Dynamical recurrence analysis for modeling neural activity during epilepsy seizures

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\textsuperscript{1st} Summit on Gender Equality in Computing (GEC 2019)
Problem Formulation

- **Absence Seizures**
  - **Between Seizures:**
    - Patient is normal
  - **During Seizure:**
    - Vacant stare
    - Eyes roll upward
    - Cease activity
    - Lack of response

- **Goal:** Modeling Brain Neuronal Activity during Absence Seizures
  - Identify Patterns
  - Temporal Correlations among neurons
  - Dimensionality Reduction
Challenges - Motivation

- **Real Dataset:**
  - Background Noise (Unmodeled)
  - Extremely rare firing within thousand time bins

- **Solution:** *Recurrence Quantification Analysis (RQA)!*
  - Can be applied to rather short and even nonstationary data
  - Does not make any assumption about the model that governs the system or the data (e.g., linearity, convexity, stationarity)
  - Is robust to outliers
Methodology – Experimental Results

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Critical Parameters
- Embedding dimension $m$
- Time Delay $\tau$

Phase Space (States $x_k$)

Binary Recurrence Matrix

Recurrence Plot

<table>
<thead>
<tr>
<th>Mean ± Standard Deviation</th>
<th>Seizure</th>
<th>Non-seizure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision</td>
<td>68.93±0.99</td>
<td>57.46±0.41</td>
</tr>
<tr>
<td>Recall</td>
<td>38.12±0.99</td>
<td>82.95±0.77</td>
</tr>
<tr>
<td>Specificity</td>
<td>82.95±0.77</td>
<td>38.12±0.99</td>
</tr>
<tr>
<td>F-score</td>
<td>49.08±0.93</td>
<td>67.89±0.44</td>
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