

BE4 Computational Neuroscience: Problem set 9

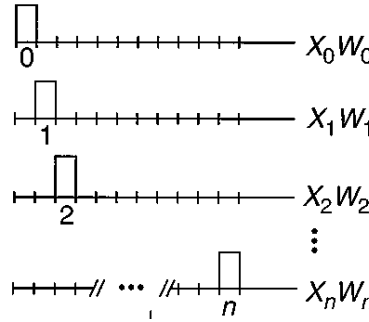
Synaptic Plasticity

Temporal Difference (TD) Learning

In this exercise you will have to implement a TD learning model of a classical conditioning experiment. The code in file `dopamine.m` already provides the structure of the experiment. You will have to complete it by implementing the update rules for the value function $\hat{V}(t)$, the prediction error $\delta(t)$ and the weights \mathbf{w} .

The experiment consists of 100 identical trials. In each trial, a stimulus (e.g. a light, a bell, etc...) is presented at time $t_{cue} = 5s$ and kept active until the end of the trial. Following the cue, at time $t_{rew} = 20s$, a reward is delivered and the trial ended.

In our model, the stimulus is represented by a vector $\mathbf{x}(t) = \{x_1(t), x_2(t), \dots\}$ that describes the presence (or the absence) of the cue at time t . In particular, we have that $x_i(t) = 1$ if the cue is on and its onset was i timesteps ago, $x_i(t) = 0$ otherwise. The weight vector \mathbf{w} consists of $n = 15$ (cue duration) different weights, one for each component of $\mathbf{x}(t)$.



Remember from the lecture the rules you need to implement:

$$\hat{V}(t) = \sum_i \mathbf{w}_i \mathbf{x}_i(t) \quad (1)$$

$$\delta(t) = r(t) + \gamma \hat{V}(t+1) - \hat{V}(t) \quad (2)$$

$$\Delta w_i = \alpha \sum_t x_i(t) \delta(t), \quad (3)$$

where $r(t)$ is the reward received at time t , γ is a discounting parameter and α is the learning rate. Note that all these rules can be written in matrix form.

2.1

Implement the rules and set the parameters $\gamma = 1$, $\alpha = 0.6$.

Check that the association between stimulus and reward is successfully learned from both the prediction error and the value function. What results do you expect to see?

2.2

Try to omit the reward in one of the late trials, when the association between stimulus and reward has already been established. What do you observe?

2.3 - optional

Try different values of γ and α . What are the effects of the two parameters?

How does γ affect V ? To what value do we expect V to converge when $\gamma < 1$?