Contact during exam:
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ENGLISH

EXAM IN COURSE

TDT4136 Logic and Reasoning Systems

Tuesday December 4. 2007
Time: 09.00 – 13.00

Allowed aids D:
No printed or hand written aids are allowed.
Specific simple calculator is allowed.

The grading is expected in week 51, 2007 .

A translation from English to Norwegian is enclosed.
You are free to answer in any of these languages.

TASK 1 (25 %)

The department of Artificial Intelligence (DAI) at NTNU has acquired a robot called Marvin. One of Marvins tasks is to deliver mail into offices.

In the department, there is a corridor which is divided into two wings (West/East) with a door in between (X). There are several rooms, e.g. R1 and R2 with doors marked D1 and D2. The entry door is marked E.

The corridor has the following plan (Figure. 1.1.).

```
       ------------------------------------
      |    West        |   East            |
 _____|                |                   |_____
|R1   |                |                   |   R2|
|    /D1             \                    D2\    |
|   /                 \X                     \   |
|_____|                |                   |_____|
      |                |                   |
      |____     _______|___________________|
           \E
            \
```

Figure 1.1

R1 and R2 are offices. Each door has one colour, front and back.

Some doors are automatic (opens and closes automatically), some doors are manual.

Marvin does not know which doors are automatic, but he can sense colours, and he knows the following:

1. If all green doors are automatic then all blue doors are manual.
2. All doors are either manual or automatic but not both.
3. If there exists a blue door then all green doors are automatic.
4. E is green.
5. X is blue.

The task is to find if door X is automatic or not.

a) Formulate the problem and the task in first order predicate logic by means of the following predicates.

O(X) : X is an office

D(X) : X is a door

A(X) : X is automatic

M(X) : X is manual

C(X,Y): X has colour Y

b) Convert this set of problem formulation together with a negation of the task formulation into clausal form.

c) Use Resolution to prove whether door X is manual.

TASK 2 (20 %)

In this task, we shall treat the problem of finding a path in the corridor as a planning problem.

Marvin shall make a plan to arrive from outside through the entry door, drop mail in rooms that he has a mail for.

All doors are initially closed.

Initially, Marvin is situated at the entry door with mail to R2.

Assume that Marvin can deduce whether a door is automatic or not.

As an action repertoire, Marvin has the following:

- open door (if necessary)
- close door (if necessary)
- go to door (in the same room)
- go through door
- drop mail (in room)

a) Formulate the problem as a planning problem using Partial Order Planning.

b) Make a complete set of operator definitions for Marvin.

Make yourself a suitable set of predicates for the state of the matters.

c) Discuss problems that can arise for a Partial order planner to solve this problem.

d) Show how a plan is built up gradually as the planning evolves. Complete details are not required, but the principles must be illustrated.

TASK 3 (20 %)

Consider the two-player game described below.

```
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|A |   |  |B |
------------

Figure 3.1
```

The starting position of the simple game is shown in the figure, with both A and B standing still. A moves first.

The purpose for both agents is to remain alone after the combat. The game is played in turns. In each turn, one agent may change a velocity , and then move as far as the velocity indicates. Thereafter, it is the other agents's turn.

The velocity can be changed by +1/0/-1 at each turn. E.g. if an agents position and velocity is [2,0], it can change the velocity to -1,0 or +1, and the next state to [1,-1], [2,0] or [3,+1].

An agent is out of the game if either the other agent lands in the same field as the agent, or he goes out of the row.

a) Explain the principles for analysis of game trees by the help of Minimax analysis.

b) Draw the complete game tree down to the level of 4 plys (half-moves) using the following conventions

- Draw each state as a picture of the situation, but with the velocities added. For example, the start state could be drawn.

```
-------------
|A0|  |  |B0|
------------
```

```
Figure 3.2
```

- Mark each terminal state and write its game value (1 A wins, -1 B wins) in a circle.
- Mark the loop states with a '?', and don't expand them further. A loop state is a state that already appears on the path to the root with the same agent in turn.
- Mark non terminal nodes with a 0.

c) Now mark each node with its backed-up minimax value. Explain how you handle the '?' values and why.

d) Prove whether or not A has a winning strategy.

e) Explain what is meant by alpha-beta pruning of game trees. What are the benefits and drawbacks in relation to Mininax analysis.

f) Illustrate how the alpha-beta algorithm would shorten the search work.

TASK 4 (20 %)

Suppose that a cock is on a board of the following shape:

```
-----------------------------
| | | | |A| | |X|X| | | | |Z|
-----------------------------

  Figure 4.1
```

Squares filled with X are unavailable, while A and Z are positions on the board.

The cock can move after the following principle:

The cock has a velocity in either direction, measured in squares/timeunit

A move is to change (or keep) the velocity by one of 3 possibilities -1,0 or +1, whereafter the velocity is added to the positon.

The cock may never get outside the board or land on a X-filled square.

The cock starts in position marked A with velocity 0 and shall end in position Z with velocity 0.

a) Show how we can formulate this problem as a heuristic search problem.

b) What is the meaning and purpose/benefit of each of these concepts

1. Admissible heuristics
2. Monotone heuristics

c) Give an example of a non-trivial (e.g. non zero) admissible heuristcs for this problem.

d) It is possible to find a solution by help of bidirectional search, that is simultaneous search from start and from the goal. Explain this method, how it can be realised and what benefits and drawbacks this method may have.

TASK 5 (15 %)

a) What is meant by a semantic net ?

b) Draw a semantic net for the following knowledge base:

All robots are agents.
Robots typically moves using legs.
Door robots are robots.

Door robots dont move.
Door robots work at day and at night.
All delivery robots are robots.
Delivery robots work at day.
Cleaning robots are robots.
Cleaning robots move by wheels.
Cleaning robots work at night.
Marvin is a delivery robot.
Jimmy is a door robot.
Billy is a cleaning robot.
Billy is a delivery robot.

c) Explain how property inheritance can be done in a semantic net.

d) Formulate the semantic net by means of a logical knowlegde base.

e) Formulate the property inheritance in such a way that we get verified the following statements from the knowledge base:

i) Delivery robots move by legs

ii) Billy works at night

iii) Billy moves by wheels.