

Advanced AI Techniques

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Course on Advanced AI Techniques, winter term 2005

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Advanced AI Techniques

Overall Course Outline

- I. Learning Bayesian Networks

- II. Probabilistic Approaches to Natural Language Understanding

- III. Probabilistic Approaches in Robotics (MDPs and POMDPs)

- VI. Game-Theoretic Approaches to Multi-Agent Systems

Each of these topics will be covered in roughly four weeks.

I. Learning Bayesian Networks

II. Probabilistic Approaches to Natural Language Understanding

III. Probabilistic Approaches in Robotics (MDPs and POMDPs)

IV. Game-Theoretic Approaches to MAS

V. Organization

1. Bayesian Networks – Introduction / Repetition

structure: The graph structure encodes the factors of a JPD:

parameters: Specified by a conditional probability table (CPT) attached to each node quantify direction / strength of dependencies:

- nodes represent variables,
- edges represent "direct dependencies".

$$p(x | \text{fanin}(x))$$

$$p(x_1, \dots, x_n) = \prod_{i=1}^n p_i(x_i | \text{fanin}(x_i))$$

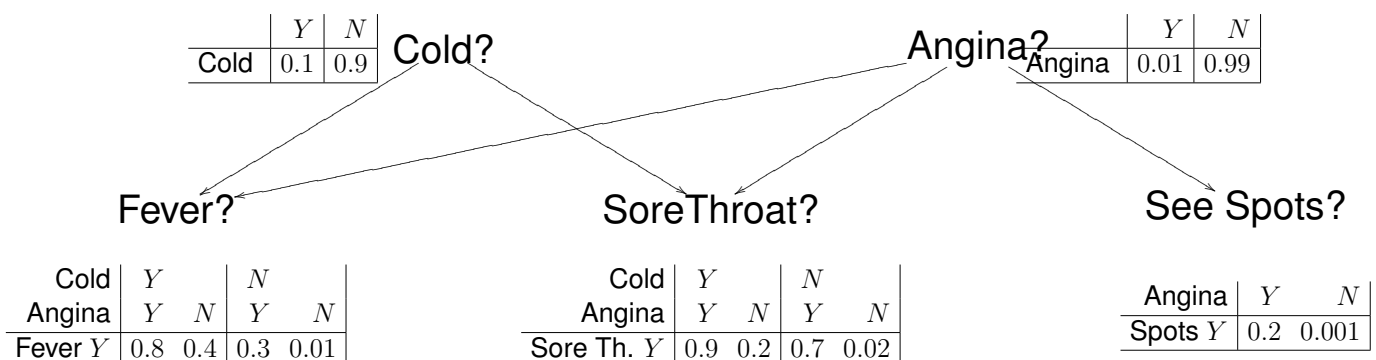


Figure 1: Example Bayesian Network.

2. Learning Parameters

If we know

- which variables may influence which others (the structure),
- but not the exact quantities (the parameters),
- and we have data,

we can estimate the parameters from data.

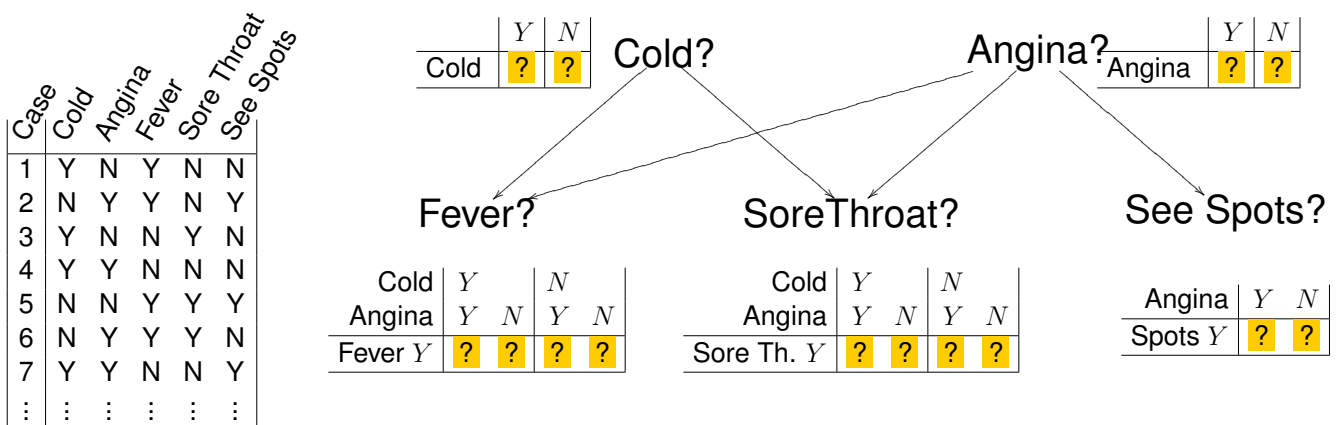


Figure 2: Bayesian network structure with unknown parameters.

2. Learning Parameters / Missing Data

If we know

- which variables may influence which others (the structure),
 - but not the exact quantities (the parameters),
 - and we have data with some missing value,
- we still can estimate the parameters from data (as well as the missing values).

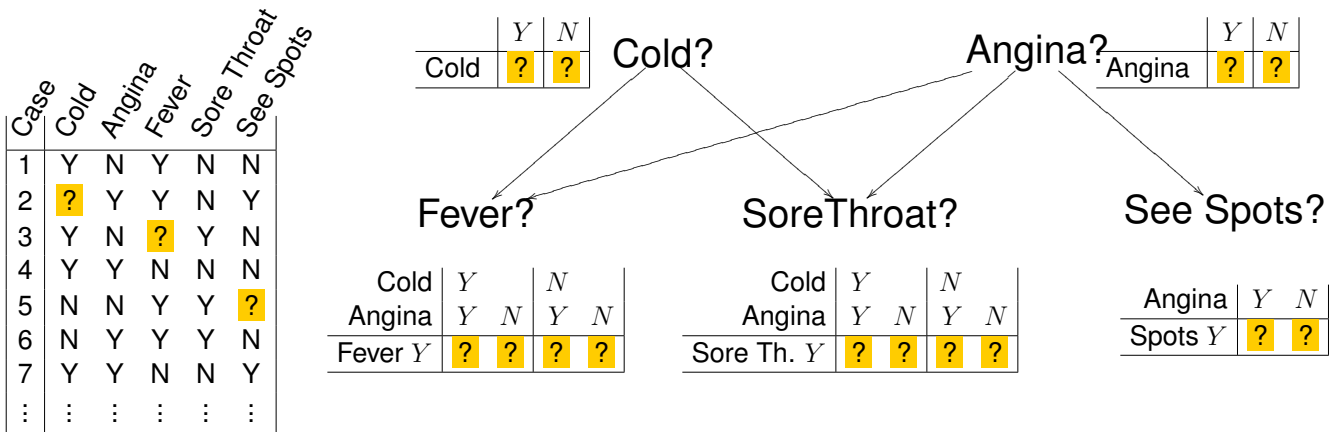


Figure 2: Bayesian network structure with unknown parameters.

3. Learning Structure

Learning structure requires

- the specification of a model selection criterion as well as
- a search procedure over a subspace of possible graph structures.

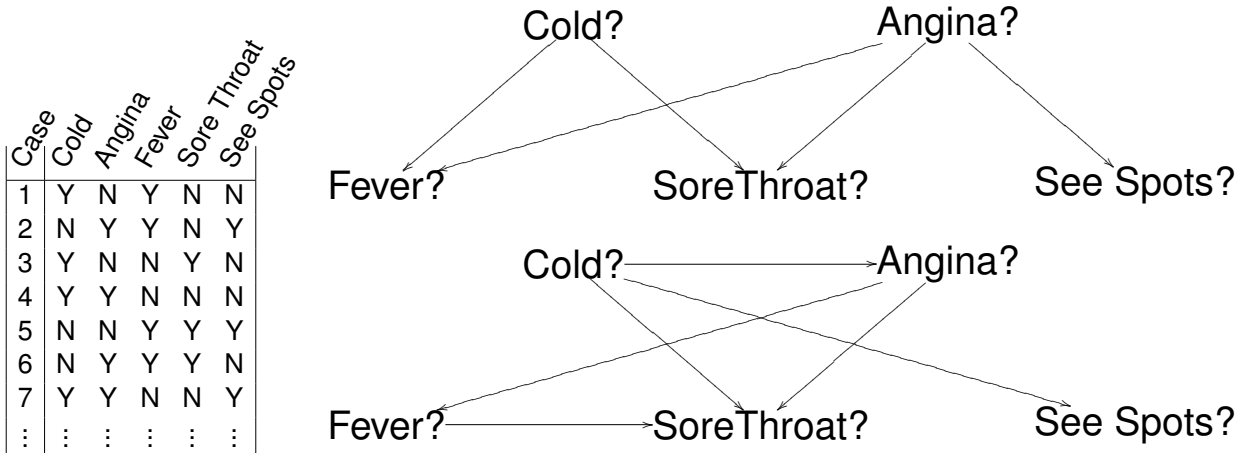


Figure 3: Different Bayesian network structures.

Text books

- Richard E. Neapolitan. *Learning Bayesian Networks*. Prentice Hall, 2003
- Finn V. Jensen. *Bayesian networks and decision graphs*. Springer, New York, 2001
- Enrique Castillo, José Manuel Gutiérrez, and Ali S. Hadi. *Expert Systems and Probabilistic Network Models*. Springer, New York, 1997
- Christian Borgelt and Rudolf Kruse. *Graphical Models*. Wiley, New York, 2002

Bayesian Networks Software

open source:

- PNL (C++, <http://www.intel.com/research/mrl/pnl>, 8/2005, V. Eruhimov & K. Murphy).
- unbbayes (Java, <http://unbbayes.sourceforge.net>, 4/2005, B. Domingues et al.)
- BNJ (Java, <http://bndev.sourceforge.net>, 7/2004, W.H. Hsu)
- jBNC (Java, <http://jbnc.sourceforge.net>, 6/2004, J. Sacha), can be integrated in Weka.
- OpenBugs (<http://mathstat.helsinki.fi/openbugs/>, 4/2005, D. Spiegelhalter).

open source, based on commercial software:

- Bayes Net Toolbox (Matlab, <http://bnt.sourceforge.net/>, 9/2005, K. Murphy), based on Matlab.

commercial software:

- Hugin (<http://www.hugin.com>)

... and there are many others (see <http://www.ai.mit.edu/~murphyk/Bayes/bnsoft.html>).

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Advanced AI Techniques / V. Organization

Exercises and tutorials

- **Weekly Tutorials by Niels Landwehr, Alexander Scivos and Karen Tso**
first tutorial at Fr. 18.11. 10:00 – 11:45.
- **One exercise sheet per week**
first sheet at Tue. 8.11.
- **Sheets are due next Tuesday**
and will be discussed the following Friday in tutorial.

Wissenschaftliche Hilfskräfte

Zwei offene Stellen als wissenschaftliche Hilfskraft in der Gruppe CGNM:

- Interesse an Maschinellem Lernen / Datenanalyse / wissenschaftlichem Programmieren
- Sehr gute Java- oder C++-Kenntnisse.

Zunächst für 1/2 Jahr,
aber wir haben vor allem Interesse an Studenten, die mindestens
1 – 1 1/2 Jahre bleiben möchten.

Bei Interesse, Email schicken oder vorbeischaun.

References

- [BK02] Christian Borgelt and Rudolf Kruse. *Graphical Models*. Wiley, New York, 2002.
- [CGH97] Enrique Castillo, José Manuel Gutiérrez, and Ali S. Hadi. *Expert Systems and Probabilistic Network Models*. Springer, New York, 1997.
- [Jen01] Finn V. Jensen. *Bayesian networks and decision graphs*. Springer, New York, 2001.
- [Nea03] Richard E. Neapolitan. *Learning Bayesian Networks*. Prentice Hall, 2003.