Real-time Epileptic Seizure Detection using Reservoir Computing

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Reservoir Computing (RC)

Description:
• Training method for Recurrent Neural Networks (RNN’s)
• Random RNN – “reservoir”
• Random input connections
• Only single layer of linear output nodes is trained

Advantages:
• Recurrent network: random processing abilities
• Fast training: one linear neuron per output channel
• No convergence issues
• Works with practically any kind of neurons (analog, spiking, ...)

EEG Data

Intracranial data from Rats:
• GAERS
  • Genetic Altered Rats from Strasbourg
  • Absence seizures
  • 1.5 seizures/min
  • Last 8 to 50 s
  • In total: 15 hours 17 minutes
  • 10% for training

• Kindling Model
  • Brain stimulation to develop epilepsy
  • Tonic-clonic seizures
  • 2 seizures/h
  • 40s to 4 minutes
  • In total: 4 hours 23 minutes
  • 20 % for training

Seizure Detection Setup

EEG Features Selection Reservoir (200 Neurons) Output

Results

ROC-curves:
• Receiver Operator Characteristics
• Sensitivity versus Specificity
• Area Under Curve (AUC)

GAERS:
• AUC:
  • RC = 0.99
  • 2nd best, Faselow and Osorio-Frei = 0.96
• Detection delay:
  • RC = 0.3s
  • Osorio-Frei = 0.9s
  • Fanselow and others > 3s

Kindling:
• AUC:
  • RC = 0.99
  • 2nd best, White = 0.82
  • Osorio-Frei = 0.78
• Detection delay:
  • RC = 1.5s
  • Osorio-Frei = 1.8s
  • White and others > 2.5s

Detection delay:
• Delay before seizure is detected
• For threshold of sensitivity = specificity

Further Work

More rat data
• Results are on a small dataset
• Currently extending results

Human (scalp) EEG
• Human data has different patterns
• Scalp EEG contains artefacts and noise
• Preliminary results promising

More features
• Currently small set of features
• Adapt features from literature

Accelerometry, ECG and others
• Use features from different sources

Conclusion

• Epileptic seizure detection is possible with Reservoir Computing
• It renders good results on intracranial rat data
• It results in a small detection delay