

Final Exam II - 5DV019 – Artificial Intelligence  
(AI Techniques Section)  
Thursday January 7th, 2010  
Skrivsal 2 (#108321)  
9.00 - 13.00

NUMBER: \_\_\_\_\_

Write this number on each sheet in the exam body.  
-10pts if your name appears in the exam body

NAME: \_\_\_\_\_

PERSON NUMBER: \_\_\_\_\_

EMAIL: \_\_\_\_\_@cs.umu.se

Total extra credit from assignments: \_\_\_\_\_

Exam point total: \_\_\_\_\_

Total points: \_\_\_\_\_

Grade: \_\_\_\_\_

**PROVIDE ANSWERS ON THE GIVEN SHEETS.  
NO EXTRA PAGES ALLOWED!**

## 1 True or False - 200 points

Each question is worth 10 pts. If you mark a question wrong, then you loose 5 pts. The lowest possible score on the entire section is 0 pts. Place answers in the space (\_\_\_\_).

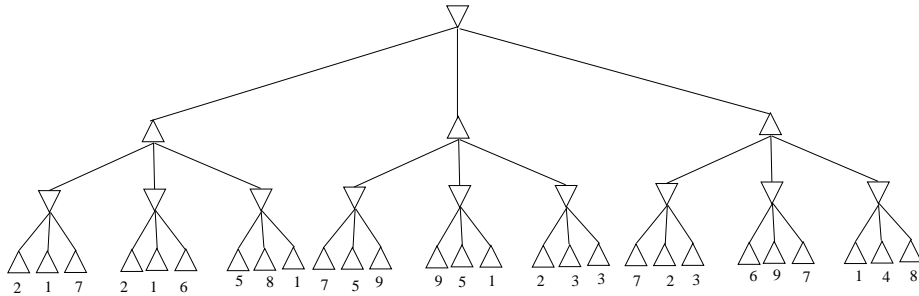
1. \_\_\_\_\_ A\* using GRAPH-SEARCH always finds an optimal solution when the heuristic function is consistent.
2. \_\_\_\_\_ A consistent heuristic is always admissible.
3. \_\_\_\_\_ GRAPH-SEARCH may give exponential speed up over TREE-SEARCH.
4. \_\_\_\_\_ There are problems where TREE-SEARCH requires constant space, but GRAPH-SEARCH requires exponential space.
5. \_\_\_\_\_ Perceptron learning converges quickly when learning the majority function.
6. \_\_\_\_\_ There are  $n^n$  semantically distinct formulas over  $n$  propositional variables.
7. \_\_\_\_\_ Auto-association is a type of supervised learning.
8. \_\_\_\_\_ A utility function is a mapping from states to their desirability.
9. \_\_\_\_\_ Hill climbing always finds a local maximum.
10. \_\_\_\_\_ If a sentence is valid, then it is satisfiable.
11. \_\_\_\_\_ Queries over singly connected (poly-tree) Bayesian networks may be solved in linear time in the number of nodes in the network.
12. \_\_\_\_\_ Agent performance measures should be based solely on agent actions.
13. \_\_\_\_\_ Bayesian networks are a compact way in which to represent a joint probability distribution.
14. \_\_\_\_\_ Propositional logic and probability theory make the same ontological commitments.
15. \_\_\_\_\_ To apply resolution, you must convert your formula to a CNF.
16. \_\_\_\_\_ An admissible heuristic always underestimates the cost to reach the goal.
17. \_\_\_\_\_ Decision trees may express any propositional formula.
18. \_\_\_\_\_ Neural networks with a hidden layer can represent any arbitrary function.
19. \_\_\_\_\_ Predicate logic has the quantifiers  $\forall$  and  $\exists$ .
20. \_\_\_\_\_ Depth-first search requires constant memory.

## 2 Fill in the blank (40 points)

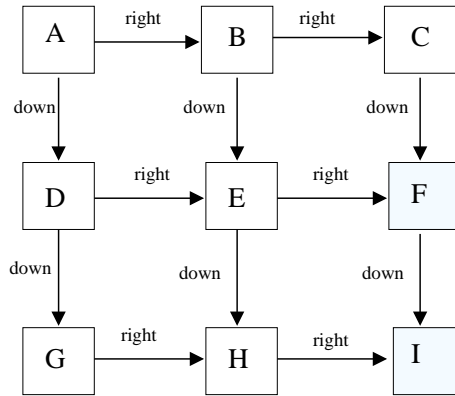
- How many models are there for  $(c \vee \neg b) \vee (a \vee \neg b)$  among all of the interpretations over three boolean variables? \_\_\_\_\_
- At most how many parameters are required in a Bayesian network over five boolean variables. \_\_\_\_\_
- For c, what are the fewest number required. \_\_\_\_\_
- How many subsets are there of  $n$  distinct items. \_\_\_\_\_

## 3 Game Tree Search (60 points)

Assuming that search order is left to right, mark the nodes that get expanded under alpha beta pruning.



**4 Search - 200 points**



The above diagram shows state space. The states F and I are goal states and A is the initial state. Assuming unit costs for actions, give the order of **node expansion** for the following cases. Represent each node by the state it contains. You may represent two distinct nodes with the same state label. (e.g. A, B, D, E, E, ... represents 5 search tree nodes.) Prefer the action 'down' over 'right' when there is a tie.

- a. depth first - under TREE-SEARCH \_\_\_\_\_
- b. breadth first - under TREE-SEARCH \_\_\_\_\_
- c. iterative deepening - under TREE-SEARCH \_\_\_\_\_
- d. depth first - under GRAPH-SEARCH \_\_\_\_\_
- e. breadth first - under GRAPH-SEARCH \_\_\_\_\_

Assume the following action costs:  $cost(A \rightarrow B) = 1$ ,  $cost(A \rightarrow D) = 2$ ,  $cost(B \rightarrow E) = 2$ ,  $cost(D \rightarrow E) = 2$ ,  $cost(B \rightarrow C) = 4$ ,  $cost(E \rightarrow H) = 3$ ,  $cost(D \rightarrow G) = 5$ ,  $cost(G \rightarrow H) = 1$ ,  $cost(E \rightarrow F) = 6$ ,  $cost(C \rightarrow F) = 5$ ,  $cost(F \rightarrow I) = 1$ ,  $cost(H \rightarrow I) = 5$  and the heuristic measures:  $h(A) = 9, h(B) = 8, h(C) = 4, h(D) = 4, h(E) = 6, h(F) = 0, h(G) = 5, h(H) = 3, h(I) = 0$ .

Give the order of **node expansion** under the following search strategies:

- f. uniform-cost - under GRAPH-SEARCH \_\_\_\_\_
- g. greedy - under GRAPH-SEARCH \_\_\_\_\_
- h. A\* - under GRAPH-SEARCH \_\_\_\_\_
- i. A\* - under TREE-SEARCH \_\_\_\_\_
- j. Is the heuristic measure admissible? \_\_\_\_\_. In the heuristic measure consistent? \_\_\_\_\_.

## 5 Logic (200 points)

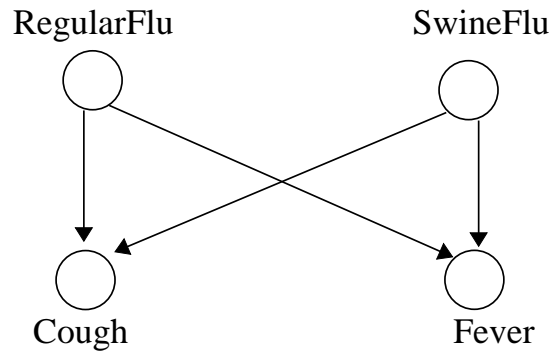
In propositional logic express the following in the space provided:

- a A person is either *watching tv*(tv – suggested name of proposition) or *sleeping*(s) or *eating*(e).
- b A person can not sleep and eat at the same time
- c If it's *late night*(ln) then the person is not eating.
- d If it's *early night*(en) then the person is eating
- e It is never both late night and early night at the same time.
- f If watching TV then there is a *light in the window*(l).

Now assume that  $\Sigma$  represents a conjunction of all the statements (a-e) and that  $\vdash_{res}$  represents the resolution refutation procedure.

Show  $\Sigma \wedge en \vdash_{res} \neg s$

## 6 Bayesian Networks (200 points)



$P(\text{regularFlu}) = .1, P(\text{swineFlu}) = .05, P(\text{cough}|\text{regularFlu} \wedge \text{swineFlu}) = .9, P(\text{cough}|\neg \text{regularFlu} \wedge \text{swineFlu}) = .8, P(\text{cough}|\text{regularFlu} \wedge \neg \text{swineFlu}) = .7, P(\text{cough}|\neg \text{regularFlu} \wedge \neg \text{swineFlu}) = .2, P(\text{fever}|\text{regularFlu} \wedge \text{swineFlu}) = .9, P(\text{fever}|\neg \text{regularFlu} \wedge \text{swineFlu}) = .8, P(\text{fever}|\text{regularFlu} \wedge \neg \text{swineFlu}) = .7, P(\text{fever}|\neg \text{regularFlu} \wedge \neg \text{swineFlu}) = .1.$

What is  $P(\text{swineFlu}|\neg \text{fever} \wedge \text{cough})$  \_\_\_\_\_?

Show all work to obtain a solution. Please use method employing a normalization constant  $\alpha$ .

## **7 Essay (100 points)**

What is the *technological singularity* and do you find it plausible? Give a nuanced answer based on arguments from the lectures and readings. Limit essay to this page.