

Unfinished ISN project by Connor Zawacki (connorzawacki@brandeis.edu)

Brief Abstract/Introduction

An attractor network is a model for a system of neurons whose activity tends towards one of several discrete steady stable states, called attractor states. A network of neurons with a large number of attractor states with comparatively few neurons could provide a plausible framework for information processing. In the past, attempts to computationally replicate such a network have yielded inadequate results, characterized by problems such as unbiologically high firing rates or requiring the fine tuning of many parameters. There is strong experimental evidence in cortical and hippocampal circuits for system dynamics to follow an inhibition stabilized regime, characterized by strong recurrent excitation which is stabilized by stronger recurrent inhibition. Use of firing rate models in the inhibition stabilized regime yields more promising results, as multiple attractor states can be stabilized with arbitrary low firing rates. By simulating large variations of connection strengths while fixing other parameters, we can test both the number of possible steady states for a given parameter set, and potentially define a relationship between connection strengths required to produce multistability. We successfully produced several networks capable of a combinatorial explosion of attractor states. Moreover, this network continued to produce this large number of attractor states for a variety of connection strengths between units. There are several plausible steps forward from here, the goal of course being to define under exactly what conditions this combinatorial explosion of attractor states are stable.

Code

Naming convention: ISN_net_excitFiringRate_InhibFiringRate_crossConnection_#ofPairs

Note concerning HPCC results: I specifically did not include code I have written for the Brandeis HPCC. The reason for this is twofold. Firstly I was unable to locate an error or two in what I have written for it causing some figures to be inaccurate. Secondly some of the code isn't widely applicable (i.e. is specific to the batch scripts I have written and the pathnames on my machine)

single_unit_sweep.m

A single E-I pair param sweep for excitatory and Inhibitory threshold, produces a grid plot of param combinations resulting in bistability for the single E-I pairing

single_unit_Bistable_QI.m

A single E-I pair with a nonlinear inhibitory firing rate equation exhibiting bistability

ISN_net_QE_linI_EIX_20.m

20 E-I pairs with no E-I cross connection and nonlinear firing rate equations for excitatory units. With current parameter set anywhere between 2 and 19 of the 20 pairs can be "on" at once, and the rest are suppressed.

ISN_net_QE_linI_40_EIX.m

Originally written by Professor Miller. 40 total E-I pairs, 10 of which are active. Nonlinear firing rate equation for excitatory units, and linear for inhibitory. E-I cross connection

ISN_net_linE_QI_IEX_10.m

10 E-I pairs with linear excitatory firing rate equations and nonlinear inhibitory firing rate equations. I-E cross connection. Anywhere from 3-5 units can be “on” at once. Worth exploring stability more, as this particular regimen seem a bit more “fragile” than the others.

ISN_net_linE_QI_0x_2.m

Originally written by Professor Miller. 2 E-I pairs, 1 of which is active. Nonlinear firing rate equation for inhibitory units, and linear for excitatory. No cross connection, essentially just exhibiting bistability in a single unit.

ISN_net_lin_IEX_20.m

20 total E-I pairs with only linear firing rate equations. I-E cross connections. With current parameter set anywhere between 1-18 E-I pairs can be on at once, the rest being suppressed.

ISN_net_lin_IEX_10p.m

Originally written by Professor Miller 10 E-I pairs, 8 of which are active. Linear firing rate equations and i-e cross connection.

ISN_net_lin_IEX_10.m

Very close to ISN_net_lin_IEX_10p, just exploring slightly different parameters and number of active E-I pairnigs.