



1. Your job is to design a multilayer perceptron which receives three binary-valued (i.e. 0 or 1) inputs x_1, x_2, x_3 , and outputs 1 if exactly two of the inputs are 1, and outputs 0 otherwise. All of the units use a hard threshold activation function: $z = 1$ if $z \geq 0$ and $z = 0$ otherwise.

Specify weights and biases which correctly implement this function. There is a bias for each hidden unit as well as the output unit. You do not need to explain your solution. (9 points)

2. Consider the binary threshold neuron, $h = \text{sign}(w \bullet x)$ defined such that $h \in \{0, 1\}$, with no bias b . Consider the following set of four input features, x : $(1, 0, 0)$, $(0, 1, 0)$, $(0, 0, 1)$, $(1, 1, 1)$. Find a three-dimensional parameter vector w such that the neuron will have the output pattern $h = \{1, 1, 1, 1\}$ for the given four input features. (1 point)

1. You want to train the following model using gradient descent. Here, the input x and target y are both scalar-valued. Use the chain rule to give the expression for the back propagation rule to update w_2 . Make sure to give each portion of the chain rule explicitly, as well as the final update rule. (8 points)

$$z = w_0 + w_1x + w_2x^2$$

$$y = 1 + e^z$$

$$L = \frac{1}{2}(\hat{y} - y)^2$$

2. Consider the binary threshold neuron, $h = \text{sign}(w \bullet x)$ defined such that $h \in \{0, 1\}$, with no bias b . Consider the following set of four input features, x : $(1, 0, 0)$, $(0, 1, 0)$, $(0, 0, 1)$, $(1, 1, 1)$. Find a three-dimensional parameter vector w such that the neuron will have the output pattern $h = \{1, 1, 1, 1\}$ for the given four input features. (2 points)