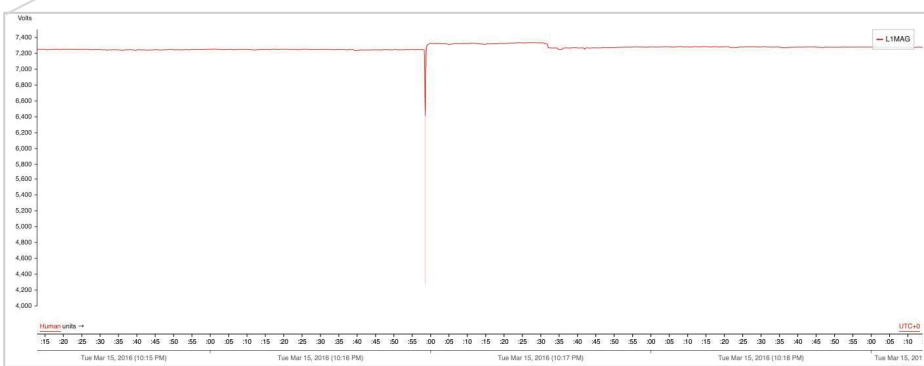
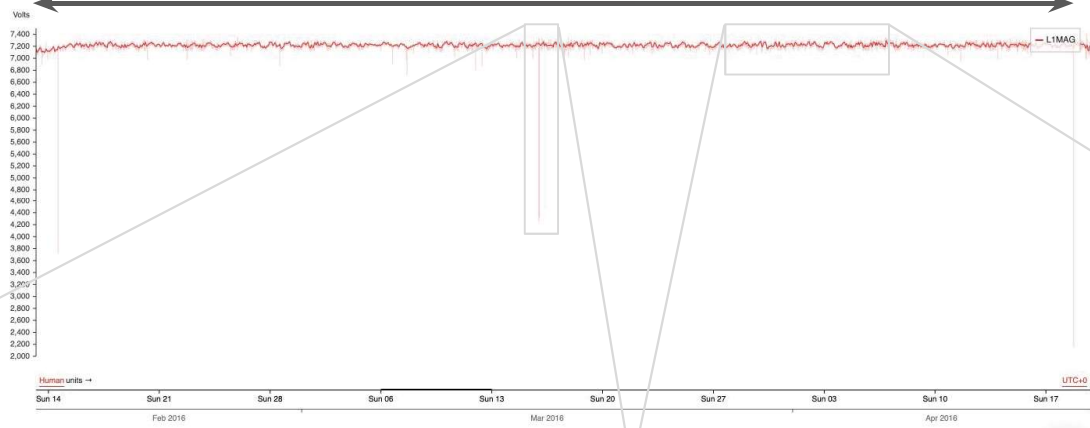


Voltage angle

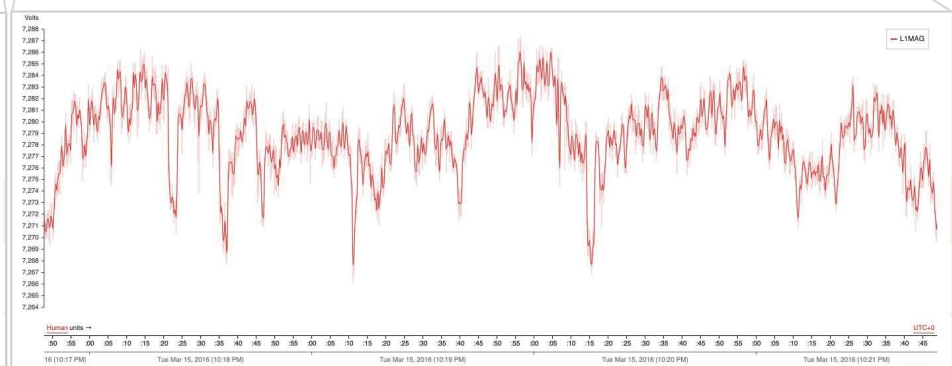


Current angle

Months



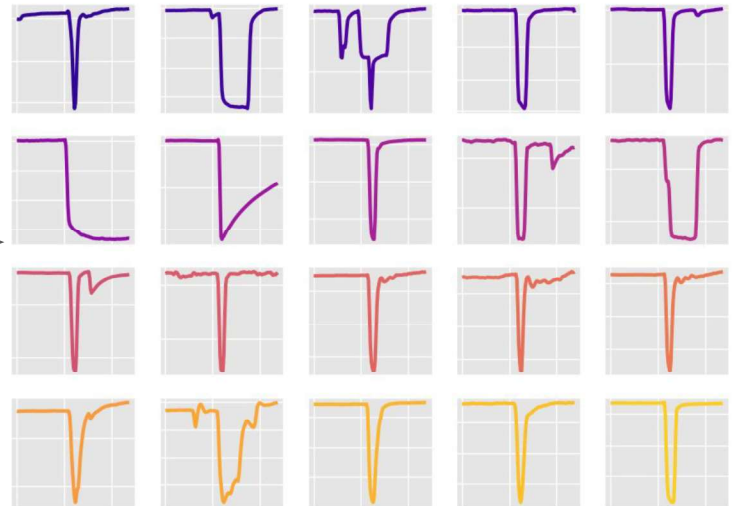
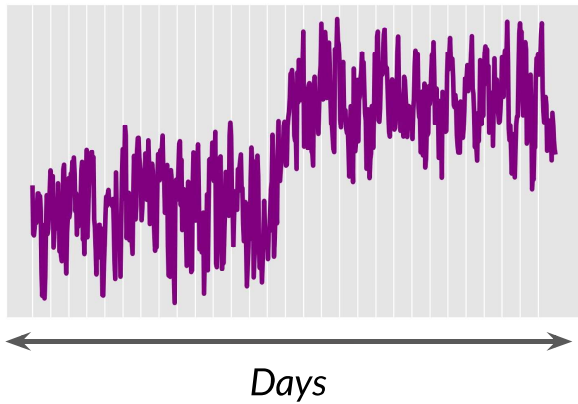
Minutes



Days

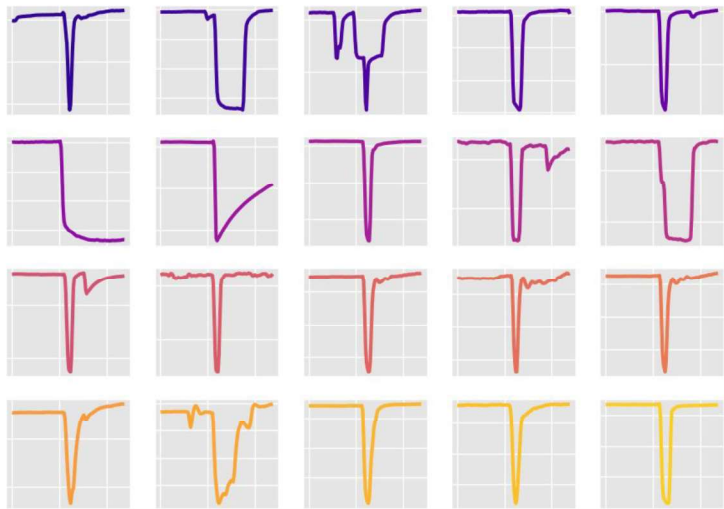
Making sense of data: towards a human scale

Step 1: Event Detection

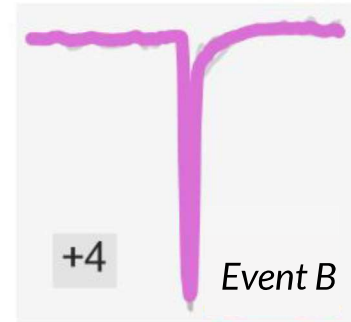
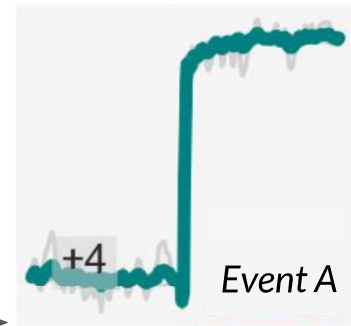
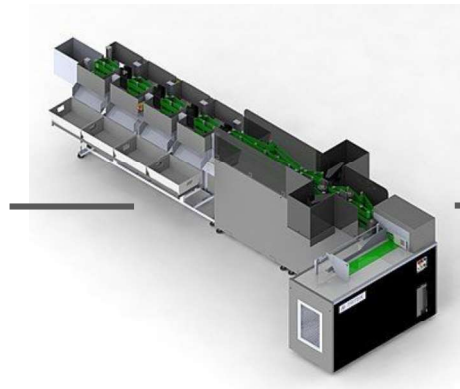


Making sense of data: towards a human scale

Step 2: Event Classification & Analysis



Many events



Outline

- Motivation
- **Event Detection**
- Event Classification & Analysis



Event Detection

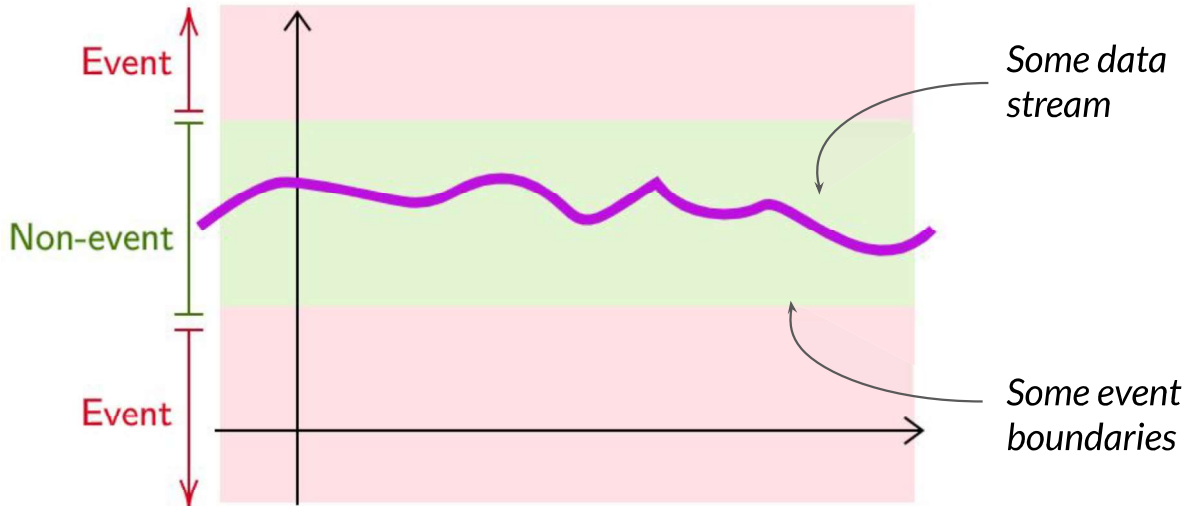
In the copious event detection literature, events are detected...

in various data streams:

- Raw measurements
- Wavelet transform
- Singular values

with various techniques:

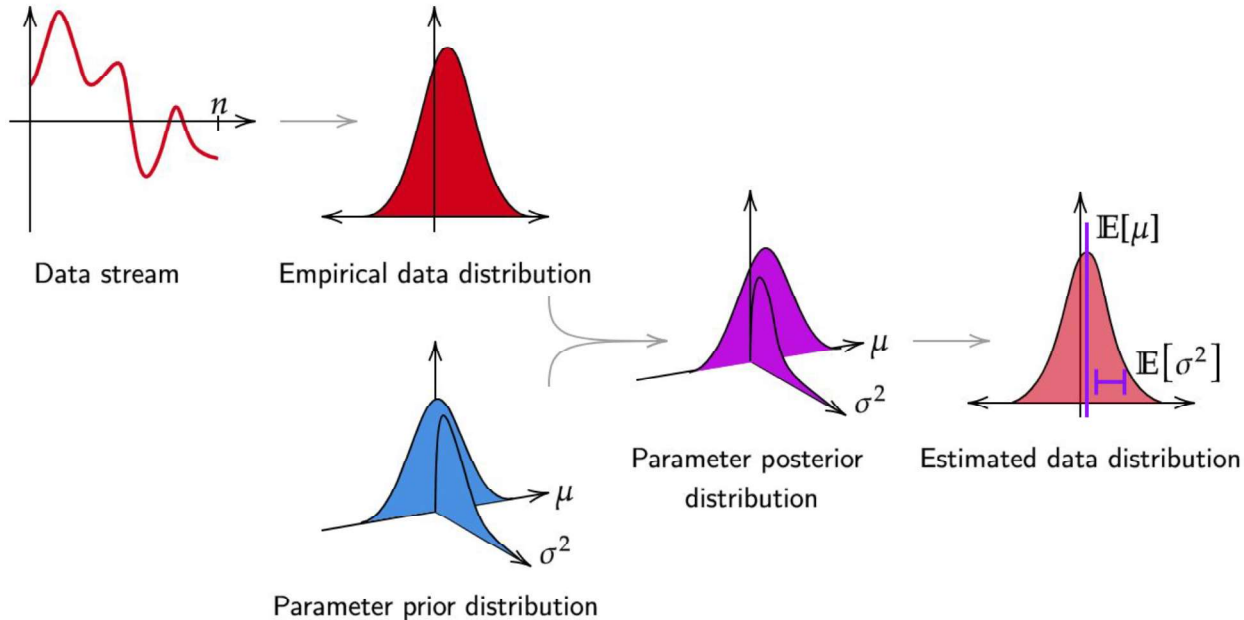
- Constant thresholds
- Regression thresholds
- Machine Learning models



Statistical Event Detection

Statistical approaches benefit from being interpretable and often unsupervised.

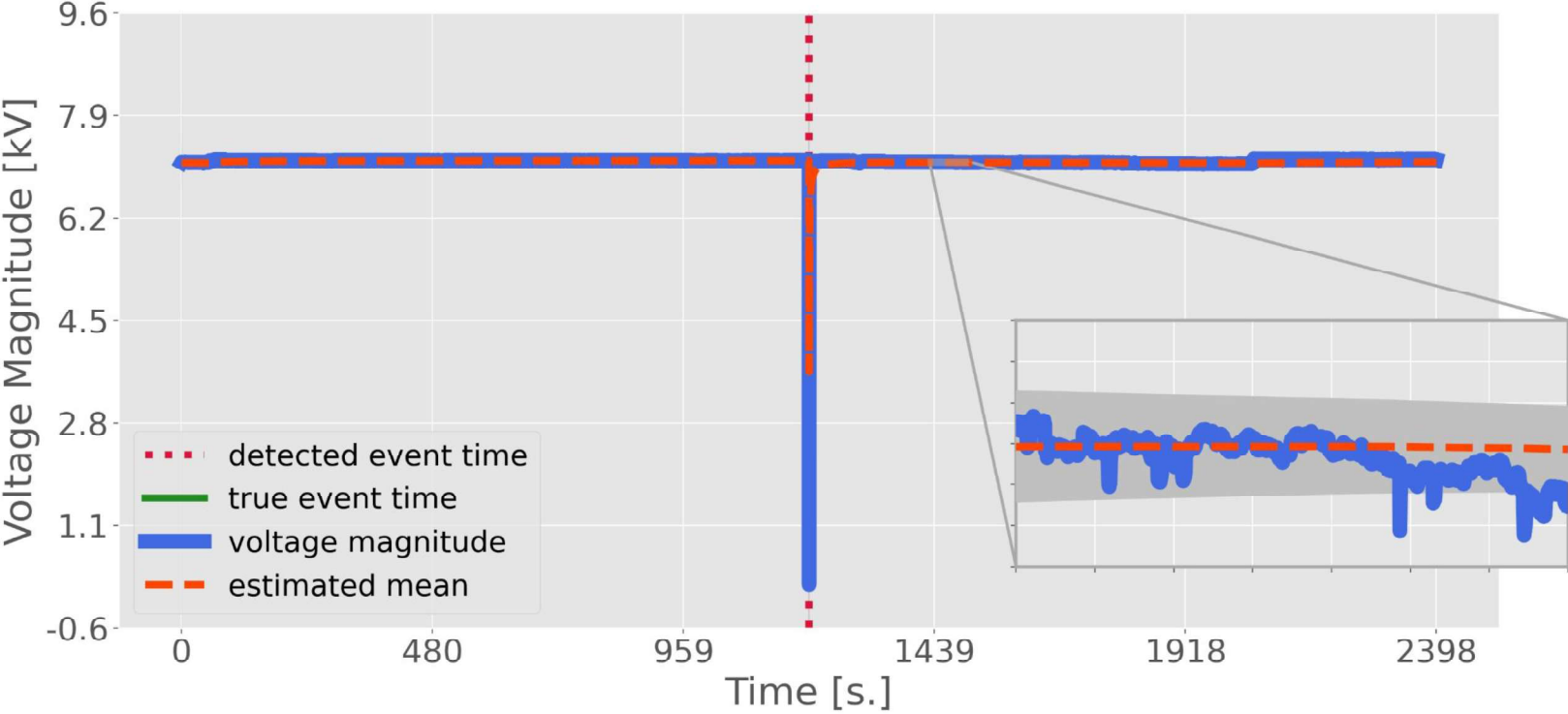
A Bayesian approach to event detection



Sajan, K. S., Bariya, M., Basak, S., Srivastava, A., Dubey, A., von Meier, A., & Biswas, G. (2020, April). Realistic Synchrophasor Data Generation for Anomaly Detection and Event Classification. In *2020 8th Workshop on Modeling and Simulation of Cyber-Physical Energy Systems* (pp. 1-6). IEEE.

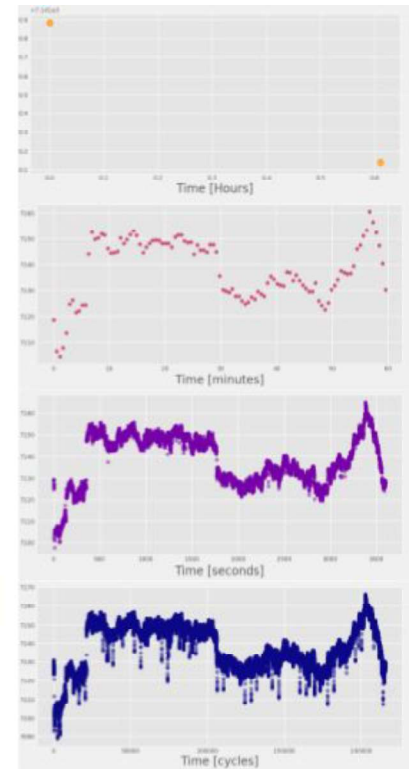
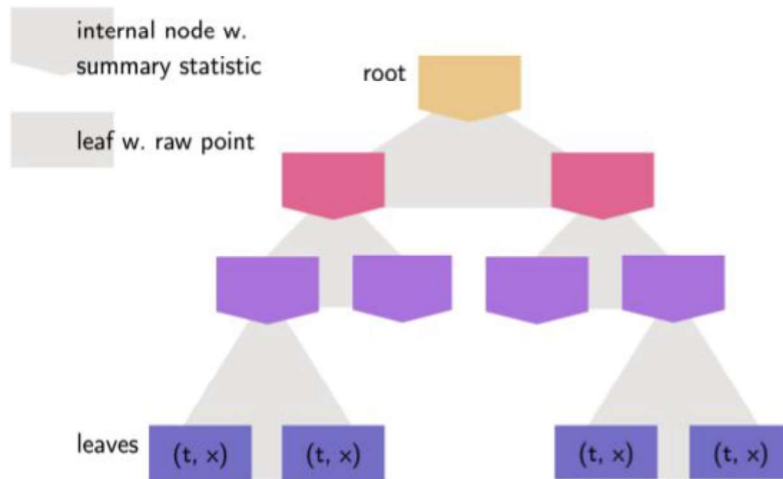
Statistical Event Detection

A Bayesian approach to event detection



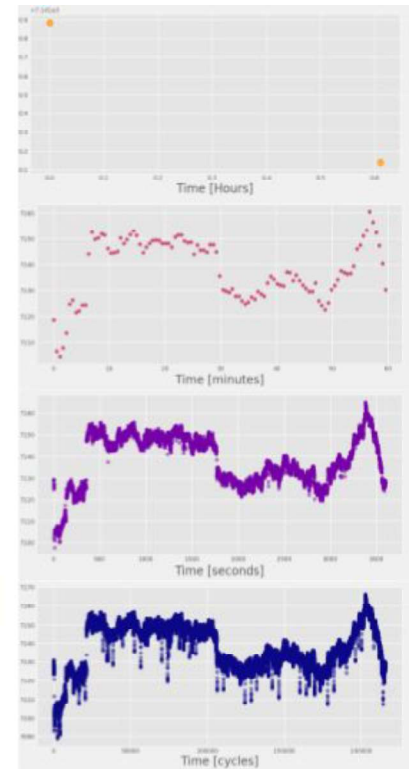
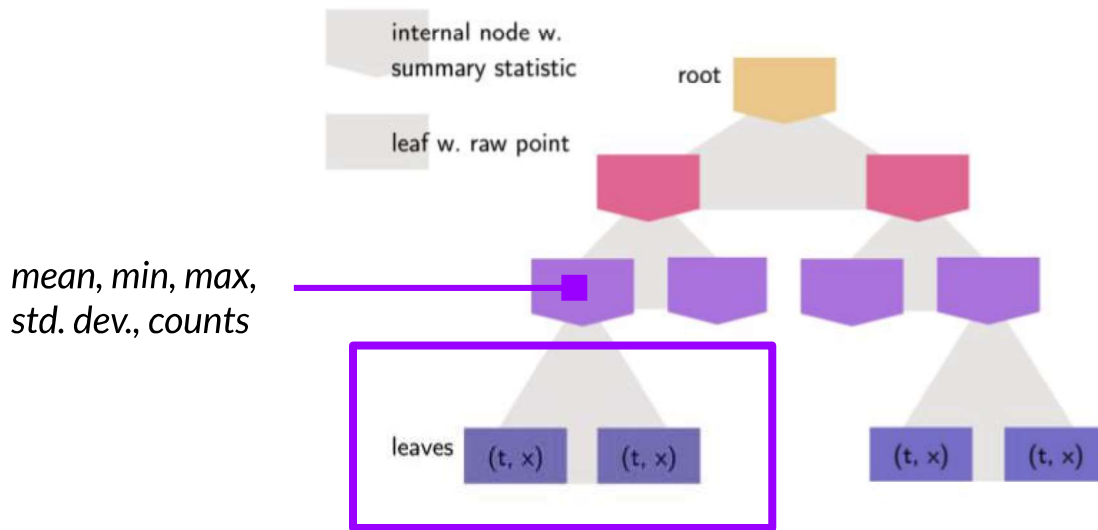
Leveraging the Platform

Methods designed with the database architecture in mind can be run efficiently over vast data volumes.



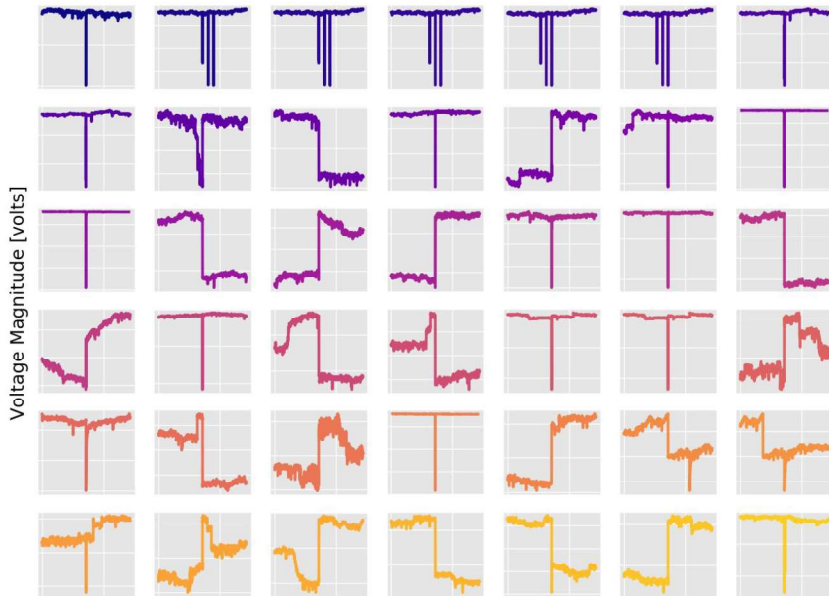
Leveraging the Platform

Methods designed with the database architecture in mind can be run efficiently over vast data volumes.

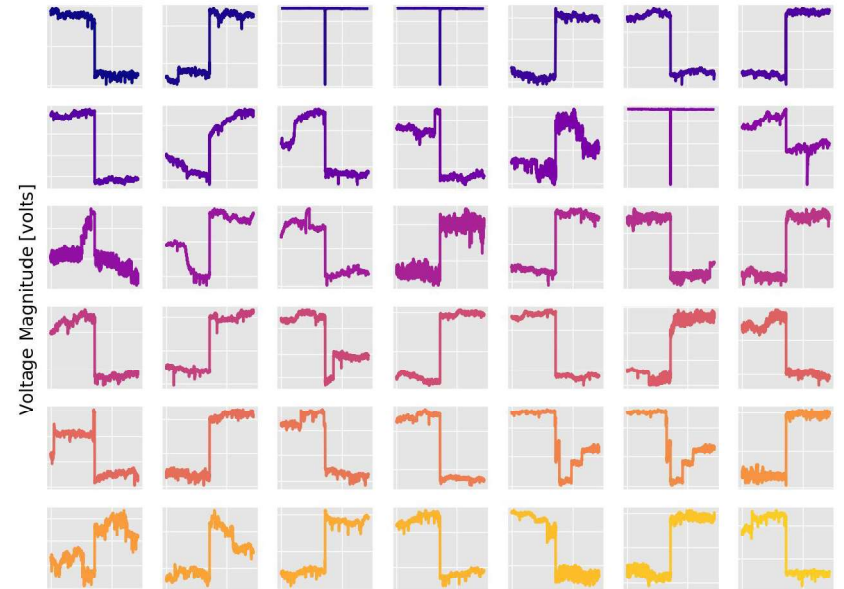


Finding Events with Extreme Statistics

With this architecture, it is easy to find statistical extremes.



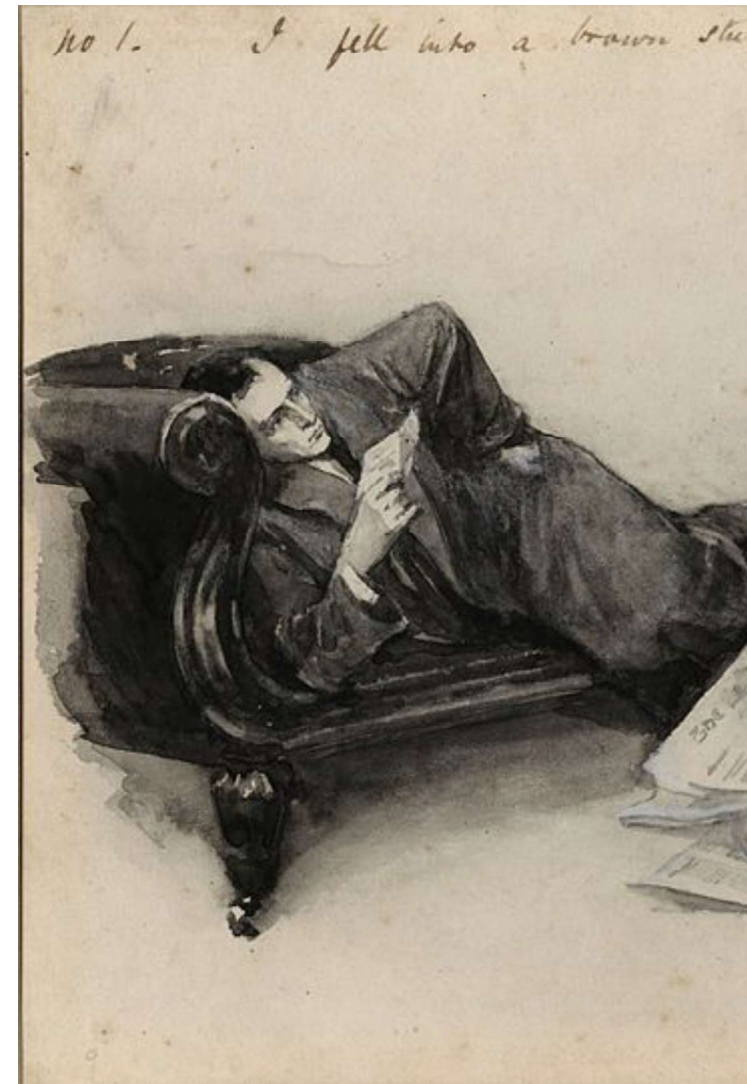
Using max-min metric



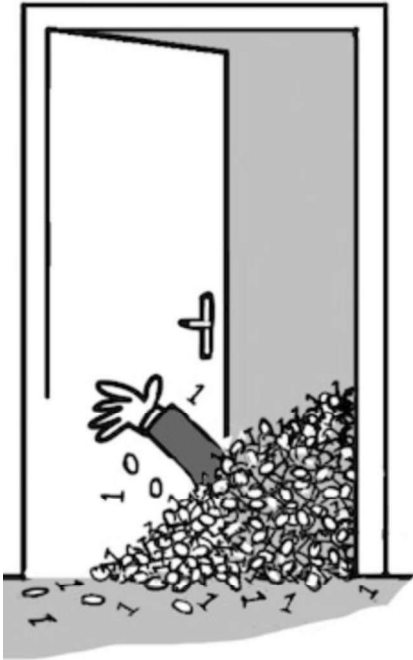
Using standard deviation metric

Outline

- Motivation
- Event Detection
- **Event Classification & Analysis**



Classification by Clustering



Clustering is a promising classification approach because:

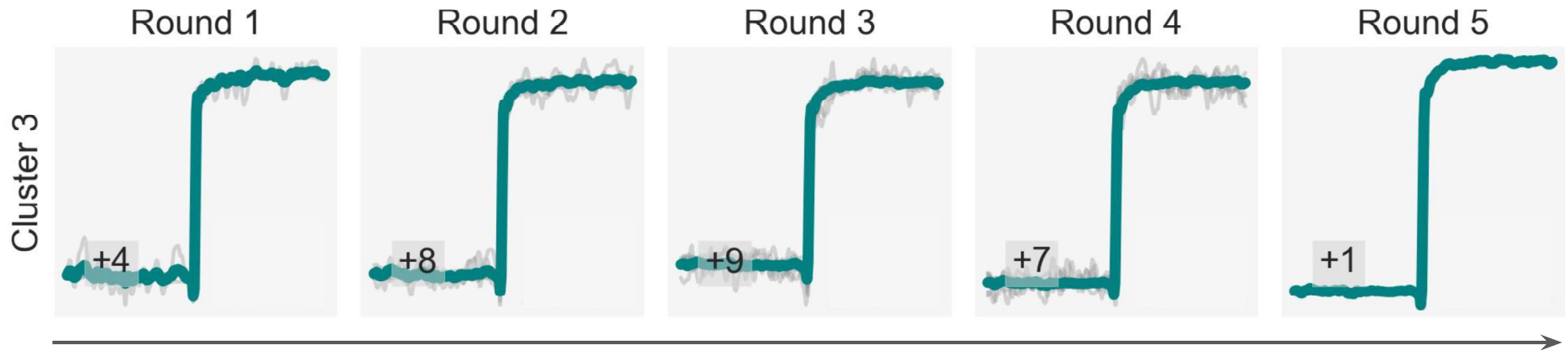
- it can be applied to unlabeled data (unsupervised)
- if applied to physically meaningful features, it is highly intuitive.

Clustering *organizes* data in an insightful and manageable manner.

But what clustering algorithm to use? Data arrives in a streaming manner, and new events keep happening.

Streaming Clustering of Events

k-ShapeStream allows streaming clustering of events.

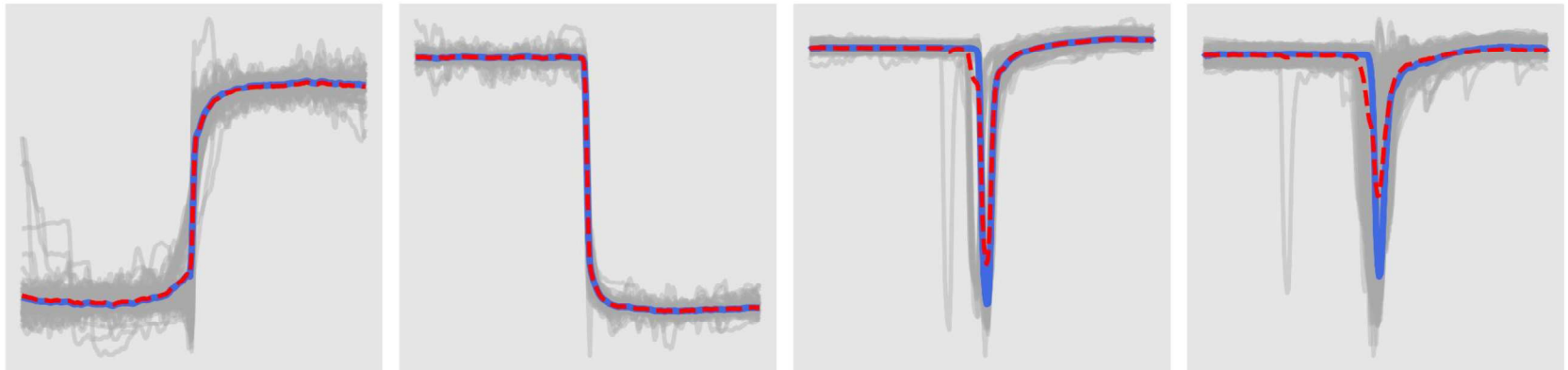


Events added to cluster over time. Cluster centroid modified based on new events.

Bariya, M., Paparrizos, J., von Meier, A., Franklin, M. (2021, July).
k-ShapeStream: Probabilistic Streaming Clustering for Electric Grid Events. In
2021 14th IEEE PowerTech (forthcoming). IEEE.

An efficiently computed cross-correlation distance metric that is well suited to time series data and handles time misalignment.

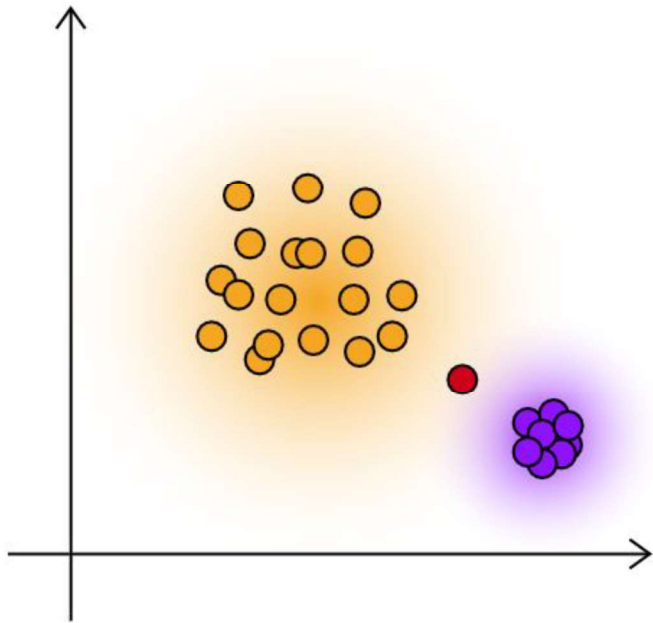
Cluster centroid computation using principal components which preserves sharp features.



— k-shape centroid
- - - arithmetic mean centroid

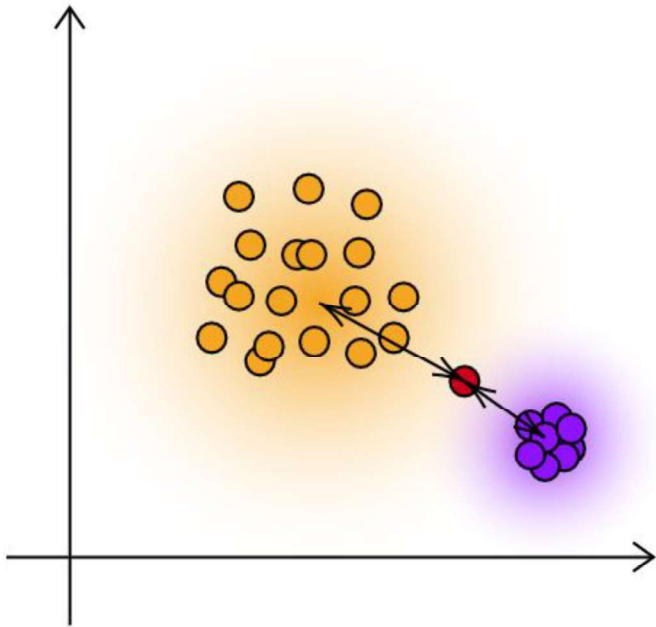
Bariya, M., Paparrizos, J., von Meier, A., Franklin, M. (2021, July).
k-ShapeStream: Probabilistic Streaming Clustering for Electric Grid Events. In
2021 14th IEEE PowerTech (forthcoming). IEEE.

An probabilistic proximity metric for assigning time series to a cluster.



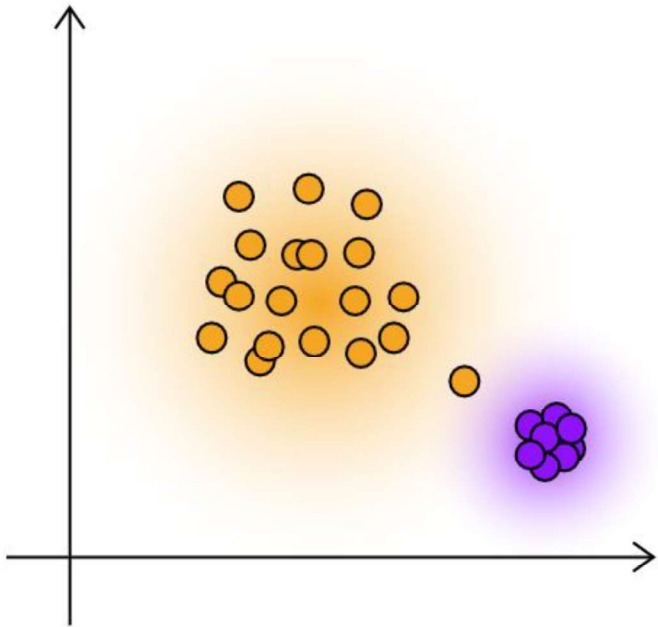
Bariya, M., Paparrizos, J., von Meier, A., Franklin, M. (2021, July).
k-ShapeStream: Probabilistic Streaming Clustering for Electric Grid Events. In
2021 14th IEEE PowerTech (forthcoming). IEEE.

An probabilistic proximity metric for assigning time series to a cluster.



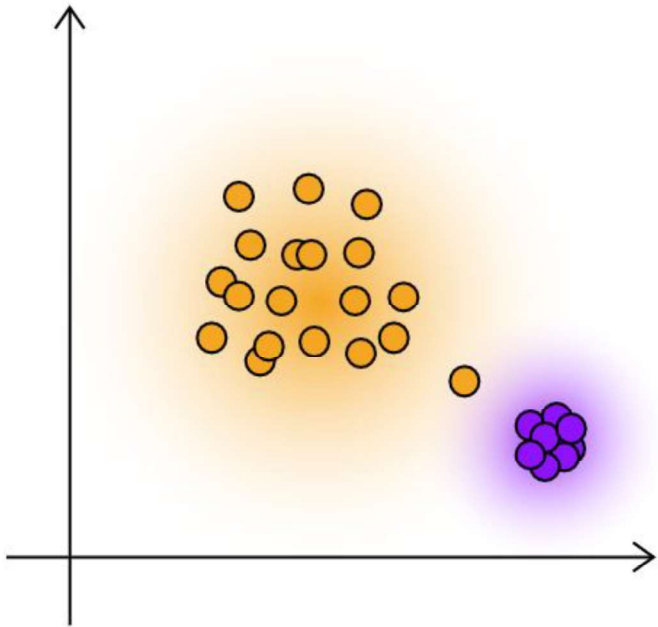
Bariya, M., Paparrizos, J., von Meier, A., Franklin, M. (2021, July).
k-ShapeStream: Probabilistic Streaming Clustering for Electric Grid Events. In
2021 14th IEEE PowerTech (forthcoming). IEEE.

An probabilistic proximity metric for assigning time series to a cluster.



Bariya, M., Paparrizos, J., von Meier, A., Franklin, M. (2021, July).
k-ShapeStream: Probabilistic Streaming Clustering for Electric Grid Events. In
2021 14th IEEE PowerTech (forthcoming). IEEE.

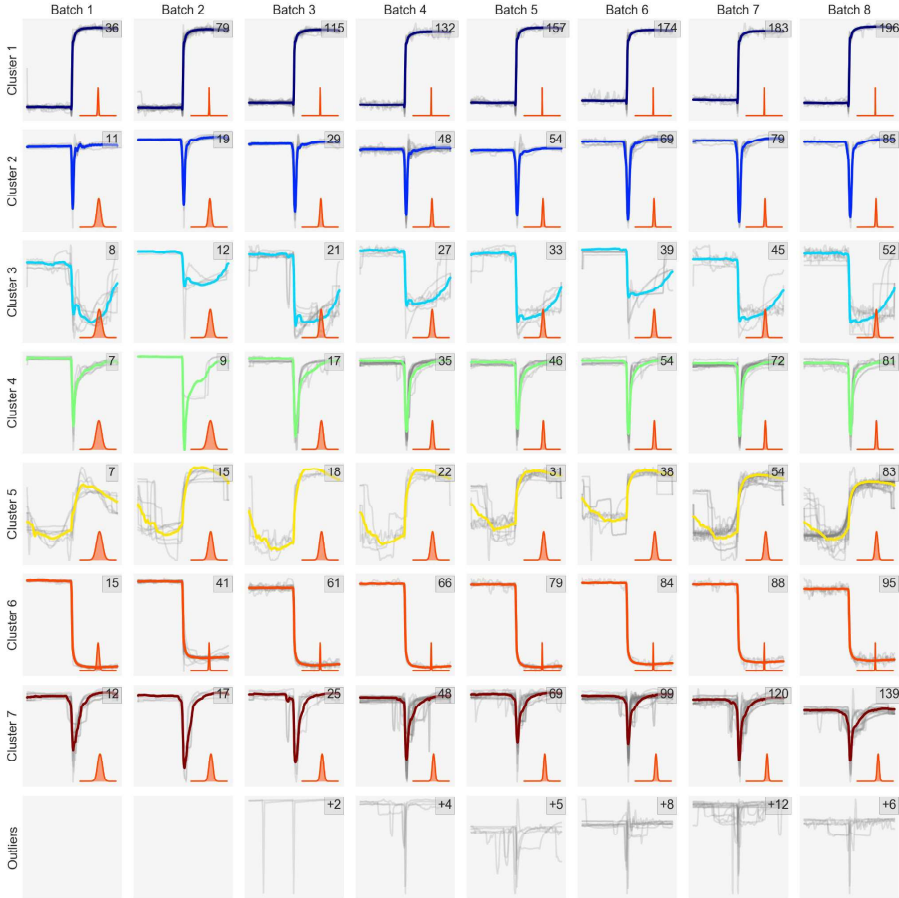
An probabilistic proximity metric for assigning time series to a cluster.



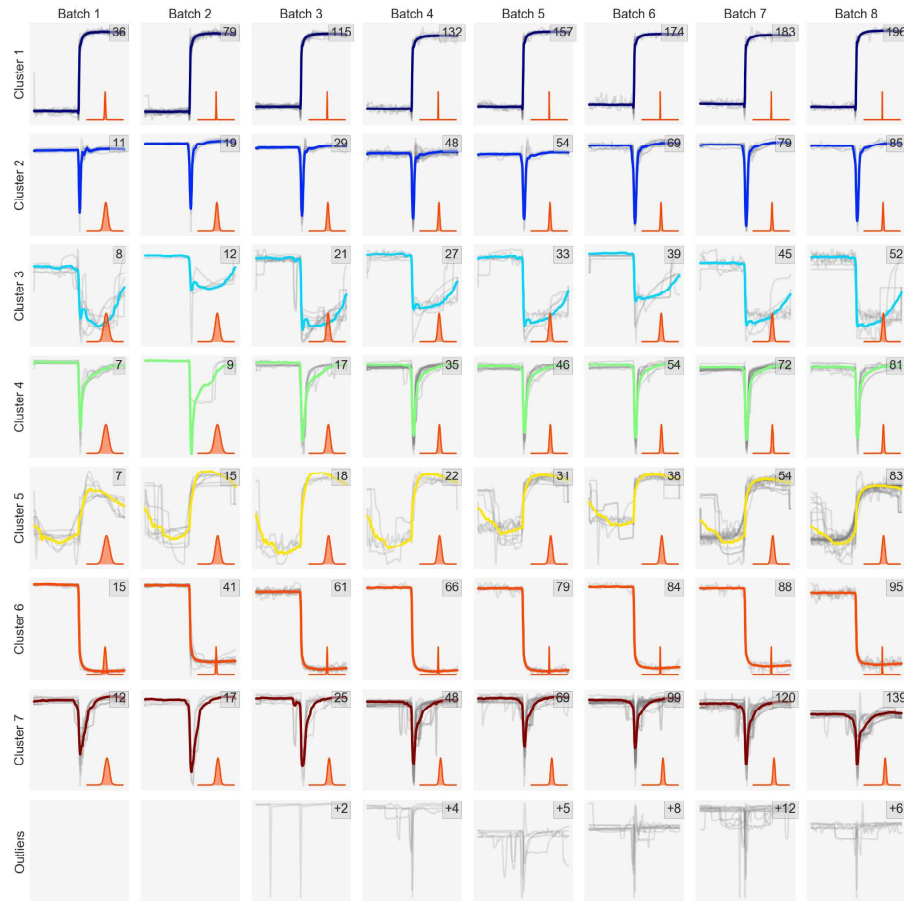
This also allows outliers to be flagged.

Bariya, M., Paparrizos, J., von Meier, A., Franklin, M. (2021, July).
k-ShapeStream: Probabilistic Streaming Clustering for Electric Grid Events. In
2021 14th IEEE PowerTech (forthcoming). IEEE.

k-ShapeStream applied to events detected in voltage magnitude data.

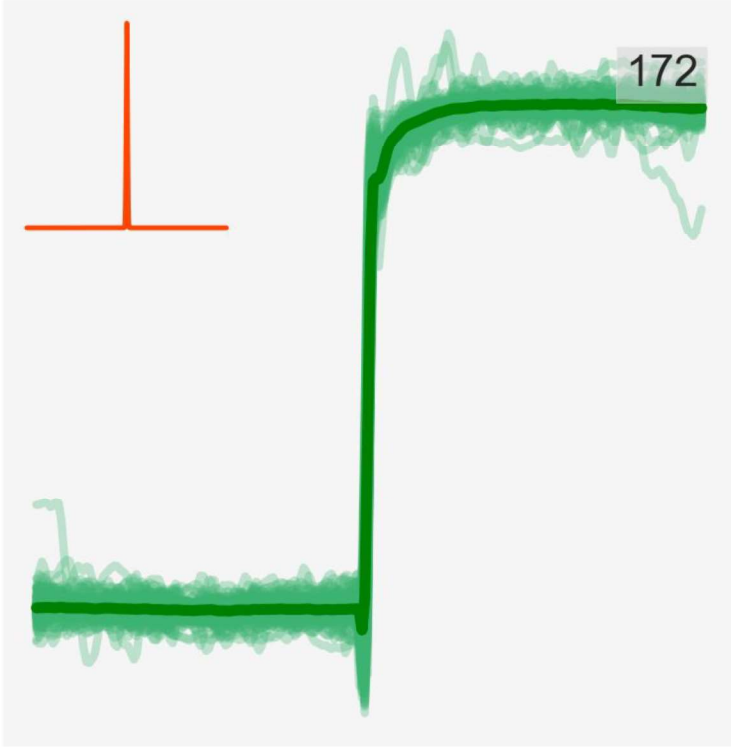
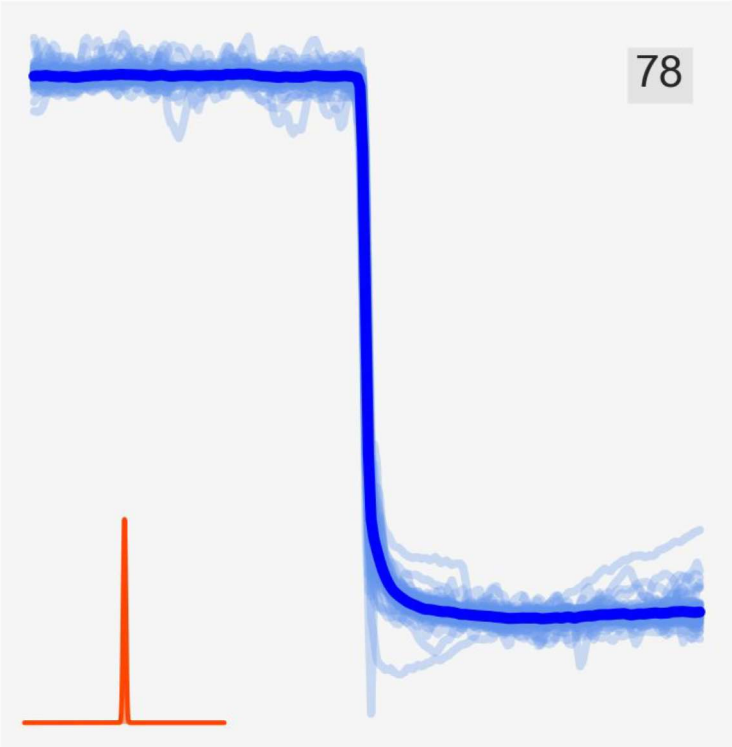


k-ShapeStream applied to events detected in voltage magnitude data.

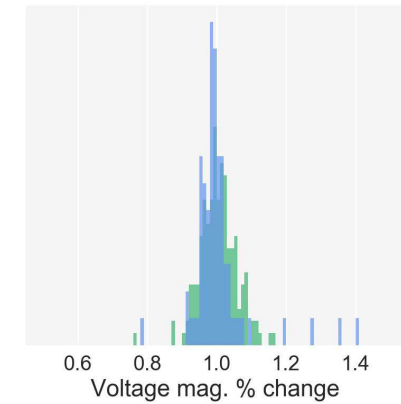
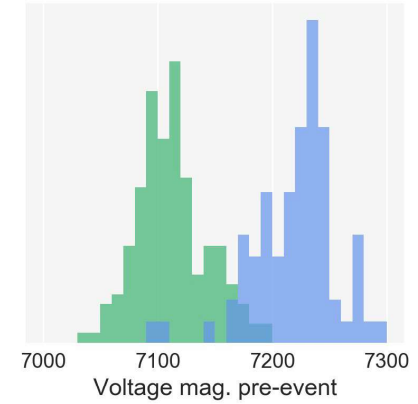
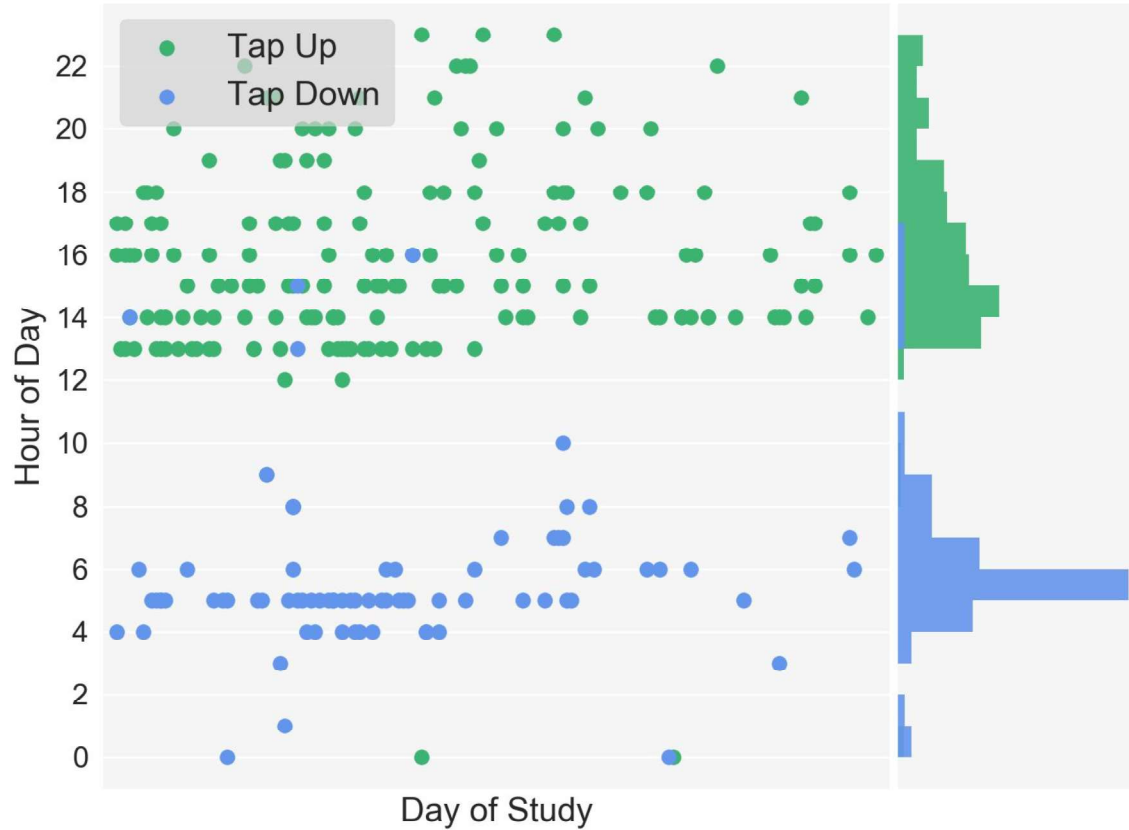


Clusters can then be analyzed for further insight.

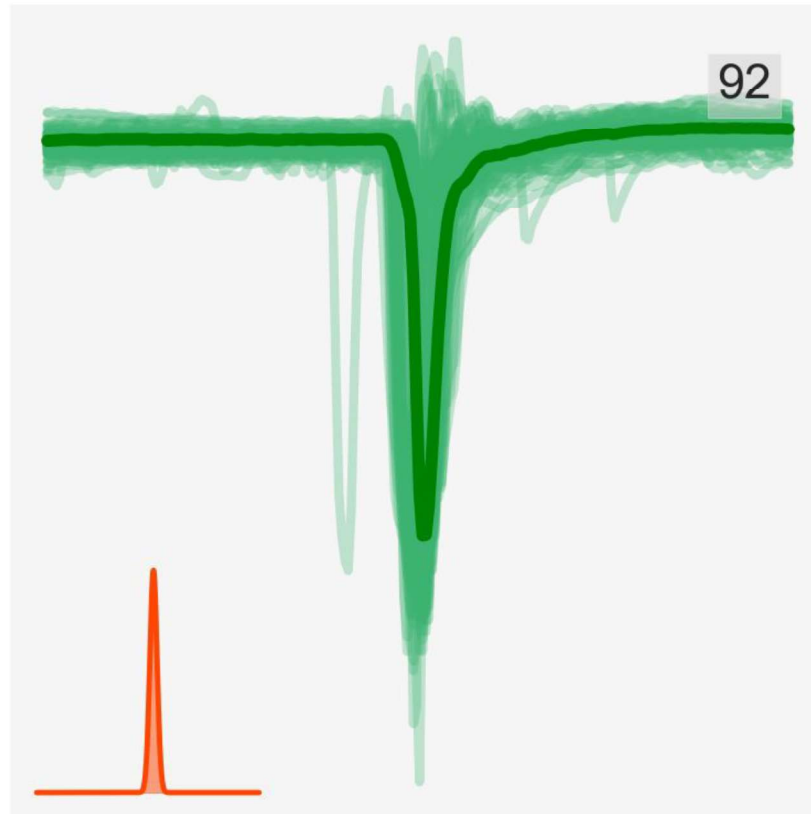
One recognizable cluster seems to correspond to tap change operations.



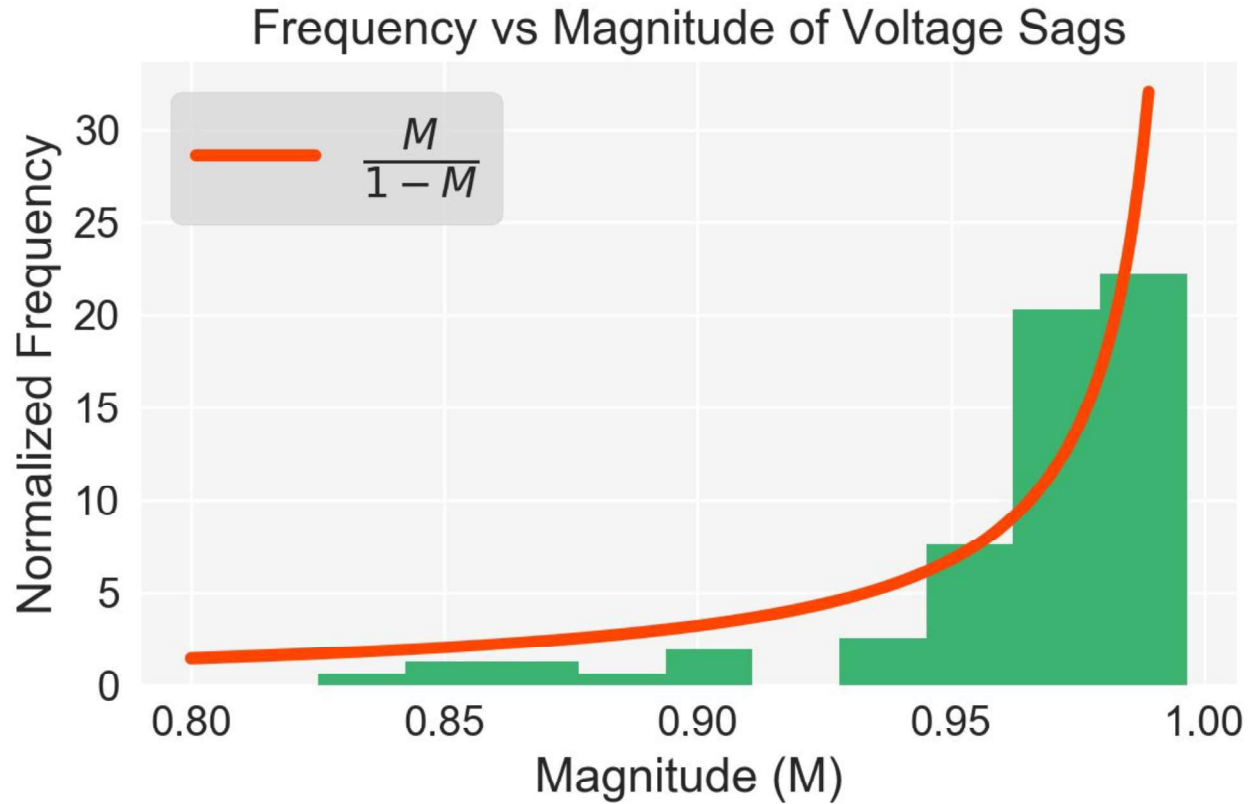
One recognizable cluster seems to correspond to tap change operations.



Another cluster consists of voltage sags.



We can compare empirical sag magnitudes with a simplified model from the literature.



And do further analysis on sags for operational insight.

