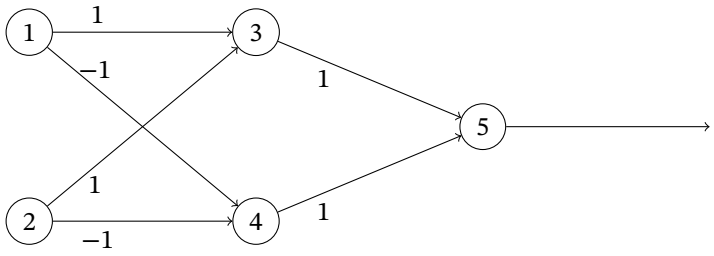
Assignment9 – Learning

Given: July 3 Due: July 8

Problem 9.1 (XOR Neural Network)

Consider the following neural network with

- inputs a_1 and a_2
- units 3, 4, 5 with activation functions such that $a_i \leftarrow \begin{cases} 1 & \text{if } \Sigma_j w_{ji} a_j > b_i \\ 0 & \text{otherwise} \end{cases}$
- weights w_{ij} as given by the labels on the edges



1. Assume $b_3 = b_4 = b_5 = 0$ and inputs $a_1 = a_2 = 1$. What are the resulting activations a_3, a_4, and a_5?
2. Choose appropriate values for b_3, b_4, and b_5 such that the network *implements* the XOR function.

Problem 9.2 (Neural Networks in Python)

Implement neural networkss in Python by completing the implementation of `network.py` at `https://kwarc.info/teaching/AI/resources/AI2/network/`.

Hint: You can test your *implementation* with `test.py`. Note that `test_train_xor_gate` may occasionally fail for a correct solution because it is randomized.

Problem 9.3 (Statistical Learning)

We use two observations to determine if it has rained on our property: whether the ground is wet, and whether a bucket we left outside is full.

1. Model this situation as a naive Bayesian network with a boolean class and two boolean attributes.
2. Explain why this network requires 5 parameters ($2n + 1$ where $n = 2$ is the number of attributes). Choose 5 names for the parameters and use them to give the conditional probability table of the network.
3. Now assume we have observed for 50 days with the following results:

rain	ground wet	bucket full	number of days
yes	yes	yes	10
yes	yes	no	5
yes	no	yes	6
yes	no	no	4
no	yes	yes	2
no	yes	no	9
no	no	yes	3
no	no	no	11

State the formula for the likelihood of this list of 50 observations in terms of the 5 parameters.

4. Give the Maximum Likelihood approximations for the 5 parameters given these 50 observations. (You just need to compute them, not derive the formula for computing them.)

Problem 9.4 (Statistical Learning)

You observe the values below for 20 games of a sports team. You want to predict the result based on weather and opponent.

Weather	Opponent	Number of wins	Number of losses
Rainy	Weak	3	1
Cloudy	Weak	0	1
Sunny	Weak	4	2
Rainy	Strong	0	2
Cloudy	Strong	2	3
Sunny	Strong	0	2

1. What is the hypothesis space for this situation, seen as an *inductive learning problem*?
2. Explain whether we can learn the function by building a decision tree.
3. To apply Bayesian learning, we model this situation as a Bayesian network $W \rightarrow R \leftarrow O$ using random variables W (weather), O (opponent), and R (game result). What are the resulting entries of the conditional probability table for the cases

   1. $P(W = rainy) =$ ☐

   2. $P(R = win \mid O = weak) =$ ☐