ASSIGNMENT 6 — DECISIONS, LEARNING, AND COST FUNCTIONS

For all questions below, provide all programming code and plots in the report. Total marks (undergrad 27 | graduate 43).

Decision-Making

1. Plot token movements for the Bias For and Bias Against token patterns shown in the lecture. 1 mark.

2. Plot $p(R|N_R, N_I, N_C)$ for the Bias For and Bias Against token patterns. 1 marks.

3. Plot the current evidence (E) by discretizing p(R) over time (step size: h = 0.001s). Assume a token moves every 200 ms. 1 mark.

4. For the drift-diffusion model with leak, set $g = 1500$, $L = 0.5$, $N = \mathcal{N}(\mu = 0, \sigma = 0.0)$, $T = +500\& - 500$, $h = 0.001$, $DV_0 = 0.0$. 6 marks.

   a. Plot the decision variable or the Bias For and Bias Against token patterns. 4 marks

   b. What time (ms) does the decision variable cross the threshold for both simulations? 1 marks.

   c. Rerun the drift diffusion model 10 times and plot the decision variable for each token pattern, but this time include noise ($N = \mathcal{N}(\mu = 0, \sigma = 3.0)$). 1 marks

5. For the urgency gating model with low pass filter, set $g = 1000$, $\tau = 0.05$, $N = \mathcal{N}(\mu = 0, \sigma = 0.0)$, $T = +500\& - 500$, $h = 0.001$, $EV_0 = 0.0$. (**Graduate Only**). 6 marks.

   a. Plot the decision variable or the Bias For and Bias Against token patterns. 4 marks

   b. What time (ms) does the decision variable cross the threshold for both simulations? 1 marks.

   c. Rerun the urgency gating model 10 times and plot the decision variable for each token pattern, but this time include noise ($N = \mathcal{N}(\mu = 0, \sigma = 0.7)$). 1 marks

6. Additional questions to be answered independently. (3 marks | 5 marks)

   a. What are classic decision-making phenomena?

   b. Why does the drift diffusion model predict different decision times for the bias for and bias against token patterns?

c. Why does the urgency gating model predict the same decision times for the bias for and bias against token patterns?

d. Do you think task selection and a movement control policy are separate? (**Graduate Only**)

e. Do movements reflect deliberation or decisions? (**Graduate Only**)

Learning

One-State Model (6 Marks)

7. Let us assume a participant is performing a visuomotor rotation task. There are 50 baseline trials without rotation, then 50 adaptation trials with a $30°$ rotation, followed by 50 washout trials with no rotation.

a. Assume only an adaptation rate ($B = 0.2$). Plot the adaptation and error curves. 3 marks.

b. Now include a retention rate ($A = 0.98$; $B = 0.1$). Plot the adaptation and error curves. 1 mark.

8. A participant performs 25 baseline trials without rotation, then 75 trials with a $30°$ rotation, 10 trials with a $-30°$ rotation, followed by 40 washout trials with no perturbation. Assume $A = 0.98$; $B = 0.1$.

a. Plot the adaptation and error curves. 1 mark.

b. Assume the following are clamp trials: [27, 36, 45, 53, 62, 71, 80, 89, 98, 110-150]. Plot the adaptation and error curves. 1 mark.

Two-State Model (3 marks | 6 marks)

9. A participant performs 25 baseline trials without rotation, then 75 trials with a $30°$ rotation, 10 trials with a $-30°$ rotation, followed by 40 washout trials with no perturbation. Assume $A_s = 0.998$, $B_s = 0.049$, $A_f = 0.597$, $B_f = 0.227$.

a. Plot the fast state (X_f), slow state (X_s), net adaptation (X_{net}), and error. 2 marks.

b. Assume the following are clamp trials: [27, 36, 45, 53, 62, 71, 80, 89, 98, 110-150]. Plot X_f, X_s, X_{net}. 1 mark.

10. Fit the two-state model to X_{net} from **3b** above. Make your initial parameter guesses as follows: $A_s = 0.994$, $B_s = 0.025$, $A_f = 0.521$, $B_f = 0.268$ (**Graduate Only**):

a. Plot X_f, X_s, X_{net} from the best-fit parameters, and list the best-fit parameters. 3 mark.

11. Additional learning questions to be answered independently (3 marks | 5 marks).

  a. What is a real-world example of generalization made by the motor system (other than the example in class)? 1 mark.

  b. What type of error will the nervous system most likely store? 1 mark.

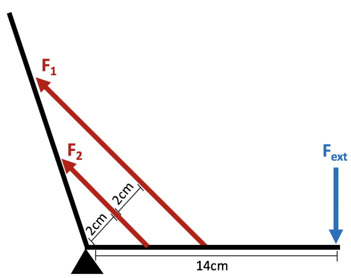
  c. Why is motor variability more important in reinforcement learning than error learning? 1 mark.

  d. What are reasons we do not fully adapt? **Graduates Only**. 1 mark

  e. How many timescales of adaptation are there? **Graduates Only**. 1 mark

Cost Functions

12. Predict muscle activation by minimizing the sum of (muscle force)^2. Assume $F_{ext} = 75N$, a muscle stress of 35, and a PCSA of 10 for both muscles. Interpret the result. 3 marks



13. Additional learning questions to be answered independently (3 marks)

  a. What are cost functions trying to resolve and how do they provide insight into the nervous system? **Graduates Only**. 1 mark

  b. Optimal Feedback Control uses multi-objective optimization. What is OFC minimizing when it is used to model reaching towards a target? **Graduates Only**. 1 mark

  c. According to Daniel Wolpert, what is the sole purpose of our brain? **Graduates Only**. 1 mark