Name: ____

CptS 440/540 – Artificial Intelligence
Fall 2017

Final Exam

December 12, 2017, 10:10am-12:10pm

Duration: 120 minutes

Instructions: Clearly write your name at the top of this exam. Complete all problems on this exam. Write all your work on this exam; you may use the backs of pages if needed. The exam is closed book, closed notes, and closed neighbor. No electronic devices are allowed, except your own calculator. Failure to turn in your exam at the end of 120 minutes will result in deduction of points. Anyone cheating on the exam will receive a zero.

Problem	Points Possible	Your Score
1	2	
2	6	
3	12	
4	10	
5	6	
6	15	
7	10	
8	6	
9	6	
10	10	
11	8	
12	9	
Total	100	

1. (2 points) Suppose a computer passes the Turing test. Does this show that the computer exhibits weak AI or strong AI?

2. (6 points) For each of the task environments below, indicate whether it is fully or partially observable, deterministic or stochastic, and static or dynamic.

    a. Wumpus world.

    b. Arcade game like Flappy Bird, Pac-Man or Tetris.

3. (12 points) Consider the following initial and goal states for the 8-puzzle search problem. The four actions are moving the blank tile (0) left, right, up or down, and the actions are always considered in this order. Actions that do not move the blank tile are not valid (e.g., right and up are not valid in the initial state).

Initial:	Goal:
1 2 0	1 2 3
4 5 3	4 5 6
7 8 6	7 8 0

a. (5 points) Show the search tree generated using breadth-first search.

b. (2 points) How many nodes will be generated using iterative-deepening depth-first search.

c. (5 points) Show the search tree generated by A* search using the heuristic “sum of city block distances of tiles out of place”. Note this heuristic does not include the blank tile in the sum. Show the values of f, g and h next to each node.

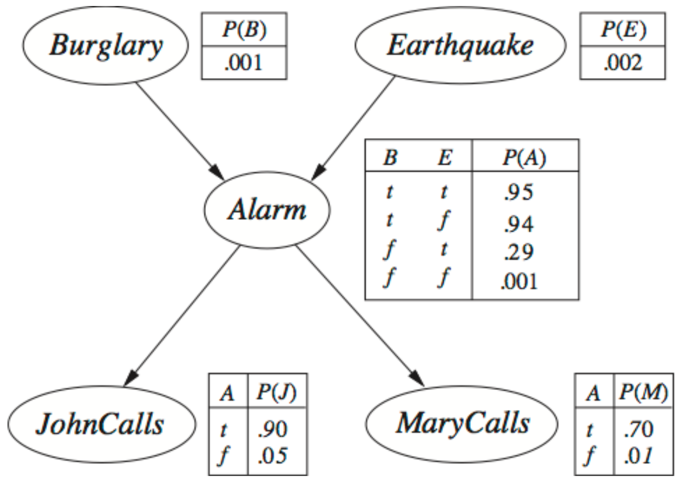
4. (10 points) Consider a first-order logic model using the predicates *calls(X,Y)*, which is true if person *X* calls person *Y*; *hears(X,Y)*, which is true if person *X* hears *Y*; and *feels(X,Y)*, which is true if person *X* feels *Y*. The model also uses the constants *john*, *mary*, *larry*, *alarm*, *burglary*, and *earthquake*.

   a. (3 points) Express the sentence "If a person hears an alarm, but does not feel an earthquake, then that person calls Larry" in first-order logic.

   b. (3 points) Convert your sentence in (a) into clausal form.

   c. (4 points) Given your clause from (b), and the facts *hears(john,alarm)* and *¬feels(john,earthquake)*, show a resolution proof by refutation of *calls(john,larry)*.

5. (6 points) Given the following Bayesian network, compute the P(Burglary=true | Alarm=true). Show your work.



6. (15 points) Suppose we are given 64 training examples, where 29 are positive examples and 35 are negative examples. Each example is described using two Boolean attributes: A1 and A2. Of the 64 examples, 26 have A1=true (of which 21 are positive and 5 are negative), 38 have A1=false (of which 8 are positive and 30 are negative), 51 have A2=true (of which 18 are positive and 33 are negative), and 13 have A2=false (of which 11 are positive and 2 are negative).

   a. (3 points) Calculate the Entropy of the set of 64 training examples. Show your work.

   b. (5 points) Calculate the Gain of choosing A1 as the root attribute of a decision tree. Show your work.

   c. (5 points) Calculate the Gain of choosing A2 as the root attribute of a decision tree. Show your work.

   d. (2 points) Based on your results from (b) and (c), which attribute should the decision tree learning algorithm choose as the root attribute?

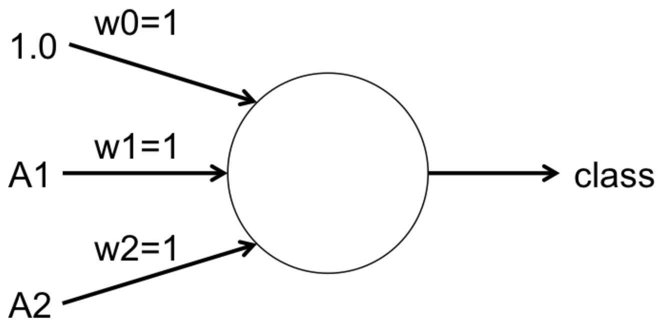
7. (10 points) Recalling the scenario in Problem 6, we want to use a naïve Bayes classifier to classify the instance A1=true, A2=true.

   a. (4 points) Compute the P(class=positive | A1=true, A2=true). You may use normalization constant α in your final answer. Show your work.

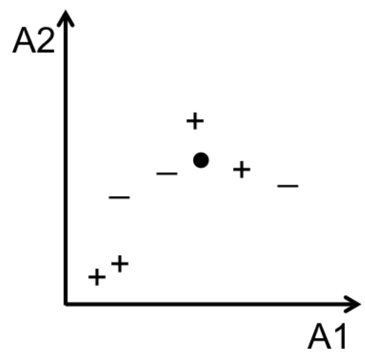
   b. (4 points) Compute the P(class=negative | A1=true, A2=true). You may use normalization constant α in your final answer. Show your work.

   c. (2 points) Based on your results from (a) and (b), how would naïve Bayes classify this instance?

8. (6 points) Consider the perceptron below, which takes two attributes A1 and A2 as input. If the sum of the weighted inputs is greater than or equal to 0, then the perceptron outputs a 1; otherwise, it outputs a 0. Suppose the perceptron is given an input example, where A1=1, A2=1 and the correct output should be 0. What are the new weights after the perceptron learns from this example? You may assume the learning rate $\eta = 0.5$. Show your work.



9. (6 points) Suppose we are given the seven training examples (+ = positive, – = negative) shown below, described in terms of real-valued attributes A1 and A2. We want to classify the instance (the dot) using the k-nearest-neighbor method.

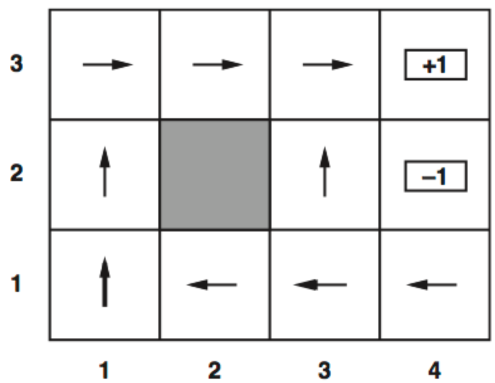


a. (2 points) How would k-nearest-neighbor classify the instance for k=3?

b. (2 points) How would k-nearest-neighbor classify the instance for k=5?

c. (2 points) How would k-nearest-neighbor classify the instance for k=7?

10. (10 points) Recall the reinforcement learning scenario below, where a robot it moving around a grid world. When the robot executes a move (up, down, left, right), the robot has an 80% chance of actually moving in the desired direction, a 10% chance of moving in the direction 90 degrees to the left, and a 10% chance of moving in the direction 90 degrees to the right. The robot receives a reward of -0.04 in each state, except (4,3) where the reward is +1, and (4,2) where the reward is -1. If the robot tries to move outside the grid or into (2,2), it just stays in its current location. The optimal policy is shown on the left, and the utilities for this optimal policy are shown on the right (except for U([1,3])).



	1	2	3	4
3	?	0.868	0.918	+1
2	0.762		0.660	–1
1	0.705	0.655	0.611	0.388

a. (4 points) Compute the utility U([1,3]) according to the above policy. You may assume $\gamma=1$. Show your work.

b. (6 points) Suppose we want to use a Q-value approach to this problem. Assuming the Q-values for all non-terminal states are zero initially, show the values for Q([2,3],right) and Q([3,3],right) after each of three iterations of observing the robot starting in [2,3], moving right into [3,3], and then moving right into [4,3]. You may assume α=1 and γ=1.

11. (8 points) Below are the lexicon and grammar from the Natural Language lecture.

Noun → stench | breeze | glitter | wumpus | pit | agent | gold
Verb → is | see | smells | shoot | feel | stinks | grab | eat
Adjective → right | left | smelly | breezy | dead
Adverb → here | there | nearby | ahead
Pronoun → me | you | I | it
RelativePronoun → that | which | who | whom
Name → John | Mary | Boston
Article → the | a | an | every
Preposition → to | in | on | of | near
Conjunction → and | or | but | yet
Digit → 0| 1| 2| 3| 4| 5| 6| 7| 8| 9

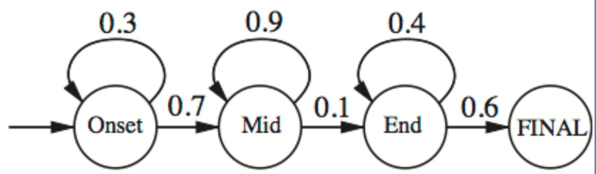
S → NP VP | S Conjunction S
NP → Pronoun | Name | Noun | Article Noun | Article Adjectives Noun
    | Digit Digit | NP PP | NP RelativeClause
VP → Verb | VP NP | VP Adjective | VP PP | VP Adverb
Adjectives → Adjective | Adjective Adjectives
PP → Preposition NP
RelativeClause → RelativePronoun VP

a. (3 points) Show the parse tree for the sentence "the wumpus is smelly".

b. (5 points) Show a single grammar rule containing only non-terminals that, if added to the grammar, will allow the grammar to parse the sentence “smelly the wumpus is”, and show the parse tree.

12. (9 points) Below is the Hidden Markov Model for the [m] phoneme. Compute the maximum probability that the [m] phoneme was spoken given the sequence of feature values $C_1C_2C_3C_4C_6$. Show your work.

Phone HMM for [m]:



Output probabilities for the phone HMM:

Onset:	Mid:	End:
C_1: 0.5	C_3: 0.2	C_4: 0.1
C_2: 0.2	C_4: 0.7	C_6: 0.5
C_3: 0.3	C_5: 0.1	C_7: 0.4

Hint: $V_{4,Onset} = 0$; $V_{4,Mid} = 0.002646$; $V_{4,End} = 0.000042$.