Artificial Intelligence
Örebro University,

DT112G, DT2016, DT2022

First Exam – Theory (4.5hp)

Date: January, 10th 2017

Teacher: Franziska Klügl (Mobile 070-6689179)

Allowed Aids: Calculator and/or Swedish/English Dictionary

Grading:

DT112G: 20 points are required for degree 3; 30 points for degree 4 and 35 points for degree 5.
DT2016: 20 points are required for degree 3; 30 points for degree 4 and 35 points for degree 5.
DT2022: 20 points are required for degree G, 32.5 points required for degree VG.

Remarks:

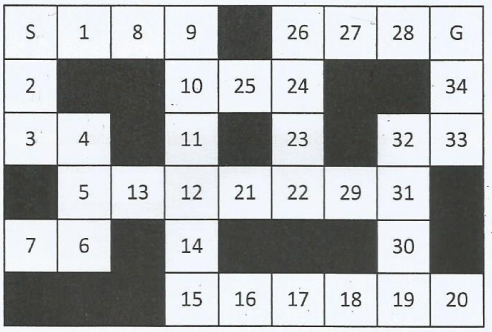
- You may answer in Swedish or English.
- Use a new sheet for the solution of each task.
- Read the task descriptions carefully and do not forget to answer **all** questions.
- **Write clearly, an un-readable answer may be end with 0 points.**
- If the task is not clear, make reasonable assumptions and document them
- Motivate and justify all your answers in sufficient detail.
  Never answer with just one word, but argue and explain. This helps the examinator to understand your reasoning and evaluate your work.

Artificial Intelligence, HT 2015/2, First Exam

Task 1: Search

a) **3 Points**

The following figure shows a layout of an exhibition space (or a labyrinth) in which a robot should move from position S to position G.



White cells can be moved on, black cells are blocked. Numbers in the cells are labels naming the cell, *not* costs passing over this cell. You may assume uniform path-costs.
Represent the robot navigation problem from location S to location G as a search problem with all the relevant elements necessary for its description.

b) **3 Points**

What path would be found, if the robot would use the following search algorithms for determining its path from position S to G. Assume that the robots always tests a left turn first (from the robot perspective, not from the user perspective), if there are different options to select:

- depth-first search.
- breadth-first search

Justify your answer! What did you do to generate the path.

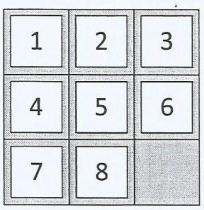
c) **3 Points**

What would be a good A* heuristic for navigating in the navigation graph/labyrinth? Justify your answer. Show how you would use A* with your suggested heuristic for solving this robot navigation problem. Hereby clearly give the content of the involved lists in each step.
Depending on your heuristic the answer to this task may take some effort. You may shortcut states with only one successor or stop after a few steps. However, it must become clear how the algorithm actually works.

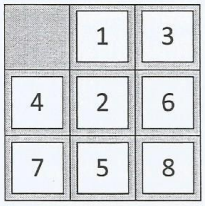
d) **4 Points**
Explain the major – at least 2 – differences between state-space search like the algorithms in b or A* and local search algorithms (like greedy search or simulated annealing)? Does it make sense to solve the robot navigation problem using local search. Explain the principle, you do not need to solve.

Task 2: Planning

Automated Planning can be also applied to Puzzles such as the N-Puzzle. In the version with 8 tiles (8-Puzzle), there are 8 numbered tiles that should be brought into the following goal state configuration:



Initially, our 8-Puzzle is in a start state like the following



To reach the goal state from this state, tiles can be moved into/through the free space. The problem is to find the minimal sequence of movements in the 8-Puzzle so that the goal state is produced starting from the initial state. The 8-Puzzle can be solved using automated planning. For that, first the planning domain with action schemata and situation descriptions need to be generated.

a) **1 points**
Describe the start and goal situation given above using the following predicates:
(tile ?x) ?x is a tile
(position ?p) ?p is a x-value or a y-value for a tile coordinate
(at ?t ?x ?y) the tile ?t is at positions ?x, ?y
(blank ?x, ?y) the empty space is at position ?x, ?y)
(dec ?p ?pp) encode decrement of positions
(inc ?p ?pp) encode increment of positions
(dec ?p ?pp) and (inc ?p ?pp) enable to formulate neighbouring positions in different directions

b) **2 Points**

Consider the following action schemata defining the planning domain for the 8-Puzzle

```
Action( move-up (?t ?px ?py ?by)
    Precondition:  (tile ?t), (position ?px), (position ?py),
                   (position ?by), (dec ?by ?py), (blank ?px ?by)
                   (at ?t ?px ?py))
    Effect   not (blank ?px ?by), not (at ?t ?px ?py)
           (blank ?px ?py) (at ?t ?px ?by)

Action( move-down (?t ?px ?py ?by)
    Precondition:  (tile ?t), (position ?px), (position ?py),
                   (position ?by), (inc ?by ?py), (blank ?px ?by)
                   (at ?t ?px ?py))
    Effect   not (blank ?px ?by), not (at ?t ?px ?py)
           (blank ?px ?py) (at ?t ?px ?by)

Action( move-left (?t ?px ?py ?bx)
    Precondition:  (tile ?t), (position ?px), (position ?py),
                   (position ?bx), (dec ?bx ?py), (blank ?bx ?py)
                   (at ?t ?px ?py))
    Effect   not (blank ?bx ?py), not (at ?t ?px ?py)
           (blank ?px ?py) (at ?t ?bx ?py)

Action( move-right (?t ?px ?py ?bx)
    Precondition:  (tile ?t), (position ?px), (position ?py),
                   (position ?bx), (inc ?bx ?py), (blank ?bx ?py)
                   (at ?t ?px ?py))
    Effect   not (blank ?bx ?py), not (at ?t ?px ?py)
           (blank ?px ?py) (at ?t ?bx ?py)
```

Give a standard sequential plan that solves the problem from task a) using the given action schemata. Why a partial order plan does not make sense in this scenario?

c) **4 Points**

Describe how regression works in general and using the given problem as an example (2 Points). What would you prefer for solving the 8-Puzzle as planning problem: regression or progression? Justify your answer (2 Points)

d) **3 Points**

What are the main differences between Planning (as in this task) and Search (as in task 1)?

Task 3: Knowledge Representation

a) **1 Points**
Transform the following a predicate logic formula into CNF (Conjunctive Normal Form)
$\forall x\ human(x) \Rightarrow (\exists t\ fallsAsleep(x,t))$

b) **2 Points**
Why Conjunctive Normal Form is so important?

c) **3 Points**
Consider the following knowledge base:

$a \Rightarrow b$
$b \Rightarrow \neg a$
$\neg b \Rightarrow (c \wedge a)$
$\neg d \Rightarrow \neg c$
a

The question is whether the knowledge base entails **d** that means we want to know whether the hypothesis **d** is true with respect to the knowledge.
In the lecture, we have discussed the following techniques for solving such a problem:

- Inference by Enumeration using Truth Tables
- Forward/Backward Chaining using Horn Clauses
- Resolution

What technique could you use for checking whether this knowledge based entails d? Are all of them applicable to the given problem? Justify your answer.

d) **4 Points**
Use **Resolution** to solve the problem described in c). Cleary describe each step that you take in the overall process.

Task 4: Problem Modeling and Solving

8+1 points

In the AI course, we have seen several problems as examples for AI problems and tried to solve them by applying appropriate generic problem solving methods. How to model the problem to be solved in a suitable way, was hereby the central question.

Image you want to program a baby-sitter robot that accompanies your child through a Christmas Market (Jul Marknad). The child obeys the robot as long as it does not see a booth with toys. The market is like a labyrinth with walkways that are more or less crowdy. There is exactly one booth with toys. The robot needs to find the fastest way through the market without passing the toy booth.

For each of the following techniques, consider how and under which circumstances this problem can be solved with the technique. Describe how you would model the problem so that the technique would fit. Is there an approach that you would not use at all?

Justify whether the method would be a good choice or not.
(*The discussion of the methods gives you 2 points each*)

a) Heuristic Search (such as A*)
b) Constraint Satisfaction
c) Intelligent Planning
d) Case-Based Reasoning

e) Which technique would you select?