Weill Cornell Medicine

Automated Seizure Detection with Machine Learning

Lead Inventors:

Zachary Grinspan, M.D., M.S.

Associate Professor of Population Health Sciences,
Weill Cornell Medical College

Associate Professor of Pediatrics,
Weill Cornell Medical College

Peter Z. Yan, M.D., M.S.

Instructor in Neurology, Harvard Medical School

Clinical Informaticist, Beth Israel Lahey Health

Clinical Neurophysiologist, Division of EEG/Epilepsy,
Beth Israel Deaconess Medical Center

Business Development Contact:

Louise Sarup

Interim Technology Licensing Officer

(646) 962-3523

lss248@cornell.edu

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Background & Unmet Need

- Seizures occur in up to 50% of critically ill patients with altered consciousness, and >80% present with no obvious clinical sign of motor activity
- These non-convulsive seizures (NCS) have associated high morbidity and mortality in critically ill patients, and warrant prompt detection and treatment
- A continuous electroencephalogram (cEEG) is the gold standard for diagnosing NCS but is resource intensive and only reviewed intermittently (often 2-3 times daily) rather than continuously monitored
- Quantitative EEG (qEEG) tools apply digital signal processing techniques to facilitate cEEG interpretation, but require lengthy clinician training and are limited in types of seizures detected
- **Unmet Need:** Access to rapid, accurate, and automated continuous EEG seizure detection

Technology Overview

- **The Technology:** Method for continuous automated seizure detection based on artificial neural network recognition of seizure patterns on a novel spectrographic display
- The method introduces the median power spectrogram (MPS), a novel qEEG spectrographic display which can consolidate multiple EEG channels into a single channel display and optimize temporal and frequency resolution, resulting in well visualized seizures
- Seizures appear as characteristic sloped harmonic bands on MPS that are visually distinct and easily identified with minimal clinician training (~5 min)
- A convolutional neural network (CNN) can be trained to recognize seizure patterns on the MPS and can automatically detect seizures in a continuous fashion
- **PoC Data:** The CNN models detected seizures with 80–90% sensitivity and specificity, on both adult and pediatric cohorts

Inventors:
Zachary Grinspan
Peter Yan

Patents:
US Application Filed

Publications:
Yan et al. *Seizure.* 2019.
Yan et al. *Seizure.* 2017.

Biz Dev Contact:
Louise Sarup
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lss248@cornell.edu

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Technology Applications

- Continuous seizure telemetry monitoring at bedside for critically ill patients that can automatically alert the bedside clinicians to enable faster intervention
- A visual bedside display where seizures are easily recognized, and the clinician has the option to visually confirm the automated seizure detection
- A visual display for the neurophysiologist that supplements and expedites traditional EEG analysis

Technology Advantages

- Concise EEG visualization where seizures are easily recognizable, requiring less clinician training
- Rapid, accurate, and continuous automated seizure detection, in a real-time telemetry fashion, at the beside that enables faster interventions
- A bedside display easily interpreted by a bedside clinician who can visually confirm automated seizure detection, and monitor response to treatment

Supporting Data / Figures

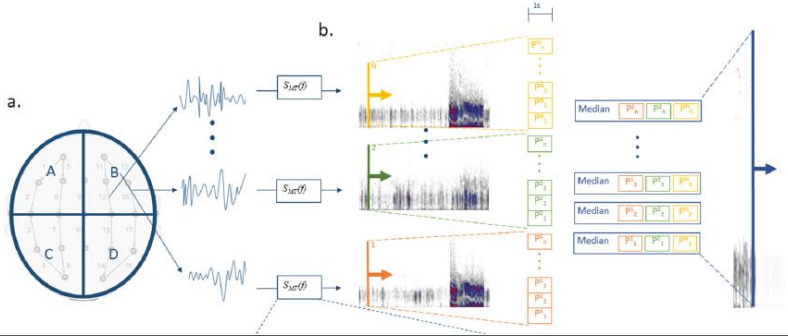

Figure 1: Overview of the signal processing method underlying the Median Power Spectrogram (MPS). Spectral content from individual EEG channel is obtained with application of multi-taper spectral estimation. The resulting spectral content from each channel is then combined via a median of the spectral power within each frequency bin at each second.

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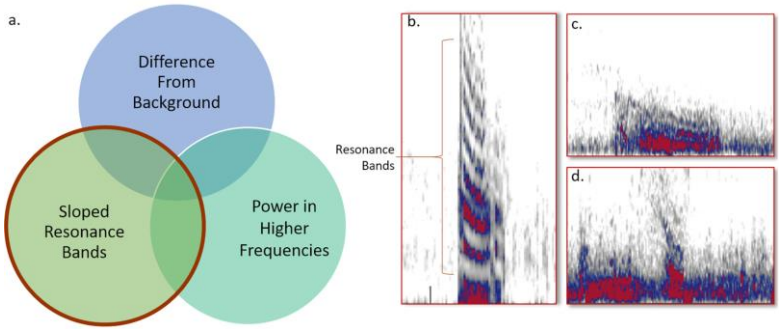

Figure 2: The three visual features that highlight seizures on the MPS (a). The slopped harmonic banding pattern that represent evolving rhythmic activity (b), characteristic of seizures, can be resolved/visualized even relative subtle seizures (c, d).

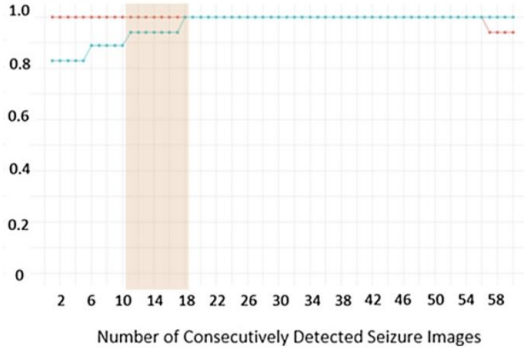

Figure 3: Seizure autodetection performance as a function of consecutively detected frames on a moving telemetry. The CNN demonstrates high sensitivity (red) and specificity (green) over a wide range of frames with the more practical range highlighted.

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