XGBoost-based Method for Seizure Detection in Mouse Models of Epilepsy

1. School of Computer Science, University College Dublin, Dublin, Ireland
2. Department of Physiology & Medical Physics, Royal College of Surgeons in Ireland, Dublin, Ireland
3. FutureNeuro, The SFI Research Centre for Chronic and Rare Neurological Diseases, RCSI, Dublin, Ireland
4. School of Electrical & Electronic Engineering, University College Dublin, Dublin, Ireland

Background

- Epilepsy is the second most common neurological disorder behind stroke, according to the World Health Organization (WHO).
- Epilepsy is caused by the dysregulation of the finely tuned inhibitory and excitatory balance in brain networks, manifesting clinically as seizures.
- Electroencephalographic (EEG) monitoring in rodent disease models of epilepsy is critical in the understanding of disease mechanisms and the development of anti-seizure drugs.
- Seizure detection with EEG requires a direct examination by a physician and substantial amount of time and effort.
- Automated detection is a powerful method to devote to this task which can reduce the annotation time of experts.
- Research on seizure detection methods applicable to multiple mouse models has been limited to date.
- In this study, an automated method for seizure detection in EEGs from different mouse models of epilepsy is proposed.

Method

- Teager-Kaiser energy operator (TKEO)-based method
  - The discrete TKEO is defined as:
    \[ \phi(x_t) = x_t^2 - x_{t-1} \cdot x_{t+1} \]

- XGBoost-based method

Results

| Mouse Model I: Intra-amygdala kainic acid (IAKA) Adult male SV129 |
|---------------------|---------------------|
| EEG signals were recorded in each mouse for 14 days, with 20 minutes of baseline on the first day. After a week, the intraperitoneal lorazepam (8 mg/kg) was injected to reduce morbidity and mortality. Following a latent period of 3-5 days, spontaneous recurrent seizures started to appear. |

| Mouse Model II: Dravet Syndrome (DS) F1.5 Scn1a+/−/Tm1Kea |
|---------------------|---------------------|
| Mice were bred with a mutation which mimics DS, a rare and severe epileptic encephalopathy. DS, F1.5 Scn1a+/−/Tm1Kea experience recurrent spontaneous seizures. These were recorded using tethered EEG monitoring from 12:30 to 6:30 pm between postnatal days p21-p28. |

Conclusion

- XGBoost-based method performed better than TKEO-based method in both mouse models of epilepsy
- A novel XGBoost-based method to detect seizures
- Assist researchers in the automated analysis of seizures in mouse models of epilepsy
- Single-channel, multi-type seizures in long mice EEG recordings
- Removes user bias when detecting seizures
- Fast, reliable, reproducible

Future work

- The method need to be validated in data sets from:
  - Larger numbers of mice
  - Different mouse models of epilepsy

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