**Date - 14/08/2015**

1. Initialised git repo at hamborger/brian.git
2. uploaded stable.py,unstable.py and stateSpace.py to github
3. Made a backup in the /storage under himanshu/brian
4. BRIAN version 1.3.1 is being used.
5. Explanation on how sigma for a group is determined:  
     
   In stateSpace.py, function estimate\_params is used to get sigma. The estimate\_params function takes in two input arguments, mon ‘spike monitor’ and time\_est ‘initial burst time’ specified in default\_params structure. The initial\_burst\_t is 50msec. In estimate\_params the spike times from the last layer are taken as input. Zip(\*mon.spikes) puts the spike time lists from all the 100 neurons in one package. The spike times, which is 100 x runtime(90ms, step size 0.1), in a time window of 30ms + synaptic delay from the initial burst time are taken. A standard deviation of spike times is then calculated in that time window by finding the mean spike time.   
     
   In short the logic is to determine the variation in spike times developed from the case if everything is synchronous in that time window.

Code snippets:

(91) initial\_burst\_t=50 \* ms

(196) net.run() #Runs the network simulation

(153) i, times = zip(\*mon.spikes)

(154) times = array(times) #datatype conversion from simple list to array

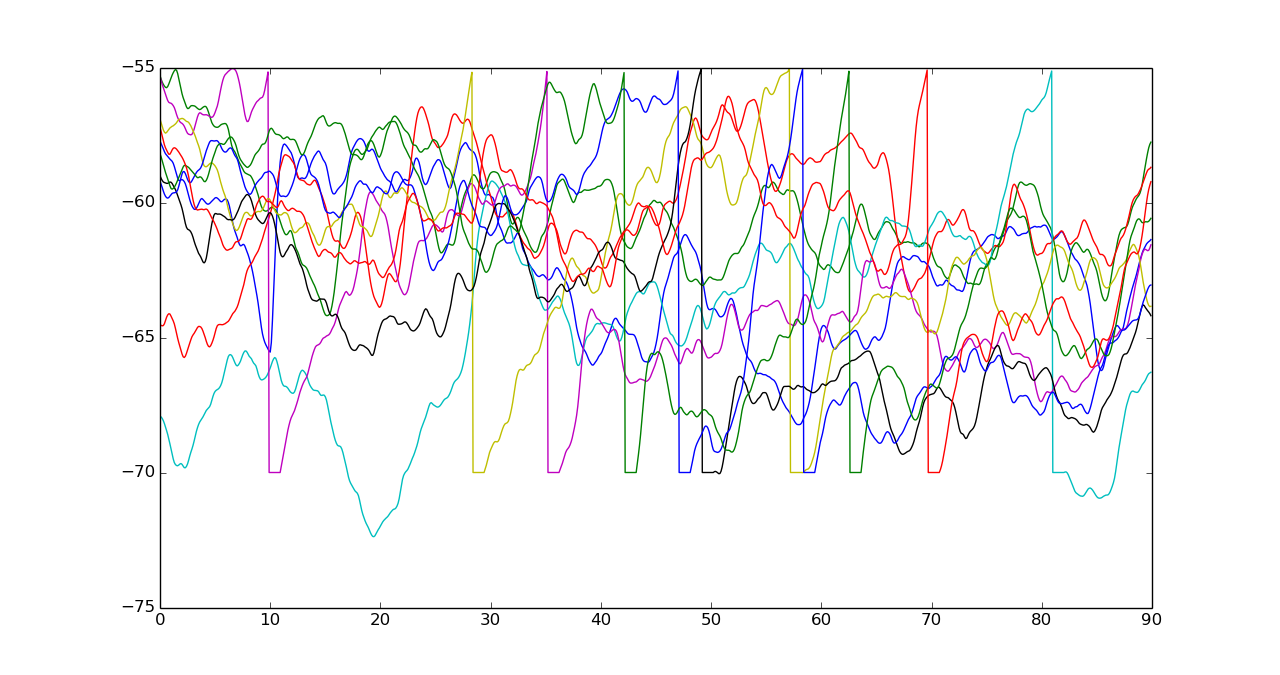
(155) times = times[abs(times - time\_est) < 15 \* ms]

(162) return (len(times),times.std())

(197) (newa, newsigma) = estimate\_params(net.mon[-1], params.initial\_burst\_t) #newsigma is the standard deviation for the last layer.

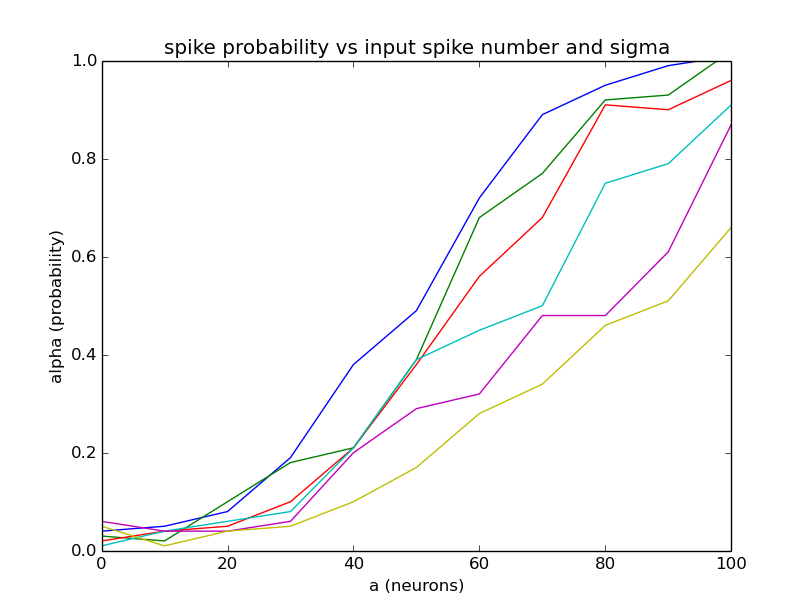
**Date - 17/08/2015**

1. Made changes in the stateSpace.py default\_params initial\_burst\_t set to 10ms not 50ms.
2. In stable.py added user input for a,sigma
3. StateMonitor(P,’v’,record=[1,101,201,301,401,501,601,701,801,901])   
   Instead of SpikeMonitor this function will give the voltage trace for the selected neurons out of total 1000 neurons.  
     
   X axis : runtime(in msec) ,Y axis : Membrane voltage(in mV)  
   Ymax : threshold voltage  
   Ymin : resting potential

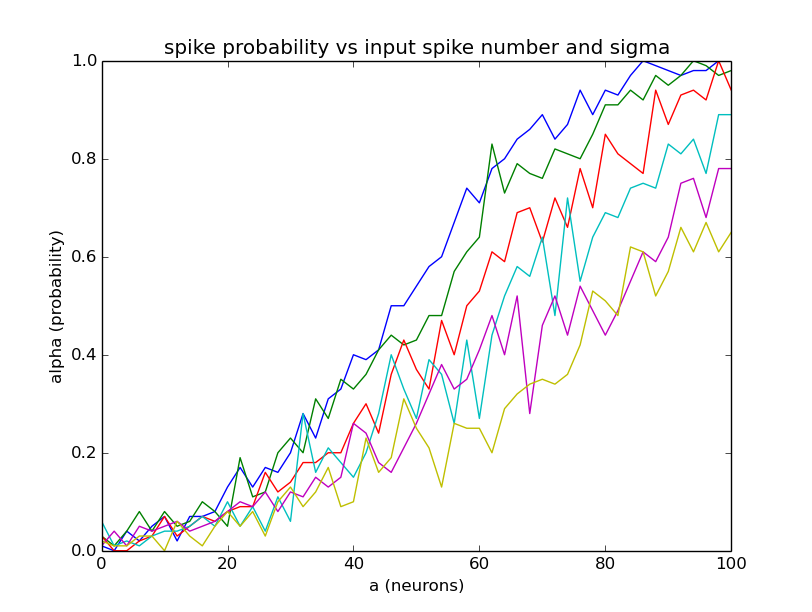


4. I reproduced figure 2C from Diesmann et. al. 1999 paper. In stateSpace.py, sigma\_vs\_a function calculates the probability or percentage of spikes occurring in the last group by finding new a and dividing it by the number of neurons in that layer which is 100. It does so by changing the input volley’s neuronal number ‘a’ fixing sigma. Hence we get response probabilities accordingly for different temporal dispersion in input.

In the figure below it is evident that violet (sigma=0ms) has the highest probability of response compared to yellow (sigma=5ms) where each line is evaluated for 10 different values of a.



Plotted for 50 equally spaced a’s from 0 to 100.



**Date - 18/08/2015**

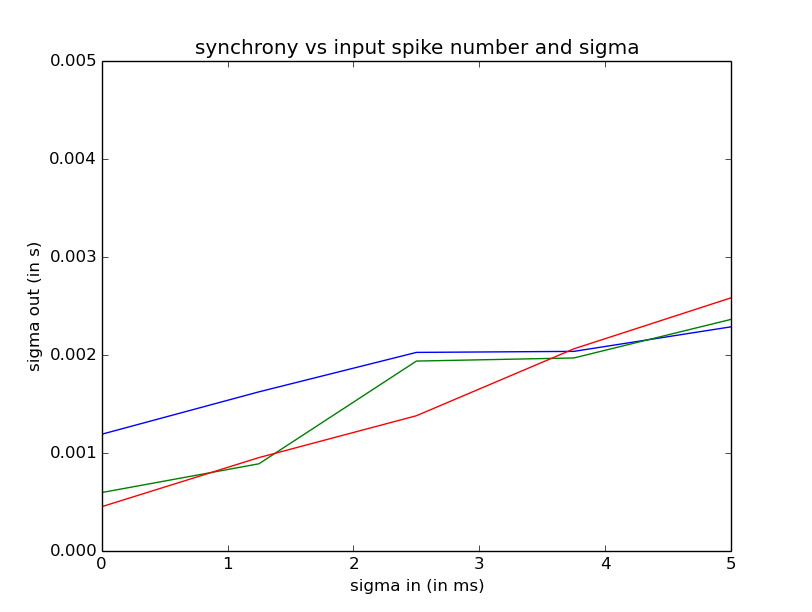
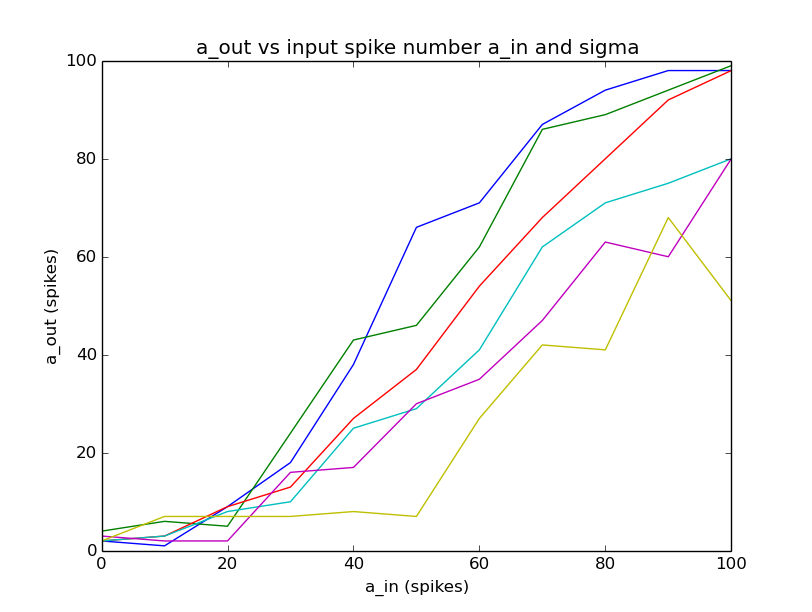
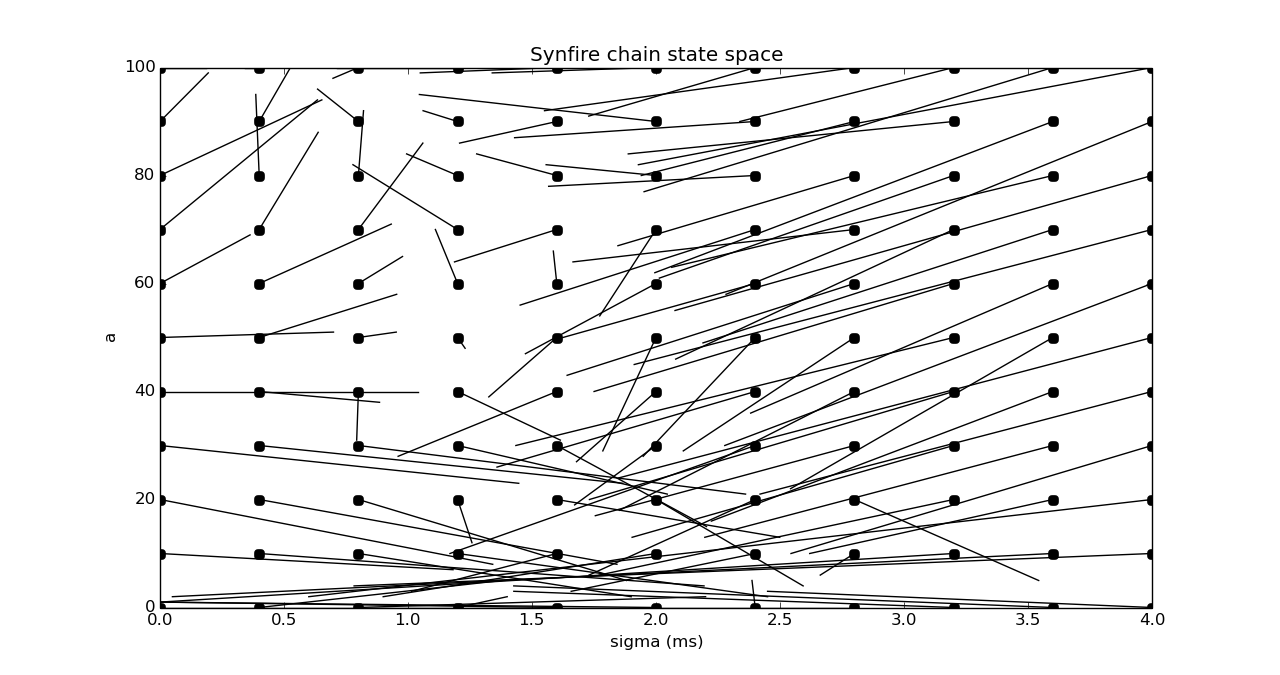
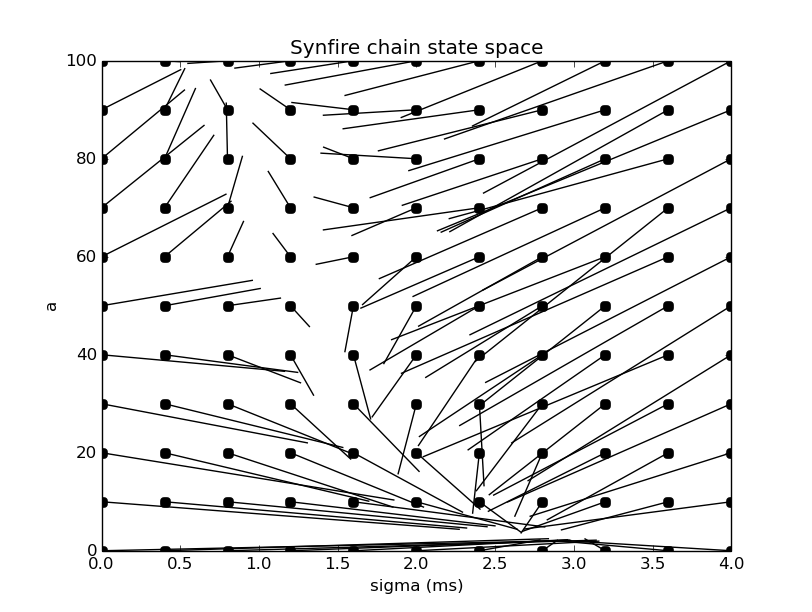
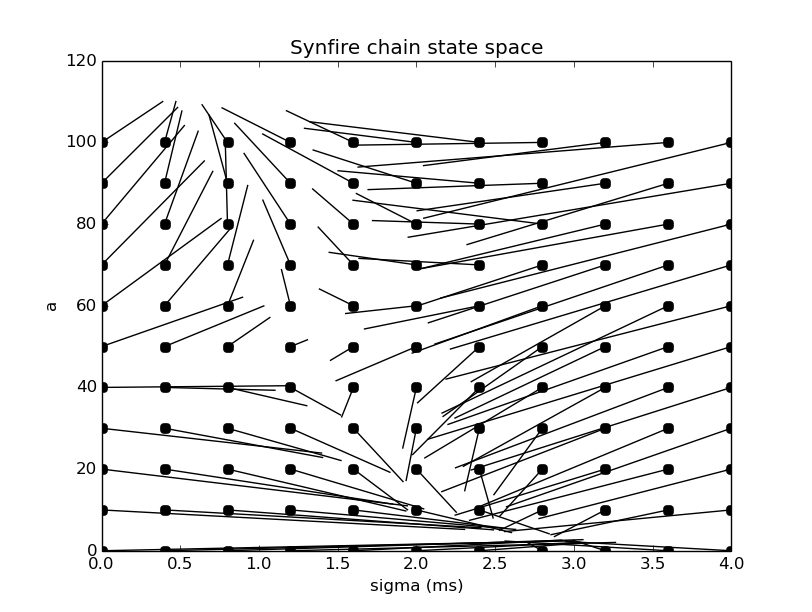
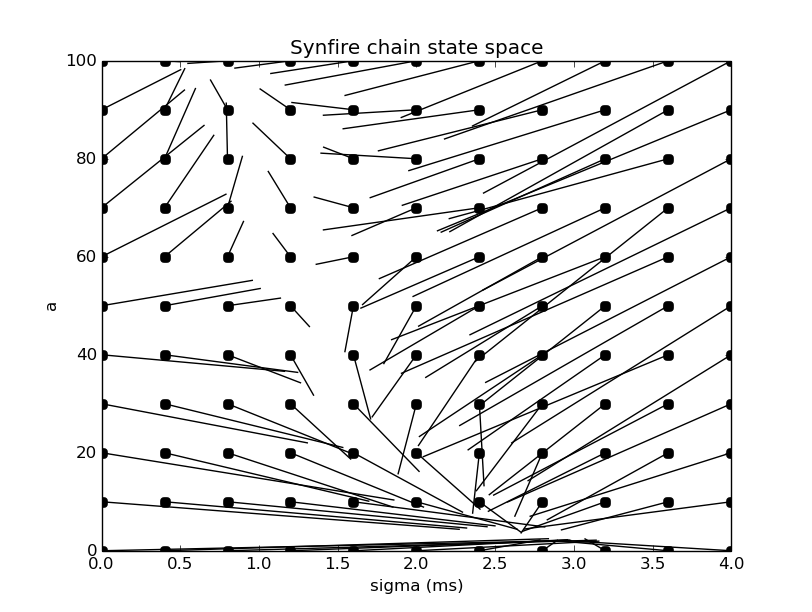
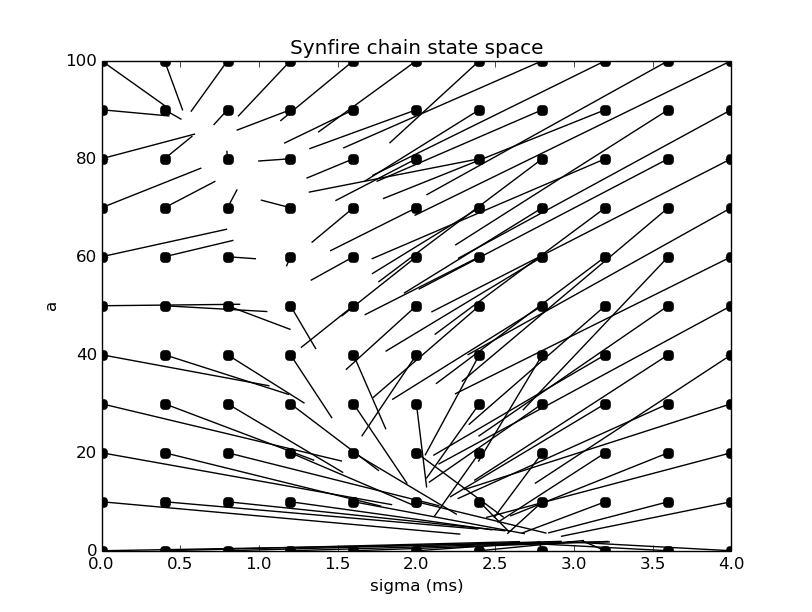
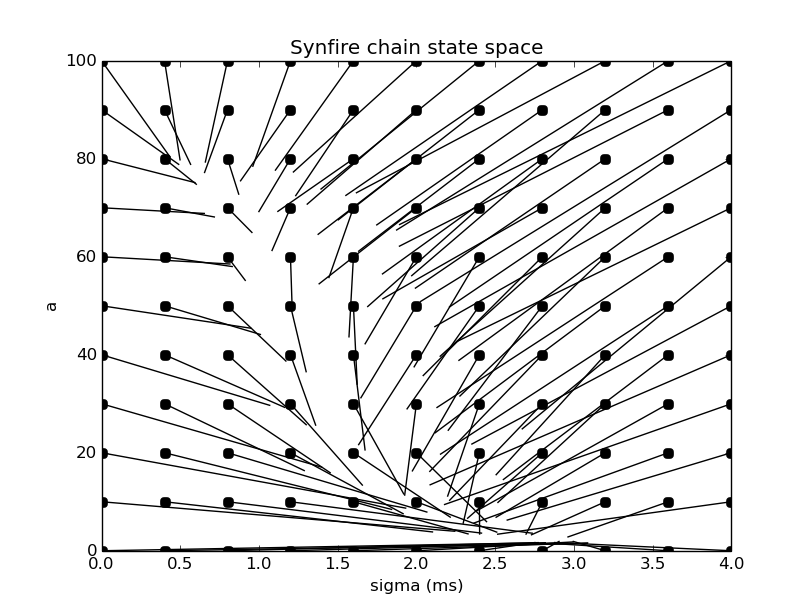
1. Plotted sigma out vs sigma in for different numbers of neurons ‘a’. It is seen that sigma is not dependent on ‘a’ where blue is 45, green 65 and red 100.
2. To reproduce figure 3a, figure 4(a,b,c,d)
3. Figure 3a:  
   In this figure the output of spikes from the last group is measured with respect to input spikes having fixed temporal dispersion of 0(Blue)-5ms(Yellow). This plot has lines each containing 10 points.  
   

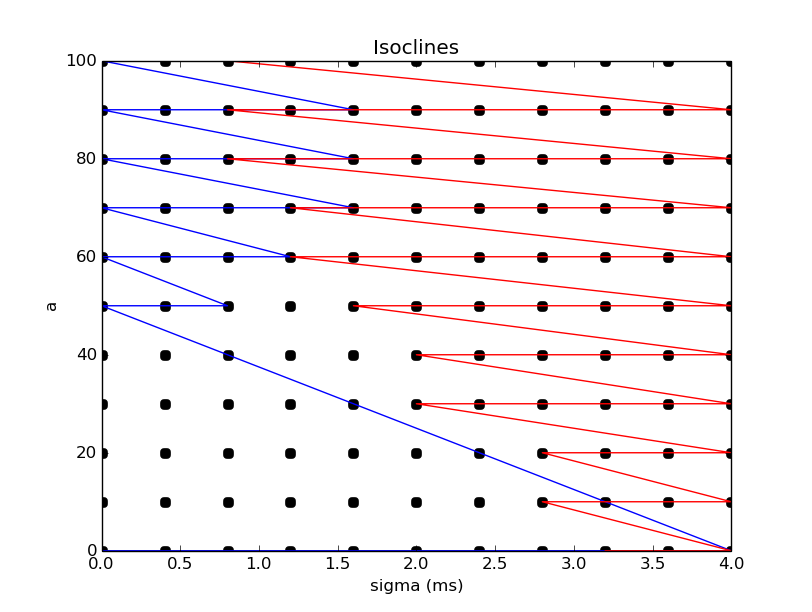
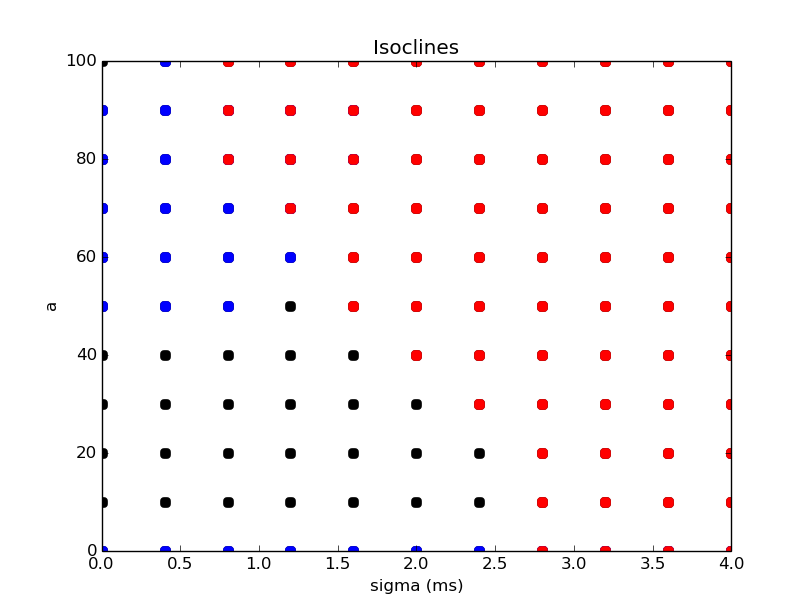
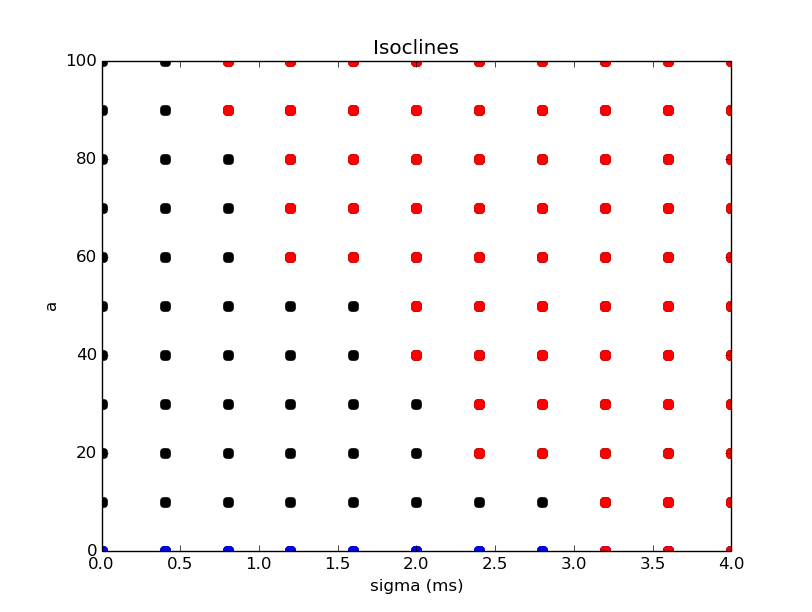
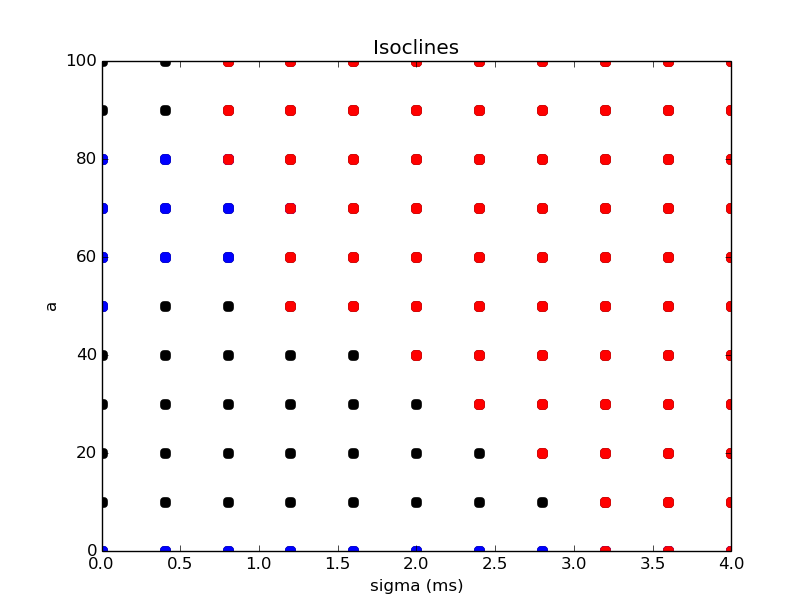
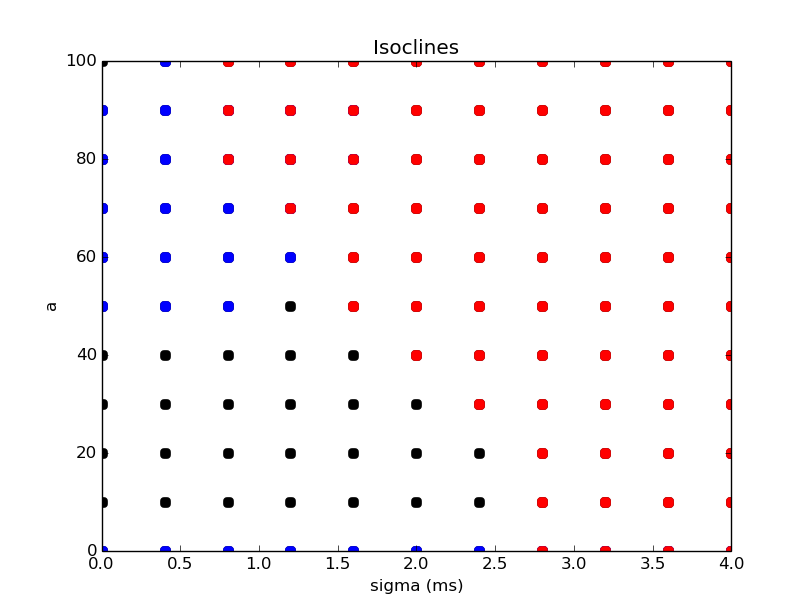
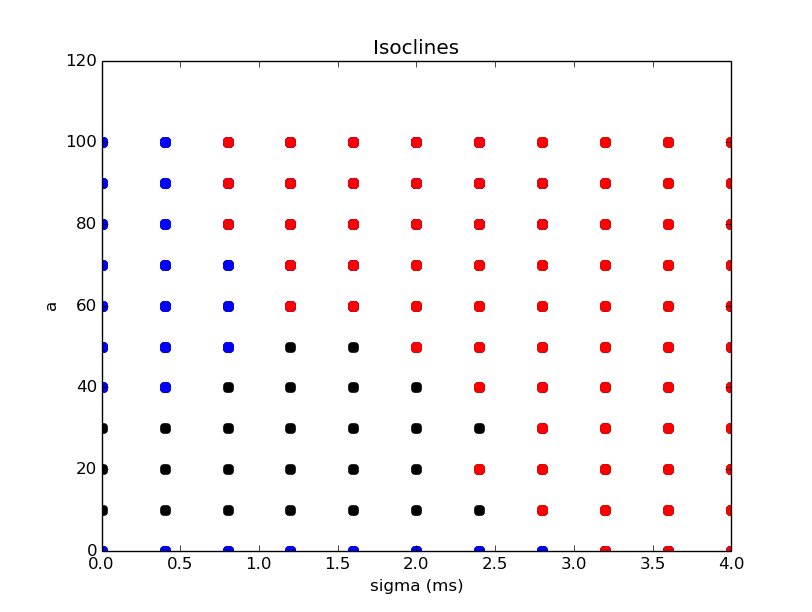
Figure 3c:  
State space plot generated using stateSpace.py with a grid of 10x10 size in the alpha-sigma phase plane. In the state space plot the top left region is converging to the stable fixed point defined as propagation with increasing synchronisation. The central region is the saddle node where the propagation can be either stable or unstable defined as propagation with increasing spread or dispersion in spike times. Neuron\_multiplicity is 1 and 50 for the corresponding figures below. Neuron\_multiplicity increases the probability of stable propagation by changing the number of neurons in a layer by a factor. Then new a is calculated by dividing the newa, returned by estimate\_param function, by neuronal\_muliplicity scaling it back to 100 or w as set in the model\_parameters. A neuron\_multiplicity of 50 means that there are 5000 (100 x 50) neurons per layer. It is observed that as we increase the multiplicity number the central region of the state space corresponding to a saddle node shrinks.

1. 
2. Figure 4a,4b,4c,4d:  
   In the plots below the role of neurons per layer w is being investigated. It is seen that as w is increased from 80 to 90 a stable fixed point comes into the picture. The stable fixed point shifts top-leftwards as we further increase the w from 90 to 110. 

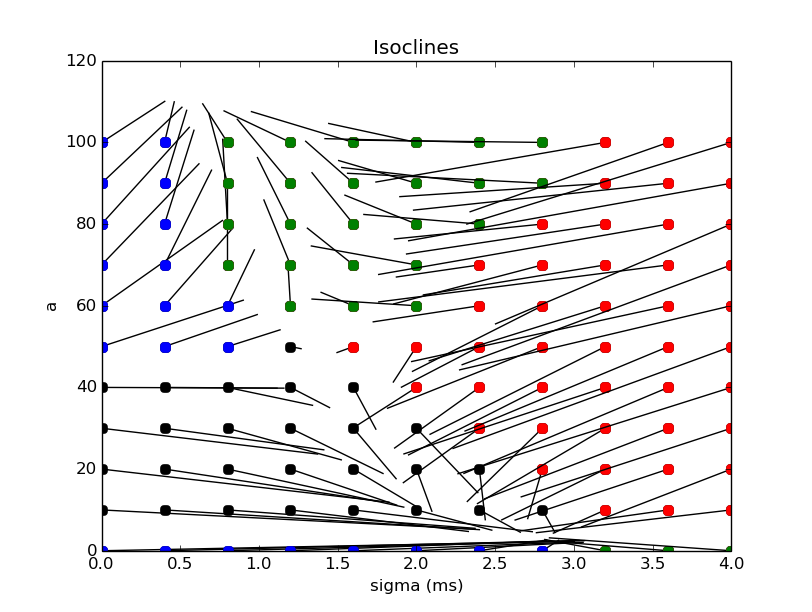
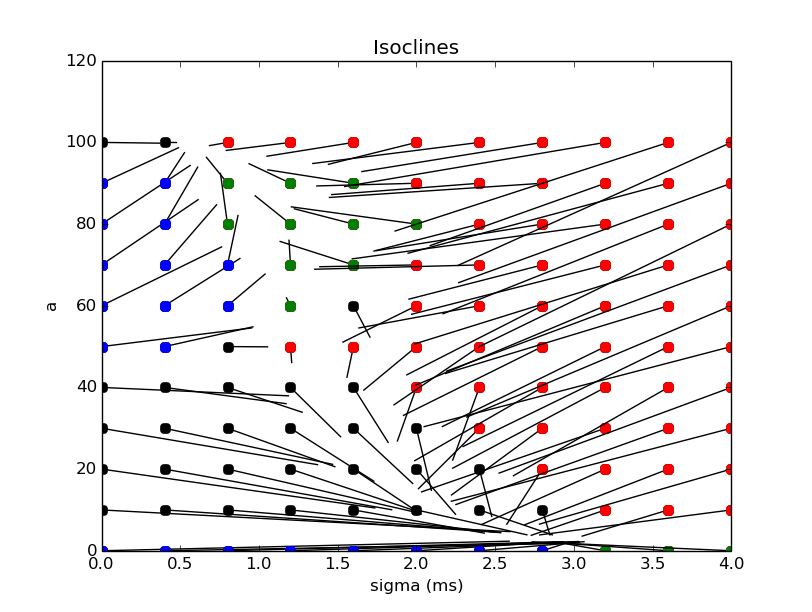
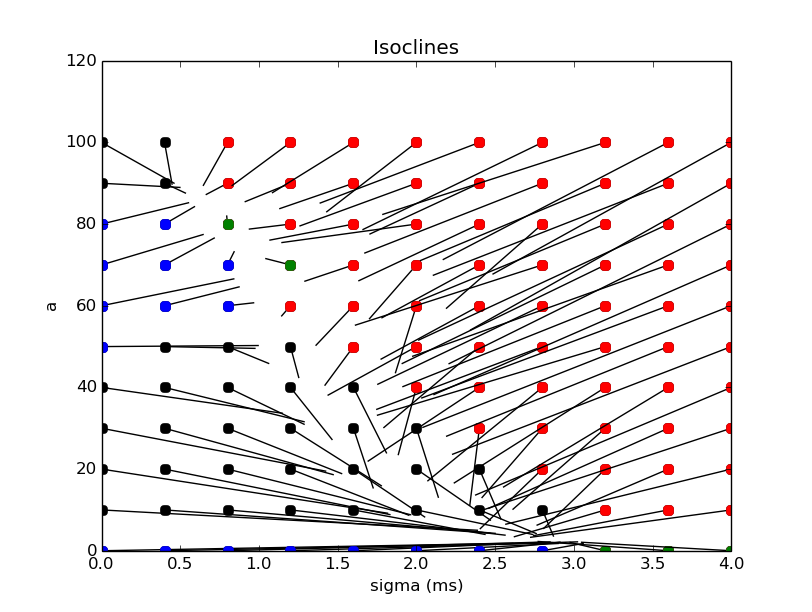
**Date - 19/08/2015**

1. Plot isoclines as a function of w. (Methods: Isoclines for figure 4(a,b,c,d))
2. Isoclines :  
   a. Sigma-isocline:   
    1. Not dependent on w.  
    2. Maintaining state of temporal spread irrespective of a.

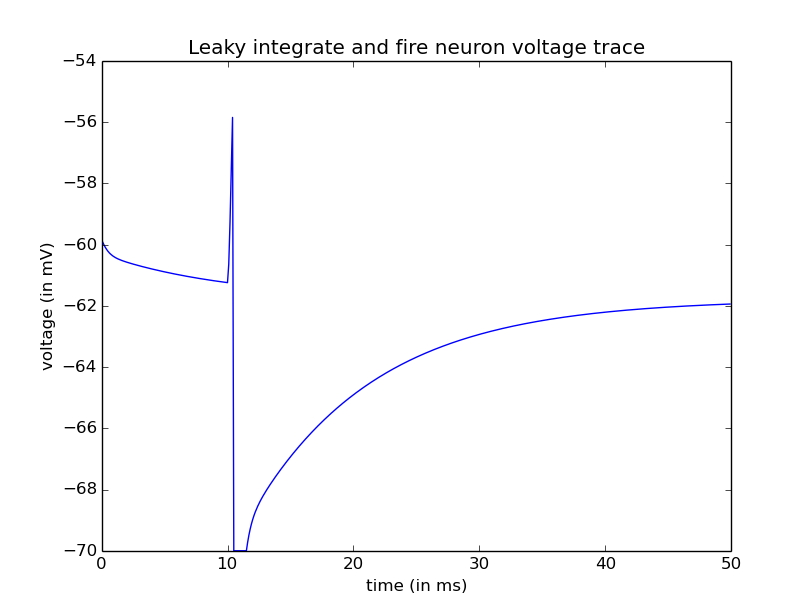
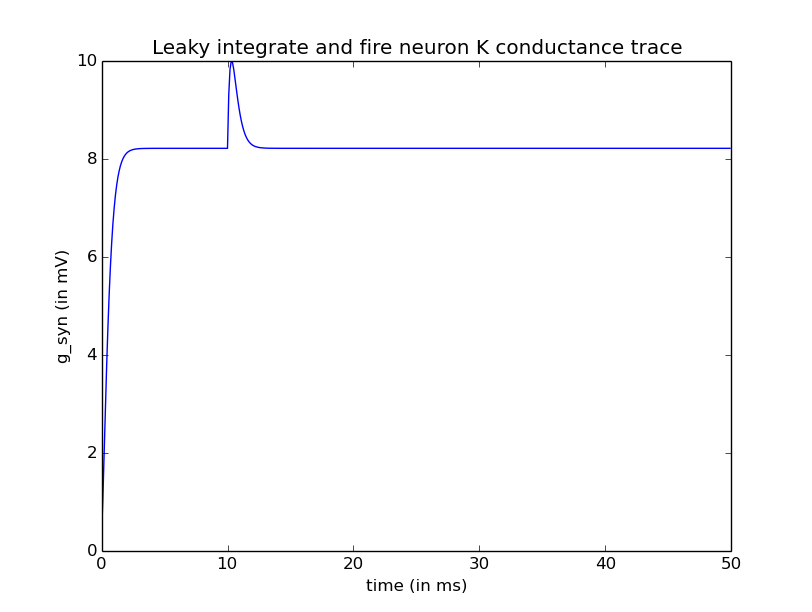
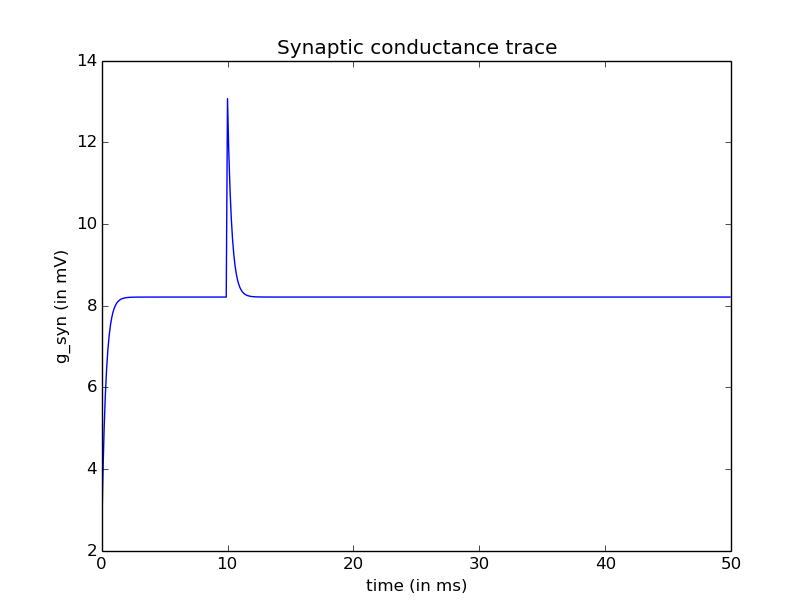
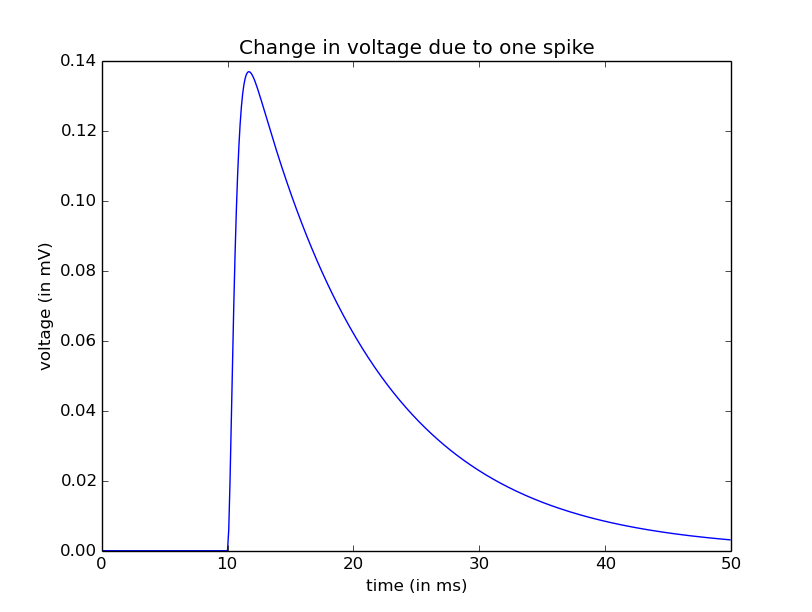
b. a-isocline:  
 1. Dependent on w  
 2. Maintaining state of having a spike number which doesn’t change   
 with sigma.

1. Methods : ?
2. a- isocline is plotted by picking all those set of points for which the a\_out-a\_in == 0 or change is a is zero.
3. sigma-isocline is plotted by picking all those points for which sigma\_out-sigma\_in == 0.
4. Since it is being done on a limited number of grid points it is difficult to exactly arrive at the isoclines. So a coloring of the region is done the blue region is where the ‘a’ increases and red where the ‘sigma\_out’ decreases. The boundary of the two regions is where the isoclines lie.  
     
   The figure below is generated for a w of 100 (neuron\_multiplicity 50). Red region is all those a\_in,sigma\_in for which the sigma\_out decreases and Blue region is where a\_out increases. The boundary of each region marks the respective nullclines.
5. Plot for w = 80 (neuron\_multiplicity 50):
6. Plot for w = 90 (neuron\_multiplicity 50):
7. Plot for w = 100 (neuron\_multiplicity 50):
8. Plot for w = 110 (neuron\_multiplicity 50): 

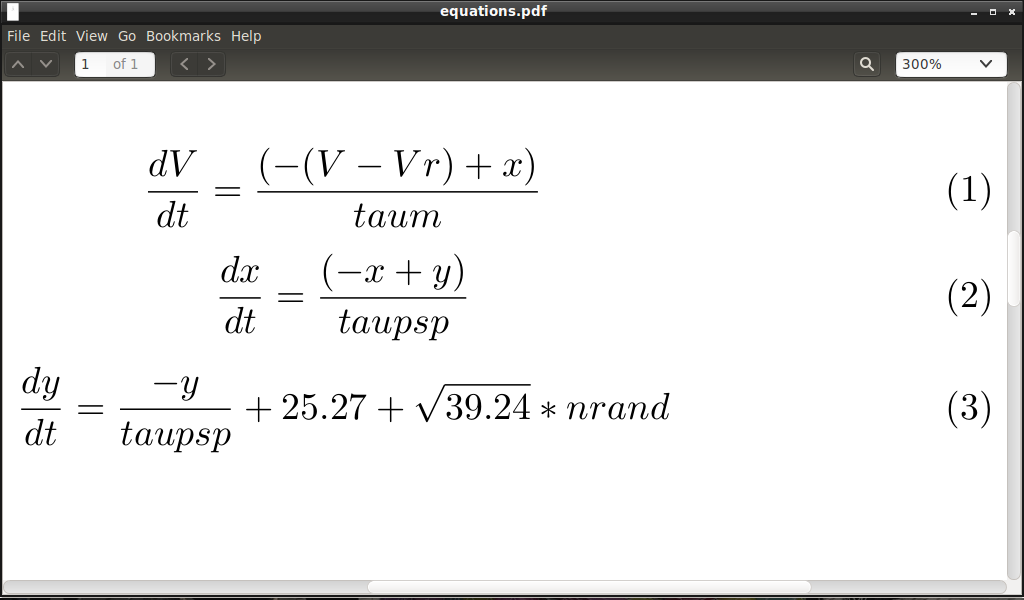
**Date - 20/08/2015**

1. Improved the coloring algorithm to find out overlapping grid points by giving them a unique color.
2. Plot for w = 110 (neuron\_multiplicity 50)
3. Plot for w (neurons/layer) = 100 (neuron\_multiplicity 50)
4. Plot for w (neurons/layer) = 90 (neuron\_multiplicity 50)

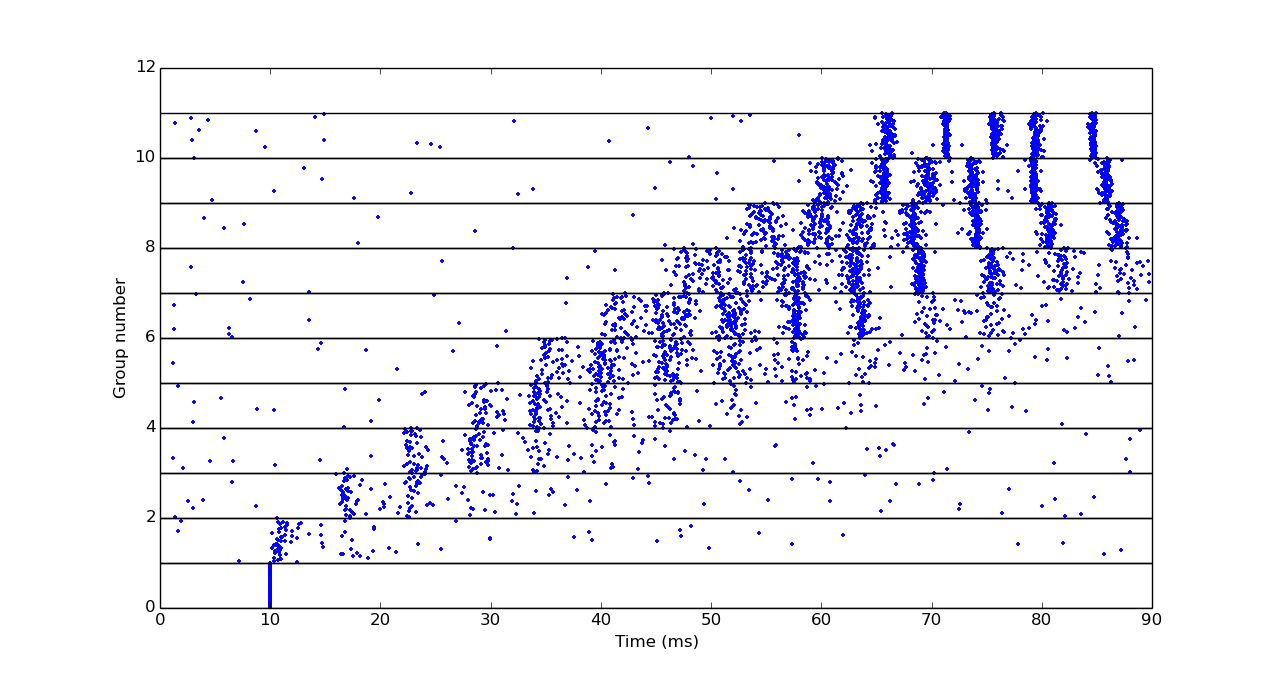
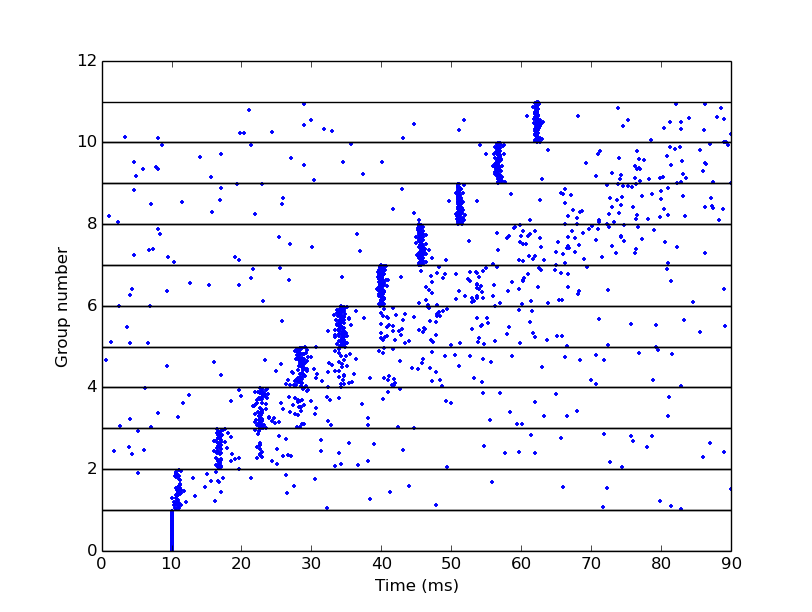
**Date - 21/08/2015**

1. Update mid-term report with figures generated using brian and attach codes.
2. Leaky integrate and fire neuron with Potassium conductance dynamics
3. Voltage trace of a single LIF neuron (runtime 50ms):
4. K conductance trace (runtime 50ms,a = 1, sigma = 0):
5. Noisey synaptic conductance trace (runtime 50ms,a = 1, sigma = 0):
6. Voltage bump due to a single spike (runtime 50ms,a = 1, sigma = 0):  
     
   Neurons were initialized at resting voltage, -70mV. Voltage difference created due to single spike was calculated by taking a difference between the neuron seeing the spike and a neuron with no synaptic input.   
   

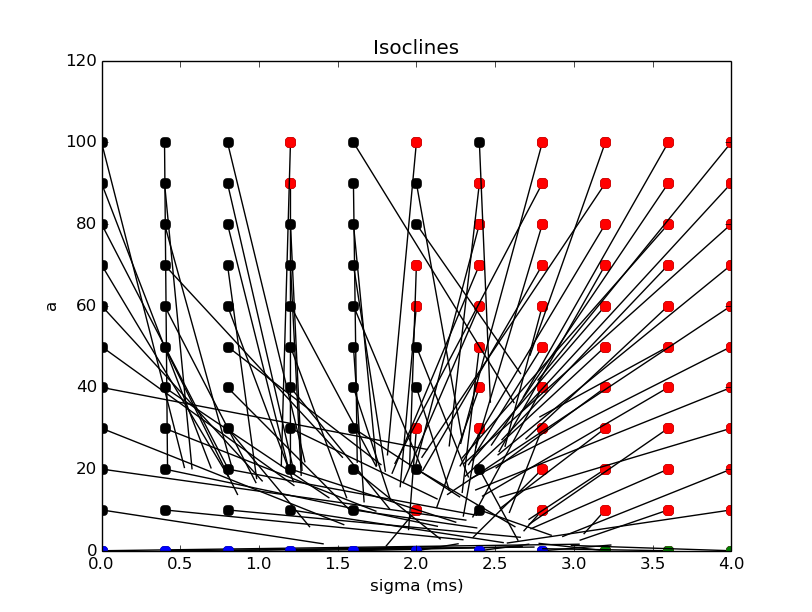
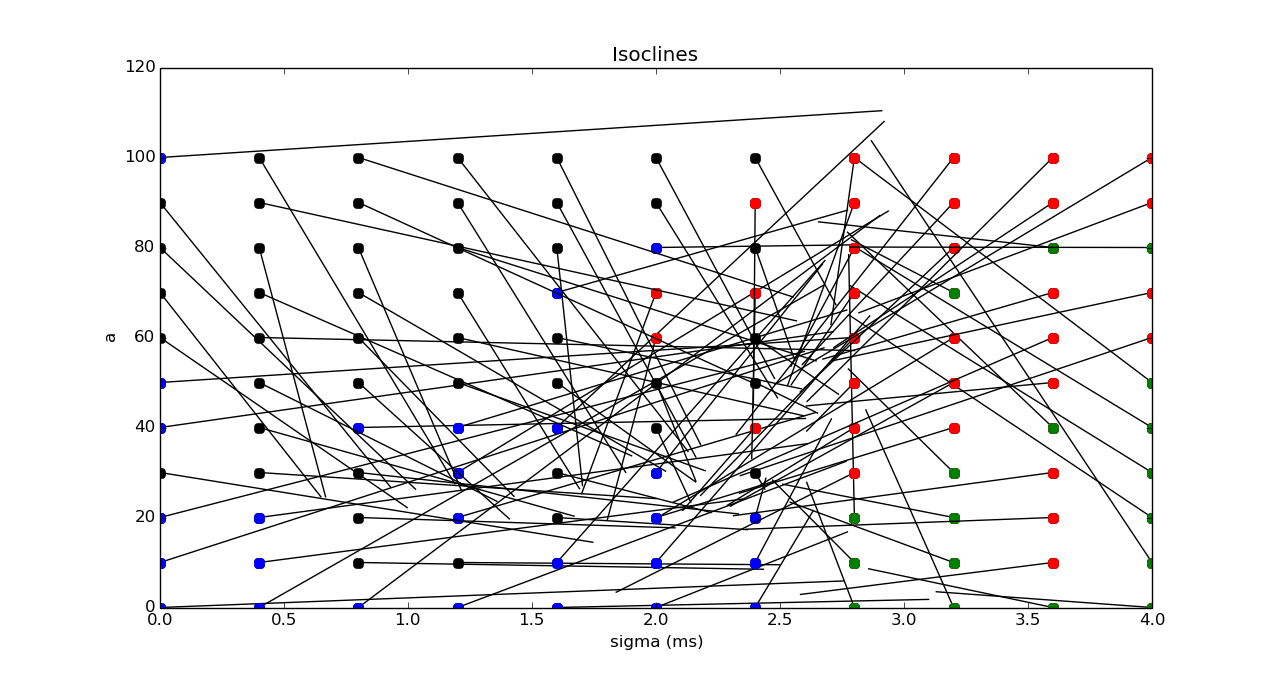
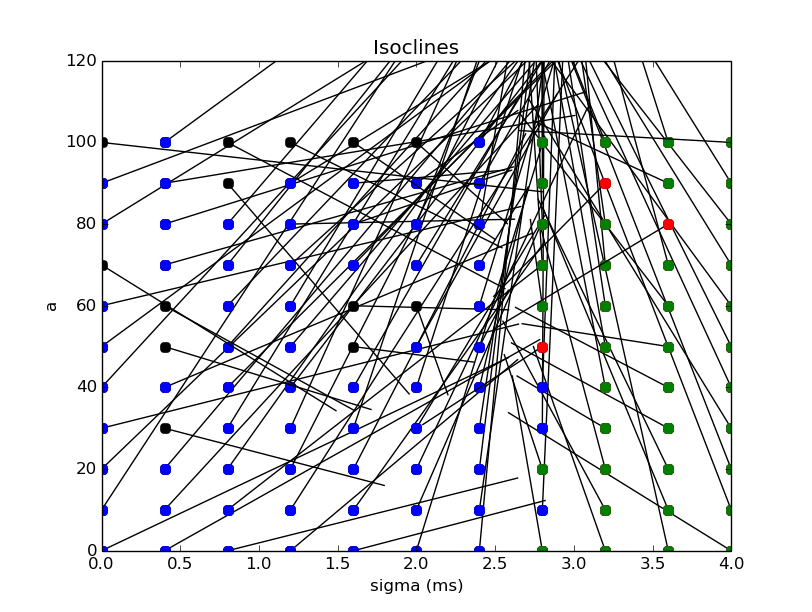
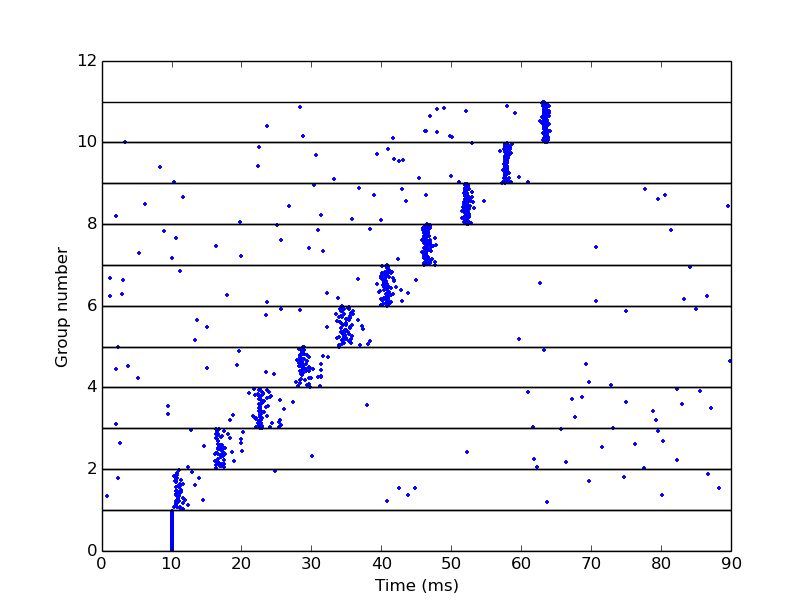
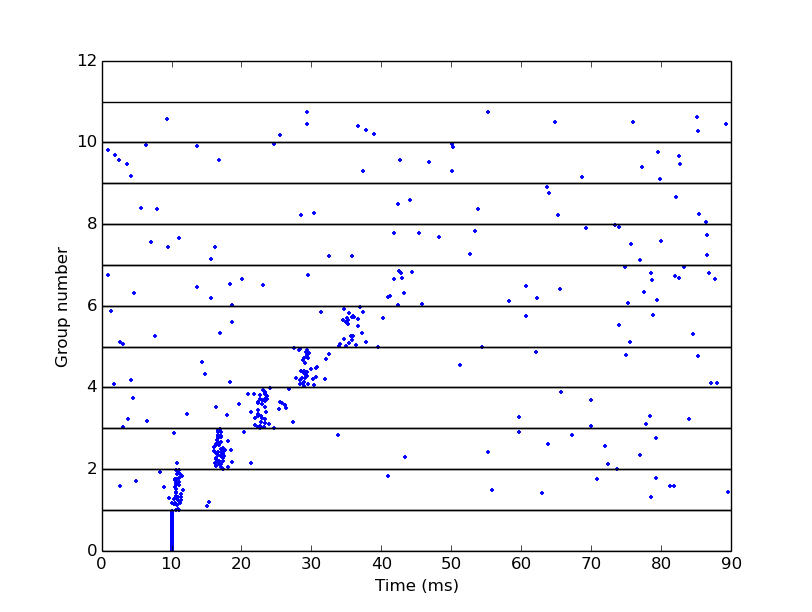
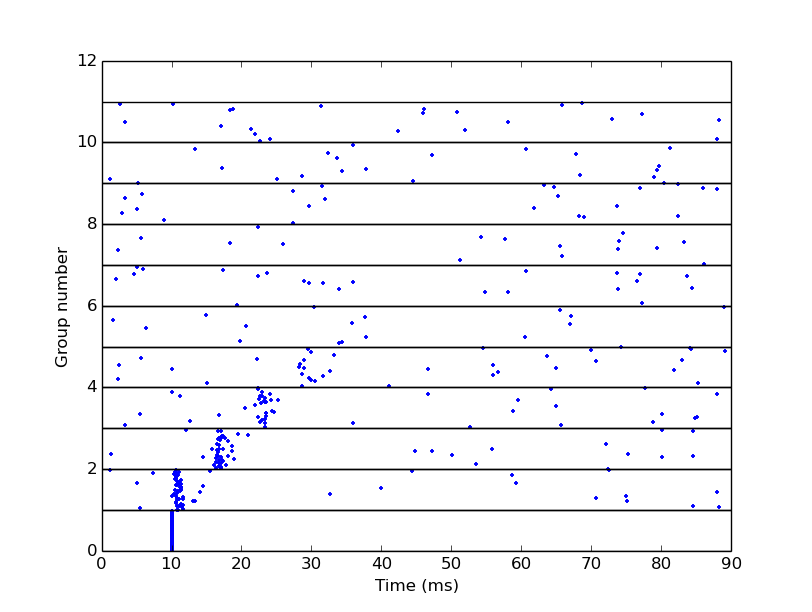
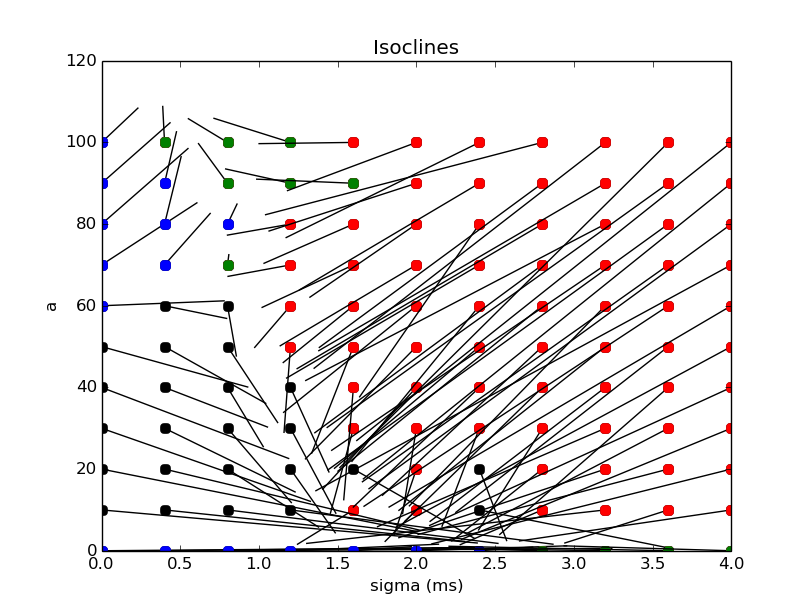
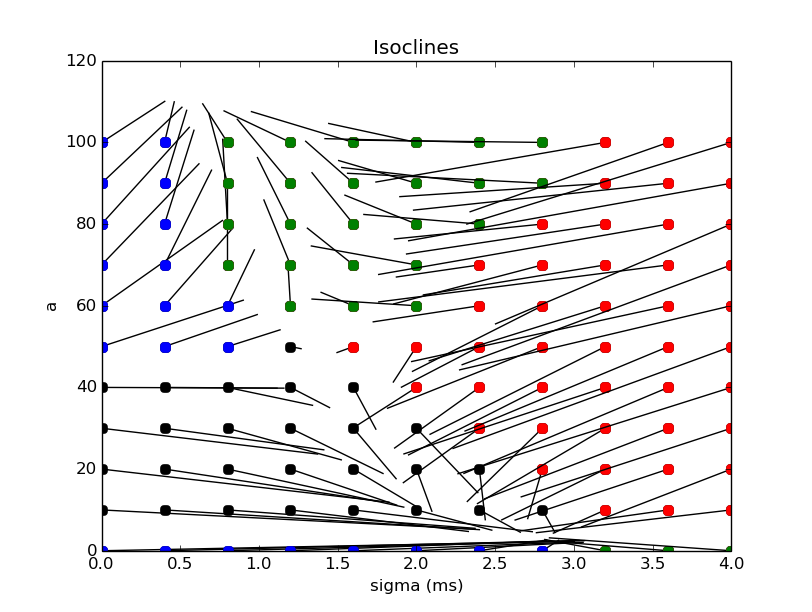
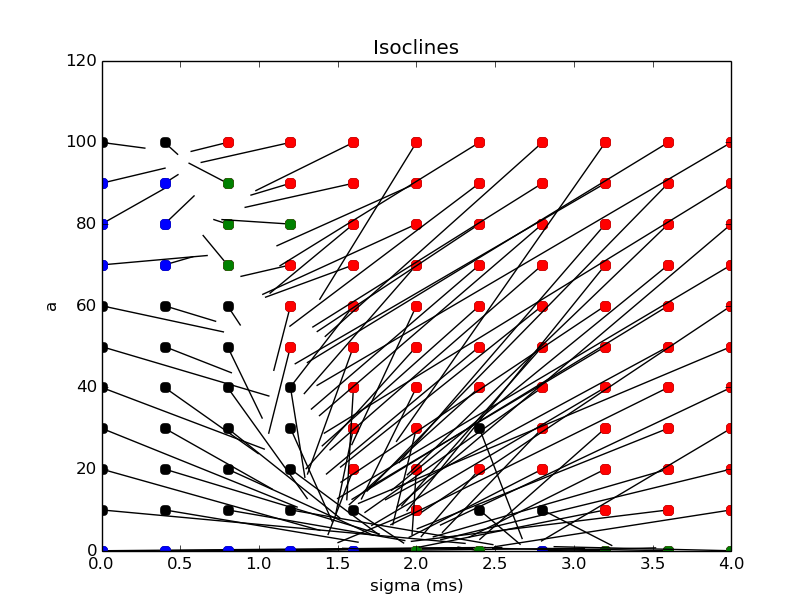
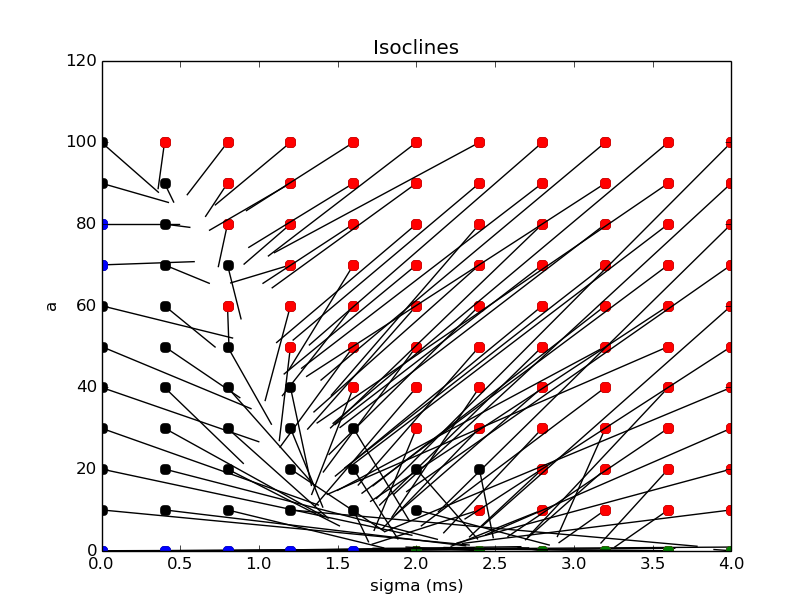
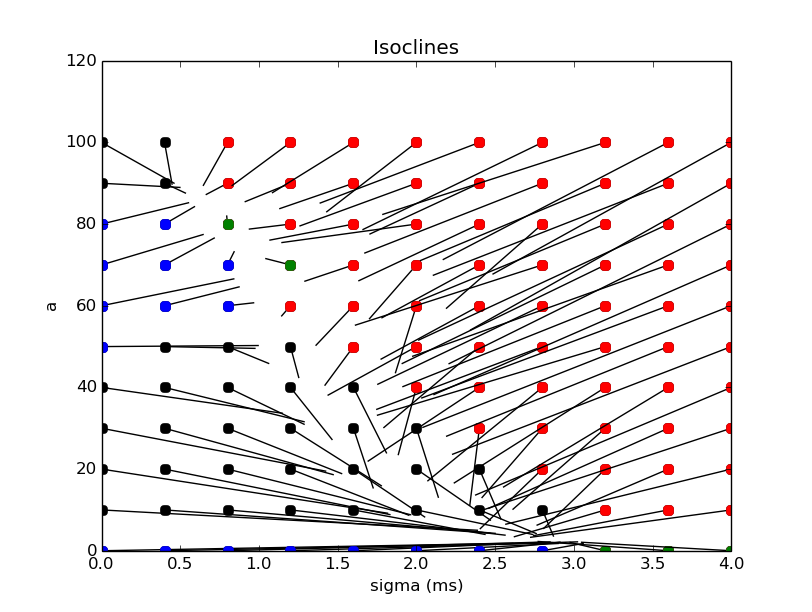
**Date - 23/08/2015**

1. Latex tutorial
2. Equations were written in tex and a cropped image from pdf was inserted in report.   
     
   where (1) is the voltage derivative, (2) conductance derivative and (3) exponential synapse.

**Date - 24/08/2015**

1. Intragroup connections were made with varying probabilities.
2. Report editing.
3. Within the group connections were all excitatory.
4. Plot with a = 53, sigma = 0, weight = 2.43:
5. Plot with a = 53, sigma = 0, weight = 1.43:

**Date - 25/08/2015:**

1. In intragroup connected network by excitatory synapses it was found that the spiking activity remained active long after the pulse was given, This happened because of neurons within the group excitating each other acting as a pulse source themselves.
2. A phase plane analysis was done to look at the nature of synchronization attained by this network.
3. State space (Grid = 10, nm = 10, weight = +34, w = 20):
4. State space (Grid = 10, nm = 10, weight = +34, w = 25):
5. State space (Grid = 10, nm = 10, weight = +34, w = 30):
6. It is seen that at w = 30 the activity converges to a highly spiking but asynchronous point.
7. Similarly to inspect the role of inhibition, the intragroup synapses were made purely inhibitory with strength of inhibition within group same as negative of strength of excitation between the groups.
8. Plot with a = 53, sigma = 0, weight = -2.43:
9. Plot with a = 53, sigma = 0, weight = -4.86:
10. Plot with a = 53, sigma = 0, weight = -5.43:
11. It is seen that as the inhibition strength is increased within the group the propagation becomes stable to unstable. Because of inhibition the input to neighbour group goes down which causes less excitation in that group and gets dominated by constant inhibition from within the group.
12. Again the behaviour of the network with inhibition is investigated by looking at the phase portrait.
13. State space (Grid = 10, nm = 10, weight = -34, w = 110):  
    compared with the activity of network lacking intragroup connection,
14. State space (Grid = 10, nm = 10, weight = -34, w = 100):
15. State space (Grid = 10, nm = 10, weight = -34, w = 100):  
    comparing it with w = 90 for no intragroup connection case,
16. From the comparisons it is evident that inhibition within the group reduces the green region which encloses the stable fixed point and saddle node.

**Date - 26/08/2015**

1. Have intragroup connections with both inhibition and excitation.
2. An algorithm to pick the grid points from the boundaries of blue, red and green regions in state space plot for any network.
3. Fit a polynomial to the boundaries and get the point of intersection.
4. Intersecting points are the eigenvalues from which a characteristic polynomial will be determined.

**Date - 31/08/2015**

Excitation-Inhibition balance and how does it affect the nature of propagation.

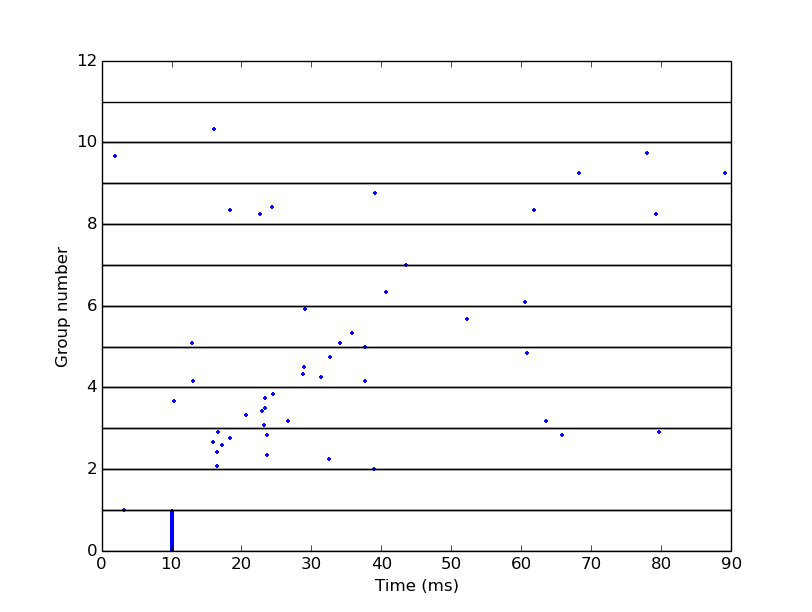
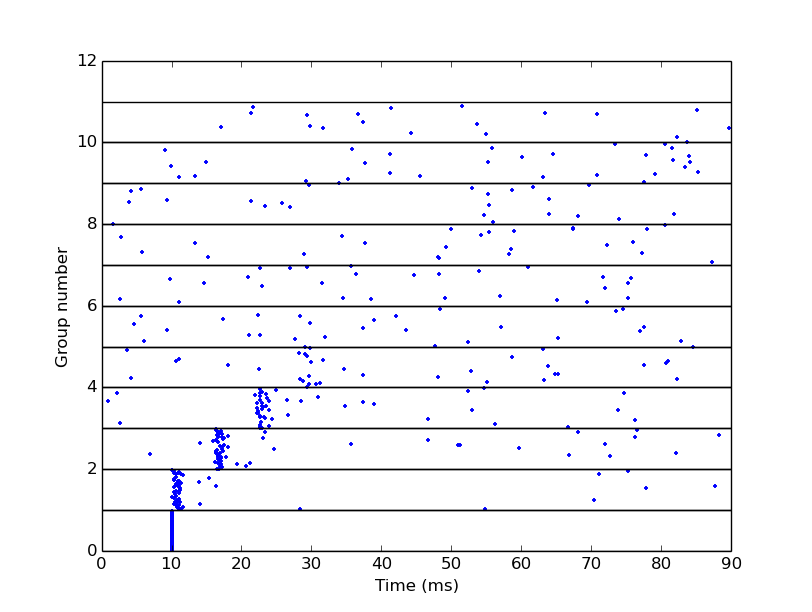
1. To set up a feed-forward network with groups containing 88% excitatory and 12% inhibitory neurons mimicking the ratio found in the Cortex ( Ref:Braitenberg, V. & SchuÈz, A. Anatomy of the Cortex (Springer, Berlin, 1991)).
2. In state space if the stable fixed point shifts then how is the shift a function of the weights of E-I.
3. Read an article on E-I balance:

Formation of excitation-inhibition balance: inhibition listens and changes its tune

Huizhong W. Tao 1,2 , Ya-tang Li 1 , and Li I. Zhang 1,3  
 Cell Press 2014

<http://www.ncbi.nlm.nih.gov/pubmed/25248294>

**Date - 01/09/2015**

1. Updated the github repository separating the development and stable version of codes.
2. E-to-I ratio 1:1, weight\_E = 4.86 mV, weight\_I = -4.86 mV :
3. State space with w = 100, E = 88% of w, I = 12% of w, neuron\_multiplicity = 50 :