Extra Credit Assignment

By Tony Kabilan Okeke

Model the two synaptic currents from Reading 1 in MATLAB (ISG and ISC):

- Re-read this section in the paper methods
- And make a plan for what your code needs to do2
- Define all constants (keep in ms and mV)
- Assume you are in voltage clamp so Vpost stays constant
- Set Vpost to -60mV
- Set gs (gmax) to 1 (to make things easier)
- Set all other parameters as defined in the paper
- Make a time vector
- in ms – from 1 to 2000 ms with 1 ms increments
- Make a presynaptic membrane vector (incorporate spikes)
- Assume Vpre is either resting at -60mV or spiking at -30mV
- Use the matlab function “randi” to make a vector of random numbers that range from 1 to 100. The length of this vector needs to be equal to the length of the time vector.
- Use this random number vector to determine when in time the neuron will spike. Assume the neuron spikes when a random number = 100 but otherwise is at rest – using this info, use your random number vector to generate the membrane potential for the presynaptic neuron **[plot]**
- Calculate sbar **[plot]** and tau
- Use a numerical method to calculate s **[plot]**
- Euler’s method should be fine
- Use s to calculate the current **[plot]**
- Submit plots and code to BbLearn for extra credit

```
clear

% Define constants
E_sg   = -70;   % mV - Nernst potential for Glutamatergic synapse
k_sg   = 1/40;  % ms - rate constant
E_sc   = -80;   % mV - Nenrst potential for Cholinergic synapse
k_sc   = 1/100; % ms - rate constant
V_th   = -35;   % mV - half-activation voltage of synapse
delta  = 5;     % slope for activation curve
V_post = -60;   % mv - postsynaptic membrane potential
gs     = 1;     % max conductance
```

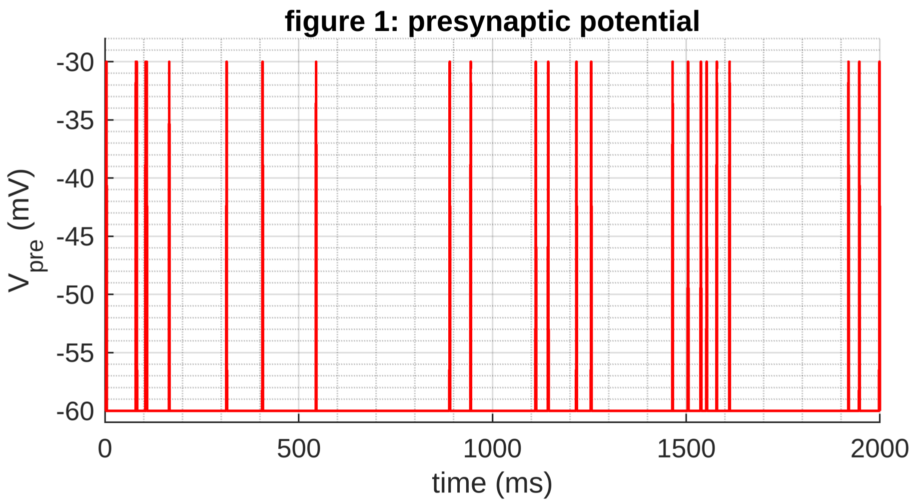
Generate Presynaptic Potential with Random Spikes

```
% time vector
time = 1:2000; % ms

% presynaptic membrane potential
%   spiking = -30mV
```

```
%   resting = -60mV
V_pre = -60 + 30 * (randi(100, 1, numel(time)) == 100);
I_spikes = V_pre == -30;

% Plot presynaptic potential
figure('Position', [0 0 500 250]); hold on;
plot(time, V_pre, 'r-', 'LineWidth', 1)
grid on; grid minor;
xlim([0 2000]); ylim([-61 -28])
xlabel('time (ms)'); ylabel('V_{pre} (mV)')
title('figure 1: presynaptic potential')
```

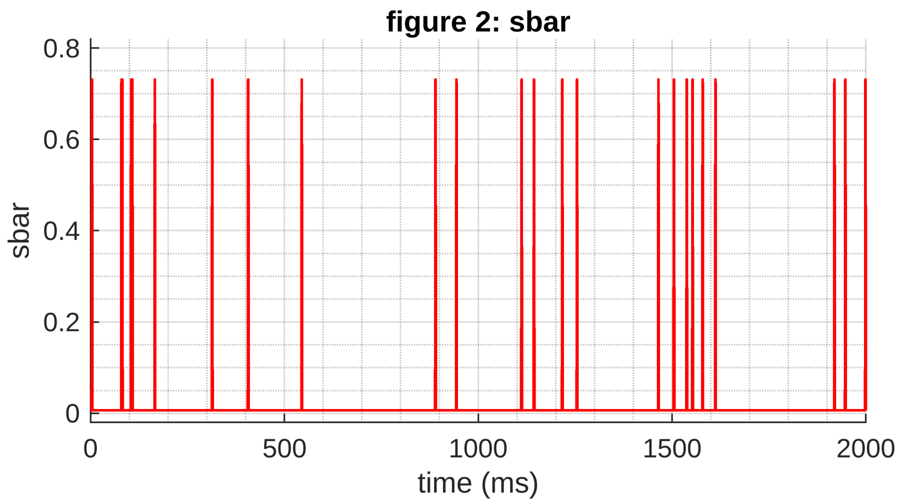


Calculate `sbar & tau`

```
% Define functions for computing sbar and tau values
sbar   = @(V_pre) 1 ./ (1 + exp((V_th - V_pre) / delta));
tau_sg = @(V_pre) (1 - sbar(V_pre)) / k_sg;
tau_sc = @(V_pre) (1 - sbar(V_pre)) / k_sc;

% Compute sbar
sbar_  = sbar(V_pre);

% Plot the activation variable
figure('Position', [0 0 500 250]); hold on;
plot(time, sbar_, 'r-', 'LineWidth', 1)
grid on; grid minor;
xlim([0 2000]); ylim([-0.02 0.82])
xlabel('time (ms)'); ylabel('sbar')
title('figure 2: sbar')
```



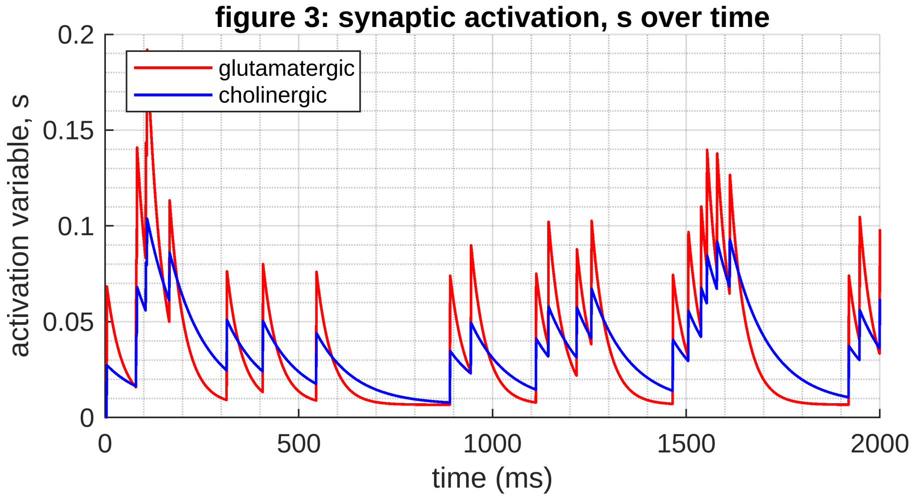
Euler's Method: Compute Activation Variable, s

```
% initialize variables
dt   = 1;                         % ms - time step size
s_sg = zeros(1, numel(time)); % glutamatergic, ic: (s,t) = (0,0)
s_sc = zeros(1, numel(time)); % cholinergic, ic: (s,t) = (0,0)

% Euler's method
for i = 1:(numel(time) - 1)
    % compute derivatives
    dsdt_sg = (sbar(V_pre(i)) - s_sg(i)) / tau_sg(V_pre(i));
    dsdt_sc = (sbar(V_pre(i)) - s_sc(i)) / tau_sc(V_pre(i));

    % update variables
    s_sg(i+1) = s_sg(i) + dt * dsdt_sg;
    s_sc(i+1) = s_sc(i) + dt * dsdt_sc;
end

% Plot results
figure('Position', [0 0 500 250]); hold on;
plot(time, s_sg, 'r-', 'LineWidth', 1, 'DisplayName', 'glutamatergic')
plot(time, s_sc, 'b-', 'LineWidth', 1, 'DisplayName', 'cholinergic')
grid on; grid minor;
xlim([0 2000]); ylim([0 0.2])
xlabel('time (ms)'); ylabel('activation variable, s')
title('figure 3: synaptic activation, s over time')
legend('Location', 'northwest')
```



Compute Currents, `I_sg` and I_sc

```
% Compute currents
I_sg = gs * s_sg * (V_post - E_sg);
I_sc = gs * s_sc * (V_post - E_sc);

% Plot currents
% Plot results
figure('Position', [0 0 500 250]); hold on;
plot(time, I_sg, 'r-', 'LineWidth', 1, 'DisplayName', 'glutamatergic')
plot(time, I_sc, 'b-', 'LineWidth', 1, 'DisplayName', 'cholinergic')
grid on; grid minor;
xlim([0 2000]); ylim([0 2])
xlabel('time (ms)'); ylabel('channel current (nA)')
title('figure 4: channel currents')
legend('Location', 'northwest')
```