

A long short-term memory neural network to identify surgical targets in human epilepsy

Mira Chu-Shore

Epilepsy is the most common neurological disorder, characterized by recurring, unprovoked seizures. One third of patients have seizures despite maximal medical therapy, and for these patients, neurosurgery is the most effective treatment. The success of neurosurgical interventions requires accurate identification of the epileptogenic zone (EZ), the brain region responsible for generating seizures. Spike ripples have recently emerged as the most reliable biomarker for the EZ. The current validated method to detect spike ripples in intracranial electroencephalogram (EEG) data performs well ($F1 = 0.68$, specificity = 0.42, positive predictive value (PPV) = 0.79), but is computationally inefficient and therefore impractical to use. Long short-term memory (LSTM) networks are a type of recurrent neural network specifically designed to process and predict data sequences over time. We hypothesized that the LSTM network would have similar accuracy but improved computational efficiency to detect spike ripples in human intracranial EEG compared to the current approach. We used data from 18 epilepsy subjects with available intracranial EEG recordings prior to surgery, known EZ, and epilepsy cure after resection. To evaluate the performance of the LSTM network to classify spike ripples, we trained the neural network on the data of all subjects but one and tested the performance of the network on the left-out subject's data. This process was repeated for all subjects. The optimal mean F1 score was 0.76, which was achieved using a probability threshold of 0.13. At this threshold, the mean PPV was 0.73 and the mean sensitivity was 0.84. In addition, the LSTM detector required ~150s to analyze 10 min of data from 10 channels on a single processor with 2.3 GHz CPU (32 GB RAM). The LSTM network performed with similar or superior accuracy to the currently available detector and had improved efficiency, making it more suitable to identify the EZ in patients undergoing epilepsy surgery evaluation.