Example exam for IN4010TU Artificial Intelligence Techniques

Rogier van Dalen

23rd December 2005

This example exam is meant solely to give you an idea of what kind of questions you can expect on the actual exam and how much extra preparation you will need. It is not representative for the real exam in terms of length or coverage of topics.

1. This question will view the problem of sorting a list of items as a search problem. Given a list of numbers in random order, for example $\{35, 57, 4, 473, 1029, 96\}$, we want to get the same numbers in ascending order. We define a successor function that swaps any two numbers.

   (a) Give the initial state and goal test.

   > **Solution:**
   >
   > **Initial state** The numbers are in a random order.
   >
   > **Goal test** The list of numbers is in ascending order; i.e. every adjacent pair of numbers is in ascending order.

   (b) Give a possible cost function.

   > **Solution:** Trivial: every swap costs 1, or another constant number.

   (c) Give an admissable heuristic function and explain why it is admissable.

   > **Solution:** An admissable heuristic is one that never overestimates the cost to reach the goal. A trivial one that is correct is $h(n) = 0$. Another one is the number of adjacent pairs that are not in ascending order. No swap will cause more than two adjacent pairs to become ordered if they were not yet. (You can prove this if you want.)

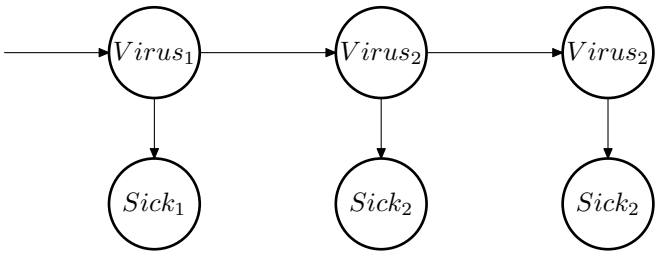
2. Your housemate is not always able to get up in the morning, due to sickness. This may be caused by a virus, but other causes (think: being hungover) are also possible. However, you need to decide whether you are going to make her fresh orange juice. To help you make the best decision you produce a dynamic Bayesian network with the following dependencies:

$$\begin{aligned} P(Virus_i = true | Virus_{i-1} = true) &= 0.7 \\ P(Virus_i = true | Virus_{i-1} = false) &= 0.02 \\ P(Sick_i = true | Virus_i = true) &= 0.95 \\ P(Sick_i = true | Virus_i = false) &= 0.2 \end{aligned}$$

   (a) Which variables are the evidence variables and which are the hidden variables?

Solution: $Virus_i$ are the hidden variables; $Sick_i$ are the evidence variables.

(b) Draw part of the unrolled network. Add conditional probability tables.



Solution:

$Virus_{i-1}$	$P(Virus_i = true)$
f	0.02
t	0.7

$Virus_i$	$P(Sick_i = true)$
f	0.2
t	0.95

(c) Your housemate has been sick for two days, i.e. $Sick_1 = true$ and $Sick_2 = true$. What is $\mathbf{P}(Virus_2|Sick_1 = true, Sick_2 = true)$? Assume $\mathbf{P}(Virus_0) = \langle 0.5, 0.5\rangle$.

Solution: Using the forward algorithm, we first calculate $Virus_1$. (See page 543 in the book.)

$$\begin{aligned}
&\mathbf{P}(Virus_1|Sick_1 = true)\\
&= \alpha\mathbf{P}(Sick_1 = true|Virus_1) \sum_{v\in\{true,false\}} \mathbf{P}(Virus_1|Virus_0 = v)P(Virus_0 = v)\\
&= \alpha \Big\langle P(Sick_1 = true|Virus_1 = true) \sum_{v\in\{true,false\}} P(Virus_1 = true|Virus_0 = v)P(Virus_0 = v),\\
&\quad P(Sick_1 = true|Virus_1 = false) \sum_{v\in\{true,false\}} P(Virus_1 = false|Virus_0 = v)P(Virus_0 = v)\Big\rangle\\
&= \alpha\,\langle 0.95(0.7\cdot 0.5 + 0.02\cdot 0.5), 0.2\cdot(0.3\cdot 0.5 + 0.98\cdot 0.5)\rangle\\
&= \alpha\,\langle 0.342, 0.128\rangle \approx \langle 0.728, 0.272\rangle
\end{aligned}$$

Using that, we calculate $Virus_2$ in the same manner.

$$\begin{aligned}
&\mathbf{P}(Virus_2|Sick_1 = true, Sick_2 = true)\\
&= \alpha\mathbf{P}(Sick_2 = true|Virus_2)\\
&\quad \sum_{v\in\{true,false\}} \mathbf{P}(Virus_2|Virus_1 = v, Sick_1 = true)P(Virus_1 = v|Sick_1 = true)\\
&= \alpha\langle P(Sick_2 = true|Virus_2 = true)\\
&\quad \sum_{v\in\{true,false\}} P(Virus_2 = true|Virus_1 = v, Sick_1 = true)P(Virus_1 = v|Sick_1 = true),
\end{aligned}$$

$$P(Sick_2 = true|Virus_2 = false)$$
$$\sum_{v \in \{true,false\}} P(Virus_2 = false|Virus_1 = v, Sick_1 = true)P(Virus_1 = v|Sick_1 = true)\rangle$$
$$= \alpha \langle 0.95(0.7 \cdot 0.342 + 0.02 \cdot 0.128), 0.2 \cdot (0.3 \cdot 0.342 + 0.98 \cdot 0.128)\rangle$$
$$= \alpha \langle 0.229862, 0.045608\rangle \approx \langle 0.834, 0.166\rangle$$

You definitely should make fresh orange juice for her.