Lehr- und Forschungsgebiet Informatik V
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Feb. 20, 2002
G. Iwan

Introduction to Artificial Intelligence (Fall 2001)

Exam

Last name: _____

Given names: _____

Matriculation number: _____ Semester: _____

☐ Software Systems Engineering (M. Sc.) ☐ Informatik (Diplom)

☐ other: _____

Guidelines

Please read carefully.

- Do not forget to insert your name and matriculation number above.
- Use the space on the problem sheets for your solutions. You may also use the backsides of the sheets.
- If the space is not sufficient, you can use the additional solution sheet at the end of this exam, and, if necessary, obtain additional solution sheets from the persons in charge.
- Solutions on scribbling paper are not scored!
- You have 90 minutes to work on your solutions.
- **No aids** are allowed other than a dictionary.
- Do not write with a pencil!

Evaluation

Problem	Points	Result
1	21	
2	15	
3	15	
4	15	
5	10	
6	9	
7	15	
total:	100	

grade: .....

Problem 1 (21 Points)

a) Assume that the heuristic function h is *not* admissible.
Is A* still complete? Is A* still optimal? Justify your answers.

b) What is the computational complexity of resolution for propositional logic?
What is the computational complexity of resolution for first-order logic?

c) Recall that "$\models_c$" denotes reasoning under the closed world assumption (CWA). How is "$\models_c$" defined formally, that is, what does "KB $\models_c \alpha$" mean for arbitrary KB and α?

d) What is a "threat" in partial order planning?

e) Which functions are representable by neural feed-forward networks with (at most) one hidden layer?

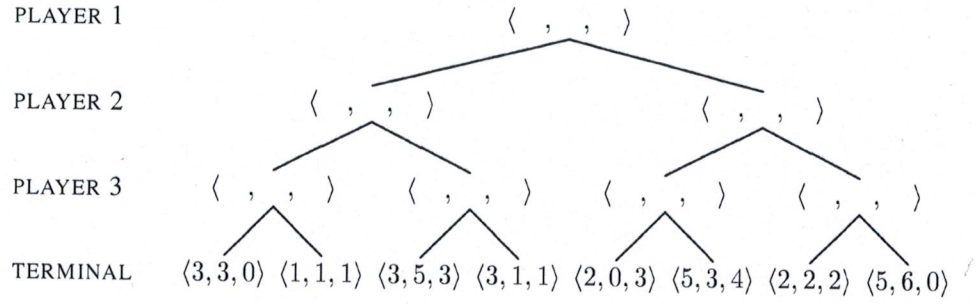
f) What are the advantages and disadvantages of neural network learning compared to decision tree learning?

g) Where does Bayesian update play a role in robotics?

Problem 2 (15 Points)

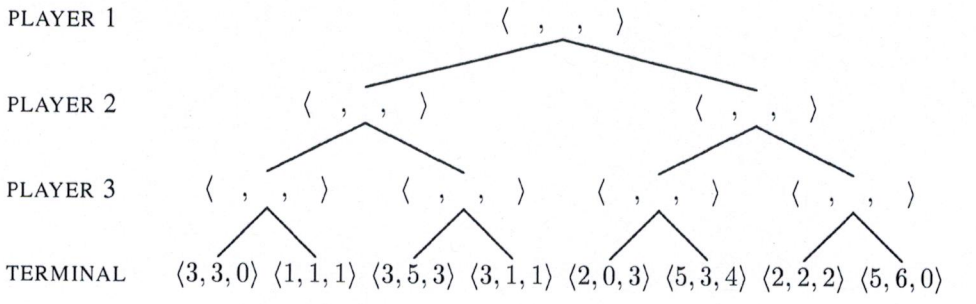
In this problem a 3-player game is considered. Therefore the utility of a state no longer is a single value but a triple of values $\langle u_1, u_2, u_3 \rangle$ where u_i is the utility value of the state for player i.

a) Assume each player i chooses the move, hence the triple $\langle u_1, u_2, u_3 \rangle$, that maximizes her own utility value u_i, e. g., for player 2 $\langle 0, 4, 6 \rangle$ is better than $\langle 1, 3, 2 \rangle$ since $4 > 3$, but for player 1 $\langle 0, 4, 6 \rangle$ is worse than $\langle 1, 3, 2 \rangle$ since $0 < 1$. Complete the following game tree by filling in the backed-up value triples for all the remaining nodes, including the root:



Which move will the first player choose (left/right)?

b) Now assume that player 1 and player 3 are playing together, that is, both choose the move that maximizes the sum of their utility values, e. g., for player 1 $\langle 0, 4, 6 \rangle$ now is better than $\langle 1, 3, 2 \rangle$ since $0 + 6 > 1 + 2$. Player 2 chooses the move as in part a). Complete the following game tree by filling in the backed-up value triples for all the remaining nodes, including the root:



Which move will the first player choose (left/right)?

Problem 3 (15 Points)

Use resolution to prove the following logical consequences:

a) $\{ (P \supset Q), (P \supset R) \} \models (P \supset (Q \wedge R))$

b) $\{ \forall x(P(x) \supset P(f(x))) \} \models ((\exists x P(x)) \supset (\exists x P(f(f(x)))))$

Problem 4 (15 Points)

Assume there are three predicate symbols $Bird$, $Flies$, Ab and two constants $tweety$ and $chilly$ (and no other predicate or function symbols). Consider the following sets of sentences:

$$\begin{aligned}\mathrm{KB}' = \{\ & \forall x[(Bird(x) \wedge \neg Ab(x)) \supset Flies(x)]\ , \\ & Bird(tweety)\ , \\ & \neg Ab(tweety)\ \}\end{aligned}$$

$$\mathrm{DC} = \{\ \forall x[x = tweety \vee x = chilly]\ \}$$

$$\mathrm{KB} = \mathrm{KB}' \cup \mathrm{DC}$$

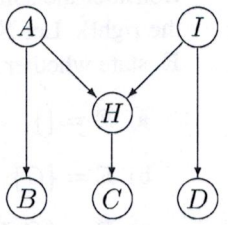
a) Determine the set Negs(KB) which is used for reasoning under the closed world assumption.

b) Prove that $\mathrm{KB} \models_c (Bird(\tau) \supset Flies(\tau))$ for $\tau = tweety$ and $\tau = chilly$.

c) Note that part b) shows that $\mathrm{KB} \models_c \forall x[Bird(x) \supset Flies(x)]$. Is this true if KB is replaced by KB′, i. e., if we do not make the domain closure assumption? Justify your answer.

Problem 5 (10 Points)

On the right, a belief network is shown.



The CPTs for B, C, D and H are given by the following tables:

A	$\mathrm{P}(B \mid \ldots)$
T	0.8
F	0.3

H	$\mathrm{P}(C \mid \ldots)$
T	0.5
F	1.0

I	$\mathrm{P}(D \mid \ldots)$
T	0.1
F	0.5

A	I	$\mathrm{P}(H \mid \ldots)$
T	T	0.9
T	F	0.4
F	T	0.7
F	F	0.0

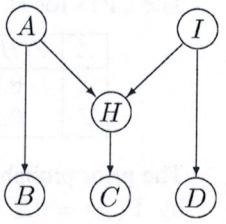
The prior probabilities for A and I are given by $\mathrm{P}(A) = 0.2$ and $\mathrm{P}(I) = 0.4$.

a) Compute $\mathrm{P}(A, \neg B, C, D, H, \neg I)$.

b) Compute $\mathrm{P}(A, \neg B, C, D, \neg I)$.

Problem 6 (9 Points)

Consider the same belief network as in the previous problem (shown on the right). Let $\mathbf{X} = \{A\}$ and $\mathbf{Y} = \{D\}$. For each of the following sets $\mathbf{E}$, state whether $\mathbf{E}$ d-seperates $\mathbf{X}$ and $\mathbf{Y}$. If so, justify your answer.



a) $\mathbf{E} = \{\}$

b) $\mathbf{E} = \{C\}$

c) $\mathbf{E} = \{C, I\}$

Problem 7 (15 Points)

Let $f(x_1, x_2)$ be the Boolean function described by the formula $(x_1 \equiv \neg x_2)$.
(Here, as usual, 0 represents FALSE and 1 represents TRUE.)

a) Is f linearly separable? Justify your answer.

b) Design a feed-forward network which represents f using *step*-functions as activation functions. (Recall: $step_t(x) = 0$ if $x < t$ and $step_t(x) = 1$ if $x \geq t$.)