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UC Davis: Winter 2003
ECS 170 Introduction to Artificial Intelligence

Final Examination, Open Text Book and Open Class Notes.
Answer All questions on the question paper in the spaces provided
Show all work clearly and neatly.

Time: 2 hours

(1) Quickies (12 points)
Decide if each of the following is True or False. Please provide a brief, one sentence, justification to your answer.

(a) **(3 points)** Breadth First Search is complete even if zero step-costs are allowed.

(b) **(3 points)** Depth-First Iterative Deepening Search always returns the same solution as breadth-first search if *b* is finite and the successor ordering is fixed.

(c) **(3 points)** Any decision tree with Boolean attributes can be converted into an equivalent feed forward neural network.

(d) **(3 points)** Assume that a rook can move on a chessboard any number of squares in a straight line, vertically or horizontally, but cannot jump over other pieces. Manhattan distance is an admissible heuristic for the problem of moving the rook from square A to square B in the smallest number of moves.

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2. Logic. (8 points)

(a) (**3 points**) For the following sentence in English, decide if the associated first-order logic sentence is a good translation. If not, explain why not and correct it. (There may be more than one error or none at all)

John's social security number is the same as Mary's

$\exists n\ \_\ HasSS\#(John, n) \wedge HasSS\#(Mary, n)$

(b) **(5 points)** Consider the following propositional 2-CNF expression, which is defined as a conjunction of clauses, each containing *exactly* two literals, namely,

$(A \vee B) \wedge (\neg A \vee C) \wedge (\neg B \vee D) \wedge (\neg C \vee G) \wedge (\neg D \vee G)$

Prove that the sentence above entails G

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3. Bayes' Theorem (10 points)
Suppose that we have two bags each containing black and white balls. One bag contains three times as many white balls as blacks. The other bag contains three times as many black balls as white. Suppose we choose one of these bags at random. For this bag we select five balls at random, replacing each ball after it has been selected. The result is that we find 4 white balls and one black. What is the probability that we were using the bag with mainly white balls?

[Hint: Start by defining A as the event "bag chosen" " then let A ={a1,a2} where a1 represents "bag with mostly white balls" and a2 represents "bag with mostly black balls"]

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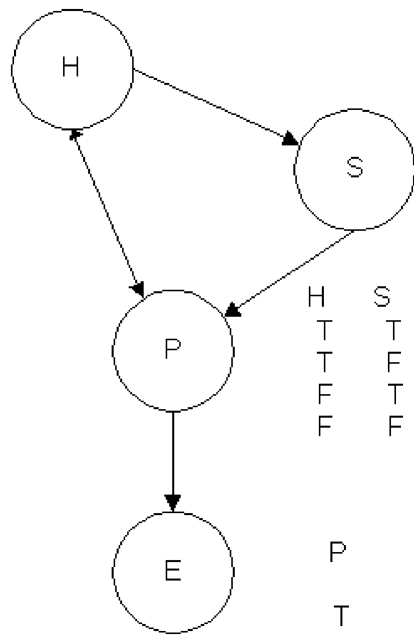
4. Belief Networks (20 points)
Consider a simple belief network with the Boolean variables H = Honest, S = Slick, P = Popular and E = Elected as shown in the figure below

P(H) = 0.1

H	P(S)
T	0.3
F	0.9



H	S	P(P)
T	T	0.9
T	F	0.5
F	T	0.8
F	F	0.2

P	P(E)
T	0.6
F	0.1

Figure A Simple Bayes Network with Boolean variables H = Honest, S = Slick, P = Popular, E= Elected

a. **(3 points)** For now, do not look at the CPT tables, but only at the structure of the network. Which, if any, of the following are asserted by the network structure.
   - P(H, S) = P(H) P(S)
   - P(E|P, H) = P(E|P)
   - $P(E) \neq P(E \mid H)$

(b) **(4 points)** Calculate $P(h, s, \neg p, \neg e)$

(c) **(5 points)** Calculate the probability that someone is elected given that they are honest.

(d) **(8 points)** Suppose we want to add the new variable L = LossOfCampaignFunds to the belief network. Describe, with justifications, all the changes you would make to the network.

(Give your answer on the next blank page)

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Write your answer for problem 4 here.

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5. Learning. (10 points)

(a) **(3 points)** Give a simple argument to show that a Perceptron cannot represent some data sets generated by decision trees.

(b) **(7 points)** Now consider the representation of Boolean functions by Perceptrons, where "True" is +1 and "False" is –1. Assume a fixed input $a_0 = -1$ and three other inputs a_1, a_2, a_3 and assume that the activation function is a step function $g(x) = +1$ if x > 0, and -1 otherwise. Design a Perceptron that represents the disjunction of the three attributes a_1, a_2, a_3 and draw its picture.

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6. Bayesian Updating. (20 points)
A doctor knows that the disease meningitis causes the patient to have stiff neck 50% of the time. The doctor also knows some unconditional facts:
Prior probability of a person having meningitis is 1/50,000.
Prior probability of any patient having a stiff neck is 1/20.

(a**) (6 points)** Starting with a patient about whom we know nothing, show how the probability of having meningitis, P(M), is updated after we find the patient has stiff neck.

(b(**(14 points)** Next show how P(M) is updated, again, when we find the patient has fever.
NOTE: During these calculations, use the following information – as necessary.
$P(F \mid \neg M) =$ same as the background frequency of fever in a population = 0.02.
$P(F \mid M) =$ 0.8

Show all steps and calculations very clearly so I can follow what you are doing.

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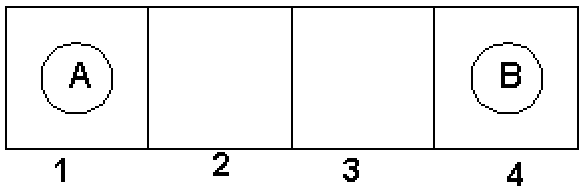
7. Games (20 points)
Consider a two-player game featuring a board with four locations, numbered 1 through 4 and arranged in a line. Each player has a single token. Player A starts with his token in space 1 and Player B starts with his token in space 4, as shown below. Player A moves first.



The two players take turns moving, and each player must move his token to an open adjacent space *in either direction*. If an opponent occupies an adjacent space, then the player may jump over the opponent to the next open space, if any. (For example, if A is on 3 and B is on 2, then A may move back to 1.) The game ends when one player reaches the opposite end of he board. If Player A reaches space 4 first, the value of the game is +1; if Player B reaches space 1 first, the value of the game is –1.

(a) **(10 points)** Draw the complete game tree, using the following conventions.

- Write each state as an ordered pair (s_A, s_B) where s_A and s_B denote the token locations.
- Put the terminal states in square boxes and annotate each with its game value in a circle.
- Put *loop states* (that is, states that already appear on the path to the root) in double square boxes. Since it is not clear how to assign values to these states, put a ? in a circle.

(b) **(5 points)** Now mark each node with its backed-up minimax value (also in a circle) . Explain in words how you handles the ? values and why.

(c) **(5 points)** Explain why the standard minimax algorithm would fail on this game tree and briefly sketch how you might fix, drawing on your answer to part (b). Does your modified algorithm give optimal decisions on all games with loops? Why?

(Continue your answer on the attached blank sheet)

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Continue your answer for problem 7 here.