cpt_s 540_Artificial Intelligence Final Exam

1.
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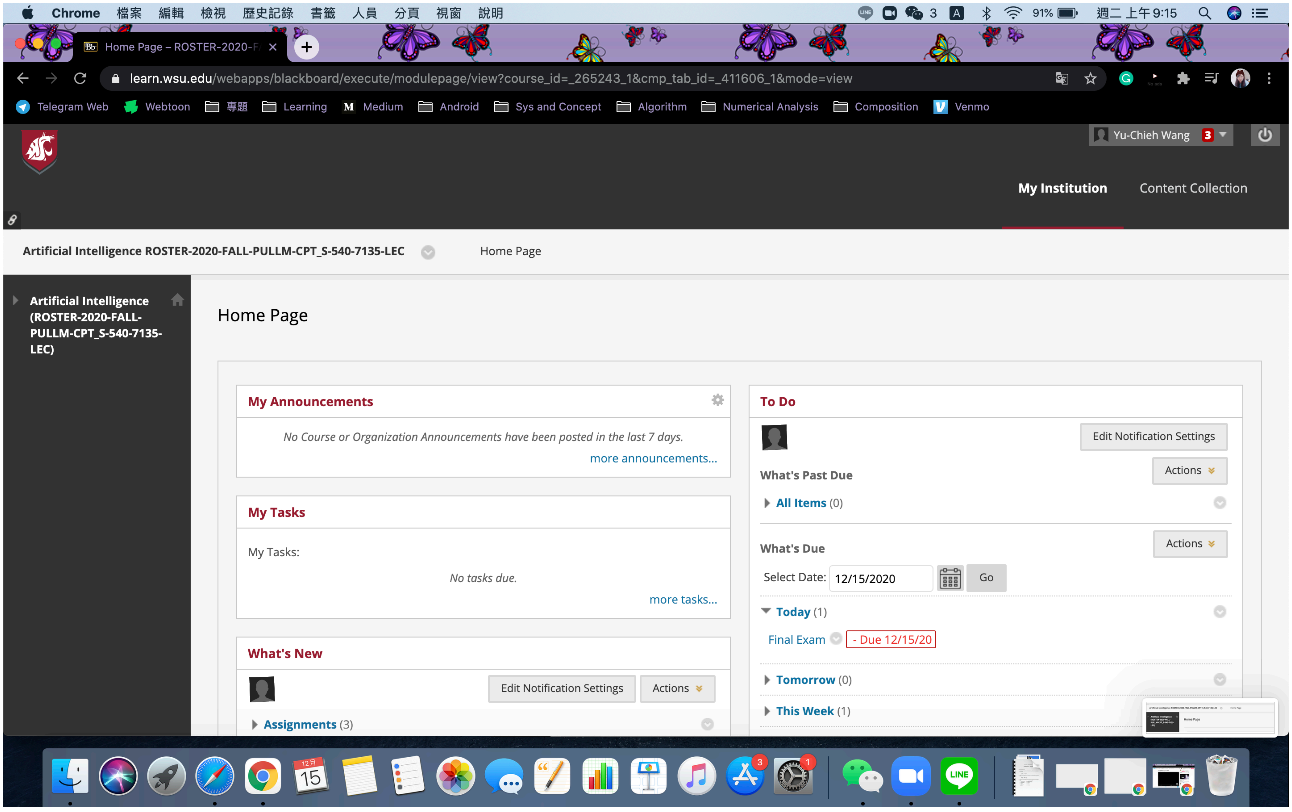
2.



3. (2 points) Which of the following best describes the purpose of the Turing test?

   a. Check if a computer is thinking humanly.

   b. Check if a computer is acting humanly.

   c. Check if a computer can beat a human at chess.

4. (2 points) Which of the following best describes the approach to AI taken in this course?

   a. Design a computer that thinks rationally.

   b. Design a computer that acts rationally.

   c. Design a computer that can beat a human at chess.

5. (6 points) Consider the following variants to the Wumpus World game. For each variant, indicate whether the environment is fully or partially observable, deterministic or stochastic, static or dynamic.

   a. If the agent doesn't respond with an action within one second, it loses one point.

Fully-observable	or	Partially-observable
Deterministic	or	Stochastic
Static	or	Dynamic

   b. When the agent returns an action, there is an 80% chance the action is ignored.

Fully-observable	or	Partially-observable
Deterministic	or	Stochastic
Static	or	Dynamic

6. (10 points) Consider the following initial and goal states for a 3x3 Wumpus World search problem. The initial state has the agent in (1,2) facing Right, and the goal state is that the agent is in (3,2), co-located with the gold, regardless of orientation. There are only two available actions, TurnLeft (TL) and GoForward (GF), and should be considered in this order.

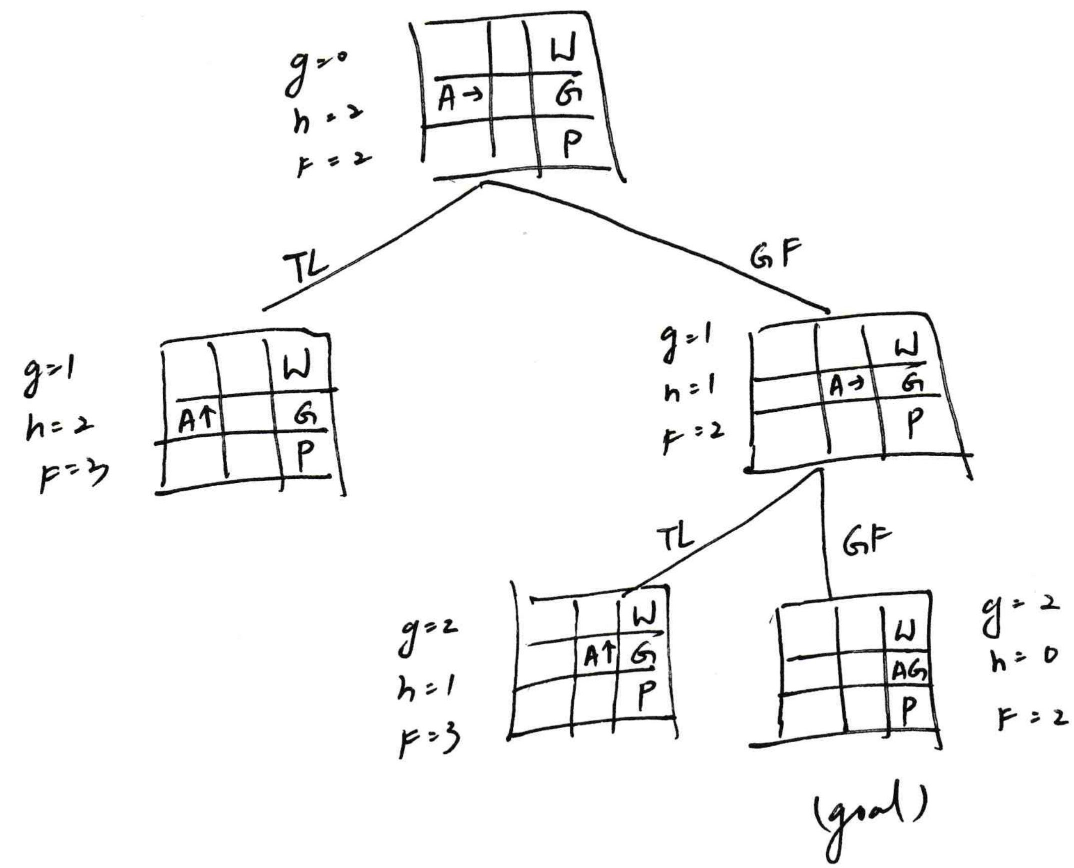
		W
A→		G
		P

Initial State

		W
		AG
		P

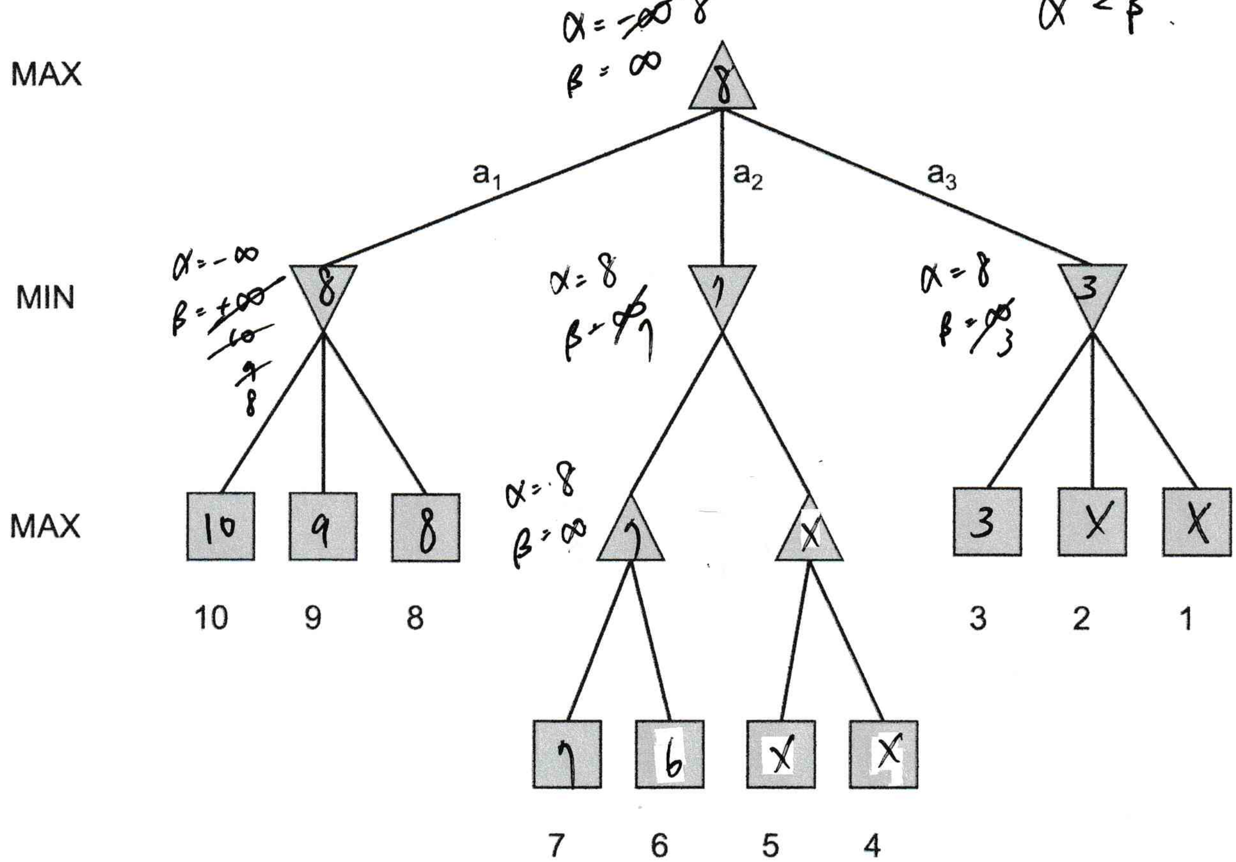
Goal State

Draw the search tree generated by the A* search algorithm, as described in the lecture notes, to solve this problem using the city-block distance for the heuristic *h*. The city-block distance for a Wumpus World state is the city-block distance between the agent's current location and the agent's goal location. Next to every node, show the values of *f*, *g* and *h*. Each node should be drawn as a 3x3 grid like the above initial and goal states.



7. (8 points) Perform Alpha-Beta-Search on the game tree below. 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.

$\alpha < \beta$.



a_1 shold be taken

8. (12 points) Given the following knowledge base, we want to prove Witch(Jane) is true. ⑦

① $\forall x,w$ Weight(x,w) $\wedge$ Weight(Duck,w) $\Rightarrow$ Floats(x)
② $\forall x$ Floats(x) $\Rightarrow$ MadeOf(x,Wood)
③ $\forall x$ MadeOf(x,Wood) $\Rightarrow$ Burns(x)
④ $\forall x$ Burns(x) $\Rightarrow$ Witch(x)
⑤ Weight(Jane,20)
⑥ Weight(Duck,20)

a. (5 points) Convert the knowledge base to conjunctive normal form. Give each clause a number.

C N F

① $\forall x,w\ \neg(\text{Weight}(x,w) \wedge \text{Weight}(\text{Duck},w)) \vee \text{Floats}(x)$

$\neg\text{Weight}(x,w) \vee \neg\text{Weight}(\text{Duck},w) \vee \text{Floats}(x)$

② $\forall x\ \neg\text{Floats}(x) \vee \text{MadeOf}(x,\text{Wood})$

$\neg\text{Floats}(x) \vee \text{MadeOf}(x,\text{Wood})$

③ $\forall x\ \neg\text{MadeOf}(x,\text{Wood}) \vee \text{Burns}(x)$

$\neg\text{MadeOf}(x,\text{Wood}) \vee \text{Burns}(x)$

④ $\forall x\ \neg\text{Burns}(x) \vee \text{Witch}(x)$

$\neg\text{Burns}(x) \vee \text{Witch}(x)$

⑤ Weight(Jane, 20)

⑥ Weight(Duck, 20)

⑦ Witch(Jane)

b. (7 points) Perform a resolution proof by refutation. Show each resolution step by indicated the two clauses being resolved (be sure to use unique variable names for each clause), the resulting clause (give it a new number), and any necessary variable substitutions. Also be sure to conclude your proof with a statement of what was proven.

① $\neg\text{Weight}(x,w) \vee \neg\text{Weight}(\text{Duck},w) \vee \text{Floats}(x)$

⑥ $\text{Weight}(\text{Duck},20) \rightarrow w = 20$

$\neg\text{Weight}(x,20) \vee \text{Floats}(x)$

⑤ $\text{Weight}(\text{Jane},20) \rightarrow x = \text{Jane}$

Floats(Jane)

② $\neg\text{Floats}(x) \vee \text{MadeOf}(x,\text{Wood}) \rightarrow x = \text{Jane}$

MadeOf(Jane, Wood)

③ $\neg\text{MadeOf}(x,\text{Wood}) \vee \text{Burns}(x) \rightarrow x = \text{Jane}$

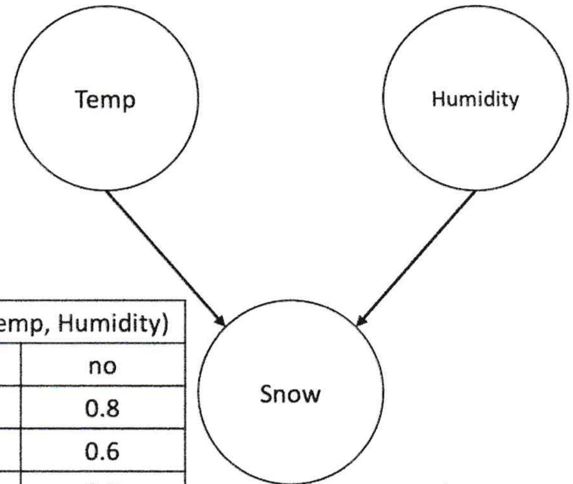
Burns(Jane)

④ $\neg\text{Burns}(x) \vee \text{Witch}(x) \rightarrow x = \text{Jane}$

Witch(Jane) is true since ① ② ③ ④ ⑤ ⑥ are true.

4 9. (5 points) Compute the probability below based on the following Bayesian network. Show your work. Final result should be a single number.

P(Temp)		
low	medium	high
0.4	0.3	0.3



P(Humidity)		
low	medium	high
0.1	~~0.2~~ 0.3	0.6

Temp	Humidity	P(Snow | Temp, Humidity)	
		yes	no
low	low	0.2	0.8
low	medium	0.4	0.6
low	high	0.8	0.2
medium	low	0.1	0.9
medium	medium	0.3	0.7
medium	high	0.5	0.5
high	low	0.1	0.9
high	medium	0.2	0.8
high	high	0.3	0.7

P(Temp=low | Snow=yes) = ?

$$= \frac{P(Temp=low)P(Snow=yes \mid Temp=low)}{P(Snow=yes)} = \alpha P(Temp=low) P(Snow=yes \mid Temp=low)$$

$$= \alpha \sum_{Humidity} P(Temp=low) P(Snow=yes \mid Temp=low, Humidity) P(Humidity)$$

$$= \alpha P(T=low) [P(S=y \mid T=low, H=low) P(H=low) + P(S=y \mid T=low, H=medium) P(H=medium) + P(S=y \mid T=low, H=high) P(H=high)]$$

$$= 0.4\alpha [(0.2)(0.1) + (0.4)(0.3) + (0.8)(0.6)] = 0.4\alpha (0.02 + 0.12 + 0.48) = 0.248\alpha$$

$$= 0.248 \times 2.373 = 0.588104$$

4

$$P(Temp = medium \mid Snow = yes)$$

$$= \frac{P(Temp=m)\,P(Snow=yes \mid Temp=m)}{P(Snow=yes)} = \alpha\, P(Temp=m)\,P(Snow=yes \mid Temp=m)$$

$$= \alpha\, P(Temp=m) \sum_{H} P(Snow=yes \mid Temp=m, H)\, P(H)$$

$$\begin{aligned} = 0.3\,\alpha\,[\, & P(snow=yes \mid Temp=m, H=low)\, P(H=low) + \\ & P(snow=yes \mid Temp=m, H=m)\, P(H=m) + \\ & P(snow=yes \mid Temp=m, H=h)\, P(H=h)\,] \end{aligned}$$

$$= 0.3\alpha\,[(0.1)(0.1) + (0.3)(0.3) + (0.5)(0.6)]$$

$$= 0.3\alpha\,(0.01 + 0.09 + 0.3) = 0.12\alpha = 0.2708$$

$$P(Temp = high \mid Snow = yes)$$

$$= \frac{P(Temp=h)\,P(snow=yes \mid Temp=h)}{P(snow=yes)} = \alpha\, P(Temp=h)\,P(snow=yes \mid Temp=h)$$

$$= \alpha\, P(Temp=h) \sum_{H} P(snow=yes \mid Temp=h, H)\, P(H)$$

$$\begin{aligned} = 0.3\alpha\,[\, & P(snow=yes \mid Temp=h, H=low)\, P(H=low) + \\ & P(snow=yes \mid Temp=h, H=m)\, P(H=m) + \\ & P(snow=yes \mid Temp=h, H=h)\, P(H=h)\,] \end{aligned}$$

$$= 0.3\alpha\,((0.1)(0.1) + (0.2)(0.3) + (0.3)(0.6)]$$

$$= 0.3\alpha\,(0.01 + 0.06 + 0.18) = 0.075 = 0.169$$

$$\alpha = \frac{1}{0.248 + 0.12 + 0.075} = 2.2573$$

10. (10 points) Consider the table of data below, which contains 8 examples of the class Snow (yes, no) based on two features: Temp (low, medium, high) and Humidity (low, medium, high). Suppose we want to classify the new instance <Temp=low, Humidity=high> using the Naïve Bayes learning method. Compute the following. Show your work.

Temp	Humidity	Snow
low	low	no
low	medium	yes
medium	low	no
medium	medium	yes
medium	high	yes
high	low	no
high	medium	no
high	high	no

$P(T=low \mid S=no) = \frac{1}{5}$

$P(T=m \mid S=no) = \frac{1}{5}$

$P(T=h \mid S=no) = \frac{3}{5}$ ← Max

$P(H=low \mid S=no) = \frac{3}{5}$ ← Max

$P(H=m \mid S=no) = \frac{1}{5}$

$P(H=h \mid S=no) = \frac{1}{5}$

a. Compute the prior probabilities P(Snow=yes) and P(Snow=no).

$P(Snow=yes) = \frac{3}{8}$

$P(Snow=no) = \frac{5}{8}$ ← Max

b. Compute P(Temp=low | Snow=yes) and P(Temp=low | Snow=no).

$P(Temp=low \mid Snow=yes) = \frac{1}{3}$

$P(Temp=low \mid Snow=no) = \frac{1}{5}$

c. Compute P(Humidity=high | Snow=yes) and P(Humidity=high | Snow=no).

$P(Humidity=high \mid Snow=yes) = \frac{1}{3}$

$P(Humidity=high \mid Snow=no) = \frac{1}{5}$

d. Compute P(Snow=yes | Temp=low, Humidity=high) and P(Snow=no | Temp=low, Humidity=high).

$P(Snow=yes \mid Temp=low, Hum=high)$

$= \frac{P(Snow=yes)P(Temp=low, Hum=high \mid Snow=yes)}{P(Temp=low, Hum=high)}$

$= \alpha P(Snow=yes) P(Temp=low \mid Snow=yes) P(Hum=high \mid Snow=yes)$

$= \alpha (\frac{3}{8})(\frac{1}{3})(\frac{1}{3}) = \frac{\alpha}{24} = 0.625$

$P(s=n \mid T=low, H=high)$

$= \frac{P(s=n)P(T=low, H=high \mid S=n)}{P(T=low, H=high)}$

$= \alpha P(s=n) P(T=low \mid S=n) P(H=high \mid S=n)$

$= \alpha (\frac{5}{8})(\frac{1}{5})(\frac{1}{5}) = \frac{\alpha}{40} = 0.375$

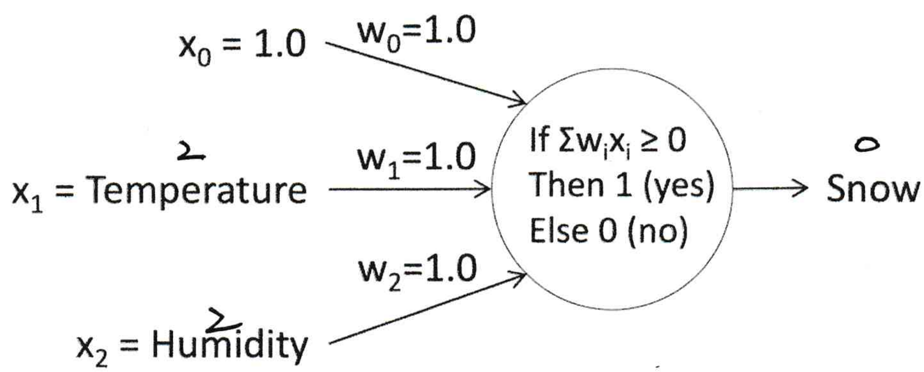
$\alpha = \frac{1}{\frac{1}{24}+\frac{1}{40}} = \frac{120}{8} = 15$

e. Which class would Naïve Bayes choose for the new instance?

$P(Snow=no) P(Temp=hight \mid Snow=no) P(Humidity=low \mid Snow=no)$

$= (\frac{5}{8})(\frac{3}{5})(\frac{3}{5}) = \frac{9}{40} = 0.225$

11. (5 points) Consider the perceptron below designed to solve the previous problem of predicting Snow based on Temperature and Humidity. Assuming we map "low" → 0, "medium" → 1, "high"→ 2, "no" → 0, and "yes" → 1, this perceptron will make a mistake on the example: <Tempterature=high (2), Humidity=high (2), Snow=no (0)>. Compute the weight update for each weight based on this mistake. You may assume the learning rate $\eta = 0.5$. Show you work.



$\text{sign}(X_0 W_0 + X_1 W_1 + X_2 W_2) = \hat{y}$ (predict result)

$(1)(1) + (2)(1) + (2)(1) = \text{sign}(5) = 1 \leftarrow$ but $y = 0$ (real result)

So, we modify weights : $\Delta W_i = \eta (y - \hat{y})(x_i)$, $W_i = W_i + \Delta W_i$

$\Delta W_0 = (0.5)(0-1)(1) = -0.5$, $W_0 = 1 - 0.5 = 0.5$

$\Delta W_1 = (0.5)(0-1)(2) = -1$, $W_1 = 1 - 1 = 0$

$\Delta W_2 = (0.5)(0-1)(2) = -1$, $W_2 = 1 - 1 = 0$

$(1)(0.5) + (2)(0) + (2)(0) = \text{sign}(0.5) = 1 = \hat{y} \leftarrow$ but $y = 0$, so we modify weights again.

$\Delta W_0 = (0.5)(0-1)(1) = -0.5$, $W_0 = 0.5 - 0.5 = 0$

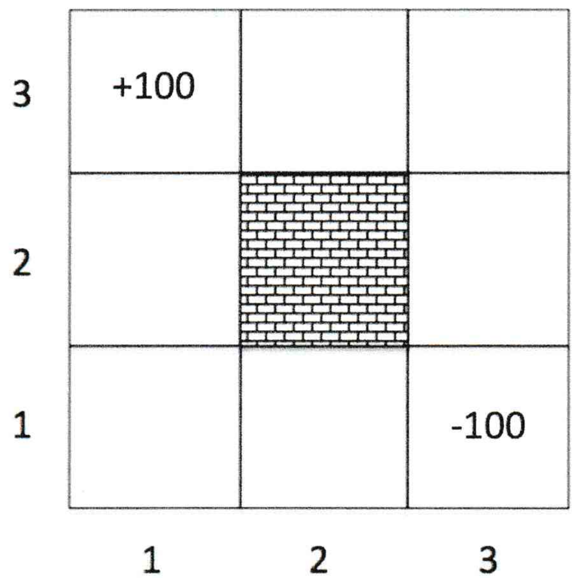
$\Delta W_1 = (0.5)(0-1)(2) = -1$, $W_1 = 0 - 1 = -1$

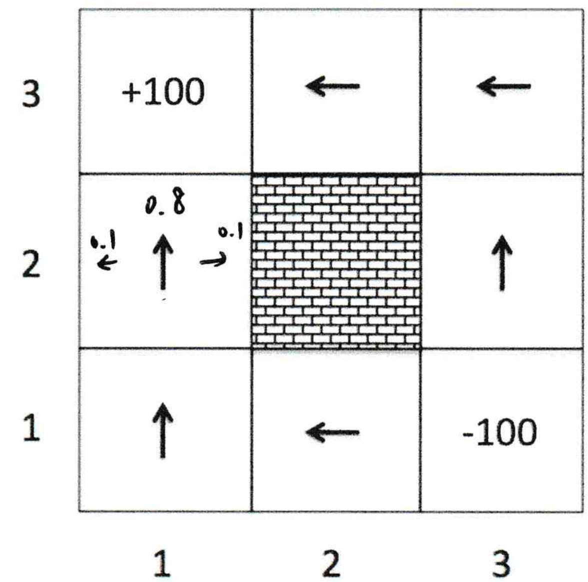
$\Delta W_2 = (0.5)(0-1)(2) = -1$, $W_2 = 0 - 1 = -1$

$(1)(0) + (2)(-1) + (2)(-1) = \text{sign}(-4) = 0 = \hat{y} = y$

Weights $\begin{cases} W_0 = 0 \\ W_1 = -1 \\ W_2 = -1 \end{cases}$

12. (10 points) Consider the following scenario (below left) in which an agent moves around a 3x3 world using the actions: up, down, left, right. For each action, the probability the agent actually executes the action is 0.8, the probability the agent moves 90 degrees to the left is 0.1, and the probability the agent moves 90 degrees to the right is 0.1. If the agent attempts to move into a wall or the obstacle in the middle, then the agent remains in its current location. The reward for terminal state (1,3) is +100, the reward for terminal state (3,1) is –100, and the reward for every other non-terminal state is –1.





a. (4 points) Assuming initial utility values for all non-terminal states are zero, compute the final utility value of state (1,2) according to the policy in part (a). You may assume $\gamma = 1$. Show your work.

$U^{\pi}(s) = R(s) + \gamma \sum_{s'} P(s' \mid s, \pi(s)) U^{\pi}(s')$

① $U([1,2]) = -1 + 1\,[(0.8)\,U([1,3]) + (0.1)\,U([1,2]) + (0.1)\,U([1,2])]$

$= -1 + [(0.8)(100) + (0.1)(0) + (0.1)(0)] = 79$

② $= -1 + [(0.8)(100) + (0.1)(79) + (0.1)(79)] = 94.8$

③ $= -1 + [(0.8)(100) + (0.1)(94.8) + (0.1)(94.8)] = 97.96$

④ $= -1 + [(0.8)(100) + (0.1)(97.96) + (0.1)(97.96)] = 98.592$

⑤ $= -1 + [(0.8)(100) + (0.1)(98.592) + (0.1)(98.592)] = 98.7184$

⑥ $= -1 + [(0.8)(100) + (0.1)(98.7184) + (0.1)(98.7184)] = 98.74368$

⑦ $= -1 + [(0.8)(100) + (0.1)(98.74368) + (0.1)(98.74368)] = 98.748736$

⑧ $= -1 + [(0.8)(100) + (0.1)(98.748736) + (0.1)(98.748736)] = 98.7497472$

⑨ $= 98.7499494$

⑩ $= 98.7499899$

⑪ 98.749998

⑫ 98.7499996

⑬ 98.7499999

⑭ 98.75

⑮ 98.75

b. (6 points) Assuming initial Q-values for all non-terminal states are zero, compute the values for Q[(1,1),up] and Q[(1,2),up] after observing the following three sequences of actions. Show both Q values after each action. You may assume α = 1 and γ = 1.

① (1,1) —up→ (1,2) —up→ (1,3)
② (1,1) —up→ (1,2) —up→ (1,3)
③ (1,1) —up→ (1,2) —up→ (1,3)

$$Q(S,a) \leftarrow Q(S,a) + \alpha'(R(s) + \gamma' \max_{a'} Q(s',a') - Q(S,a))$$

① $Q([1,1],UP) \leftarrow Q([1,1],UP) + ((-1) + Q([1,2],UP) - Q([1,1],UP))$

$= 0 + (-1) + 0 - 0 = -1$

$Q([1,2],UP) \leftarrow Q([1,2],UP) + ((-1) + Q([1,3],\text{Terminal}) - Q([1,2],UP)$

$= 0 + (-1) + 100 - 0 = 99$

② $Q([1,1],UP) = -1 + (-1) + 99 - (-1) = 98$

$Q([1,2],UP) = 99 + (-1) + 100 - 99 = 99$

③ $Q([1,1],UP) = 98 + (-1) + 99 - 98 = 98$

$Q([1,2],UP) = 99 + (-1) + 100 - 99 = 99$

4

13. (8 points) Given the following bigram model, compute the probability of the two sentences below. Show your work. Be sure to compute a final number – no fractions.

100	"agent is"
50	"agent wants"
100	"is hungry"
75	"is smart"
200	"the agent"
100	"the gold"
150	"the wumpus"
100	"wants the"
50	"wumpus is"
100	"wumpus wants"

a. (4 points) "the agent wants the gold"

$$= P(agent \mid the) \cdot P(wants \mid agent) \cdot P(the \mid wants) \cdot P(gold \mid the)$$

$$= \left(\frac{200}{200+100+150}\right)\left(\frac{50}{100+50}\right)\left(\frac{100}{100}\right)\left(\frac{100}{200+100+150}\right)$$

$$= \left(\frac{200}{450}\right)\left(\frac{50}{150}\right)(1)\left(\frac{100}{450}\right)$$

$$= \left(\frac{4}{9}\right)\left(\frac{1}{3}\right)\left(\frac{2}{9}\right) = \frac{8}{243} = 0.032921$$

4

b. (4 points) "the wumpus wants the agent"

$$= P(wumpus \mid the) \cdot P(wants \mid wumpus) \cdot P(the \mid wants) \cdot P(agent \mid the)$$

$$= \left(\frac{150}{200+100+150}\right)\left(\frac{100}{50+100}\right)\left(\frac{100}{100}\right)\left(\frac{200}{200+100+150}\right)$$

$$= \left(\frac{150}{450}\right)\left(\frac{100}{150}\right)(1)\left(\frac{200}{450}\right)$$

$$= \left(\frac{1}{3}\right)\left(\frac{2}{3}\right)\left(\frac{4}{9}\right) = \frac{8}{81} = 0.098765$$

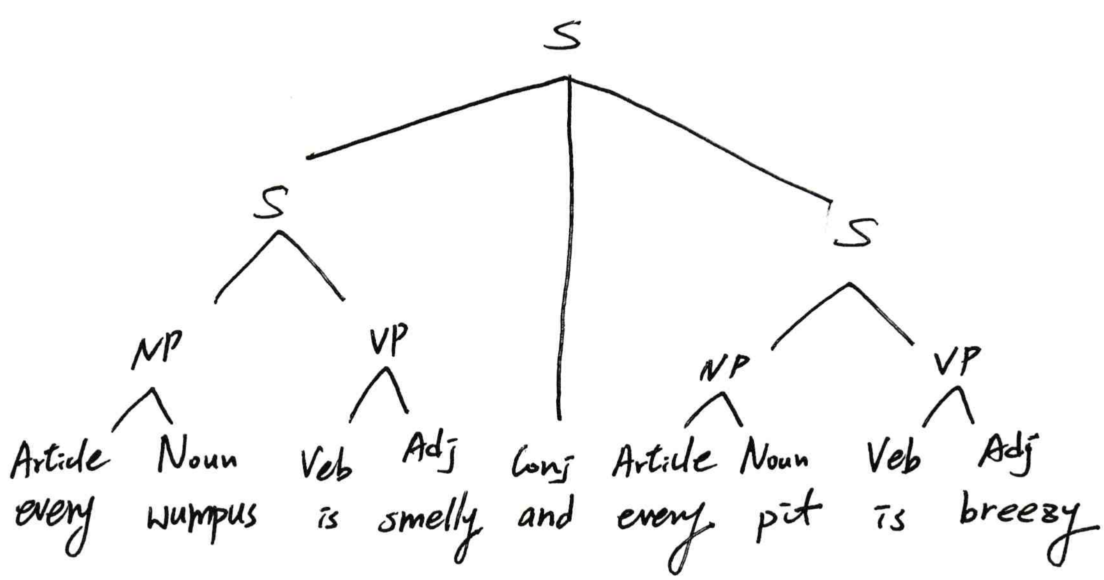
4

14. (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

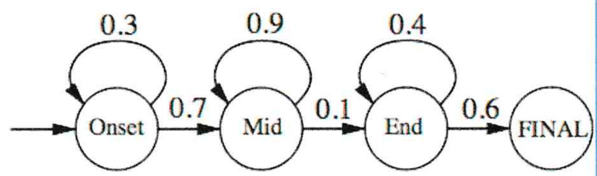
S → NP VP | S Conjunction S
NP → Pronoun | Name | Noun | Article Noun | Article Adjectives Noun
    | Digit Digit | NP PP | NP RelativeClause
VP → Verb | VP NP | VP Adjective | VP PP | VP Adverb
Adjectives → Adjective | Adjective Adjectives
PP → Preposition NP
RelativeClause → RelativePronoun VP

Show the parse tree of the sentence: "every wumpus is smelly and every pit is breezy".



15. (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 $C_1C_3C_5C_7$. 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.

C_1 C_3 C_5 C_7

Onset, Onset, Mid, End

$= (0.5)[(0.3)(0.3)][(0.7)(0.1)][(0.1)(0.4)](0.6)$

$= 0.0000756$

b. (4 points) Second path.

C_1 C_3 C_5 C_7

Onset, Mid, Mid, End

$= (0.5)[(0.7)(0.2)][(0.9)(0.1)][(0.1)(0.4)](0.6)$

$= 0.0001512$ ← highest

16. (6 points) Imagine AI technology far beyond that of deep fakes that can physically impersonate a human.

a. (3 points) Would this be an example of Weak AI or Strong AI? Justify your answer.

It would be an example of Weak AI because the system has a performance guarantee. It acts like humans but does not think like humans.

b. (3 points) Suppose a country's leader is ill and unable to attend an important international meeting. The country decides to send the impersonator robot instead. Is this ethical? Justify your answer.

If the robot can be completely controlled by the remote leader, this way is feasible and ethical. However, if the robot has its own will and acts according to its own idea, this way is not ethical because no one can restrain its behavior and cannot be held responsible for what it does.