Non-convulsive status epilepticus detection

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PROMOTORS:

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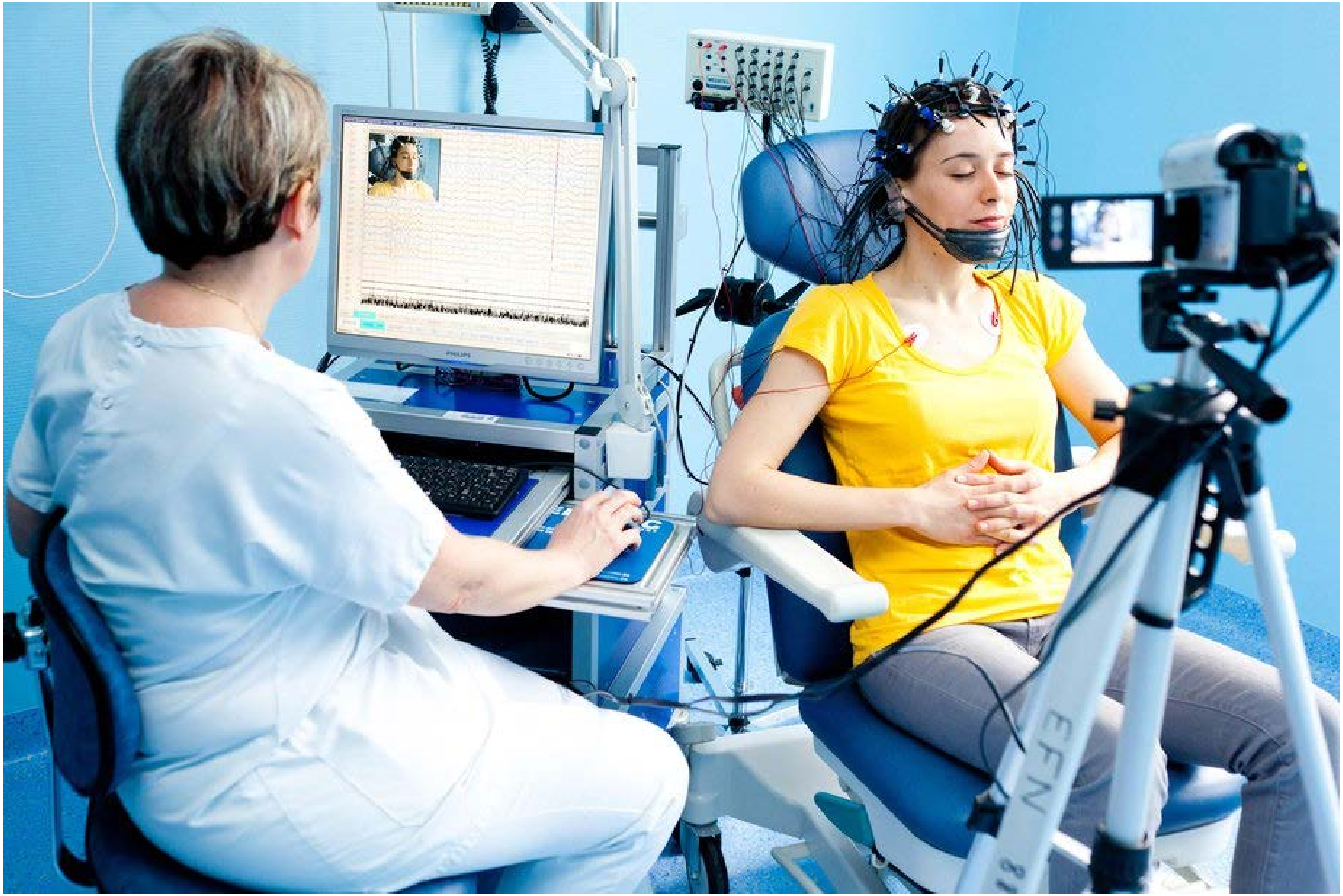
Nonconvulsive Status Epilepticus (NCSE)

- "**Nonconvulsive status epilepticus** is a term used to denote a range of conditions in which electrographic seizure activity is prolonged and results in non-convulsive clinical symptoms." [1]
- NCSE temporal criteria: Seizures persisting or continuing over 10 minutes. [2]
- Long-term NCSE with high degree of unresponsiveness:
  - Structural brain damage (increase risks of death) for people at ICU;
  - Unknown for chronic patients, need to be monitored.

[1] Shorvon S. What is nonconvulsive status epilepticus, and what are its subtypes? Epilepsia 2007;48:35–8. doi:10.1111/j.1528-1167.2007.01344.x.
[2] Schomer DL, Silva FL Da. Niedermeyer's Electroencephalography: Basic Principles, Clinical Applications, and Related Fields. 2018. p568-609.



Jane McGrath "How the Emotiv EPOC Works" 10 December 2008.
HowStuffWorks.com. <https://electronics.howstuffworks.com/emotiv-epoc.htm> 24 September 2018

BrainWave Project

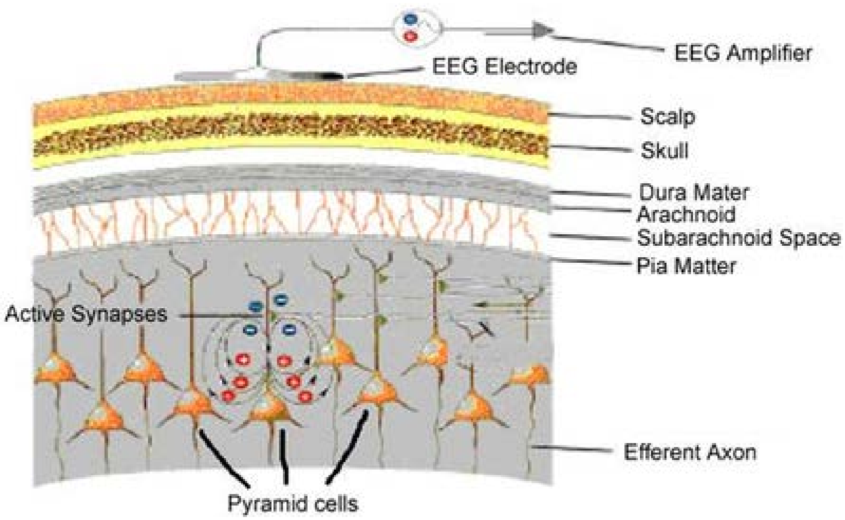
- Brainwave: a project aiming at developing a 24/7 wearable brainwave processing alarm platform (“Brain Wave chip”) for epilepsy and Parkinson’s patients;
- Cooperation research project between Eindhoven University of Technology (SPS, TU/e), Radboud University Nijmegen (Donders) and Kempenhaeghe research center;
- Development of algorithms for **online seizure detections in epilepsy (Non-convulsive seizures)** & **freezing of gait (FOG) prediction in Parkinson’s Disease**;

➢ *Oral presentation about FOG part:*
Day 2, Session “Neuromuscular lower extremities 1”:
EEG Analysis of Freezing of Gait in Local-Moving Experiment;

➢ *Relevant Posters about FOG part:*
Poster Session 1:
***#23** Eye Blinks Related to Freezing of Gait in Parkinson’s Patients;*
***#28** Improvement of Fog Detection in Parkinson’s Disease Patients Via Multimodal Data Analysis;*
*Poster Session 2: **#1** Analyzing Freezing of Gait Using Foot Switch Data;*

Electroencephalographic (EEG)

- "EEG signal reflects the activity of millions of neurons located in a multitude of brain structures." [1]
- Scalp EEG:
  - A non-invasive technique;
  - Electrodes placed on the scalp;
- Intracranial EEG:
  - Electrodes placed directly on the exposed surface of the brain.



[2]

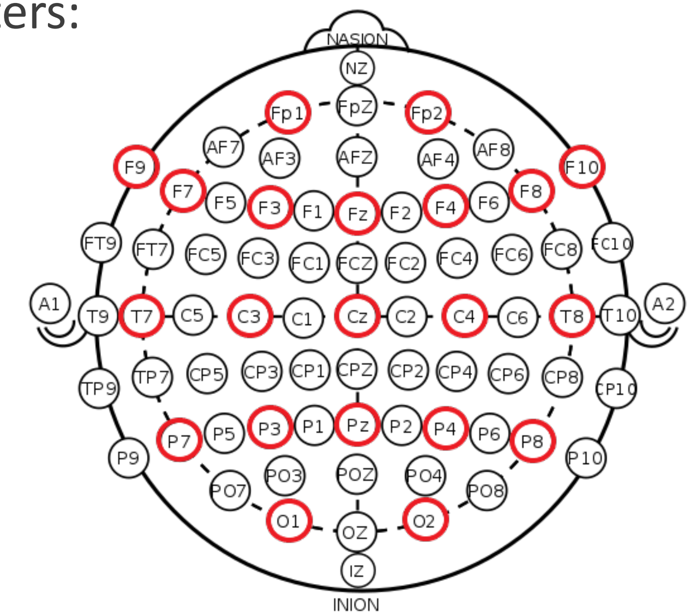
[1] Schomer DL, Silva FL Da. Niedermeyer's Electroencephalography: Basic Principles, Clinical Applications, and Related Fields. 2018. p89-103.
[2] Basic Science of EEG | Epilepsy Foundation n.d. https://www.epilepsy.com/learn/professionals/diagnosis-treatment/basic-science-eeg (accessed September 7, 2018).

Subject Demography

- 16 subjects with NCSE were mainly analyzed;
- Age of 21 +/- 10 years; 13 males and 3 females;
- With heterogeneous clinical backgrounds;
- With different types of seizure history;
- With varied IQ level:
  - 7 subjects with normal IQ;
  - 4 subjects with light IQ;
  - 1 subject with moderate IQ;
  - 4 subjects with severe IQ.

NCSE dataset

- The data recordings were archived at Kempenhaeghe Research Center;
- 21 common electrodes;
- The length of data recordings are from ca. 14 minutes to ca. 22 hours;
- NCSE dataset were annotated by two independent raters:
  - focal or generalized discharges;
  - four patterns of the discharges:
    fast spike, spike wave, wave and EMG-like discharge;
  - Minimal 20-second length.



Statistics about Ictal discharges in NCSE dataset

14 of 16 NCSE subjects show discharges in the EEG recordings.

Agreement:

- Cohen Kappa: 0,499 (Moderate agreement [0,4 0,6]);
- Fleiss Kappa: 0,3773

Total number of ictal discharges: 331

Ictal Proportion (the seconds of ictals/ the seconds of all EDF duration) : ca. 7.9%

Ictal Distribution:

- Focal: 47 (14,2%)
- Generalized: 284 (85,8%)

Ictal definite/possible:

- Definite: 168
- Possible: 163

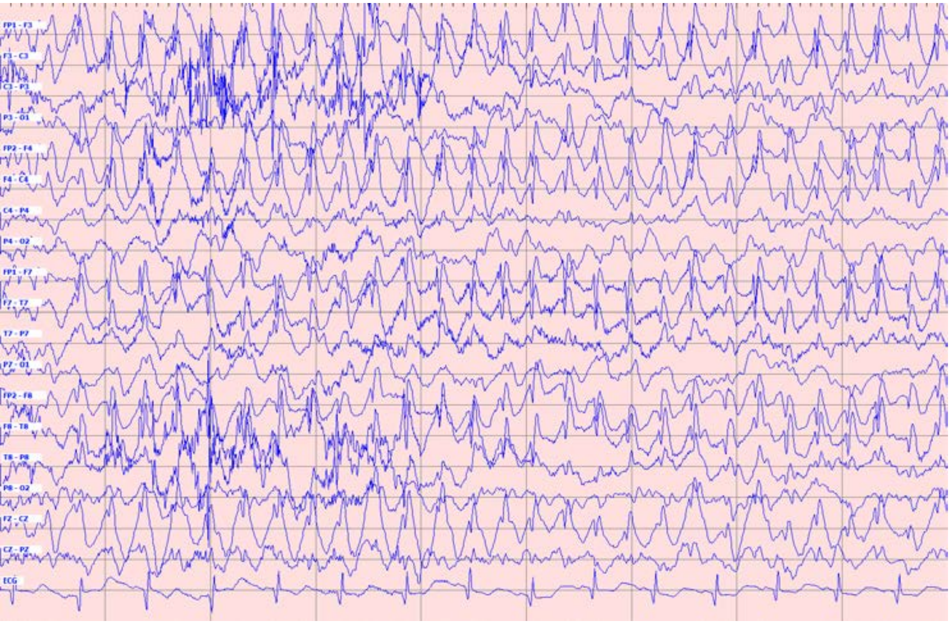
Ictal number of patterns:

- **Spike Wave: 254 (76,7%);**
- Wave: 78 (23,6%);
- Fast Spike: 34 (10,3%);
- Unknown: 12 (3,6%)
- ~~EMG-Like discharges: 2 (0.6%);~~

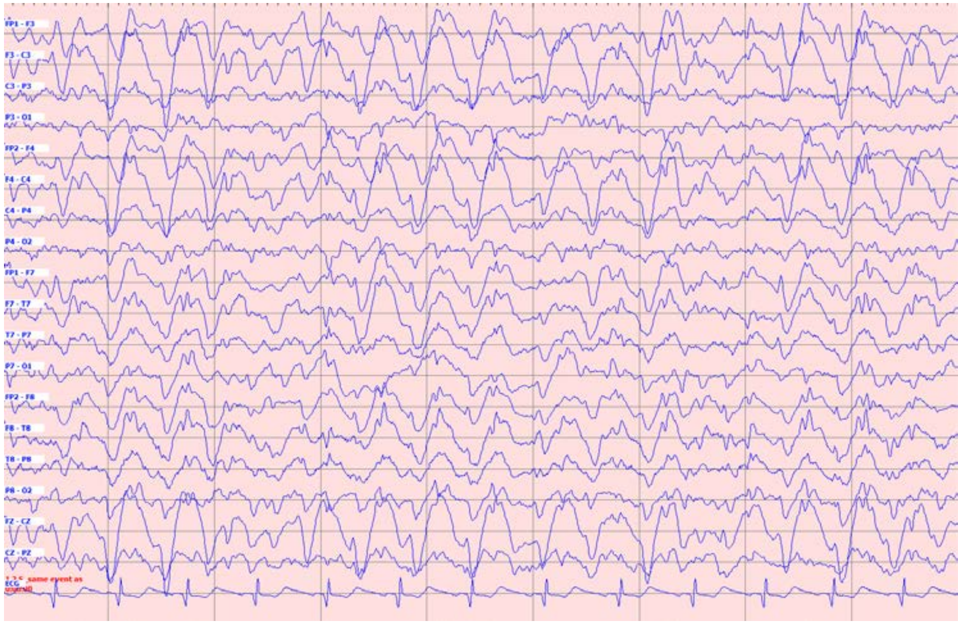
Ictal onset:

- Clear: 187 (56,5%)
- Blurry: 144 (43,5%)

NCSE Discharge (EEG) Example: Spike Waves

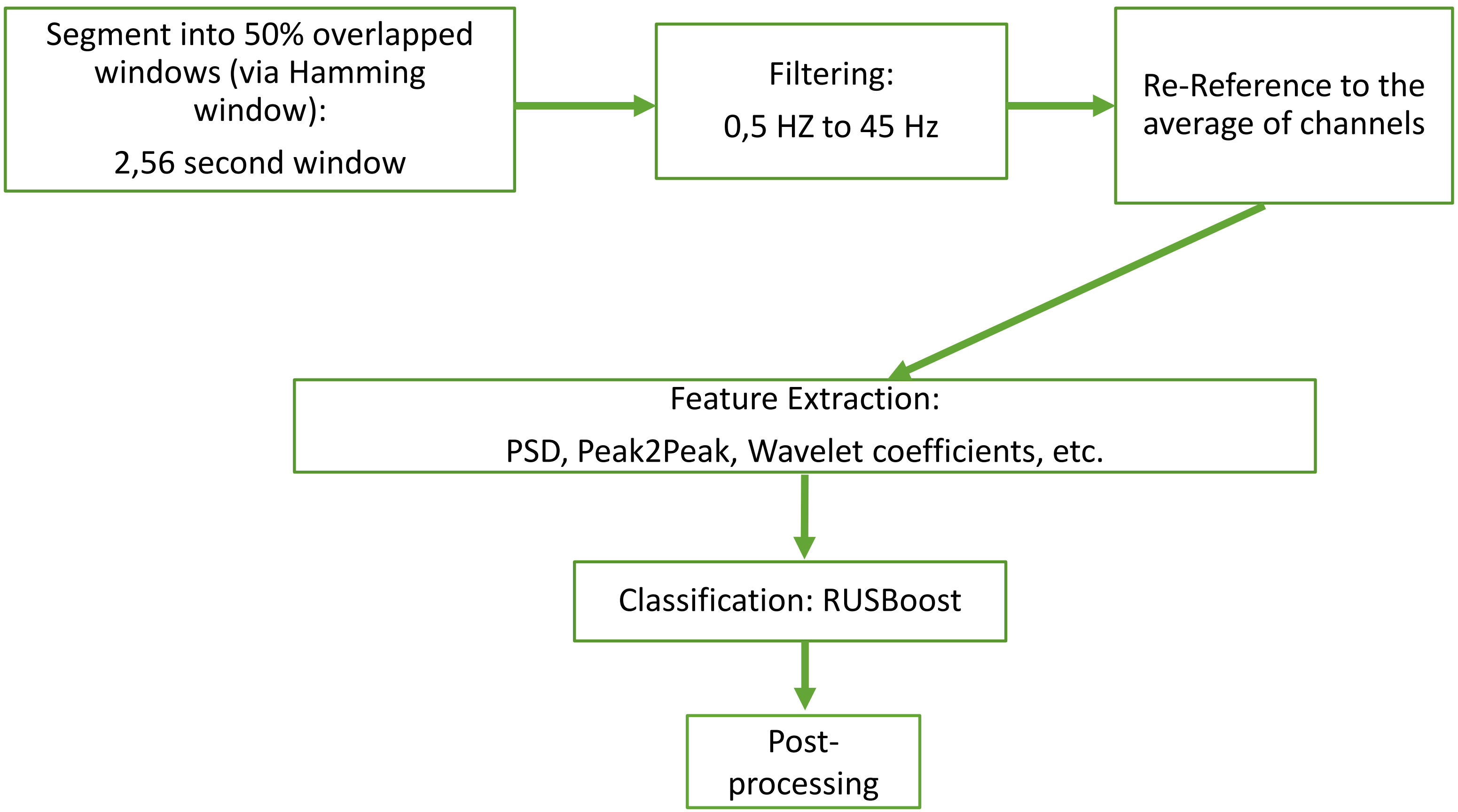


Classic Spike Waves



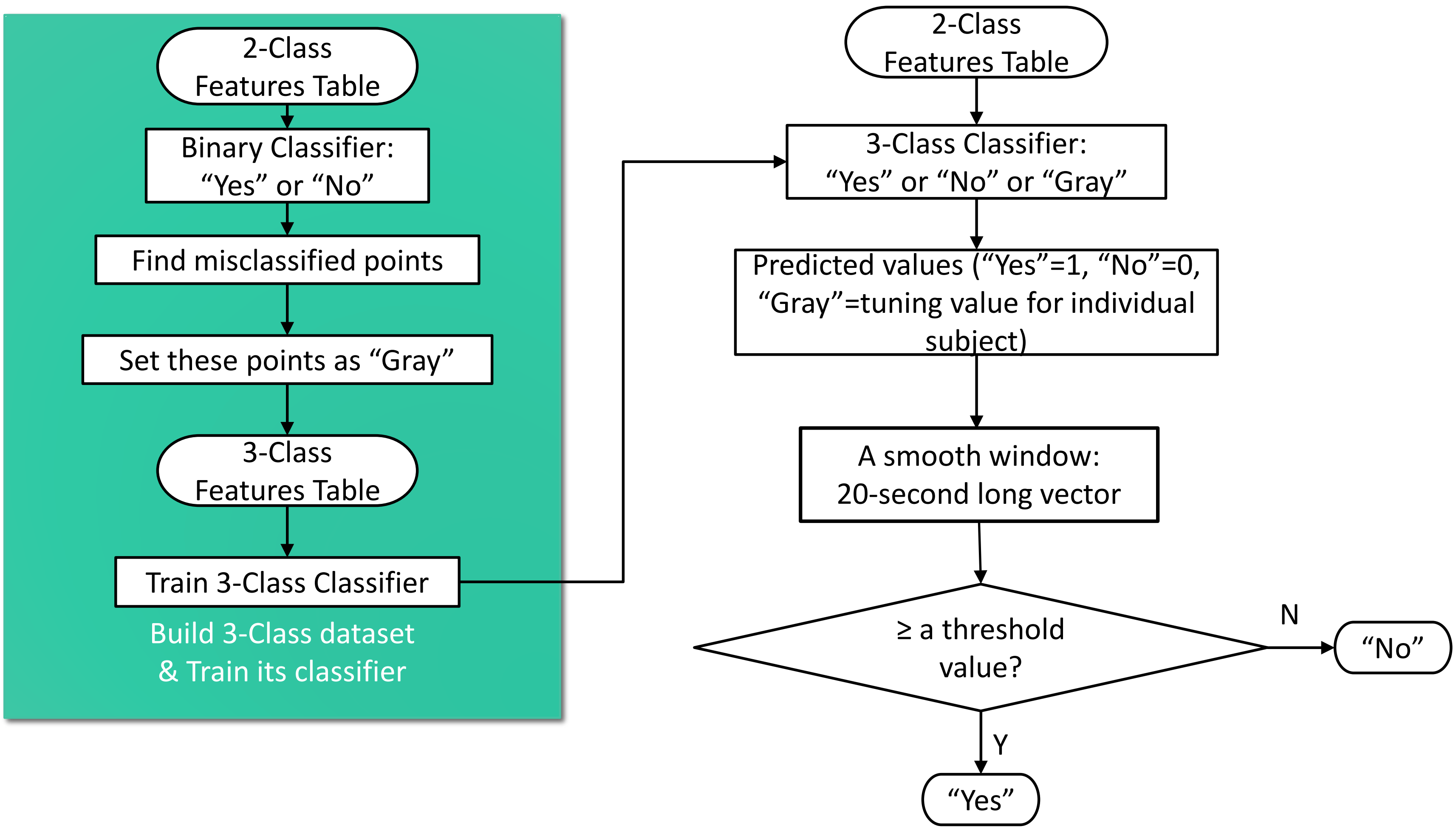
Not classic Spike Waves
(wave pattern merged)

Workflow of NCSE detection



Seiffert, Chris, et al. "RUSBoost: A hybrid approach to alleviating class imbalance." *IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans* 40.1 (2010): 185-197.

Workflow of 3-class classification + Post-Processing



Performance on average

2-Class Classifier			3-Class Classifier		
TPR	PPV	TNR	TPR	PPV	TNR
86%	23%	40%	80%	71%	72%

TPR (sensitivity) = $\frac{TP}{TP+FN}$;

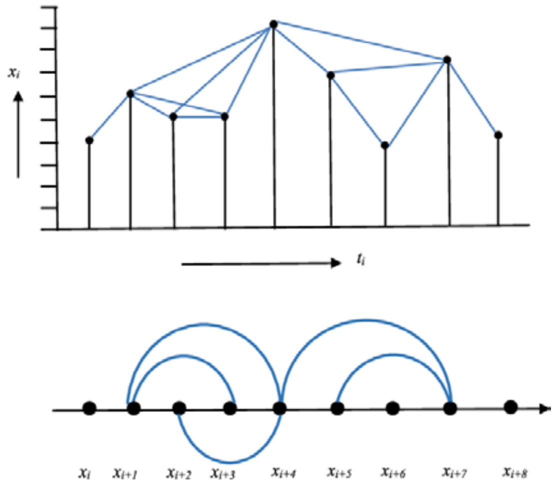
PPV (precision) = $\frac{TP}{TP+FP}$;

TNR (specificity)= $\frac{TN}{TN+FP}$;

TP → True Positive Events; TN → True Negative Events;
FP → False Positive Events; FN → False Negative Events;

Avoid pitfalls in NCSE detection?

- Too many inter-ictals or short ictal discharges (less than 20 seconds) in EEG recordings;
- Our Current algorithm cannot distinguish the three types well:
  - Inter-ictal;
  - Slow activities (caused by drowsiness or slow activities shown by some damage brains);
  - Ictal;



Potential solutions:

Visibility Graph (VG) method and its extension

(Oral presentation at 14:30 by Hui Du

"Visibility Graph methods in Nonconvulsive Seizure Detection")

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