AI: Principles and techniques - Programming assignment 3

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/) or it's Jupyter-based alternative AISpace2 (https://aispace2.github.io/AISpace2/index.html). 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.

Report

Write a short scientific report on your implementation, describing the project, your code, your experiments, their results, and your interpretation & conclusions. You can use the various parts of the assignment to help you structure the report. For a full list of elements to include in your report, check out the "writing a programming report" section at the course guide (learning task 0) and the assessment form for this assignment. We expect a formal (!) report of ca. 4 – 8 pages (not counting possible appendices).

To hand in

Both a report (pdf) and the code (zip). Do not forget to list your name(s), student number(s), course, number of the task, date, etc. in your code and report. If you submit in a couple, let one of the students submit the report and code, and the other just a text file with the name of the other student for easy reference.

The deadline of this assignment will be communicated through Brightspace.

Programming questions can be sent to the teaching assistants either during the practical sessions (preferably) or by email. Content-wise questions can be sent to the lect