Excercise 1

Contents

question

Hands-on Exercise: # 1

Construct an integrate-and-fire model with an excitatory synaptic conductance based on the equation,

$$c_m \frac{dV}{dt} = -\overline{g}_L(V - E_L) - g_{ex}(V - E_{ex})$$

with $c_m = 10$ nF/mm^2, $\overline{g}_L = 1.0\ \mu$S/mm^2, $E_L = -70$ mV, and $E_{ex} = 0$. Also, the threshold and reset potentials for the model are $V_{th} = -54$ mV and $V_{reset} = -80$ mV. The excitatory conductance should satisfy the equation

$$\tau_{ex} \frac{dg_{ex}}{dt} = -g_{ex}$$

with $\tau_{ex} = 10$ ms. In addition, everytime there is a presynaptic action potential, add an amount Δg_{ex} to g_{ex},

$$g_{ex} \rightarrow g_{ex} + \Delta g_{ex}$$

with $\Delta g_{ex} = 0.5\ \mu$S/mm^2. Plot V(t) in one graph and the synaptic current, defined as,

$$I_{ex} = g_{ex}(V - E_{ex}),$$

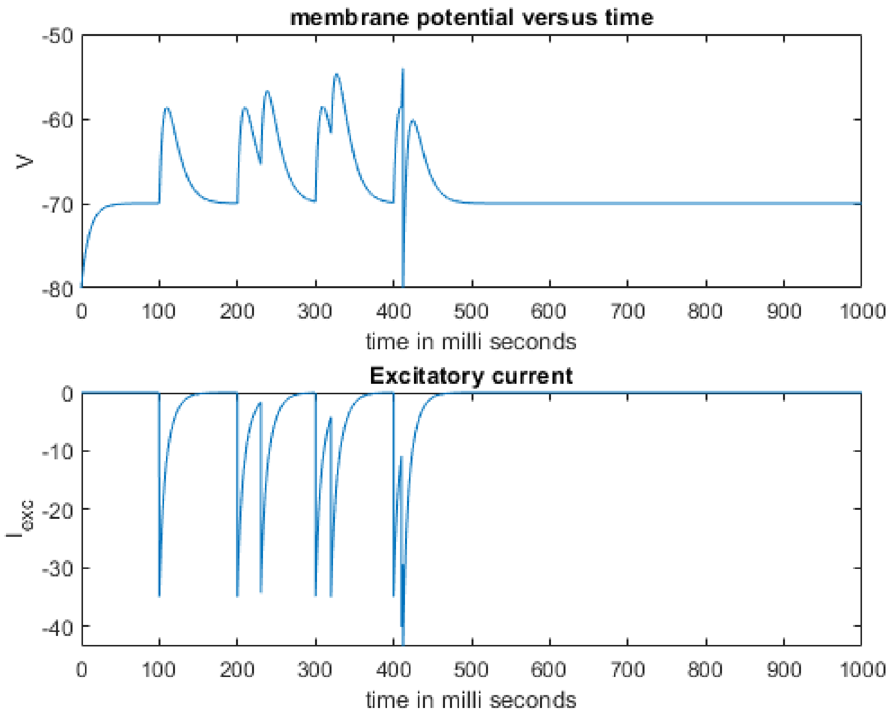
in another. Trigger presynaptic action potentials at times 100, 200, 230, 300, 320, 400, and 410 ms. Explain what you see.

```
clc
clear
close all

E_L = -70; % mV
E_x = 0;
g_L = 1; % \micro S / mm^2
c_m = 10; % \nano F / mm^2
V_th = -54; % mV
V_reset = -80; % mV

tau_exc = 10; % ms
Delta_g_exc = 0.5; % \micro S / mm^2

tot_data_points = 100000;    %total number of datapoints
dt = 0.01; %time step in ms
t = (0:tot_data_points) * dt;         %time in milli seconds = number of data points * step time
```

Excercise 1

```
Presyn_SpikeTimes= [100 200 230 300 320 400 410] / dt;   %time/step time = data point number

V = zeros (1, tot_data_points) ; % membrane potential
g_exc = zeros (1, tot_data_points);
X = zeros (1, tot_data_points); % Spikes
I_exc = zeros (1, tot_data_points); % Excitatory currents

V(1) = V_reset;

for i = 1 : tot_data_points

    V(i + 1) = V( i ) - dt/c_m * ( g_L * ( V( i ) - E_L ) + g_exc ( i ) * ( V( i ) - E_x));  %Euler method

    g_exc(i + 1) = g_exc ( i ) - (dt / tau_exc)  * g_exc ( i );                                        %Euler method

    if ismember(i+1, Presyn_SpikeTimes)
          g_exc (i+1) = g_exc (i+1) + Delta_g_exc ;
    end

    I_exc (i + 1) = g_exc (i + 1) * ( V (i + 1) - E_x );

    if V ( i + 1 ) >= V_th
         X(i + 1) = 1 ;
         V(i + 1) = V_reset;
    end

end

n_spikes = sum(X);
spike_times = find(X==1)*dt;  % in milli seconds
figure
subplot (211)
plot (t, V)
title ( ' membrane potential versus time ' )
xlabel ( ' time in milli seconds ' )
ylabel ( ' V ' )

subplot(212)
plot( t , I_exc )
title ( ' Excitatory current ' )
xlabel ( ' time in milli seconds ' )
ylabel ( ' I_e_x_c ' )

fprintf('Number of spikes \t Time of spiking(in milli seconds)\n')

for i =1:length(spike_times)
        fprintf('\t%d\t\t\t   %.2f\n',i,spike_times(i))
end
```

```
Number of spikes         Time of spiking(in milli seconds)
        1                          412.28
```



- The spike time was 412ms. because there are 2 EPSPs occuring at 400 & 410 which are so close together and this caused a spike!
- This is a good presentation of the integration in the LIF model.
- We can also change the presynaptic times to generate more spikes as well.

Published with MATLAB® R2023a