Decision Dynamics
ISRC-CN³ Lab - Day 2 (27th August 2024)

1. The two-choice drift-diffusion model (DDM) can be described by:

$$dX = A\,dt + \sqrt{dt}\,\sigma\,\eta$$

where X is the decision variable, A the drift rate determined by the input or stimulus information, σ denotes the size of the noise, and η is a random variable that follows a Gaussian/normal distribution with mean of 0 and standard deviation of 1.

The discretized form of the above equation can be rewritten as below, allowing computational simulation (iteration) over time with a time step of Δt :

$$X(t+1) = X(t) + (\Delta t \cdot A + \sqrt{\Delta t}\,\sigma\,\eta)$$

(a) Use the provided MATLAB code DDM_1.m to simulate the DDM. Assuming that the initial or starting point of $X(t=0)$ is 0, $A = 0.03$, sigma $\sigma = 0.2$, and the decision thresholds for the two choices are at 1 and -1, discuss the behaviour of this model with these specific parameter values.

(b) Discuss how the DDM's decisions changes, if instead, the following is individually changed:
   (i)   the starting point is $X(t=0) = 0.2$;
   (ii)   the drift rate is $A = -0.03$;
   (iii)   the noise level sigma is $\sigma = 0.25$; or
   (iv)   the decision thresholds are 0.8 and -1.2

2. Use the provided UM_1.m MATLAB code to simulate the (simpler, linearised version of the) two-choice leaky competing accumulator (LCA or Usher-McClelland) model. This is a simple neural network model for modelling decision dynamics.
By varying the LCA model's parameters (in a similar way as in 1(b)), discuss the similarities and differences between the LCA model's decision dynamics and behaviour and that of the DDM.
Decrease the values of the inhibitory coupling connection b and rate of decay k. What happens? Now, have different values for b and k. What happens now?

3. Use the code python or matlab codes to simulate (a simpler version of) the biologically more realistic decision-making model by Wong and Wang (2006). For python version nsure the files are located in the same folder together. In your own time modify the parameters … and observe the changes in the decision dynamics, choice reaction time and choice accuracy. In what ways are the decision dynamics similar to the more abstract and linearised LCA model?

References:

1. Roger Ratcliff, Philip L. Smith, Scott D. Brown and Gail McKoon (2016) Diffusion Decision Model: Current Issues and History. Trends in Cognitive Sciences, 20(4):260-281.
2. Marius Usher and James L. McClelland (2001) The time course of perceptual choice: The leaky, competing accumulator model. Psychological Review, 108(3):550-592.
3. Kong-Fatt Wong and Xiao-Jing Wang (2006) A recurrent network mechanism of time integration in perceptual decisions. The Journal of Neuroscience, 26(4):1314-1328.