Written examination
TIN172/DIT410, Artificial Intelligence

Tuesday 2nd June 2015, 14:00–18:00

Examiner: Peter Ljunglöf, 0736–24 24 76
(will come to the exam at 15:00–15:30)

This examination consists of eight questions of which two are advanced (questions 5 and 8). A correctly answered question gives you one point, and if the answer is almost correct you might get a half point.

Grades   To get grade 3/G you need at least 4 points.

To get grade 4/VG you need at least 5 points,
of which at least 1 must be from the advanced questions.

To get grade 5/VG+ you need at least 6 points,
of which at least 2 must be from the advanced questions.

Tools   Paper and pencil.

Crayons, paper glue, scissors.

One A4 cheat sheet with any information you want on it (both sides allowed).

No books or calculators.
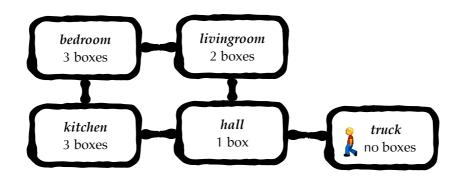
Notes   Start every question on a new paper,
and write your ID number at the top of every paper.

Write readable, and explain your answers!

Moving out of your apartment

After having successfully completed the AI course, you get a job in another town (as an AI expert of course), and you have to move out of your apartment. You have already packed all your belongings in nine moving boxes, scattered around the apartment, now all you have left to do is to move these boxes into the moving truck, which is parked just outside of the apartment. The boxes are too big to carry, so you have to push them between the rooms. The following graph shows the four rooms in the apartment, the truck, how many boxes are initially in which rooms, and how the rooms are connected:

On each turn, you can either *move* or *push a box* into an adjacent location, in any direction: *north, south, east, west*. When this story begins, you have just parked the truck.

Question 1. Formulate this problem as a search problem, i.e.:

  a) What is a suitable representation of the search states?

  b) How will the starting state look like?

  c) How will the goal check be?

Question 2. The following is a heuristic, where *N(r)* is the number of boxes in location *r*:
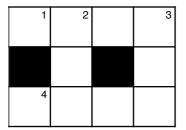
$$h \; = \; \sum_{r \neq truck} N(r)$$

  a) Explain why *h* is admissible.

  b) Describe a different admissible heuristics *h'* that dominates *h* (i.e., $h' \geq h$ in all search states). Explain why it is admissible and why it is dominating.

Question 3. Formulate the problem as a STRIPS planning problem, i.e.:

  a) What features variables are needed, and what are their respective domains?

  b) What actions are there?

  c) Give a STRIPS definition of one of the pushing actions.

Crossword puzzle

Lexicon: APA, ASP, FALK, FALL, KAP, KUL, SPEL

This crossword puzzle can be formulated as a CSP using the following variables and constraints:

Variables are of the form X_i, meaning to place a vertical or horizontal word in the ith square. All variables have the whole lexicon as domain.

Constraints are of the form $X_i[n] = X_j[m]$, meaning that the nth letter of word X_i is equal to the mth letter of word X_j; and of the form $len(X_i) = k$, meaning that the word X_i has k letters.

Question 4. Draw the constraint graph and make it arc consistent, i.e.:

a) Perform domain consistency and draw the constraint graph with the resulting variable domains. Name the arcs so that you can refer to them in (b).

b) Perform arc consistency on the whole graph. Write in which order you process the arcs.

c) How will the domains be after the whole graph is arc consistent?

Question 5* (advanced). Perform Variable Elimination on this CSP:

a) First eliminate the variable corresponding to the rightmost vertical word.

b) Then eliminate the bottommost horizontal word.

Ragnarök

Rising ocean levels (O) can be a result of global warming (G), or be a sign that Ragnarök (R) has started, the final apocalypse in Norse mythology. Another result of Ragnarök is that the sun is devoured (D) by the Fenris wolf.

The probability that Ragnarök has started is 10%, but global warming is happening with 90% probability. If Ragnarök is happening, then it is absolutely certain that the oceans will rise and the sun will be devoured. However, if Ragnarök is not happening, we have the following probabilities:

$$P(+d \mid -r) \quad\quad = \; 20\%$$
$$P(+o \mid -r, +g) \; = \; 80\%$$
$$P(+o \mid -r, -g) \; = \; 40\%$$

(where $+x$ means that the event X is a fact, and $-x$ means that X is false).

Question 6. Draw the Bayesian network corresponding to the information given above.

Also write down the corresponding probability tables.

Question 7. Calculate the following probabilities:

   a) What is the probability that the sun is devoured?

   b) What is the probability that Ragnarök is happening, given that the sun is devoured?

Since you don't have a calculator, you don't have to do the calculations – it's enough if you answer as a quotient (e.g., 34/86). But you have to explain how you got that result.

Question 8* (advanced). Calculate the following probabilities using Variable Elimination:

   a) What is the probability of Ragnarök, given that the oceans are rising?

   b) What is the probability of Ragnarök, given that the oceans are rising and that the sun is devoured?

Remember to explain the steps in your reasoning, and don't perform unnecessary calculations.