Developing algorithms for analysis of brain EEG activity in epilepsy: Project Report

Sarin Leigh and Christopher Tucker
School of Physics and Astronomy, University of Nott241aTB, United K241dom

May 30, 2014

For this reason any detection algorithm created must either be adaptive; designed for the detection of a particular type of epilepsy, or must contain many analytical tools to enable any type of spike

3.2 Software

All scripts ware

Cross-correlation in MATLAB

The `XCORR' function in the `Signal Processing Toolbox' within Matlab calculates the cross-correlation between two variables as a function of time shift or `lag' between them. The function requires the vectors be the same length, so the template is resized to the length of the signal, and a vector of 2N - 1 correlation coe cients is returned for lags with indexes between [-N+1:N-1], where

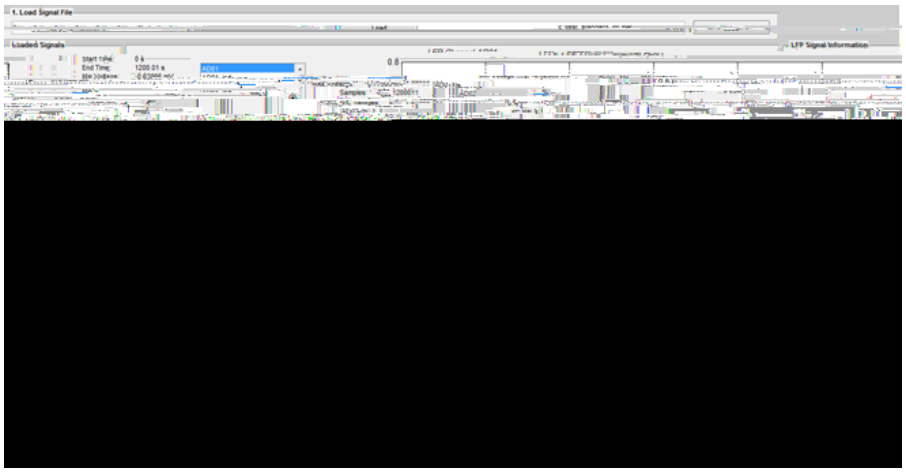


Figure 4: Screenshot of the Main Window of the software where the user can upload, view signal les and segment raw LFP signals for subsequent seizure detection analysis.

Figure 5 (a) - (c) below shows the GUI platforms for the SWM, FFT and RVE algorithms. The input parameters common to all three GUIs are; frequency bounds for the Butterworth notch lter, length and overlap of the sliding window, MSD and MID, and threshold position. The `Frequency Detect' parameter panel includes additional inputs to allow the user to pre-set frequency bands for

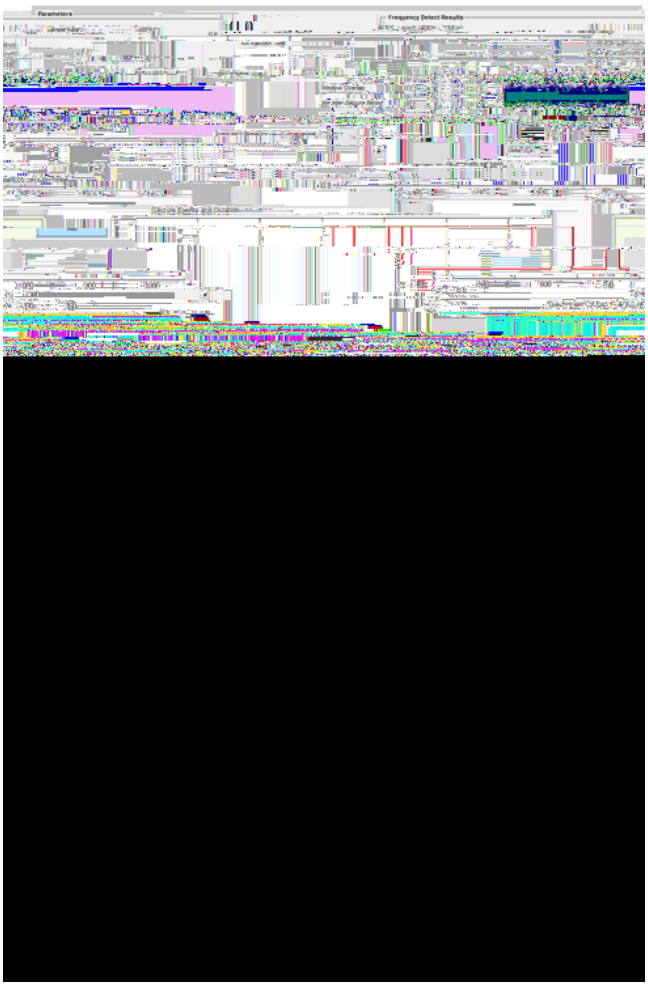


Figure 5: Subplots (a) - (c) Show GUI windows for the SWM, FFT and RVE algorithms respectively. Information

Figure 6

Figure 10: A plot of the raw LFP signal of a human `tonic-clonic' seizure. Basal activity occurs up until 60 seconds

Figure 17:

Figure 19:

The entropy response was analysed based on electrode location in the brain and experimental design. This was done by applying the algorithm to all 16 signal channels within the kainate LFP data used for testing. Following observations of the entropy time series for all 16 channels, the algorithm was run using a data set from a di erent experiment where the kainic acid was injected into the body cavity, as opposed to locally in the brain. For this experiment the kainic acid was injected into the body cavity at 1846 seconds, and data sampled at 1000Hz. Data was collected from the same four regions of the brain as for the previous experimental design, allowing the entropic responses between methods with respect to both electrode placement and kainate administration location.

Electrode Placement

The entropic response varied across all 16 channels, displaying either a sharp decrease in entropy at the time of the kainic acid injection, or remaining largely constant for both the basal and seizure

Figure 22: Subplots (a) - (d) showing the di erence in the average entropy time course response between the left [(a) + (b)], and right [(c) + (d)] side of the brain for kainic acid delivered locally.

is no long-lasting increase or decrease in the entropic response during the seizure as observed in some channels for both kainate model experiments. However when the spacing between windows was reduced when calculating the rank vectors, sensitivity to repetitive spike and slow-wave patterns, identi ed by Dr Mike `O' Donoghue, were observed in the response. These waveforms begin at 115 seconds where the entropy is observed to spike down in the RVE axis. This is arguably due to the increased coherence of the identi ed spike and slow-wave waveforms.

Figure 24:

Therefore it is important to note that any errors in output values such as the TDSD are only with

between those of the FFT and SWM algorithms, whereas the RVE curve displays little or no similarity to the other two for a given set of input variables. As discussed previously, the sensitivity and selectivity of the algorithms can be adjusted to the preferences of the user at will, but it is always desirable to maximize the level of concurrence between algorithm outputs so that they can be used collectively as a diagnostic aid. It is important to note that all the algorithms identify di erent features within an LFP signal, some of which cannot be directly linked to what is visibile through observation by a clinician, such as variations in entropy. Therefore each algorithm may require di erent input values in order to achieve a speci c desiredorderut. Itas for this reason that the default threshold value for the RVE algorithm was raised by 0.85 SDs to o set the di erence between its output values and those of the other two algorithms. With more extensive testing into the e ects

Figure 27: Output of `Cross-Correlation Detect' GUI showing template matches highlighted in red, and the original user selected `spike and slow wave' template on the right.

5.3 Further Discussion: RVE Algorithm

For local administration of kainic acid, the resultant entropic pro les outputted by the algorithm suggests there may be a di erence in RVE lineshape between signals originating from the lefta nd right side of the brain. Repeated experiments are necessary in order to conclude whether this is a consistent response, which would allude to a need for further modi cation of the algorithm to account for such variations between electrode placement.

The contrast in entropic behaviour seen between experiments administering kainic acid locally or within the body cavity suggests the response is unique to experiment design. Parameter sets tailored to speci c experiment designs may therefore be required to give clinicians more con dence in utilising the detection outputs from the algorithm. These contrasts in response are not unsurprising, as it has been suggested by Dr Rob Mason that seizures take on di erent forms depending on whether the kainic acid reaches the brain intravenously, or is injected locally. Furthermore, the variation in complexity dynamics between the rat data and human data is not surprising as they are not directly comparable in terms of the type of epilepsy they model.

potentially be uTloaded onto portable microchip devices to be worn by patients as early warning systems, and advanced data collection devices.

References

[1] Niedermeyer, Ernst, and FH Lopes da Silva, eds. `Electroencephalography: basic principles, clinical

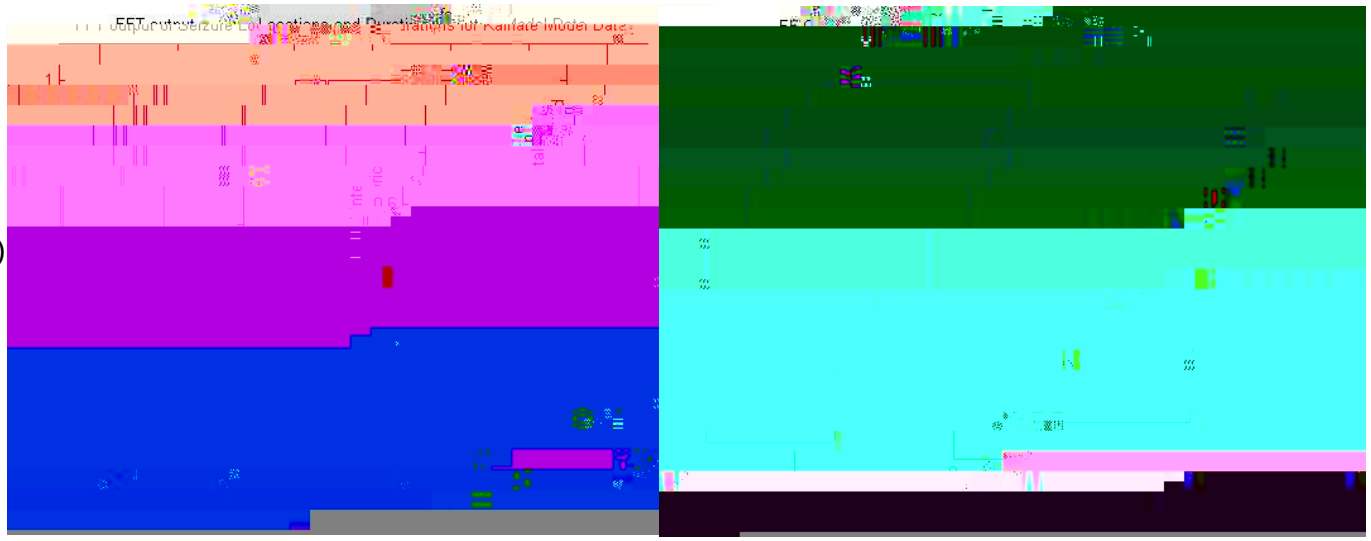
[17] Tzallas, Alexandros T., Markos G. Tsipouras, Dimitrios G. Tsalikakis, Evaggelos C. Karvounis, Loukas Astrakas, Spiros Konitsiotis, and Margaret Tzaphlidou. `Automated epileptic seizure detection methods: A review study.' Epilepsy-Histological, Electroencephalographic and Psychological Aspects. InTech (2012).

[18] James, Christopher J. `Detection of epileptiform activity in ththoe oF [(`Dearti ci)-3hou-

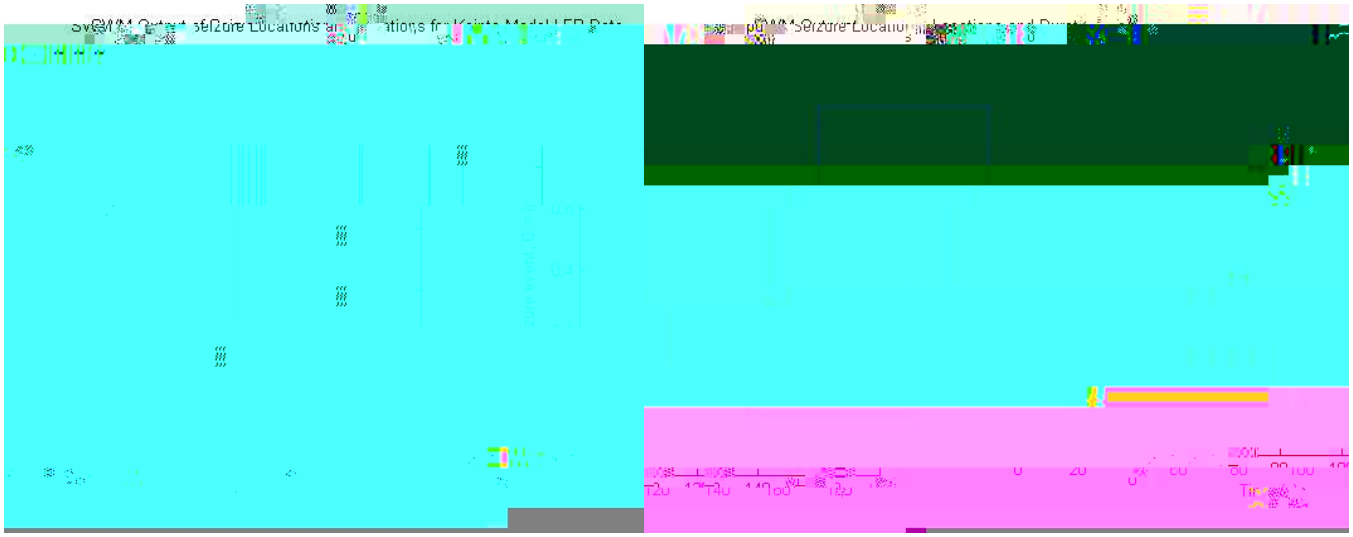
APPENDIX 1

APPENDIX 3

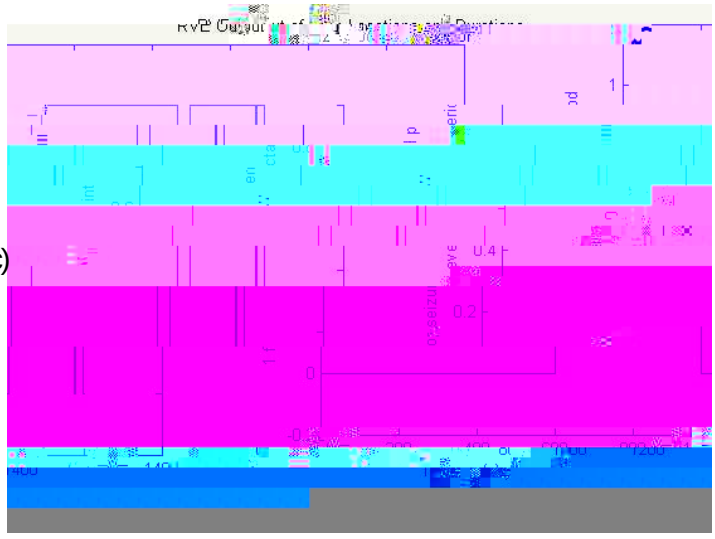
(a)



(b)



(c)



APPENDI X 5

Image(a)

Table of Contents

Quick Start User Guide

9. Seizure detection method is chosen by selecting the appropriate button in the ¶ ' H W H F W L Rpanel which launches a new GUI plat6 84.984 2/44.984 239.45 7

Frequency DetectGUI Platform

1. The Frequency Detect GU

4. 7KH ¶)LOWHU· parameter determines the upper and lower bounds of the Butterworth (50/60Hz notch) filter applied to the selected epoch.

   Default values

7. 6 H O H F W L Q J W K H

Detection Parameters

Frequency Detect, Entropy Detect and Amplitude Detect GUI platforms have the same adjustable parameters that direct the detected seizure output. The parameters include: Sliding Window Size, Window Overlap, Inter-Seizure Period, Min Seizure Duration and Standard Deviation Threshold. This section gives an overview of these parameters. The reader is directed to the Auto_Detect report for more information about the

1. ¶6OLGLQJ:LQG parameter is the size of the segment of data (in seconds) the algorithm uses to calculate the mean value of the feature the algorithm is sensitive to.

4. 7KH ¶)LOWHU·

Entropy Detect GUI Platform

1. The Entropy Detect GUI platform is launched from the Main Window when the ¶ (Q W ·bu Rn \ is pressed in W K H ¶ ' H W H F W L R Ç

2. The selected epoch is plotted W K H ¶

4.

7. The RVE algorithm requires a
decay rate to be entered by th
user.

The decay rate determines th
L P S D F W R I W K H

10. The entropy time course displayed in the axis belo

W K H ¶ E v e n t s] & U H
' X U D W L R Q V · D |

4. Pressing opens a

template will always roun
down 2(a)-o 2(a)-he near
This migh2(a)- increase e
of e neatemplate.e

Long platel l return
fewerna2(a)-c(e)-s.

6. Once a suitablee template is see cted and displayee inf(a)-ormation is pree ee in thee ¶ 7 H P S O D W H , Q I R U P D W L R

11.

12. To viewa te
match in th
axis, ensure
manipulation
are toggled o

Then click onc
the white main a
to pause Matlab
command windo
for Matlab status)

When ready to selec
template, press the
space bar to unpause
the programme. This
will change the

will changadv