Contact during exam:
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ENGLISH

TEST EXAM IN COURSE

TDT 4136 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 (15 %)

In a corridor at the Faculty of Artificial intelligence (FAI) at NTNU, there shall be aquired an ICG (Intelligent Corridor Guide) which has got the name Marvin. One of Marvins tasks is to deliver mail into offices.

The corridor is divided into two wings (West/East) with a door in between (M). There are several rooms, e.g. RA and RZ with doors marked A and Z. The entry door is marked E.

The corridor has the following plan (Fig. 1.).

```
       -------------------------------------
      |    West         |    East            |
 -----|                 |                    |------
|RA  _|                 |                    |_    RZ|
|   /A                \ M                     Z\     |
|  / _                 \                      _ \    |
|_____|                 |                    |______|
     |                  |                    |
     |_____     -------|--------------------|
           \E
            \
                 Fig. 1
```

In the corridor, there are 4 doors, A, E, M, Z.

RA and RZ are offices.

Marvin is colour blind, but he knows that

- all doors are either red, blue or yellow
- each door has at most one colour. (All doors have the same colour on both sides.)
- all office doors are red,
- the entry door is yellow,
- if two doors belong to the same room, they have different colours

The task is to show that there exists a colour that the door M can have, and to find this colour.

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

O(X) : Room X is an office

D(X) : X is a door

B(X,Y): Door X belongs to room Y

C(X,Y): Door X has colour Y

b) Convert the predicat logic formulas to clausal form.

c) Combine earlier formulas in clausal form with the negation of the sentence that shall be proved, and show the steps which are used in order to achieve Resolution refutation.

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, visit room A and Z in arbitrary order, and thereafter to get out again to the starting point.

The entry door is initially closed.

When Marvin is finished, all doors must be left in the state which they were in initially, but doors shall not be opened and closed unnecessarily.

As an action repertoire, Marvin has the following:

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

a) Make a complete set of STRIPS operators for Marvin.

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

b) Discuss problems that can arise, and whether this task is suited for a linear planner.

TASK 3 (20 %)

A goods delivery robot can move is a quadratic city araea, not unlike Manhattan, and shall try to find the shortest way from a road cross to another. However, the robot has a somewhat simplified apprehension of the the situation because during its planning, it tries to find the shortest way by straight lines.

a) Describe this problem as a problem for searching in a state space.

b) Which consequences will the robot's imperfect heuristics have for the result and the efficiency of the solution.

c) Explain what is meant by the concepts admissible and monotone heuristics.

Explain which benefits one can have if it is known that the heusristics is monotone.

Also, explain whether the robots' heuristics is admissible and/or monotone.

d) Suppose that the robot has a built in adaptability that makes it cabable of adjusting the heuristics on the basis of experiences during the solution of subtasks, when the estimates are wrong relative to the correct costs, by a constant factor. Use this to modify the algorithm for heuristic search taking this into consideration.

e) Suppose that the robot has am optimal heuristics for quadratic city blocks, but that the robot is put on the task of delivering goods in open terrain.

Discuss once more which concequences that robot's imperfect heuristics have for the result and the efficiency of the solution.

TASK 4 (20 %)

Consider one case of a crossword puzzle (e.g. this week's Guardian Weekly Crossword Puzzle as shown below)

```
----------------------------
|## 1   2   3   4   5  ####|
|##  ##  ##  ##  ##  ## 6##|
| 7              ## 8      |
|##  ##  ##  ##  ##  ##  ##|
|## 9      ##10            |
|######  ##11##  ######  ##|
|##12              13    ##|
|##  ######  ##  ##  ######|
|14    15      ##16    17##|
|##  ##  ##  ##18##  ##  ##|
|19      ##20              |
|##  ##  ##  ##  ##  ##  ##|
|####21                  ##|
----------------------------
```

```
Across

 1. Virtual  environment (10)
 7. System of divine worship (8)
 8. Opinion (4)
 9. Lay hold of (4)
10. English cheese (7)
12. Uninvited guest (11)
14. North American mammal (7)
16. Fall (4)
19. Hereditary unit (4)
20. Mild mental disorder (8)
21. Outward look (10)
```

Down

```
 1. Trunk (5)
 2. Cut of beef from near the ribs (7)
 3. Destroy (4)
 4. Exactly on time (8)
 5. Quibble (5)
 6. Eat voraciously (6)
11. Cadge (8)
12. Tufted beard on chin (6)
13. Barbed whaling spear (7)
15. Inexpensive (5)
17. Cost of purchase (5)
18. Dialectical characteristic (4)
```

SOLUTION

```
----------------------------
|   C Y B E R S P A C E     |
|   H   R   U   U   A   D   |
| R E L I G I O N   V I E W|
|   S   S   N   C   I   V   |
|   T A K E   S T I L T O N|
|       E   S   U       U   |
|   G A T E C R A S H E R   |
|   O       A   L   A       |
| R A C C O O N   D R O P   |
|   T   H   U   B   P   R   |
| G E N E   N E U R O S I S|
| E     A   G   R   O   C   |
|     A P P E A R A N C E   |
----------------------------
```

a) Given that a computerized crossword puzzle dictionary has listed for each keyword and length of solution, a complete list of candidates.

Then, the task of distributing the letters on the crossword can be seen as a constraint satisfaction problem. Discuss methods for efficiently solving this kind of problem, (disregarding that a fast computer can solve it by brute force).

b) We shall now concentrate on the problem of finding candidates that are not stored in the list of candidates.

Discuss methods how you can use a knowledge base and a reasoning system to create such candidates.

You shall show some general strategies, but you need only consider examples that are specific to this particular puzzle. The treatise shall be so that in principle they can be applied to some other crossword puzzles. You may ignore problems of noun plurality (boy, boys) and verb tenses (play,plays).

TASK 5 (20 %)

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

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

c) It is known that CHESS 4.5 used iterative deepening with pre-sorting of the nodes as a strategy for playing chess. Explain the benefits of this strategy.

d) Make an example showing that it may pay off to pre-sorting of the nodes in the alpha-beta procedure.