CS 4810/6810 Fall 2017 Sample **Final sample solution**

You have 110 minutes

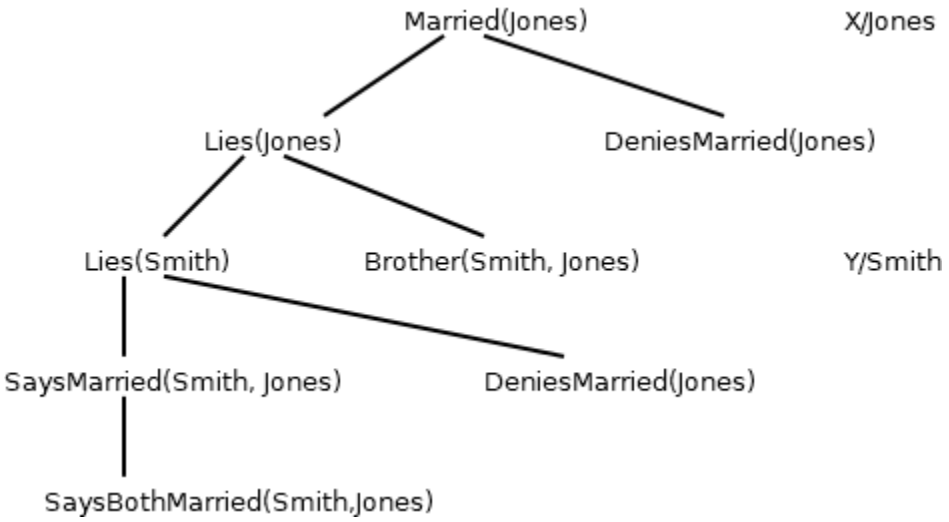
Please silence all cellphones, pagers, etc.

You may ask questions about the problems, but not about your answers.

1. First-order logic

Given the following predicates, use backwards chaining with first-order logic to show Jones is married – show your substitution

- Lies(X) ∧ DeniesMarried(X) ⇒ Married(X)
- Lies(Y) ∧ Brother(Y, X) ⇒ Lies(X)
- SaysMarried(Y, X) ∧ DeniesMarried(X) ⇒ Lies(Y)
- SaysBothMarried(Y,X) ⇒ SaysMarried(Y, X) ∧ ¬DeniesMarried(Y)
- DeniesMarried(Jones)
- Brother(Smith, Jones)
- SaysBothMarried(Smith, Jones)



2. Decision trees

Given the following table of training data (last column is the correct class), show which feature is used at the root of the decision tree. The data has been set so you should not need to do any real calculations – you should be able to give the formulas and reason from there. Show your work.

A	B	Class
0	a	X
0	bb	X
1	ccc	X
1	ccc	X
1	bb	Y
2	ccc	Y

[Using information gain heuristic. All log's are base 2]

Root:

Using A, A = 0 → entropy = H0 = -2/2 * log (2/2) = 0 (all class X)
A = 1 → H1 = -2/3 * log (2/3) – 1/3 * log(1/3)
A = 2 → H2 = -1/1 * log (1/1) = 0 (all class Y)
Total H = 2/6*H0 + 3/6* H1 + 1/6 * H1 = ½ * H1

Using B, B = a → Ha = = -1/1 * log (1/1) = 0 (all class X)
B = bb → Hbb = -1/2 * log (1/2) -1/2 * log (1/2) = 1
B = ccc → Hccc = -2/3 * log (2/3) – 1/3 * log(1/3)
Total H = 1/6 * Ha + 2/6 * Hbb + 3/6 * Hccc = 1/3 + ½ * Hccc

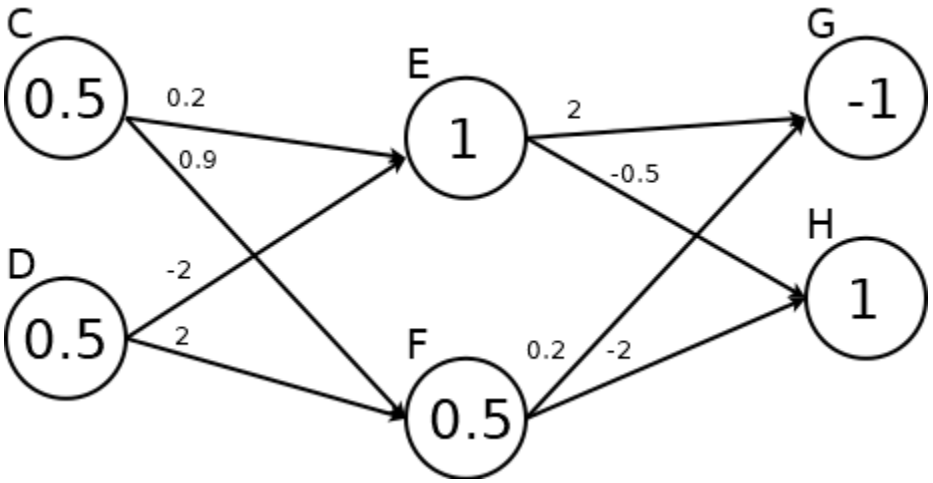
Note that ½ * H1 = ½ * Hccc, so the total entropy using B is larger. We should pick A to get the most information gain.

3. Neural networks

Given the following table of training data (last column is the correct class):

- Map your inputs to appropriate values and inputs
- Show the first round of calculations for the following neural network for the 3rd row (1, s), where the weights on outputs from the input layer are for the edge directly below, and bias weights are the numbers inside the nodes.
    - Assume that the activation function is a simple step function (for ease of computation).
    - Show the equations you are using and do rough calculations to get any needed intermediate values.

A	B	Class
0	s	X
0	t	Y
1	s	X
1	t	X
1	t	Y

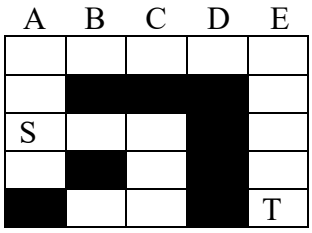


Map s to 0, t to 1 (other way around is fine, too)
Map feature A to top input, B to lower input
[Note that for a domain with more than 2 values, you can map it using one input for each value. For example, if A could also be 2, you could have 3 inputs for A, and a 0 would be modeled by 1, 0, and 0 for the 3 inputs. A 1 would be 0, 1, 0. A 2 would be 0, 0, 1.]

For row 3, the outputs for the labeled nodes would be, from top to bottom:
C: weighted sum = 0.5*(-1) + 1 = 0.5, output = 1
D: weighted sum = 0.5*(-1) + 0 = -0.5, output = 0
E: weighted sum = 1*(-1) + .2*1 + -2*0 = -0.8, output = 0
F: weighted sum = 0.5*(-1) + .9*1 + 2*0 = 0.4, output = 1
G: weighted sum = -1*(-1) + 2*0 + 0.2*1 = 1.2, output = 1
H: weighted sum = 1*(-1) + -.5*0 + -2*1 = -3, output = 0

For 6810 students, do all remaining questions. For 4810 students, you may pick 1 of the lasts 2 questions, or you can do both. If you only pick 1, each question is worth 25 points. If you do both, each question is worth 20 points.

4. (A*) Consider the following "maze", with S as the starting point and T as the target point. Show the status of the A* algorithm after each of the first 3 nodes is chosen for expansion: include the search tree and the values of the *f, g* and *h* functions, and the candidates to expand for the first 3 nodes. Use the Manhattan distance to T as the heuristic function.



(Let the rows be numbered 0-4 from top to bottom. S is then at A2, T at E4)

1st node:expanding S: f = g + h = 0 + 6

2nd node: expanding one of:
A3: f = 1 + 5 = 6
B2: f = 1 + 5 = 6
A1: f = 1 + 7 = 8

Can choose either A3 or B2:
Choosing A3: candidates for expansion are:
B2: f = 6 (both numbers here are from above)
A1: f = 8
Choose B2

5. (Constraint Satisfaction)

Abby, Bob, Carl are 3 people with different jobs. Here are the constraints:

- They are a doctor, a lawyer and a teacher
- The teacher is an only child
- The teacher earns the least money
- The lawyer is unmarried
- Bob is married to Carl's sister
- Bob earns more than the lawyer

The starting assignment of jobs: Abby is the teacher, Bob is the lawyer, Carl is the doctor

Step through the first iteration of min-conflicts towards an ordering that satisfies all constraints– you may not actually complete the solution. On each iteration, you will swap the chosen person's job with another person's job. Explain how you choose the first person to move and with whom they swap jobs.

Abby has no violations
Bob has two violations – he earns more than the lawyer, but is currently assigned to be the lawyer, and the lawyer is unmarried, but Bob is married to Carl's sister
Carl has no violations

Picking swap with Bob:
If we make Bob the teacher (swap with Abby):
Bob still has one violation since he makes more than the lawyer so he does not earn the least money. Abby and Carl do not have any violations

If we make Bob the doctor (swap with Carl):
There are no violations – so swap Bob with Carl since this gives us a complete answer