

CS786: Assignment 2

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

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

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.