Example problem I

General tools for probabilistic modeling

Example problem II
A 3D bin-packing problem with a lot of physical constraints and tight time constraints
Example problem III
Frequency allocation for mobile networks
Example problem IV
A complex configuration problem, solved by combining expert knowledge with statistical data
Example problem V
Model-based visualization of high-dimensional data
Example problem VI
Analysis and prediction of web browsing behavior
The big picture

- Research areas
  - Modeling
    - Bayesian networks
    - Neural networks
    - Decision trees
    - Fuzzy logic
  - Optimization
    - genetic algorithms
    - simulated annealing
  - Visualization
Name of the game?

- Artificial intelligence (tekoäly)
- Science of uncertainty
- Intelligent systems (älykkäät järjestelmät)
- Computational intelligence (laskennallinen älykkyys)
- Soft Computing ("pehmolaskenta")
- Real-world computing
- Complex systems computation
- Deep computing
Deep computing is a term for methods solving complex and large-scale modeling and analysis problems with emerging computer systems that combine ultrafast processing with sophisticated analytical software.

**Deep**: syvä, laaja, intensiivinen, syvällinen, syventynyt, keskittyynyt, läpitunkeva, syvällekäyvä, vaikea, monimutkainen, vaikeatajuinen, selittämätön, arvoituksellinen, epämääräinen, kauas menevä, älykäs, järkevä
Deep modeling

- Challenges
  - building models from very large data streams
  - automatic discovery of features
  - universal modeling

- Techniques (multi-disciplinary)
  - computer science
  - information theory
  - mathematical statistics

- Application areas
  - Business Intelligence
  - “super modeling” in sciences
  - telecommunications
Deep optimization

- **Challenges**
  - developing intelligent search methods
  - combining search with deep modeling

- **Techniques**
  - stochastic optimization methods
  - adaptive search methods
  - approximate pattern matching

- **Applications**
  - logistics
  - resource management
  - telecommunications
Deep view

- Challenges
  - model-based visualization
  - interactive interface technologies
- Techniques
  - deep modeling with haptic interfaces
  - high-performance graphics
  - high-dimensional transformations
- Applications
  - Business Intelligence
  - scientific data analysis
Bayesian networks: a billion dollar perspective

“Microsoft’s competitive advantage, he [Gates] responded, was its expertise in “Bayesian networks”. Ask any other software executive about anything “Bayesian” and you’re liable to get a blank stare. Is Gates onto something? Is this alien-sounding technology Microsoft’s new secret weapon?”

(Leslie Helms, Los Angeles Times, October 28, 1996.)
Bayesian (belief) networks

- A graphical representation of a joint probability distribution
- The nodes of the network represent the domain variables (attributes)
- The arcs represent dependencies
- The parameters of a Bayesian network model consist of conditional probabilities determining the strengths of the dependencies
Advantages of Bayesian networks

- Decision theory offers a theoretical framework for optimal decision making
- A “white box”: offers a clear semantic interpretation of the model parameters
- Possibility to combine expert knowledge with statistical data
- Flexible applicability
- Robustness, consistent calculus
- More information
Example applications of Bayesian networks

- Microsoft
  - AnswerWizard
  - software and system troubleshooters
  - MS Home Healthcare System
  - “adaptive OS” Lumiere
  - spam mail filtering
- NASA
  - Shuttle mission control (VISTA)
  - automated classification of satellite images (LandSat, IRAS)
- Hewlett-Packard: printer fault diagnosis
- Intel: Processor fault diagnosis
- Lockheed: Autonomous underwater vehicle control
- GE: Power generator monitoring
- Mitre: Weapons scheduling
- Several medical diagnostic systems (Intellipath, DXPLAIN, ILIAD, ACORN, ...)

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