Problem 1 Overview (10 pts)

Explain terms shortly (using about one sentence each):

(a) Model-based AI

(b) Partially observable system

(c) Completeness of a search algorithm

(d) Horizon effect

(e) AI winter

Problem 2 Logical Inference (10 pts)

Formalize the following sentences in the propositional logic, and determine whether the inference performed is correct. Use concepts and technical definitions provided in the course.

(a)

If Börje can swim then Cecilia can ride a bicycle.
Cecilia can ride a bicycle or Antti cannot ski.
Antti can ski or Börje can swim.
―――――――――――――――
Cecilia can ride a bicycle.

(b)

If it is Mothers' Day then it is Sunday.
If it is Sunday then it is Monday tomorrow.
―――――――――――――――
It is Mothers' Day or it is Monday tomorrow.

Problem 3 Representation of Actions and Change in Logic (10 pts)

(a) We use three state variables a, b and c to represent states. Represent the binary relation $\{(000,001),(100,101)\}$ as a propositional formula.

(b) Assume Φ_{01} represents a transition relation (corresponding to some actions) on state variables a, b and c, in terms of atomic propositions $a_0, b_0, c_0, a_1, b_1, c_1$. Explain how you could test whether there is a sequence of actions of length 4 with which some (unspecified) state s is reached from itself.

(c) Let the state variables be x, y and z. What binary relation does the formula $x_0 \wedge (y_0 \leftrightarrow z_0) \wedge (y_1 \leftrightarrow z_1)$ correspond to?

$(\neg D \vee C) \wedge (\neg S \vee M)$

$(\neg D \wedge \neg S) \vee (\neg D \wedge M) \vee (S \wedge \neg C) \vee (S \wedge M)$

Problem 4 Markov Decision Process

(10 pts)

Consider an undiscounted ($\gamma = 1$) MDP having three states $s \in \{1,2,3\}$, with rewards $R(s) = -1, -2, 0$, respectively. State 3 is a terminal state. In states 1 and 2 there are two possible actions: a and b. The transition model is as follows:

- In state 1, action a moves the agent to state 2 with probability 0.8 and makes the agent stay put with probability 0.2.
- In state 2, action a moves the agent to state 1 with probability 0.8 and makes the agent stay put with probability 0.2.
- Action b moves the agent to state 3 with probability 0.1 and makes the agent stay put with probability 0.9.

Answer/do the following:

(a) Write the Bellman equation: $U(s) = \max_a EU(a \mid s) = \ldots$

(b) Apply 2 steps of either *value iteration* or *policy iteration* to determine a policy for states 1 and 2. State clearly whether you use value or policy iteration. If you use value iteration, assume that the initial utility function is all zero. If you use policy iteration, assume that the initial policy has action b in both states.

(c) If the policy does not change between two steps, can it be concluded that the algorithm has converged? (Please justify your answer with about one sentence.)

Problem 5 Decision Theory

(10 pts)

You are selling an apartment and are considering whether to use a real estate agent who takes 4 percent fee of the sales price. When you sell your apartment, you will either get a good price (100 k€) or a bad price (80 k€). The real estate agent increases the chance of getting a good price from 40% to 60%. Assume utility equals money.

(a) Draw the expectimax search tree that represents the problem.

(b) Calculate the expected utility (money) for each node in the tree.

(c) Should you hire the real estate agent?

2.48 0.342

$-1 + 0.8 \times (-2.1) + 0.2 \times (-1.31) = -2.822$

$U = -2 + 1.368 - 0.62 =$

$-2 + 0.8 \times (-1.31) + 0.2 \times (\ldots$

$-1 + 0.1 \times 1 + 0.9 \times (-2.1) = -2.69$ choose b

$-2 + 0.1 \times 1 + 0.9 \times (-2.1) =$

-2.29

$\sum_{s'} P(s,a,s')(R(s,a,s') + \gamma$

$R(s,a) + \gamma \sum_{s'} P(s,a,s')\, U(s')$

Max $R(s)$

$R(s) + \max_a \gamma \sum_{s'} P(s,a,s')\, U(s')$

The name of the course, the course code, the date, your name, your student number, and your signature must appear on every sheet of your answers.

Please note the following: your exam will be graded only if you have completed the three obligatory home assignments before the exam!