Forecasting interictal epileptiform discharges using a convolutional neural network

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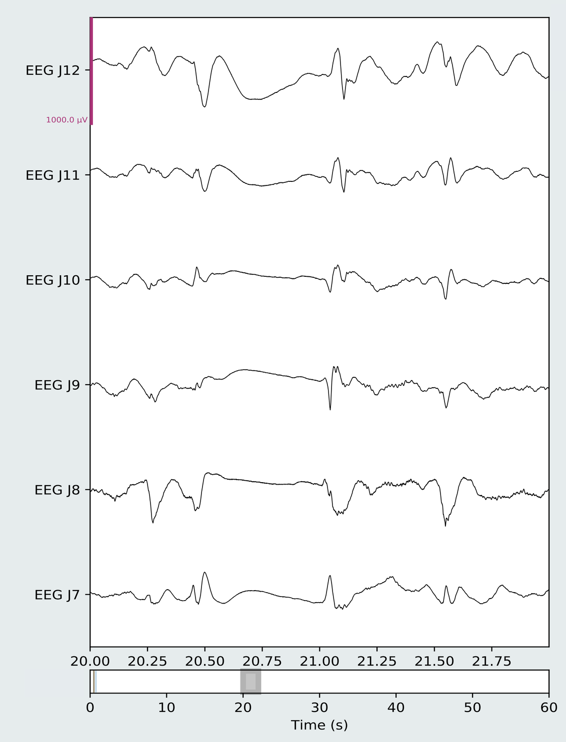
Background

- Epilepsy surgery is an important treatment option in patients with drug resistant epilepsy.
- Presurgical evaluation includes intracranial EEG and single pulse electrical stimulation (SPES).
- Responses to SPES are variable and may be brain state dependent.
- Interictal epileptiform discharges (IEDs) may be markers of brain states relevant to epilepsy.

Research Aim

- To develop a machine learning classifier that forecasts IED frequency and spread.

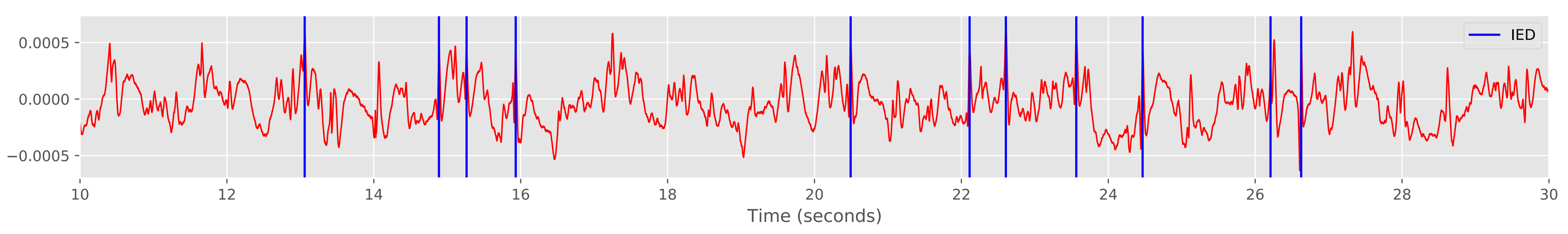


Data

- SEEG recordings from >100 paediatric patients at Great Ormond Street Hospital.
- Each recording is ~5 days long at high temporal resolution (>1kHz sampling rate).
- More than 100 SEEG contacts each.

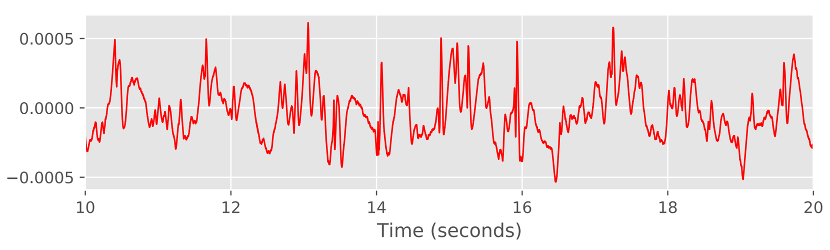
Labelling

1. Threshold-based IED detector applied to dataset.



2. Split the data into fixed-length segments labelled with the number of IEDs in the following segment.

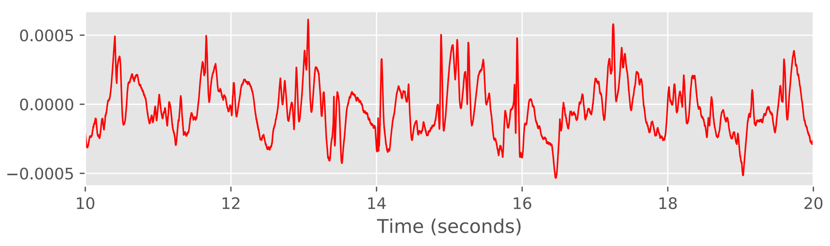
$x =$



$y = 7$

3. Formulate as a classification task: does the following segment have more IEDs than a patient-specific threshold?

$x =$



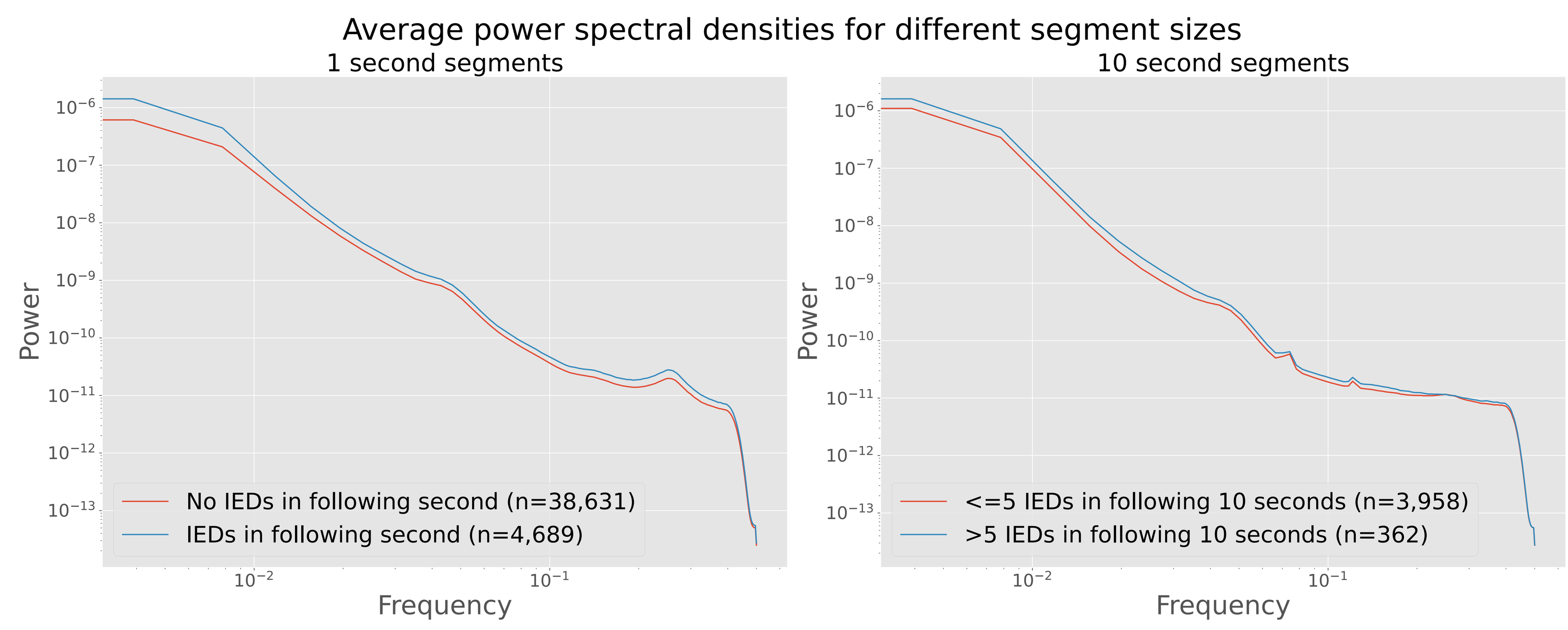
$\text{thresh} = 5$
$y = True$

Convolutional neural networks (CNNs)

- Initial investigation: 1D-CNNs applied to each channel.
- Extend to multi-channel 2D-CNNs to forecast additional IED features such as location and spread.

Preliminary analysis

- Two datasets created by applying the IED detector to a subset of data (1 patient, 1 hour, 12 channels).
- The datasets differ in segment length (1 second vs 10 seconds).
- For both segment lengths, more upcoming IEDs ⇒ higher power at lower frequencies.

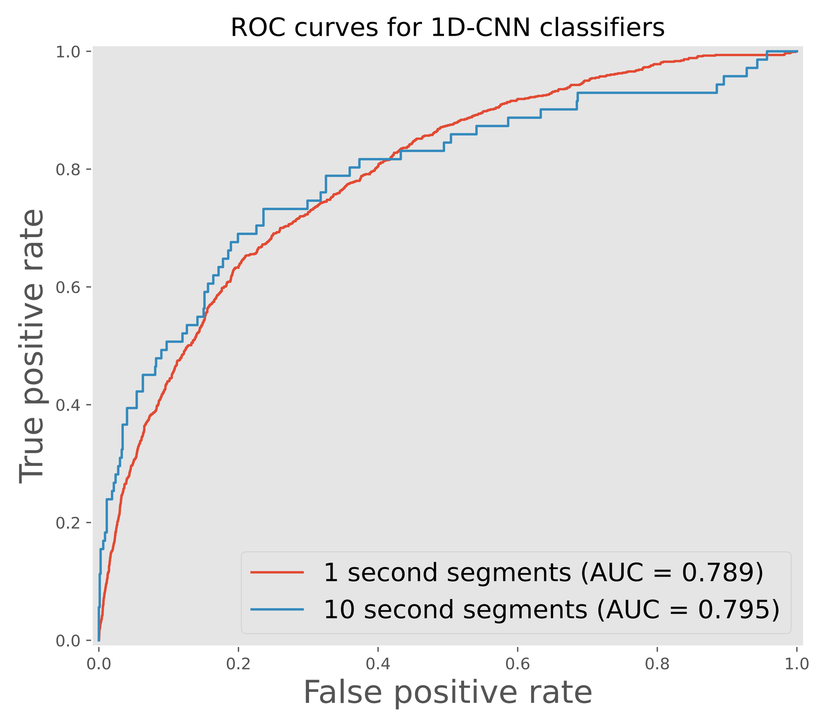


Preliminary results

- 1D-CNN trained on each dataset for classification.
- 4 convolutional layers, max-pooling, batch normalisation and early stopping.

Segment	Sensitivity*	AUROC
1 s	0.677	0.789
10 s	**0.718**	**0.795**

*For a fixed specificity of 0.750



Discussion

- A 1D-CNN can forecast high IED frequency with reasonable accuracy using single-channel data.
- Classification performance is higher using 10 second segments, though likely not statistically significant.
- So far focus has been on one brain region in one patient: model generalisability is therefore unknown.

Next steps

- Incorporate additional features: power spectral density, antiseizure medication status, features of previous IEDs, sleep status, etc.
- Extend to multi-channel data using 2D-CNNs to focus on the '*where*' as well as the '*when*'.
- Train across patients and see if a model that can generalise is possible, or if patient-specific classifiers are needed.

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