Final Exam I - TDBC70 – Artificial Intelligence
Wednesday October 29th, 2003
9.00 - 15.00

NUMBER: __KEY__
Write this number on each sheet in the exam body.
-10pts if your name appears in the exam body
Do NOT staple exam sheets together.

NAME: __________________________
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Total extra credit from assignments: ____
Exam point total: ____
Total points: ____
Grade: ____
1 True or False - 200 points

Each question is worth 10 points. If you mark a question wrong, then you lose 5 points. The lowest possible score on the entire section is 0 points.

1.) Perceptrons, arranged with no hidden layers, may express logical NOT. ___T___
2.) A finite reflex agent without state can do what a reflex agent with state can do. ___F___
3.) If \( \alpha \vdash \beta \) whenever \( \alpha \models \beta \) then the proof method is complete. ___T___
4.) \( \neg(\exists x)(P(x) \land Q(x)) \Rightarrow \neg(\exists x)(P(x)) \land \neg(\exists x)(Q(x)) \) is valid. ___F___
5.) Probability theory and fuzzy logic make the same ontological commitments. ___F___
6.) Probability theory and proposition logic make the same epistemological commitments. ___F___
7.) Bayesian networks are a compact way in which to represent a joint probability distribution. ___T___
8.) Probability gives a reasonable solution to the qualification problem. ___T___
9.) Utility theory = Decision theory + Probability theory. ___F___
10.) An admissible heuristic never overestimates the cost to reach the goal. ___T___
11.) Bayes’ rule contains both prior and posterior probabilities. ___T___
12.) A utility function is a mapping from state to action. ___F___
13.) You may use negation in preconditions of STRIPS operators. ___F___
14.) Gottlob Frege and Bertrand Russell proposed the axioms of probability theory. ___F___
15.) A mirrored surface is said to be a Lambertian surface. ___F___
16.) Propositional logic has the quantifiers \( \forall \) and \( \exists \). ___F___
17.) Image segmentation typically follows image smoothing in machine vision systems. ___T___
18.) Algorithms using iterative deepening are interruptible. ___T___
19.) An agent employing breadth first search requires less memory than depth first search. ___F___
20.) For propositional and first order logic if \( \alpha \models \beta \) then \( \alpha \land \gamma \models \beta \). ___T___
2 Short answers (100 points)

a.) How many boolean functions are there are over \( n \) boolean variables? \\

b.) How many models are there for \( a \Rightarrow b \lor c \) among all of the interpretations over three boolean variables? \\

c.) Express \( P(H|e) \) in terms of \( P(e|H) \), \( p(H) \) and \( P(e|\neg H) \). \\

d.) How many bits of information are within knowing the outcome of a roll of a fair 6 sided die. \\

e.) How many hidden layers must a neural network have to be able to approximate any continuous function? \\

3 Game Trees (100 points)

(25pts) a.) Back up the values in the game tree. \\

(25pts) b.) Indicate the path of expected game play. \\

(50pts) c.) Assuming that search order is left to right, mark the nodes that get expanded under alpha beta pruning.
4 Search (100 points)

The heuristic measures are: \( h(A) = 8 \), \( h(B) = 7 \), \( h(C) = 5 \), \( h(D) = 4 \), \( h(E) = 7 \), \( h(F) = 1 \), \( h(G) = 0 \), \( h(H) = 3 \), \( h(I) = 4 \), \( h(J) = 3 \), \( h(K) = 6 \), \( h(L) = 4 \), \( h(M) = 0 \), \( h(N) = 2 \), \( h(O) = 11 \).

Assuming that nodes are processed left to right, give the order of node expansion under the following search strategies:

- a.) depth first
- b.) breadth first
- c.) iterative deepening
- d.) uniform-cost
- e.) greedy
- f.) \( A^* \)

For the heuristic measure:

- g.) Is the heuristic function admissible? ____
- h.) Why? (for answer to g.)

- i.) In the heuristic function monotonic? ____
- j.) Why? (for answer to i.)
5 Logic (150 points)

Over the unary predicates PoliceOfficer(X), HasCriminalRecord(X), IsTrained(X) and IsQualified(X) express the following:

a.) All police are qualified.

b.) One is qualified if and only if one is trained and does not have a criminal record.

c.) John has a criminal record.

d.) John is not a police officer.

(70pts) e.) On a separate sheet, show through resolution refutation that \( d \) follows from \( a, b \) and \( c \) above.

If \( \Sigma \) is the correct formulations of \( a, b \) and \( c \) above, would:

f.) Under UNA and CWA _______

g.) Under UNA and OWA _______

h.) Not under UNA and under CWA _______

i.) Not under UNA and under OWA _______

Remember UNA means ‘unique names assumption’, CWA means ‘closed world assumption’ and OWA means ‘open world assumption’.
6 Bayesian Networks (100 points)

Assume that each of the 15 variables in the network are boolean.

a.) Ignoring the network structure, how many parameters are required to specify the full joint probability distribution over all of the variables? \(2^{15}\)

b.) How many parameters would be required to specify the joint probability given the network? \(35\)

c.) Is the cost for answering arbitrary queries over this network polynomial or exponential? \(\text{poly}\)

d.) \(P(\text{Bronchitis}) = P(\text{Bronchitis}|\text{Allergy})? \text{yes}\)

e.) \(P(\text{Bronchitis}|\text{Allergy}) = P(\text{Bronchitis}|\text{Allergy} \land \text{Cough})? \text{no}\)

f.) \(P(\text{Cough}|\text{Allergy}) = P(\text{Cough}|\text{Allergy} \land \text{FamilyHistory})? \text{yes}\)

g.) \(P(\text{Bronchitis}|\text{Cough}) = P(\text{Bronchitis}|\text{Cough} \land \neg \text{FamilyHistory})? \text{no}\)

h.) \(P(\text{Cough}|\text{Allergy}) = P(\text{Cough}|\text{Allergy} \land \text{Rash} \land \text{FamilyHistory})? \text{yes}\)

i.) \(P(\text{ExposureToOthers}|\text{ExposureToCold}) = P(\text{ExposureToOthers}|\text{ExposureToCold} \land \neg \text{Vomit})? \text{no}\)

j.) \(P(\text{ExposureToOthers}) = P(\text{ExposureToOthers}|\text{Headache} \land \neg \text{Cough})? \text{no}\)
7 Learning (150 points)

The majority function gives 1 if and only if the majority of the inputs are 1.

a.) Show the layout of the smallest possible neural net that computes the majority function of 5 input variables.

b.) Show the layout of the smallest possible decision tree that computes the majority function of 3 input variables.

c.) What is the advantage to using the sigmoid function over the simple threshold function for the activation function in neural networks? Also why is a simple linear function not used?
8 Essay - you may answer this question in Swedish (100 points)

Answer any ONE of the following essay questions. Write a minimum of 1 page, maximum 2 pages of text. Draw diagrams where helpful.

1.) Please specify a robot agent that is to clean public toilets. Give a PEAS (Performance measure, Environment, Actuators, Sensors) analysis. Remember that a slow moving guy wearing a white coat should not be mistaken for a urinal.

2.) Discuss why it is possible/impossible that a robot will ever be conscious. Please make reference to thought experiments such as the Turing test, Chinese room, brain in a vat, brain prosthesis, Star Trek teleporter, etc.

3.) Propose and give a convincing design for a game AI agent. Please use concepts from this course and be creative.