Example questions for the MI examination

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On the next six pages you will find six questions covering different aspects of the course. The questions differ in their level of difficulty, and for each correctly answered question you will get a certain amount of points as indicated by each question. When solving the questions you are allowed to use all available material such as books, pocket calculator, etc., however, laptops are *not* allowed.

Before you answer a question make sure that you have read the question carefully. Moreover, make sure that you argue for your answers (e.g. include intermediate results) so that it is possible to follow your line of thought. Finally, it is important that your solutions are presented in a readable form.

DISCLAIMER: The main purpose with this example exam sheet is to give you a general impression of the types of questions that you may see at the exam. The example questions are all taken from the exercise sheets that you have seen during the course. The actual questions at the exam may, however, differ in type, scope, and form compared to the ones that you see here.

Good luck with the questions

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Question 1 - 20 points

You are planning a dinner for three guests. The menu should consist of at least one appetizer, exactly one main dish, and at least one desert (multiple appetizers or deserts are o.k.). You have a list of candidate dishes, and for each guest you know whether they like that dish or not:

Item	Cost	Guest 1	Guest 2	Guest 3
Appetizer 1	5			o.k.
Appetizer 2	5		o.k.	
Appetizer 3	15		o.k.	o.k.
Appetizer 4	30	o.k.		
Main dish 1	90		o.k.	o.k.
Main dish 2	100	o.k.		o.k.
Dessert 1	30		o.k.	
Dessert 2	50	o.k.	o.k.	

Your menu must contain for each guest at least one item that they like. Use A^* to find a minimal cost solution:

- Define the underlying state space problem
- Define a heuristic function that underestimates the true optimal cost function *opt*.
- Show how A will find the minimal cost solution using this heuristic function.

Question 2 - 15 points

The following definite clause knowledge base describes a small kitchen scenario:

$$\begin{array}{l} \mathit{dinner\_ready} \leftarrow \mathit{soup\_ready}, \mathit{main\_ready} \\ \mathit{main\_ready} \leftarrow \mathit{main\_veggie\_ready} \\ \mathit{main\_ready} \leftarrow \mathit{main\_meat\_ready} \\ \mathit{main\_meat\_ready} \leftarrow \mathit{meat\_fried}, \mathit{sauce\_ready} \\ \mathit{main\_veggie\_ready} \leftarrow \mathit{veggies\_fried}, \mathit{sauce\_ready} \\ \mathit{meat\_fried} \\ \mathit{sauce\_ready} \\ \mathit{soup\_ready} \end{array}$$

- Draw the full proof tree generated by the query

$$\text{ask}\,\mathit{dinner\_ready}$$

- From the knowledge base in Problem 3 we can not infer $\neg \mathit{main\_veggie\_ready}$. We extend the knowledge base with the integrity constraint

$$\mathit{false} \leftarrow \mathit{main\_meat\_ready}, \mathit{main\_veggie\_ready}$$

  (we do not prepare two different main dishes). Show how you can now prove $\neg \mathit{main\_veggie\_ready}$ using the DCDeduction algorithm.

Question 3 - 15 points

In the graphs in Figures 1 and 2, determine which variables are d-separated from A.

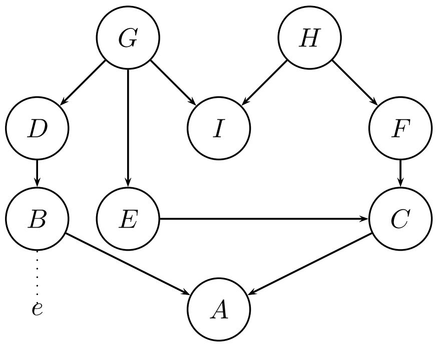


Figure 1: Figure for Question 3.

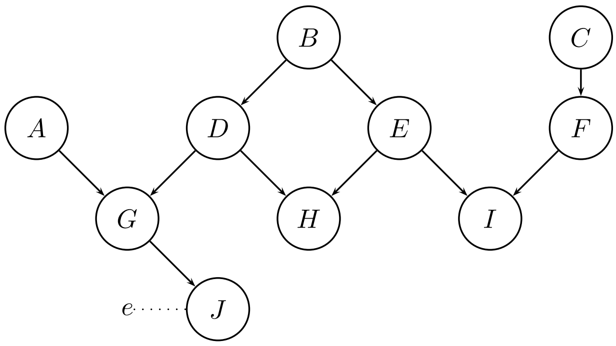


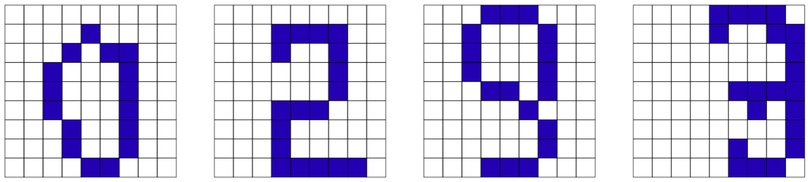
Figure 2: Figure for Question 3.

Question 4 - 15 points

A routine DNA test is performed on a person (this exercise is set in the not too distant future!). The test gives a positive result for a rare genetic mutation linked to Alzheimer's disease. The mutation is present in only 1 in a million people. The test is 99.99% accurate, i.e. it will give a wrong result in 1 out of 10000 tests performed. Should the person be worried?

Question 5 - 20 points

Design a Bayesian network that can be used to recognize handwritten digits 0,1,2,. . . ,9 from scanned, pixelated images like these:



- What are hypothesis and information variables?
- Could there be any useful mediating variables (consider e.g. the last image above)?
- How could you design a network structure
  - so that the conditional independencies are (approximately) reasonable
  - so that specification and inference complexity remain feasible
- How do you fill in the conditional probability tables?

Question 6 - 15 points

Assume that we have the following training examples:

X_1	X_2	T
1	1	1
-1	1	-1
1	-1	1
-1	-1	-1

That is, with input $X_1 = 1$ and $X_2 = -1$ we want the output 1.

Consider a perceptron with threshold input 1 and with initial weights $w_0 = 0$,$w_1 = 0$ and $w_2 = 0$.

- Show the first two iterations when learning a perceptron (having the sign function as activation function) using learning rate $\alpha = 0.25$ and error function $E = t - o$; t is the desired output and o is the actual output.