Homework 1 Advanced Machine Learning
For the deadline see Canvas
Version: Mon 19$^{\text{th}}$ Nov, 2018 at 10:35.

Introduction

1. Each group has to submit a **pdf** with their answers and explanation. **Please put your names and group number at the top of the hand in**.

2. For questions about this homework assignment use the Discussion Board on Canvas.

3. Of course you may use a calculator or a programming environment such as Matlab or Python. **But your report should not contain any code. Explain your computations and results in English!**

4. It is allowed to incorporate handwritten notes or derivations or drawings in your submission as long as these are readable!

5. Explain your answers!

Exercise 1: Bayesian networks

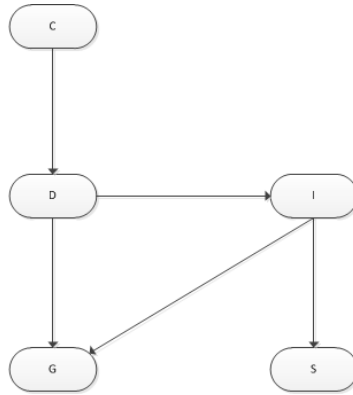Consider the Bayesian Network in Figure 2

Figure 1: Bayesian network of exercise 1.

The conditional probability distributions (CPDs) for the Bayesian Network are given below.

C	C_0	C_1
	0.4	0.6

D	d_0	d_1
c_0	0.2	0.8
c_1	0.4	0.6

I	i_0	i_1
d_0	0.5	0.5
d_1	0.6	0.4

G	g_0	g_1	g_2
d_0, i_0	0.1	0.4	0.5
d_0, i_1	0.4	0.4	0.2
d_1, i_0	0.3	0.4	0.3
d_1, i_1	0.7	0.2	0.1

S	s_0	s_1
i_0	0.3	0.7
i_1	0.8	0.2

Part a

Compute the probability distribution $P(S)$.

Part b

Compute the conditional probability distribution $P(G, I = i_0)$ and $P(G|I = i_0)$

Part c

Compute the conditional probability distribution $P(S, G = g_0)$ and $P(S|G = g_0)$

Exercise 2: Markov networks

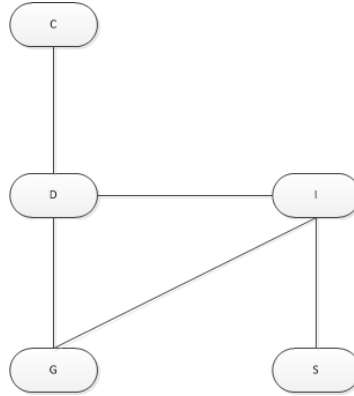Now we model the above Bayesian Network as a Markov model. With the different factors

Figure 2: Markov network of exercise 2.

given by

C	C_0	C_1
	3	7

D	d_0	d_1
c_0	2	8
c_1	3	7

I	i_0	i_1
d_0	2	2
d_1	6	2

G	g_0	g_1	g_2
d_0, i_0	1	4	5
d_0, i_1	4	4	2
d_1, i_0	3	4	3
d_1, i_1	7	2	1

S	s_0	s_1
i_0	2	8
i_1	8	2

Part a

Compute the factor $\Phi(S)$ and corresponding probability distribution $P(S)$.

Part b

Compute the factor $\Phi(G, I = i_0)$ and corresponding probability distribution $P(G|I = i_0)$.

Part c

Compute the factor $\Phi(S, G = g_0)$ and corresponding probability distribution $P(S|G = g_0)$.

Message passing

Now we want to answer the questions of Exercise 2 using message passing. But before we can do this we need to combine the factors $\Phi(I, D)$ and $\Phi(I, D, G)$ into one factor using factor multiplication.

Part a

Explain why we need to do this in order to apply message passing. Moreover compute the factor product of $\Phi(I, D)$ and $\Phi(I, D, G)$.

Part b

Solve Part a of the previous question using message passing.

Part c

Solve Part b of the previous question using message passing.