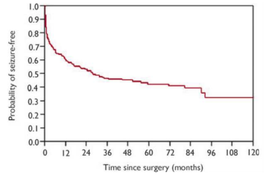
In search of biomarkers for the epileptogenic zone: A machine learning approach

Olesya Grinenko[1], Jian Li[2], John C. Mosher[3], Juan C. Bulacio[1], Jorge Gonzalez-Martinez[1], Imad Najm[1], Patrick Chauvel[1], Richard M. Leahy[2]

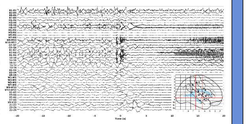
[1]Epilepsy Center, Neurological Institute, Cleveland Clinic, OH; [2]Signal and Image Processing Institute, University of Southern California, CA; [3]Department of Neurology, University of Texas, TX

Introduction

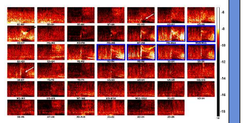
- More than 50% of patients had seizures reoccurred after surgery guided by intracranial evaluations[1], which aims at a precise localization of epileptogenic zone (EZ). One of the reasons for the unsatisfactory results is the inaccurate estimation of the EZ.



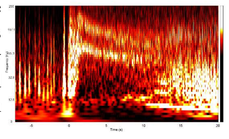
- SEEG signal-processing-based EZ identification have been explored[2,3,4], but none of these methods were validated using surgical outcomes.
- Moreover, individualized EZ prediction is strongly desired to facilitate surgical planning but unavailable using any contact-based classification methods.
- We recently proposed a EZ fingerprint (EZF) that describes the inter-ictal to ictal transitions and consists of the ***combination of*** three components:



  - initial **pre-ictal spike(s)**
  - ictal **fast activity**
  - concurrent low-frequency **suppression**.



- A support vector machine (SVM)-based approach was developed to automatically detect the EZF pattern and differentiate the EZ from other areas of the brain.

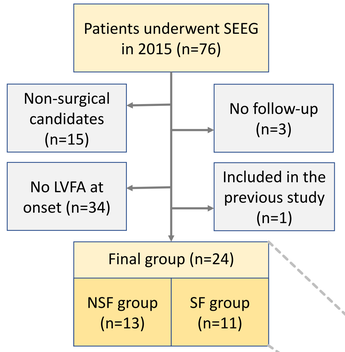


- In this work, we validate our EZF method using a completely independent series of patients, including both seizure-free (SF) and non-seizure-free (NSF) patients.
- The prediction results are mapped onto the MRI image of each patient for individualized localization of the EZ.

Methods

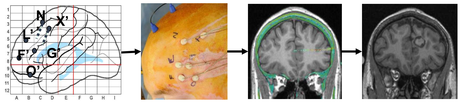
Patient Selection

- A consecutive series of patients who had seizures began with low voltage fast activity (LVFA) in the beta or gamma bands and underwent surgery after SEEG.



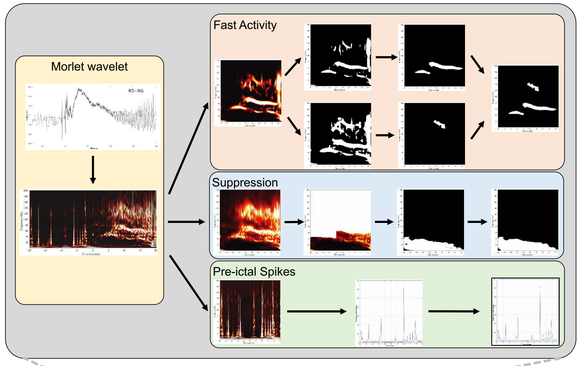
Data Collection

- **SEEG**: Multi-lead depth electrodes were implanted according to the Talairach stereotaxic method. SEEG signals were recorded on a Nihon Kohden EEG machine with a sampling rate of 1000 Hz.
- **MRI**: digital fusion of the pre-operative and post-operative MRI with post-implantation thin-sliced CT. Labelling of the electrodes contacts as being within or outside the resection.

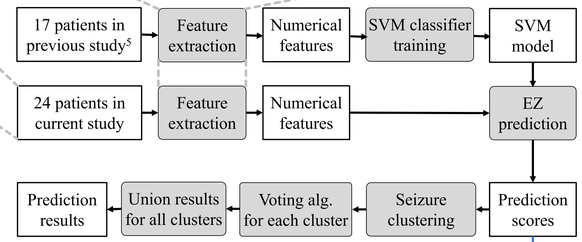


EZ Fingerprint Pipeline

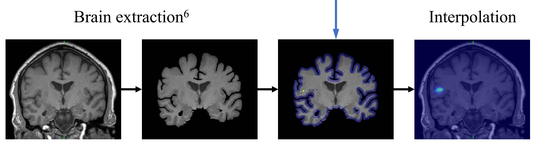
- **Feature extraction**



- **SVM-based classification**



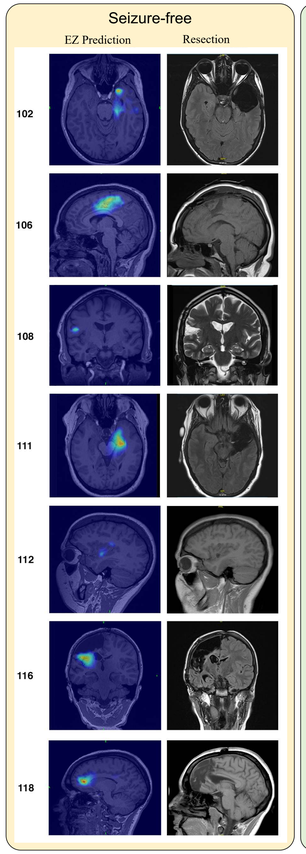
- **Individualized EZ prediction**

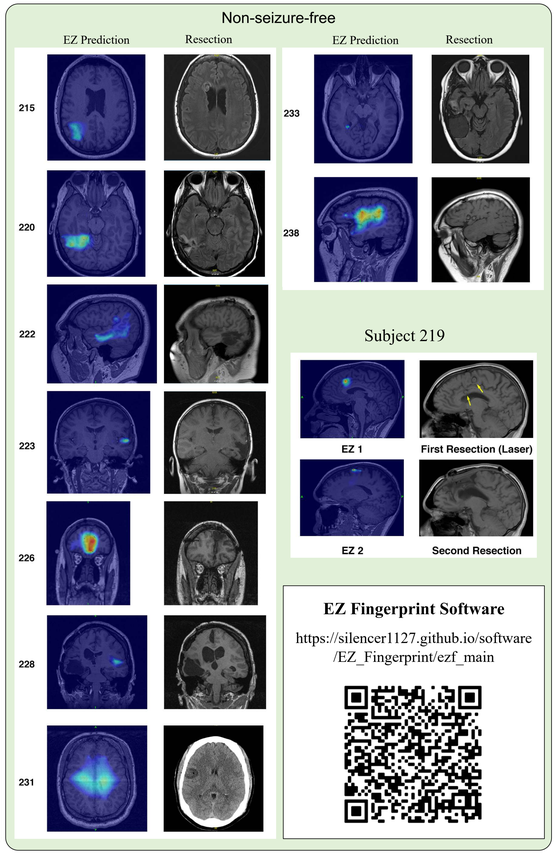


Results

	Seizure-free			Non-seizure-free		
	Predicted EZ	Predicted Non-EZ	Stats	Predicted EZ	Predicted Non-EZ	Stats
Inside Resection	42 (TP)	267 (FN)		38 (TP)	104 (FN)	
Outside Resection	5 (FP)	838 (TN)	0.0059 (FPR)	104 (FP)	1276 (TN)	0.075 (FPR)
Stats	0.894 (PPV)			0.268 (PPV)		

When the prediction mapped onto the patients' MRI image:





EZ Fingerprint Software

https://silencer1127.github.io/software/EZ_Fingerprint/ezf_main

References

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