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1.1 Epileptor paper — Jirsa, 2014

Describes the epileptor model for seizure activity [1]. The model is derived by considering invariant properties of seizures: spike frequence and amplitude trends during siezure onset and offset. They consider SLEs to be within the standard repertoir of brain states explaining why they are associated with such a wide range of afflictions. They consider that the brain then passes a bifurcation point when starting or ending an SLE. Interictal states are modeled by oscillatory states (limit cycles) and non-SLE states are in the space of a stable equilibrium point. SWEs in the preictal interval can be seen as a result of the state approaching a bifurcation point.

The model is governed by 3 ensembles comprising 5 total equations. The first ensemble is composed of two equations and deals with fast discharges (fast time scale). The second ensemble is again two equations, but now at a longer time scale and representes SWEs. The third ensemble is a single variable, called the permittivity variable, z. This variable determines how near the current state is to a seizure onset. The permitivity variable operates on a very long time scale.

The Virtual Brain Project has a GUI and a bunch of code for playing with this model - they add in some additional parameters.

In the paper, the model equations will produce a plot that looks more like the one in the paper if the g coefficient is set to 2 (instead of 0.002). Additionally, I think the traces shown are $-x_1 + x_2$ (rather than $x_1 + x_2$).

1.2 Reproducing the Model

Since the equations, parameter values, and initial conditions for the model were all given in the paper, it is easy enough to reproduce their plots (with the minor alteration in the g coefficient mentioned above). Compare the plots in Figure 1.

Note that there are a few differences: 1) the cycle seems a bit faster for mine and the initial conditions may differ - in particular, I cut off the first 500 seconds in mine to align the traces. 2) The x_2 spike frequency seems a bit higher in mine and more regular (see Fig.2).

1.3 Next steps

- Set up Kalman filter
- Look over BluePyOpt paper [3]
- Would like to read about stochastic calculus (Ito vs. Stratonovich) and review different integration methods. It looks like in the VBP they switch to integrating using

the Heun method (implicit) - supposed to allow larger step sizes. Check [2] for both of these.

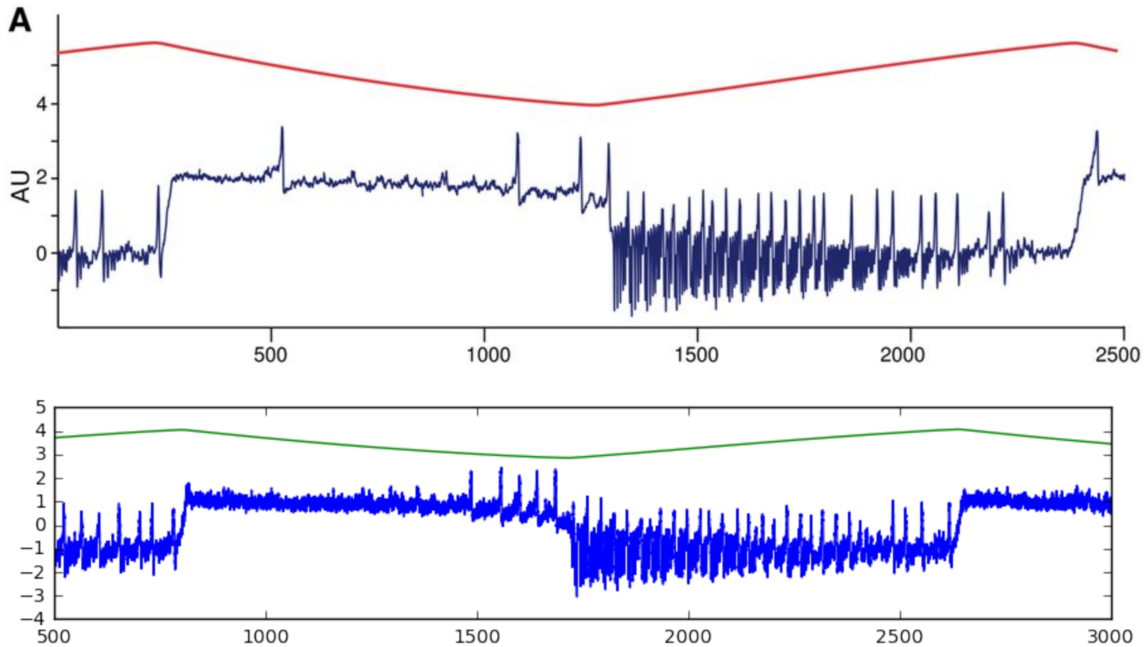

Figure 1: Comparison of model outputs. The top figure is Figure 5a from Jirsa; the bottom figure was generated using the *sdeint* package for integrating stochastic differential equations in Python. The trace shows the sum $-x_1 + x_2$.

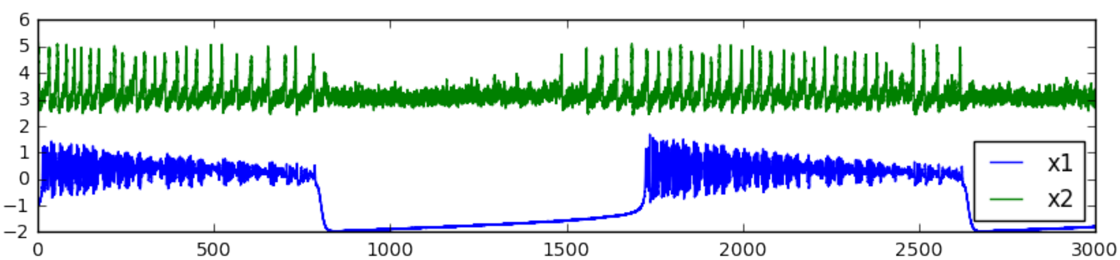

Figure 2: Variables x_1 and x_2 separated.

References

[1] Viktor K Jirsa et al. “On the nature of seizure dynamics”. In: *Brain* 137.Pt 8 (Aug. 2014), pp. 2210–30. DOI: 10.1093/brain/awu133.

[2] Peter E Kloeden and Eckhard Platen. *Numerical solution of stochastic differential equations*. 2nd corr. print. Vol. 23. Berlin: Springer, 1995. ISBN: 3540540628 (Berlin : acid-free paper).

[3] Werner Van Geit et al. “BluePyOpt: Leveraging Open Source Software and Cloud Infrastructure to Optimise Model Parameters in Neuroscience”. In: *Front Neuroinform* 10 (2016), p. 17. DOI: 10.3389/fninf.2016.00017.