BE4 Computational Neuroscience: Problem set 7

Synaptic Plasticity: Answers

Exercise 1: Bienenstock Cooper Munro (BCM) Rule

Pseudocode of the algorithm:

Initialise weights $\mathbf{w}$ and threshold θ

for $t \leftarrow 1, \ldots, T$ **do**

  $\mathbf{x} \leftarrow$ input randomly selected between $\mathbf{x}_1$ and $\mathbf{x}_2$

  $y(t) \leftarrow \mathbf{w}(t) \cdot \mathbf{x}$

  $\theta(t+1) \leftarrow \theta(t) + \frac{dt}{\tau}\left(\frac{y(t)^2}{y_0} - \theta(t)\right)$

  $\mathbf{w}(t+1) \leftarrow \mathbf{w}(t) + \alpha \mathbf{x}(t) y(t)(y(t) - \theta)$

  foreach *component i of $\boldsymbol{w}$* **do**

    if $w_i \leq 0$ **then**

      $w_i = 0$

    end

  end

end

Result of the simulation:

Please read BCM.m to see the implementation.

The competition between the two input patterns results in the neuron being responsive to one of the two patterns only. The winning pattern is chosen randomly, as you can see running the code a few times.

This means that the weight of the winning pattern converges to 1 (so that the average firing rate matches the target firing rate y_0) and the other converges to 0. The output y is therefore around 20 for the winning pattern and around 0 for the losing one.

The sliding threshold θ should also converge to 20. The outcomes of two different simulations are represented below.

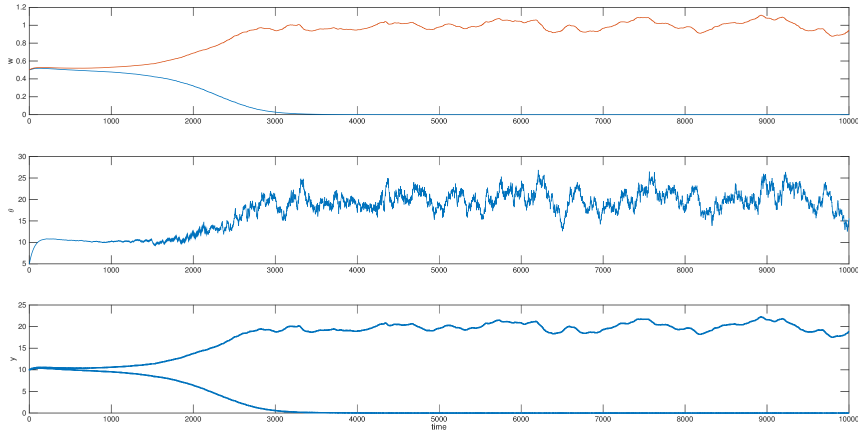

Figure 1 The neuron in this simulation is responsive only to pattern $\mathbf{x}_1$.

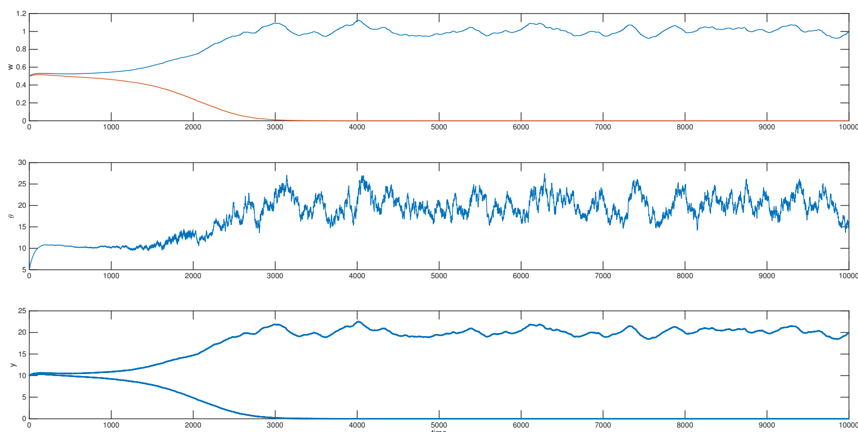

Figure 2 The neuron in this simulation is responsive only to pattern $\mathbf{x}_2$.

Exercise 4: Spike-Timing Dependent Plasticity (STDP)

Read stdp.m for the implementation. The result with the given parameters is: