# *Assignment 3: Variable Elimination for Bayesian Networks*

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## *1 Overview*

Bayesian networks provide a compact representation of the joint probability distribution of a finite set of random variables. The graph structure of a Bayesian network defines the conditional dependence of variables; the conditional probability tables (CPT) define the conditional probability distribution of the variable of a node given the variables of the the parents of the node. With the help of the chain rule and condition the joint probability distribution can be reconstructed efficiently from the network information.

## *2 The variable elimination algorithm*

The *variable elimination algorithm* for Bayesian networks is a dynamic programming technique to avoid repeated calculation of the same expression. The algorithm makes use of so-called factors that comprise fragments of probability tables. There are two main operations on factors: (i) the product of two factors; (ii) elmination of a variable. Task for this assignment is to implement the variable elemination algorithm such that it works for the provided version of the Spiegelhalter data set. The data set defines a medium-sized multiple-valued Bayesian network for the diagnosis of deceases related to birth *asphyxia*, shortage of oxygen during the delivery of a child. A description of the algorithm taken from the AIMA-book as well as the Spiegelhalter data set are available from the course website.

## *3 Implementation*

The implementation must perform the following I/O behaviour:

1. As input it accepts a probability query for one variable of the form

   $$\text{"}P(\text{"}\ \langle QueryVar\rangle\ \text{"}|\text{"}\ (\ \langle Var = Value\rangle\ )^{+}\ \text{"})\text{"},$$

   where$QueryVar$, $Var$ and $Value$ are character strings denoting the query variable, an other random variable and a data value, respectively, of the Spiegelhalter network. You may assume that the input queries given are syntacticly correct.

2. Output is a tuple representation of the query variable $QueryVar$ of the form

   $$\text{"}(\text{"}\ (\ \langle prob\rangle\text{"},\text{"}\ )^{n-1}\ \langle prob\rangle\ \text{"})\text{"}$$

   a tuple of $n$ probability values adding up to 1, if the $QueryVar$ is an $n$-valued random variable.

## 4 *Closing remark*

It is advised to focus on the representation of factors first, as this is a major design decision. Various options are possible. One may use the burglary network as a testing vehicle, possibly using the PIT-system at `http://www.pit-systems.de/Pit/P_Online/index.html` (search for "Blank Page" to fill in your own example) to check your output.