AI: Principles and techniques
Programming assignment 3 (Bayesian Networks block)

The goal of this assignment is to get a thorough understanding of inference in Bayesian networks. For this you have to implement the Variable Elimination algorithm and apply it on inference queries in different Bayesian networks. Keep a log (textfile) of the steps your algorithm does on a particular network with a particular elimination ordering according to the steps on the slides, e.g., what are the query/evidence variables, what are the factors, what is the elimination ordering, which factors are processed, etc.

There is code available in Java and Python for reading in a network from a file, and some structure to help you focus on the core of this assignment: efficiently implementing the algorithm using suitable data structures. The Bayesian Network repository (http://www.bnlearn.com/bnrepository/) gives you many examples of real-world (and less-real-world, but known benchmarks) networks. You can also construct example networks yourself. The example code uses the .bif format.

The programming assignment comes in two parts:

- In **3a** we ask you to implement multi-dimensional factors and do the necessary calculations on them (reduction, product, marginalization)
- In **3b** you build on this to implement variable elimination.

Bonus points are offered if your algorithm can process non-binary variables (1 bonus point extra; grade becomes 0.5 higher) and if you experiment with different heuristics for the elimination order (e.g., least-incoming-arcs first, contained-in-fewest-factors-first, or others; also 1 bonus point).

To see if your algorithm's results are correct, you can compare them to the outcomes in AISpace (http://aispace.org/bayes/). Write a short scientific report on your implementation, describing specification, design, implementation, testing, and conclusion (as in the IMRAD method). We expect a report of ca. 4 - 8 pages (not counting the appendices).

Also check out the assessment form on Brightspace!

The **programming language** for the task is:

1. Java (version 11 or later), or
2. Python (version 3.6 or later)

Choose informative names for the used variables, constants and functions. Use comments to make your code more accessible. Take care that your output clearly informs on the working of your algorithm. You may use libraries and pre-defined data structures etc. of course, as long as you implement the VE algorithm yourself. You may use (as example or as part of your program)

the code for reading in Bayesian networks, but document where and how you used it and clearly comment chances to the source code. It is allowed/advised to make this task in a couple.

To hand in:
Both report (in .pdf) and (zipped) code. Report on both 3a (factor calculus) and 3b (variable elimination using factor calculus) in the final report and make sure to explicate explicitly how the computations are implemented. Do not forget your name(s), student number(s), course, number of the task, date, etc. Hand in on Brightspace. If you submit in a couple, let one of the students submit report and code and the other just a text file with the name of the other student for easy reference.

Deadline:
Friday 04-12-2020 23.59 via Brightspace.