Assignment8 – Learning

Given: June 15 Due: June 25

Problem 8.1 (Statistical Learning) 0 pt

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

   (a) $P(W = rainy) =$ ☐

   (b) $P(R = win|O = weak) =$ ☐

Problem 8.2 (Neural Networks in Python) 40 pt

Implement neural networks 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 8.3 (Support Vectors) 30 pt

Consider the following 2-dimensional dataset

support vector	classification
$\mathbf{x}_1 = \langle 0, 0\rangle$	$y_1 = -1$
$\mathbf{x}_2 = \langle 0, 0.5\rangle$	$y_2 = -1$
$\mathbf{x}_3 = \langle 0.5, 0\rangle$	$y_3 = -1$
$\mathbf{x}_4 = \langle 1, 1\rangle$	$y_4 = 1$
$\mathbf{x}_5 = \langle 2, 2\rangle$	$y_5 = -1$

1. Give a linear separator in the form $h(\mathbf{x}) = \mathbf{w} \cdot \mathbf{x} + b$ for the dataset without $\mathbf{x}_5$.

2. Explain informally why no linear separator exists for the full dataset of all 5 vectors.

3. Transform the dataset into a 3-dimensional dataset by applying the function $F(\langle u, v \rangle) = \langle u^2, v^2, u + v \rangle$.

4. Give a linear separator for the transformed full dataset in the form $h(\mathbf{x}) = \mathbf{w} \cdot \mathbf{x} + b$.

Problem 8.4 (Statistical Learning) 30 pt

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.)