CptS 440/540 – Artificial Intelligence

Final Exam – Sample

1. (6 points) Introduction to AI.

   a. (1 point) Of the four approaches to AI discussed in class, which one is best evaluated by the Turing Test?

   b. (1 point) Of the four approaches to AI discussed in class, which one did we pursue in this class?

   c. (4 points) For each task property below, circle the option that best describes the Wumpus World.

i.	Fully-observable	vs.	Partially-observable
ii.	Deterministic	vs.	Stochastic
iii.	Static	vs.	Dynamic
iv.	Discrete	vs.	Continuous

2. (8 points) Suppose we want to solve the following 8-puzzle problem with A* search. Your search should consider the possible moves (moving the blank tile) in the order: down, left, up, right; only if the blank tile can move in that direction.

1	2	
4	5	3
7	8	6

Initial State

1	2	3
4	5	6
7	8	

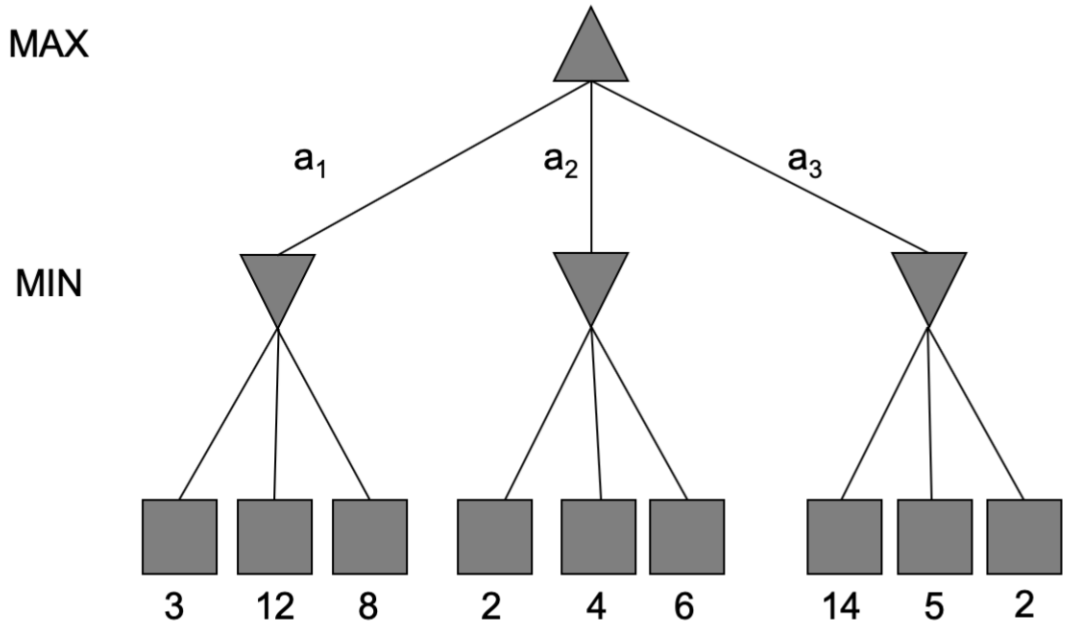
Goal State

a. (2 points) How many nodes would be generated using breadth-first search to solve this problem?

b. (2 points) How many nodes would be generated using iterative-deepening search to solve this problem?

c. (4 points) Show the search tree generated by A* to solve this problem using the city-block distance for the heuristic *h*. Next to each node show the values of *f*, *g* and *h*.

3. (6 points) Perform Alpha-Beta-Search on the game tree below. Upward-pointing triangles are MAX nodes, downward-pointing triangles are MIN nodes, and squares are terminal nodes.
   - Put an "X" over each node that is pruned, i.e., not evaluated (including all nodes in a pruned subtree).
   - Put the final value next to all other nodes.
   - Indicate which action MAX should take: a_1, a_2 or a_3.



4. (8 points) Translate each of the following English sentences into a single first-order logic sentence using the following atomic sentences, where x, y, w and z can be variables, functions or integer constants.

   - wumpus(x,y): true if there is a wumpus in location (x,y)
   - stench(x,y): true if there is a stench in location (x,y)
   - pit(x,y): true if there is a pit in location (x,y)
   - breeze(x,y): true if there is a breeze in location (x,y)
   - adjacent(x,y,w,z): true if location (x,y) is adjacent to location (w,z)
   - equal(x,y): true if x and y represent the same integer

   a. (2 points) The wumpus is in location (1,3) or (3,3).

   b. (2 points) The wumpus is not in (1,1).

   c. (4 points) There are at least two pits.

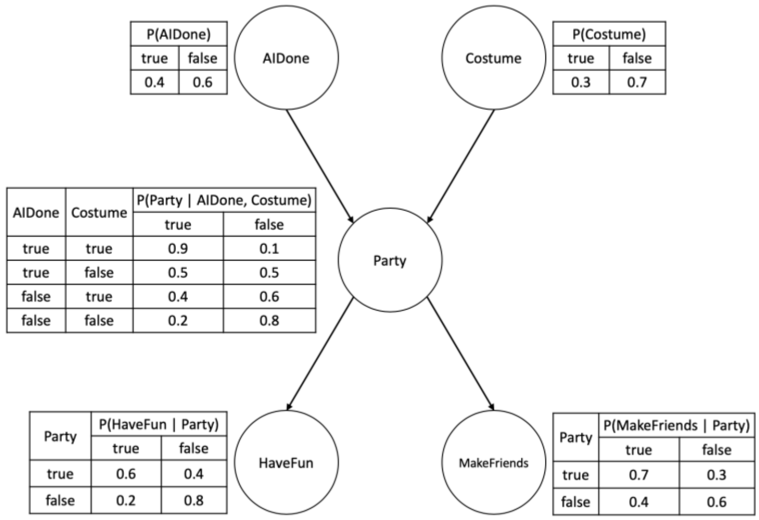
5. (8 points) Suppose we want to prove $\neg$wumpus(2,2) is entailed by the following knowledge base.

   i. $\forall$x,y,w,z ((wumpus(x,y) $\wedge$ adjacent(x,y,w,z)) $\Rightarrow$ stench(w,z))
   ii. adjacent(2,2,3,2)
   iii. $\neg$ stench(3,2).

   a. (3 points) Convert the knowledge base to CNF. Give each clause a number.

   b. (5 points) Show a resolution proof by refutation that $\neg$wumpus(2,2) is true given the knowledge base. Show each resolution step by indicating the two clause numbers being resolved, and the resulting clause (give it a new number). Also show any variable substitutions necessary for each resolution step. Be sure to standardize apart variables.

6. (8 points) Using the Bayesian network shown below, compute the following probabilities. Show your work.



a. (2 points) P(AIDone=true, Costume=true, Party=true, HaveFun=true, MakeFriends=true)

b. (6 points) P(HaveFun = true | AIDone = true, Costume = false)

7. (9 points) Suppose we want to apply naive Bayes learning to the following five examples in order to predict the class HaveFun given the features Weather and AIDone.

Weather	**AIDone**	**HaveFun**
clear	yes	yes
cloudy	yes	yes
rain	yes	no
clear	no	yes
rain	no	no

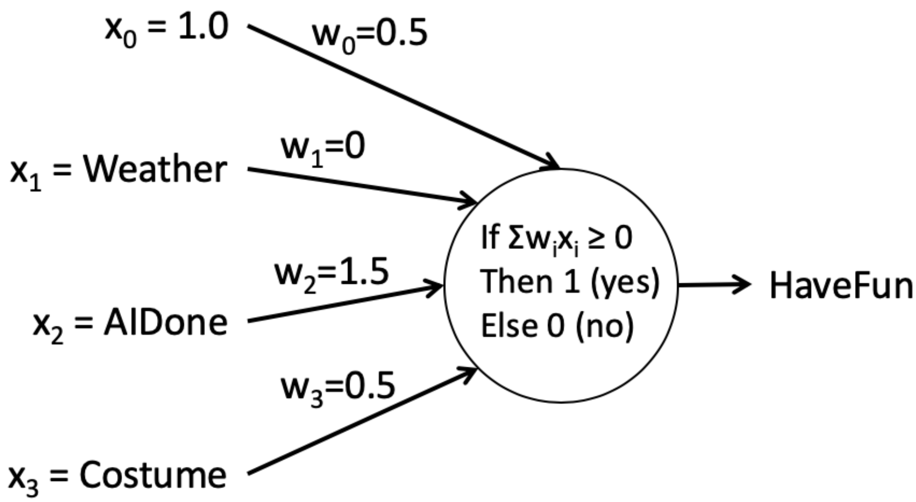
a. (2 points) Compute the prior probabilities P(HaveFun=yes) and P(HaveFun=no). Show your work.

b. (3 points) Compute P(HaveFun=yes | Weather=cloudy, AIDone=no). You may leave the normalization constant α in your answer. Show your work.

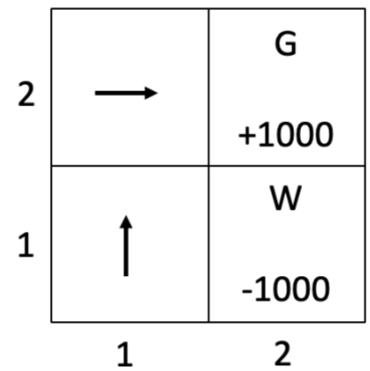
c. (3 points) Compute P(HaveFun=no | Weather=cloudy, AIDone=no). You may leave the normalization constant α in your answer. Show your work.

d. (1 point) How would naïve Bayes classify the instance <Weather=cloudy, AIDone=no>?

8. (8 points) The following perceptron is used to predict the class HaveFun given the features Weather, AIDone, and Costume. The perceptron makes a mistake on the example <Weather=1, AIDone=0, Costume=0, HaveFun=0 (no)>. Compute the weight updates resulting from this mistake. You may assume the learning rate $\eta = 0.5$. Show you work.



9. (8 points) Consider the 2x2 wumpus world shown on the right. The goal of this simplified game is to be collocated with the gold (where we get a +1000 reward) and not collocated with the wumpus (or we get a -1000 reward). All other states have a reward of -1. The agent starts in [1,1], but has only four possible actions: Up, Down, Left, Right (there is no orientation or turning). Each of these actions always works, although attempting to move into a wall results in the agent not moving. We will use reinforcement learning to solve this problem.



a. (4 points) Compute the utility *U(s)* of each non-terminal state *s* given the policy shown above. Note that [2,1] and [2,2] are terminal states, where U([2,1]) = -1000, and U([2,2]) = +1000. You may assume the discount factor $\gamma = 0.9$. Show your work.

b. (4 points) Using temporal difference Q-learning, compute the Q values for Q([1,1],Up) and Q([1,2],Right) after each of two executions of the action sequence: Up, Right (starting from [1,1] for each sequence). You may assume learning rate $\alpha = 1$, discount factor $\gamma = 0.9$, and all Q values for non-terminal states are initially zero.

10. (4 points) Given the following bigram model, compute the probability of the sentence "the wumpus ate". Show your work.

Word 1	**Word 2**	**Frequency**
the	wumpus	1,000
wumpus	ate	500
ate	the	10,000
the	agent	5,000
agent	ate	500

11. (8 points) Below are the lexicon and grammar from the Natural Language lecture. Show two different parse trees for the sentence "the agent smells the wumpus in 3 1".

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

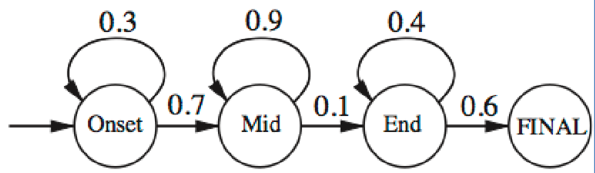
S → NP VP | S Conjunction S
NP → Pronoun | Name | Noun | Article Noun | Article Adjectives Noun
| Digit Digit | NP PP | NP RelativeClause
VP → Verb | VP NP | VP Adjective | VP PP | VP Adverb
Adjectives → Adjective | Adjective Adjectives
PP → Preposition NP
RelativeClause → RelativePronoun VP

a. (4 points) First parse tree.

b. (4 points) Second parse tree.

12. (8 points) Below is the Hidden Markov Model (HMM) for the [m] phoneme. There are two different paths through the HMM for the sequence of feature values C1C3C3C7. For each path give the sequence of states traversed and compute the probability of the path. 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

a. (4 points) First path.

b. (4 points) Second path.

13. (5 points) Philosophical and ethical issues in AI.

a. (2 points) Which of the following best describes the difference between weak AI and strong AI?

    i. Today's robots are stronger (strong AI) than the robots of a decade ago (weak AI).

    ii. Society relies on AI much more today (strong AI) than a decade ago (weak AI).

    iii. AI systems that do not have any performance guarantees (weak AI) compared to AI systems that do have performance guarantees (strong AI).

    iv. AI systems that act like humans (weak AI) compared to AI systems that think like humans (strong AI).

b. (3 points) If a robot kills a human, who is responsible: the robot or the robot's human designers? Briefly justify your answer.