Assignment 2

(Due 29th March 2021, 23:59:59)

Q1. **(40 points)** Without using any third-party libraries or toolboxes, write code to

(a) take any three variable Boolean function as input
(b) generate training examples for this Boolean function
(c) train a neural network to learn this Boolean function, and
(d) verify that the function has been learned, for five separate Boolean functions.

Q2. **(40 points)** Without using any third-party libraries or toolboxes, write code to

(a) generate a random instance of the frozen lake scenario given two inputs - the size of the lake (N) assuming its square, and the number of holes (M).
(b) implement a Q-learning agent to find a path through the lake to the goal. Report the results of the learning algorithm by plotting episode count on the x-axis and total reward received by the agent within an episode on the y-axis
(c) identify how learning performance changes when you change the parameters α and λ in your algorithm
(d) identify how learning performance changes with respect to changes in N and M.

Q3. **(20 points)** The Rulkov map is a simple dynamical systems model of neuronal action potentials. The model is a coupling of a fast and a slow dynamical system in the following form

$$x_{n+1} = f(x_n, y_n)$$

$$y_{n+1} = y_n - \mu(x_n + 1) + \mu\sigma$$

where f() is a discontinuous function of the form

$$f(x,y) = \begin{cases} \dfrac{\alpha}{1-x} + y, & x \leq 0 \\ \alpha + y, & 0 < x < \alpha + y \\ -1, & x \geq \alpha + y \end{cases}$$

For some specific parameter choices, this system can reproduce the broad outlines of neuronal action potentials, viz. bursts of spikes, tonic spiking and periods of silence. I would like you to reproduce all three modes of behavior using this model. *Hint: read the original paper for clues to appropriate parameter values.*

https://journals.aps.org/pre/abstract/10.1103/PhysRevE.65.041922

I would also like you to empirically demonstrated ranges of parameter values that govern these three different regimes of activity for the neuron model.