1. What is the coefficient of variation for an IF neuron driven by constant input?

   The coefficient of variation for an IF neuron driven by constant input is 0. Because the IF neuron will either spike regularly or does not spike when driven by constant input, measure of the variability of spike train is zero. That means, the standard deviation δ is 0, so $Cv=\delta/u=0$.

2. Simulation of IF neuron and experimental curve.

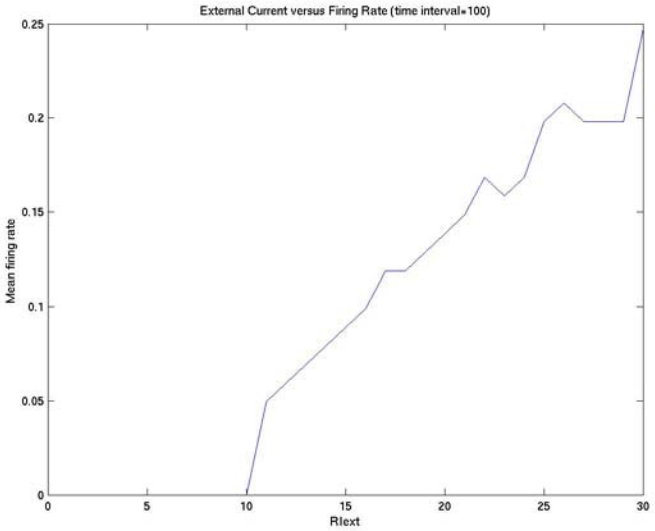


   Figure 1 is the experimental curve which shows the firing rate versus the external current with time interval 100.

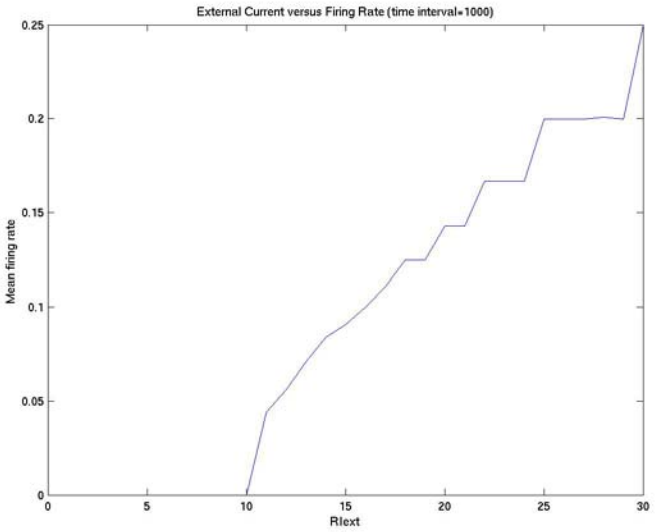
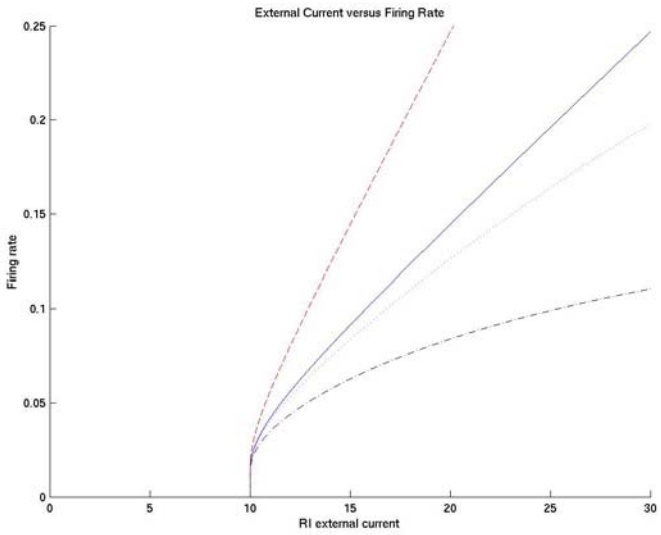


Figure 2 is the experimental curve which shows the firing rate versus the external current with time interval 1000.

It is obvious that figure 2 is more smooth than figure 1 when we set a longer time interval, and it is more close to the theoretical curve as figure 3.

Figure 3.



Theoretical curve (Gain function of a leaky IF neuron)

3. Discuss briefly the relation of a sigma node to biological neurons.

Sigma node is a basic type of node used in connectionist and neutral network modeling. It can be associated with threshold firing characteristics of single biological neuron.

As we can see, Sigma node simulates the information transmission mechanism of a single neuron. The basic feature of a biological neuron is to add up its inputs, and to produce an output if the sum is greater than the threshold value. The neuron receives input from others by synapses, and these synapses alter the effectiveness with which the signal is transmitted. The synapses which have larger weights transmit more of the signal. The neuron fires if the total inputs reach the threshold value.

A sigma node weights the input value of each input channel, and sum the inputs, then it produces output with an activation function when the value reaches a

certain threshold. This is similar to biological neurons. However, it is a simple model and does not take any account of the complex patterns of actual nervous activity in real neural systems, also it does not have the complicated features found in biological neurons.

So, in this way, the node is the basic unit in a rate model. It works either as a strong simplification of a single neuron, or as a unit that reflects the average behavior of a statistically neuronal group (page 80 of textbook).

Furthermore, the neuronal networks we are discussing can be explored in chains of simple neurons and random network models, so that we are able to analyze some important abilities of large networks. We introduce sigma node as a simple processing model to describe the average firing rate of a population of neurons, which is the way of information transmission between neurons with similar response properties.

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
% Firing Rate           %
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%
 clear;
 clf;
 tau_inv=0.1;    % inverse time constant
 uu=0;           % initial membrane voltage
 %tspan=[0 100];  % integration interval
 theta=10;       % firing threshold
 interval=1000;
 for RI=0:30

    I_ext=RI;       % constant external input
    %Integration with Euler method
    t_step=0;

    for it=0:interval;
       t_step=t_step+1;
       x=uu<theta;
       uu=x*(1-tau_inv)*uu+tau_inv*I_ext;%+randn;
       u(t_step)=uu;
       t(t_step)=it;
       s(t_step)=1-x;
    end

    X(RI+1)=RI;
    Y(RI+1)=mean(s);

end

plot( X,Y);
title('External Current versus Firing Rate');
xlabel('RIext');
ylabel('Mean firing rate');
```