Machine Intelligence 1 | **Exercise Sheet 10**
WS 2016/17, Obermayer/Böhmer | due: 19.01.2017

Bayesian Networks for Inference

Exercise T10.1: Graphical models (tutorial)

(a) Explain the relation between graph structure and corresponding set of random variables.

(b) Explain the concept of *conditional independence* and how it is exploited in (a).

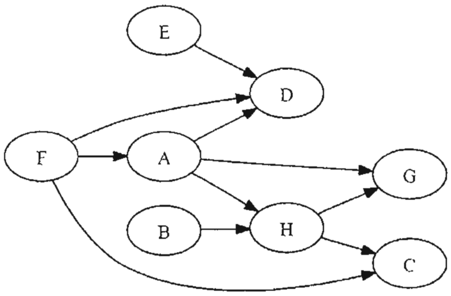
(c) What is a *Markov blanket* and how is it used to build a *moral graph*?

(d) Discuss the *running intersection* property of a *junction tree*.

(e) Construct a junction tree from a moral graph.

Exercise H10.1: Directed Acylic Graphs (homework, 4 points)

Consider the following DAG:



(a) (1 point) Give a possible topological sorting of the nodes of this DAG.

(b) (1 point) The joint distribution of the corresponding n random variables can be factorized as

$$P(X) = \prod_{i}^{n} P(X_i|\text{parents}(X_i)) \,.$$

Write down the factorization for this DAG.

(c) (1 point) Indicate which nodes belong to the Markov blanket of node A and create the moral graph of the DAG.

(d) (1 point) Identify the cliques in of the moral graph and construct a junction tree.

Exercise H10.2: Software (homework, 2 points)

Familiarize yourself with software packages for your programming language of choice (e.g., gRain[1] for R or BayesNetToolbox[2] for Matlab or BayesPy[3] for Python).

Implement the "water sprinkler" Bayesian network example in the tutorial by K. Murphy[4]. What is the probability that the sprinkler was active (S=true) after observing that the grass is wet (W=true)? What is the probability after the additional observation that it rained recently (R=true)?

Exercise H10.3: Construction of a DAG (homework, 4 points)

Consider the binary random variables B (Burglary), E (Earthquake), A (Alarm), and R (Radio broadcast) which can all take values either "true" (t) or f "false" (f).

Assume our knowledge about their co-occurrence is given by the (conditional) probabilities: $P(B=t)=0.01$, $P(E=t)=10^{-6}$, $P(R=t|E=f)=0$, $P(R=t|E=t)=1$, and

B	E	$P(A=t\|B=b,E=e)$
f	f	0.001
f	t	0.41
t	f	0.95
t	t	0.98

(a) (1 point) Create a DAG representing the corresponding factorization of the joint distribution.

(b) (2 points) Implement the DAG with a software package of your choice (see above) and calculate $P(A)$, $P(A|R=t)$, $P(B|A=t)$ and $P(B|A=t,R=t)$.

(c) (1 point) Explain the phenomenon of *explaining away* at the examples obtained in (b).

Total 10 points.

[1] gRain `http://cran.r-project.org/web/views/gR.html`

[2] BayesNetToolbox `http://code.google.com/p/bnt`

[3] BayesPy `http://www.bayespy.org/intro.html` . Another Python package that may be easier to use is `https://github.com/eBay/bayesian-belief-networks` .

[4] K. Murphy. A brief introduction to graphical models and Bayesian networks. `http://people.cs.ubc.ca/~murphyk/Bayes/bnintro.html`