Enhanced Detection of Movement Onset in EEG through Deep Oversampling

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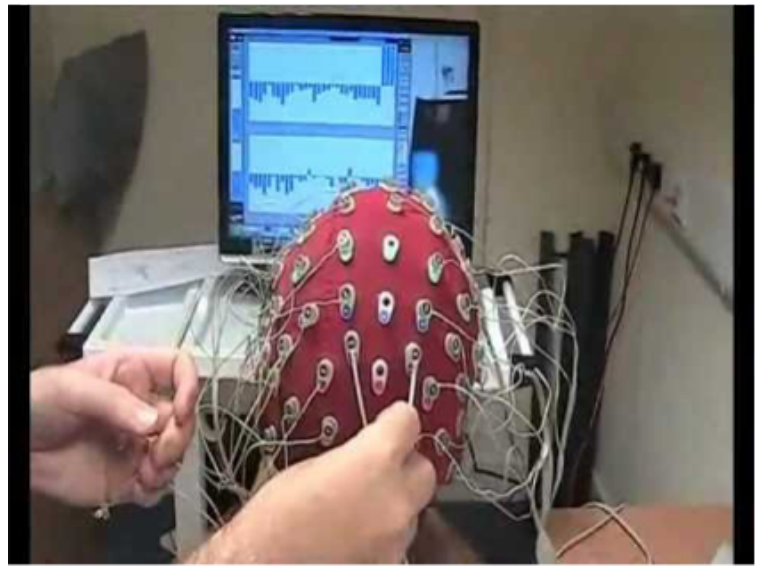
Outline

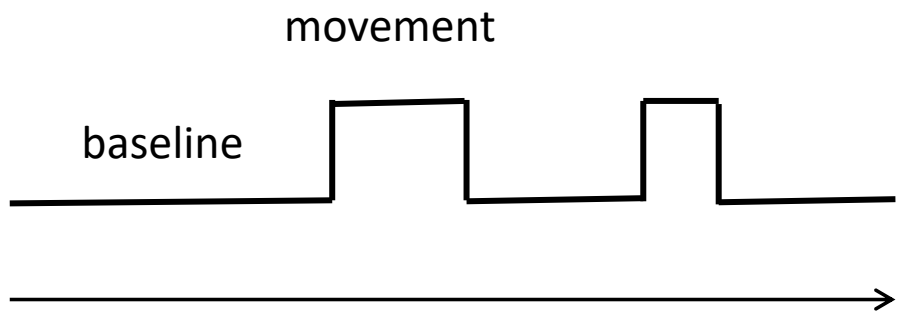
- **The Problem**
- Learning from imbalanced data
- Experimental Design
- Processing pipeline
- Results
- Subject-Independent Model

The Problem

- Imbalance movement and baseline data
- Missing labels
- High dimensionality
- Highly overlapped classes

- Brain Computer Interface
  - Detecting the onset of a move





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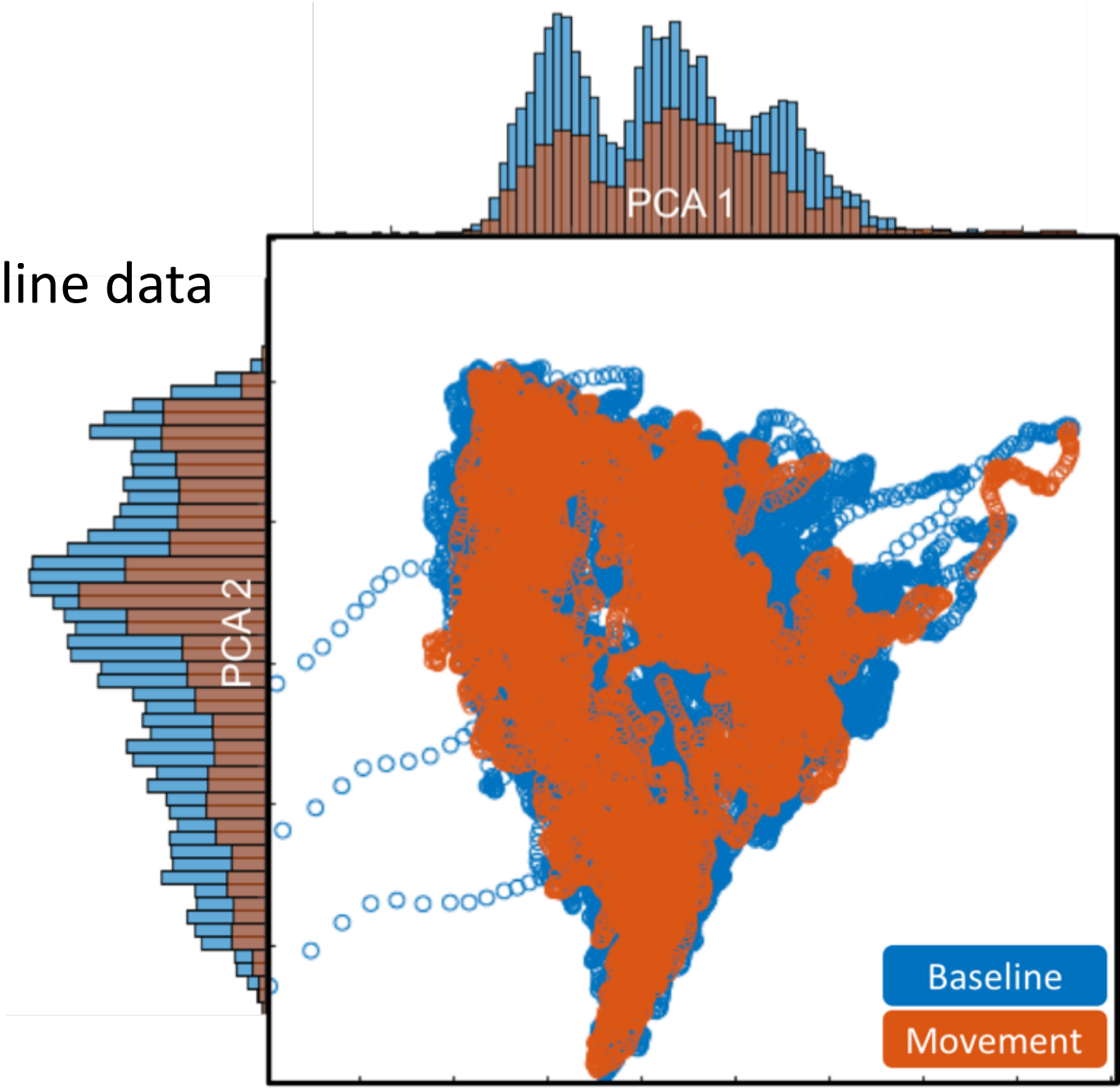

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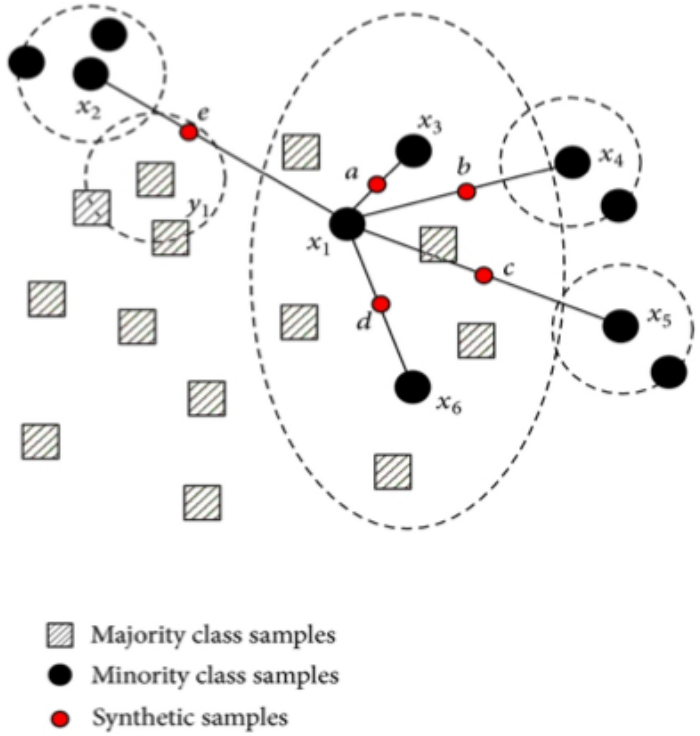
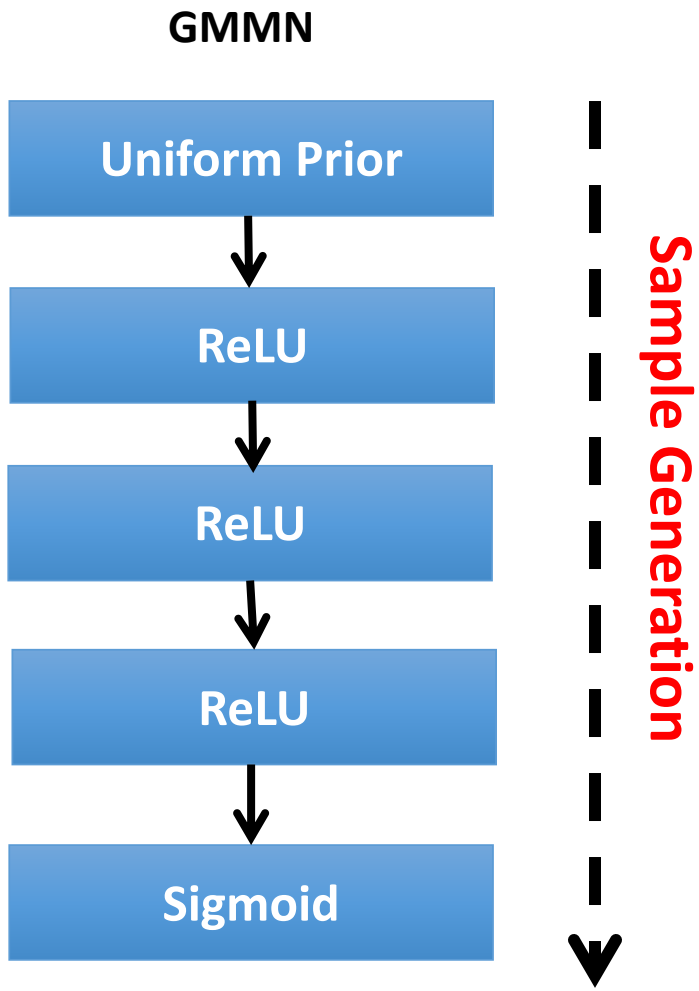
Learning from Imbalanced Data

- **Over sample the minority class**
  - **Generative Moment Matching Network (GMMN)**
  - **Synthetic Minority Over-Sampling Technique (SMOTE)**



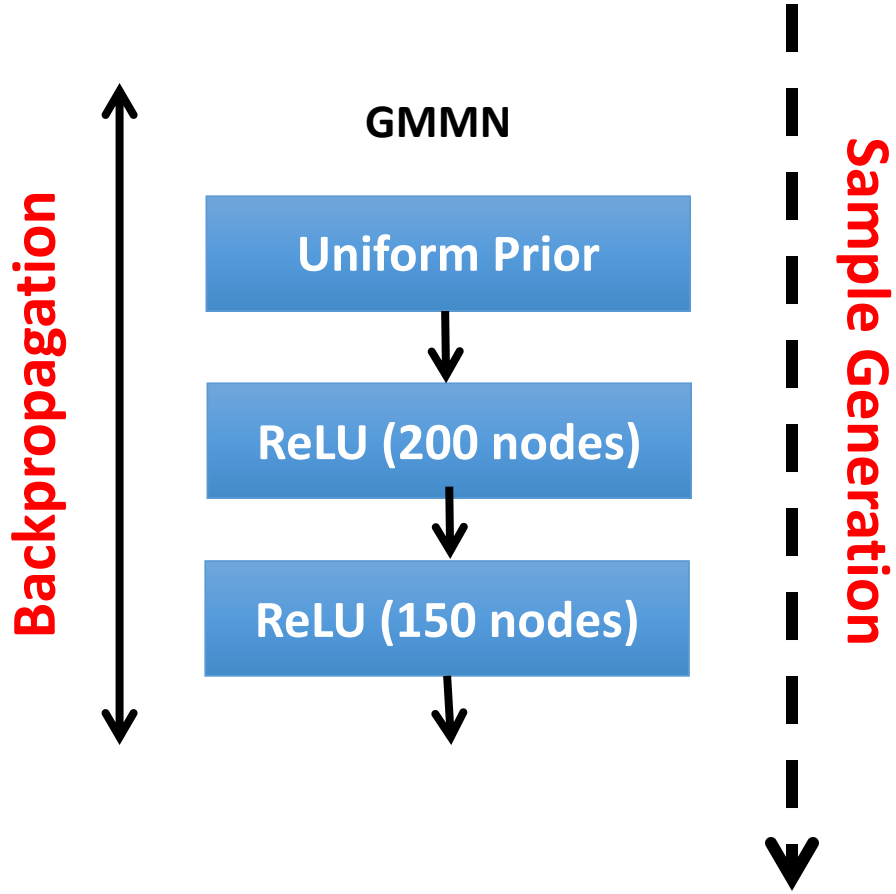


Why Generative Models?

- Model the minority (movement) class
- SMOTE only models local topography
- Generative models can be used to build subject-independent models of movement

Generative Moment Matching Network

- A feedforward network that maps an easy to sample space to the data space
- Generate samples from the uniform priors and deterministically calculate the new samples in the data space
- Parameters tuned using backpropagation



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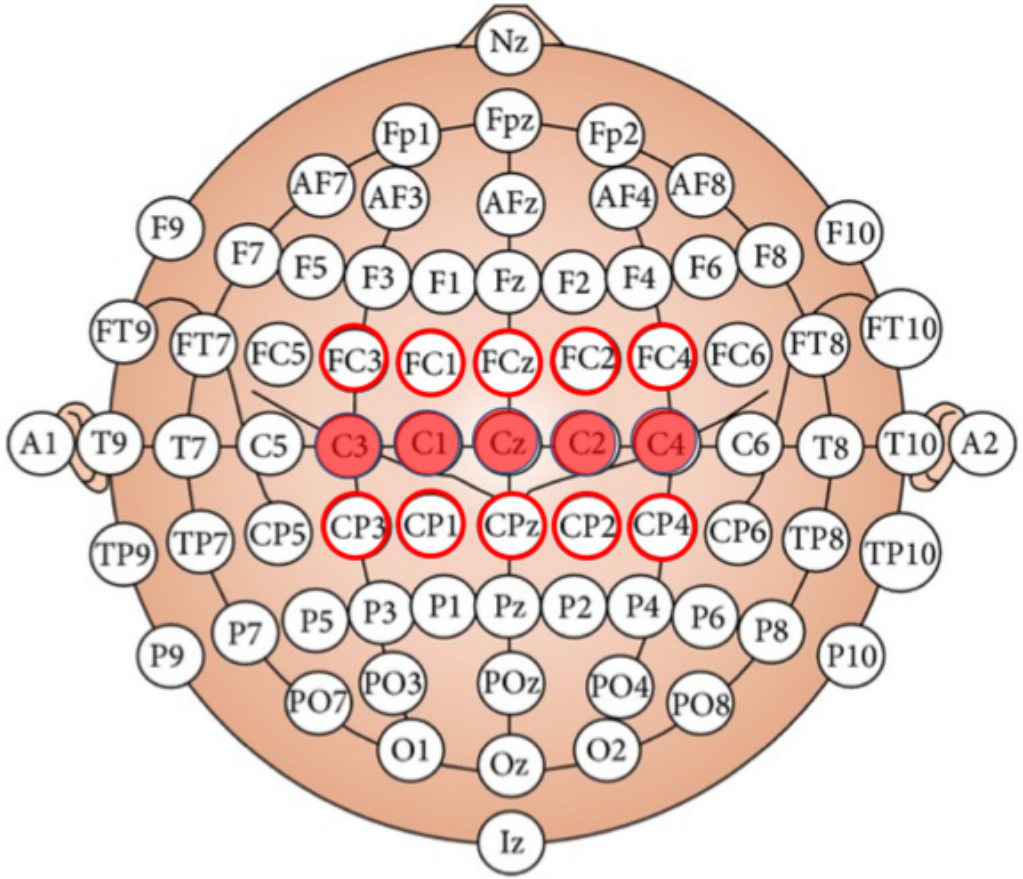
Experimental Design

- 12 right handed subjects
- 5 EEG channels around Cz
- Self-paced un-cued recording
- Simultaneous EMG for labeling
- On average: 66.3 % of data is baseline and 33.6% movement



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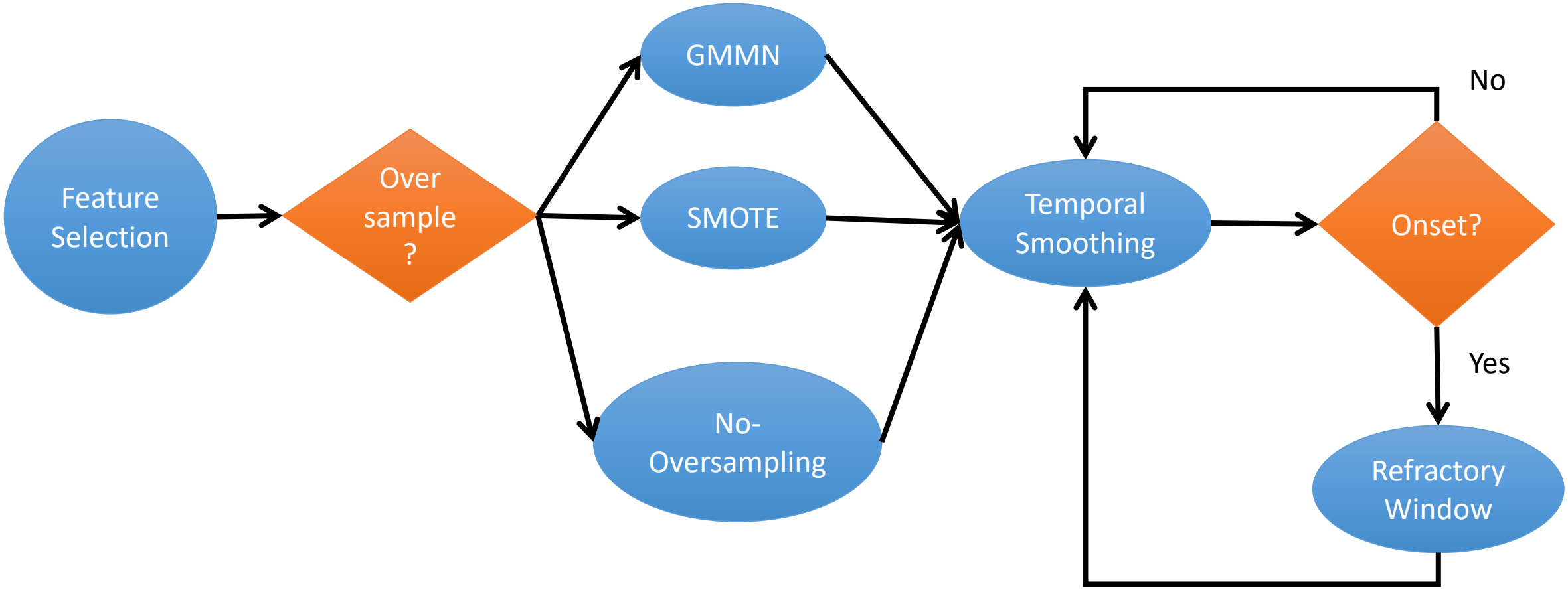
Processing Pipeline



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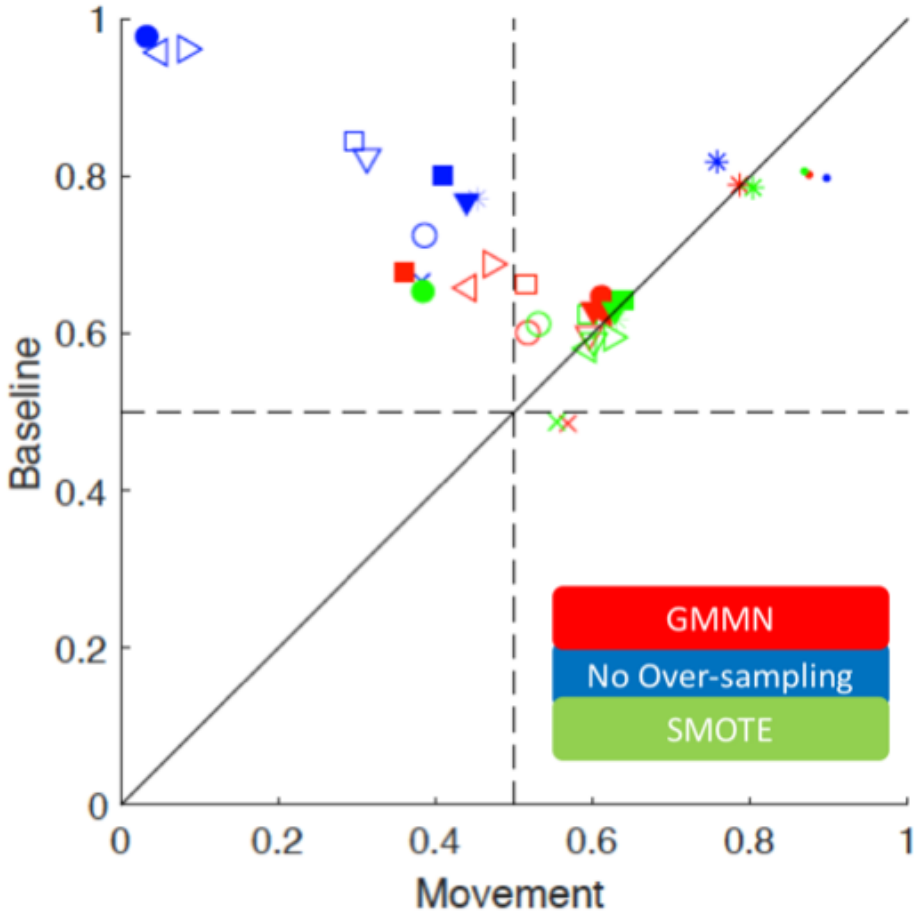
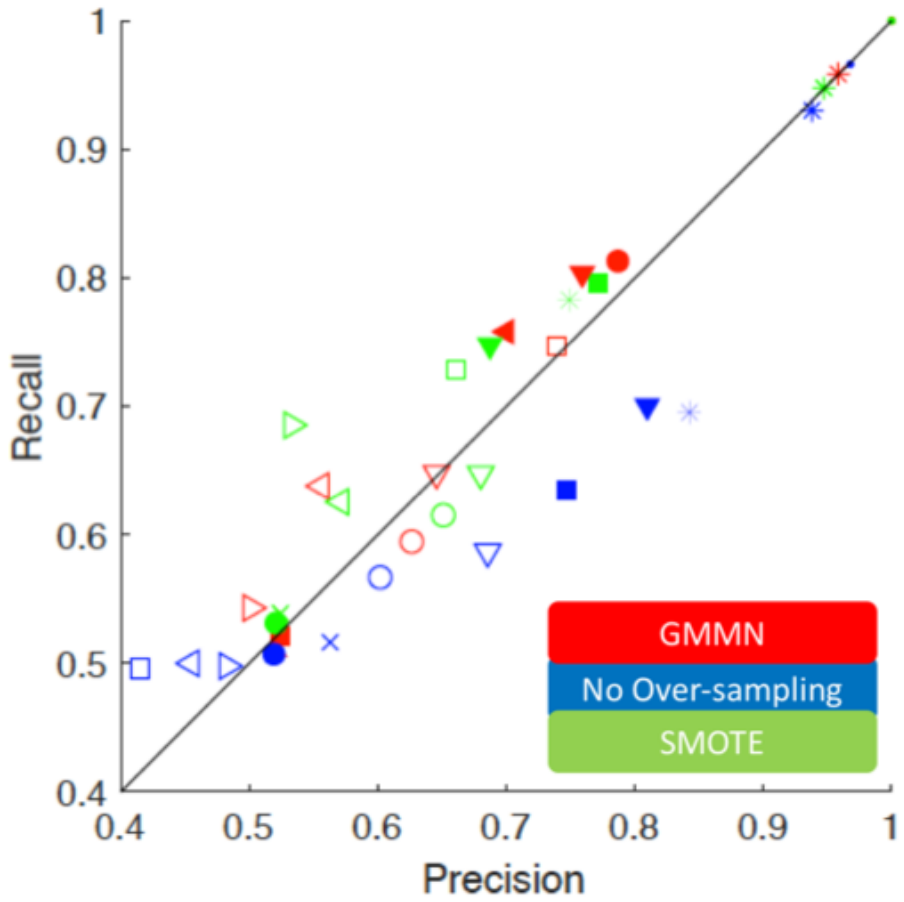
Results

Sample classification accuracy (without smoothing or refractory window)

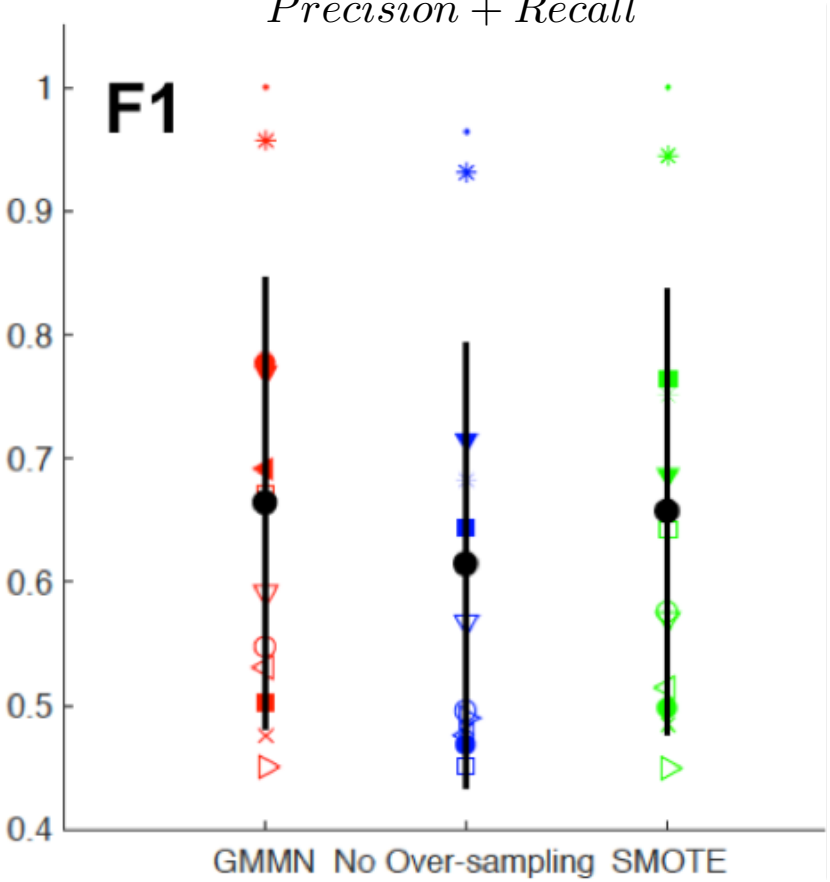




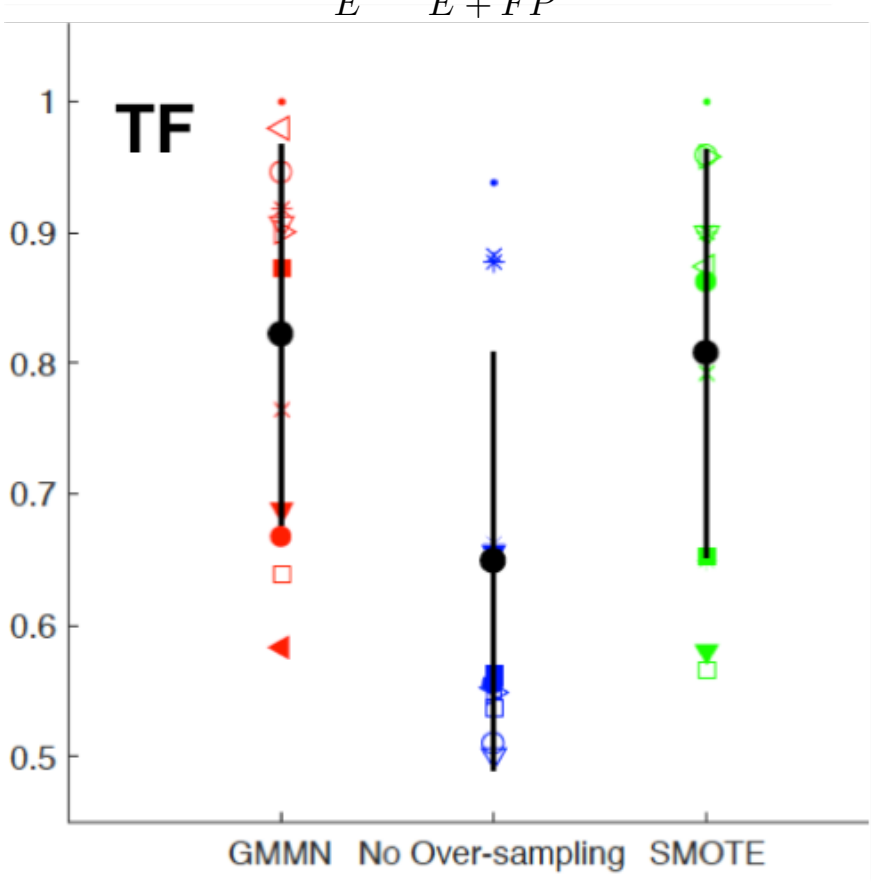
Results

Events detection accuracy

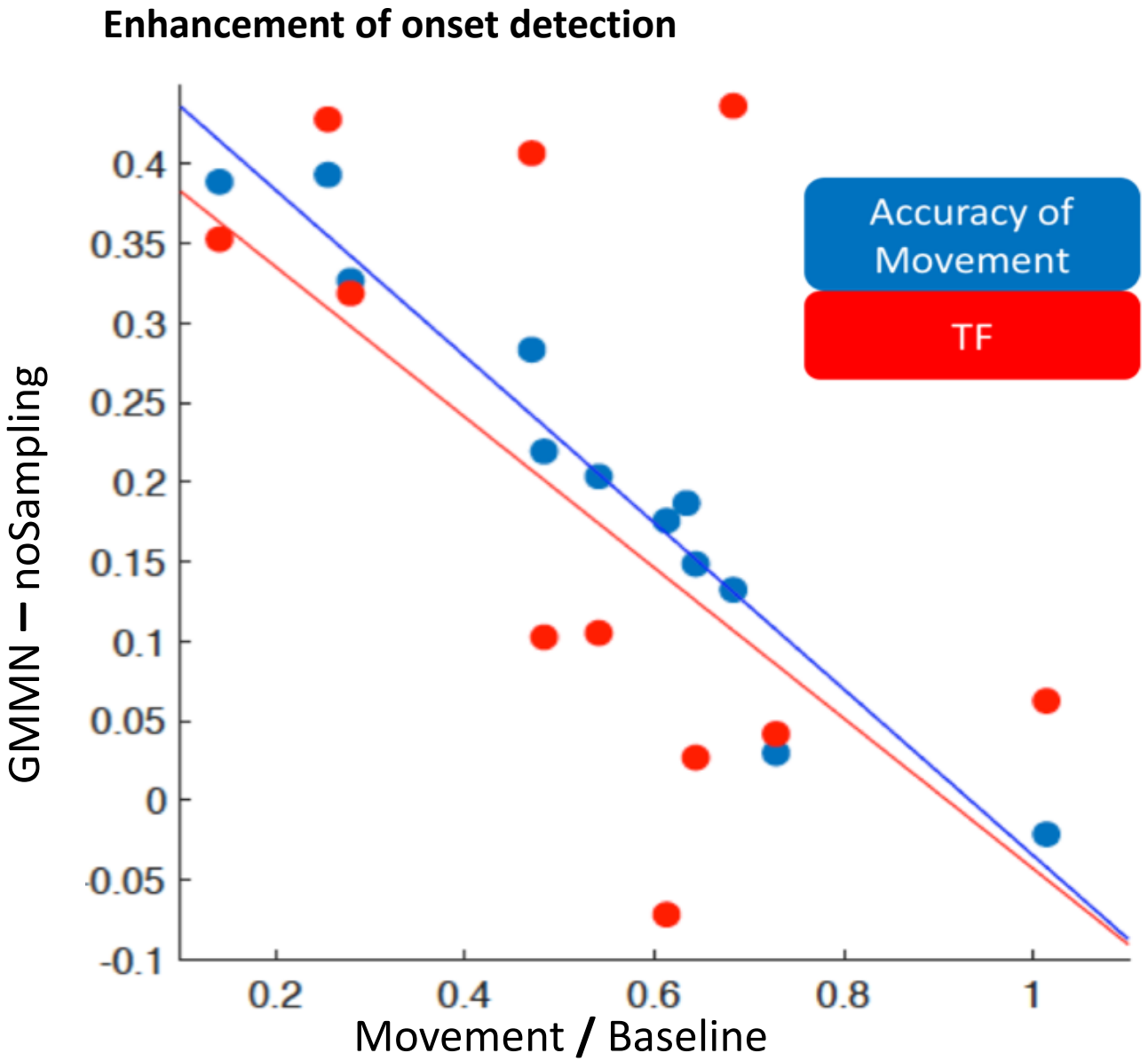
$$F1 = 2.\frac{Precision * Recall}{Precision + Recall}$$



$$TF = (\frac{TP}{E} - \frac{FP}{E + FP}) * 100$$



Results


Enhancement of onset detection
Accuracy of Movement
TF
GMMN – noSampling
Movement / Baseline
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
0.2
0.4
0.6
0.8
1

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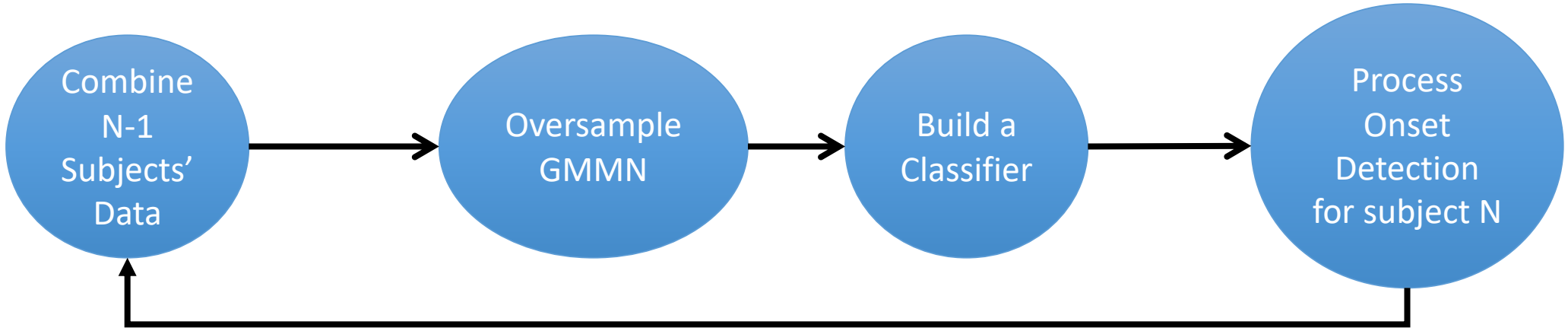
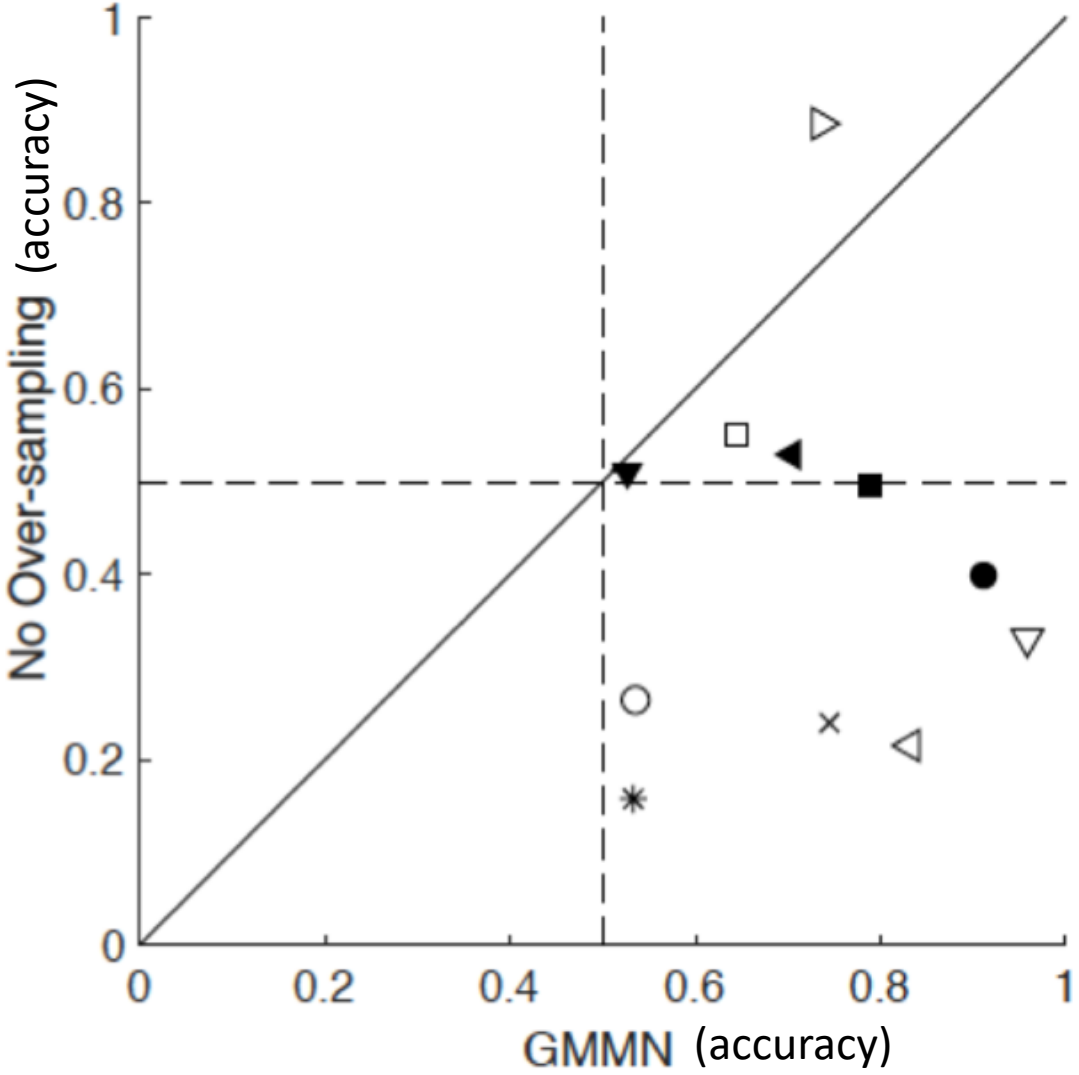
Subject-Independent Model



Subject-Independent Model



Summary

- Generative deep neural networks can be used to tackle challenging problems in BCI
- GMMN is used for oversampling the movement class in a self-paced BCI significantly enhancing the classification accuracy
- GMMN is used to build a subject-independent model of motor-imagery BCI

We Are recruiting:
- 2 PostDoc (Machine Learning / NLP)
- 1 PostDoc (Parallel Programming)
- Always looking for good PhD Candidates

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