Lehr- und Forschungsgebiet Informatik 5
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Mar. 25, 2009
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Introduction to Artificial Intelligence (Winter 2008)

Second Exam

Last name: ____________________

Given names: ____________________

Matriculation number: ____________________ Semester: ________

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

☐ Technische Informatik ☐ 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.
- You have 120 minutes to work on your solutions.
- **No aids** are allowed other than a dictionary.
- Do not write with a pencil!
- Answers can be given in English or German.

Evaluation

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

grade: ....

Problem 1 (15 Points)

Answer the following questions briefly in two or three sentences.

a) What is the "effective branching factor" and what can we measure with it?

b) Under which assumption is Bayesian Update correct? Express the assumption formally.

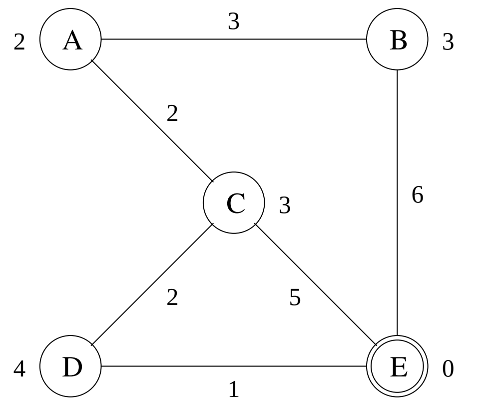
c) Name at least two strategies to speed up Resolution.

d) What is the *Markov Assumption*? Where does it play a role in robotics?

e) The negation of a satisfiable sentence is unsatisfiable. True or false? Justify your answer.

Problem 2 (10 Points)

The graph on the right represents the state space of a search problem. The initial state is A and the only goal state is E. An edge is drawn between two nodes if they can be reached from each other by an action. The edges are labeled with the costs of taking the respective action. (It is the same cost in both directions.) The heuristic values are denoted next to the states.

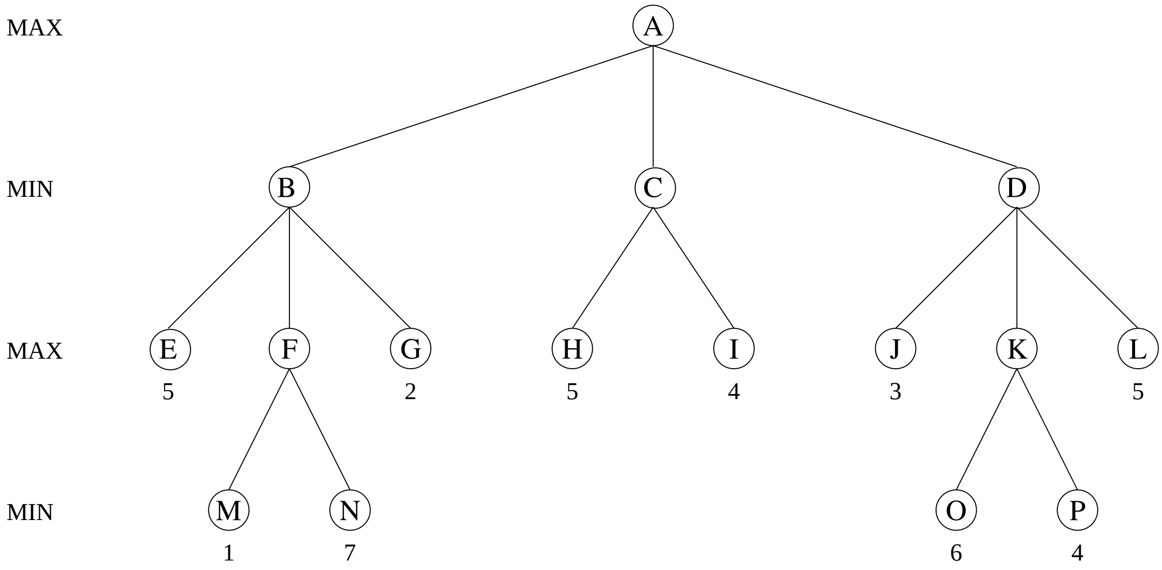


a) Draw the complete search tree that is generated by A* and indicate the order in which the nodes are **expanded** by writing "1.", "2.", "3.", etc. near the corresponding node in the tree.

b) What is the optimal path from A to E? What are the costs of this path?

c) Explain why A* did not find the optimal path and provide an alternative heuristic function h' such that A* will find the optimal path.

Problem 3 (15 Points)

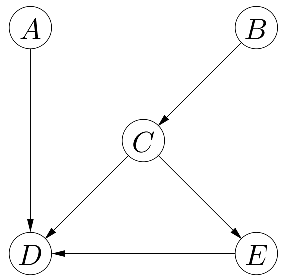


a) Perform **left-to-right** alpha-beta pruning on the given search tree. (Leaf nodes are labeled with their utility values.) Which nodes are not examined? Indicate the final values of α and β for each node.

b) Give an optimal ordering of the nodes in the search tree such that during a **left-to-right** alpha-beta pruning the minimal number of nodes is examined.

Problem 4 (15 Points)

On the right a belief network is shown together with the CPTs for the nodes C, D, and E. The prior probabilities for node B is given as $P(B) = 0.6$.



B	P(C | ...)
T	0.9
F	0.6

A	C	E	P(D | ...)
T	T	T	0.3
T	T	F	0.65
T	F	T	0.8
T	F	F	0.1
F	T	T	0.75
F	T	F	0.6
F	F	T	0.4
F	F	F	0.2

C	P(E | ...)
T	0.25
F	0.75

a) Calculate $P(\neg B \mid E)$.

b) Specify a set $\mathcal{E}$ such that $\mathcal{E}$ d-separates $\{B\}$ and $\{D\}$ and explain why this is correct.

c) Specify a prior probability for node A such that $P(D, E \mid \neg C, B) \geq 0.5$. Justify your answer.

Problem 5 (15 Points)

For each of the following statements, either prove it by means of Resolution or disprove it by specifying a suitable interpretation as a counter-example.

a) $\{\forall x \exists y P(x,y),\ \forall x(\neg P(x,x) \supset Q(x))\} \models \exists x Q(x)$

b) $\{\forall x \exists y P(x,y),\ \forall x(\exists y P(y,x) \supset Q(x))\} \models \exists x Q(x)$

Problem 6 (15 Points)

Consider the examples shown in the table on the right.

example	attributes			goal
	A1	A2	A3	*R*
1	*No*	*No*	1	*Yes*
2	*Yes*	*No*	0	*No*
3	*Yes*	*Yes*	2	*Yes*
4	*Yes*	*Yes*	0	*Yes*
5	*No*	*Yes*	2	*No*
6	*Yes*	*Yes*	1	*Yes*
7	*Yes*	*Yes*	1	*Yes*
8	*Yes*	*Yes*	2	*Yes*
9	*Yes*	*No*	1	*No*
10	*Yes*	*Yes*	0	*Yes*

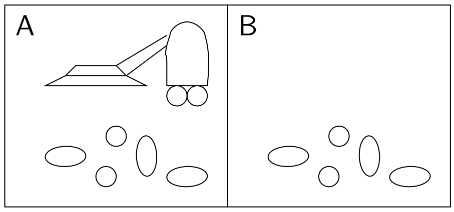
a) Perform DECISION-TREE-LEARNING for these examples, i.e. construct a decision tree by choosing the best attribute for each test *according to information theory*.
(Do *not* just draw the tree, but also provide the necessary calculations.)

In case that you need them, you may use the following values:
$I(\frac{1}{3}, \frac{2}{3}) = 0.9$;
$I(\frac{1}{4}, \frac{3}{4}) = 0.8$;
$I(\frac{1}{5}, \frac{4}{5}) = 0.7$;
$I(\frac{2}{5}, \frac{3}{5}) = 0.95$;
$I(\frac{1}{6}, \frac{5}{6}) = 0.65$;
$I(\frac{1}{7}, \frac{6}{7}) = 0.6$;
$I(\frac{3}{10}, \frac{7}{10}) = 0.9$.

b) Can the function which is given by your decision tree also by represented by a *perceptron*? If yes, present one, if no, explain why this is not possible.

Problem 7 (15 Points)

Consider the vacuum cleaner world that was introduced in the lecture, consisting of a robot and two adjacent rooms A and B, each of which can be clean or not. The robot has three possible actions at its disposal: Left, Right and Suck. The world state is described by the two unary predicates



- $In(l)$: the robot is currently in room l;
- $Clean(l)$: room l is currently clean.

a) Present STRIPS operators for the three actions Left, Right and Suck as well as appropriate Start and Finish steps using the following information:

   - After doing action Left, the robot is in room A.
   - After doing action Right, the robot is in room B.
   - After doing action Suck, the room in which the robot currently is located will be clean.
   - Initially, neither A nor B is clean, and the robot is in A.
   - The goal is to have both A and B clean.

b) Draw the partial plan that you obtain when you start with an empty plan, and subsequently insert the steps Suck, Suck and Right (in this order) to satisfy an open precondition in each case. Indicate the resulting conflict by circling the corresponding precondition/effect pair. Show how to resolve this threat.

Additional solution sheet