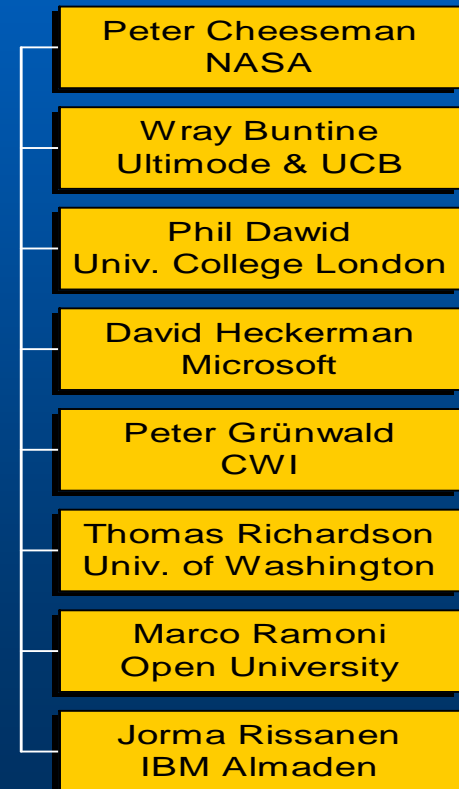
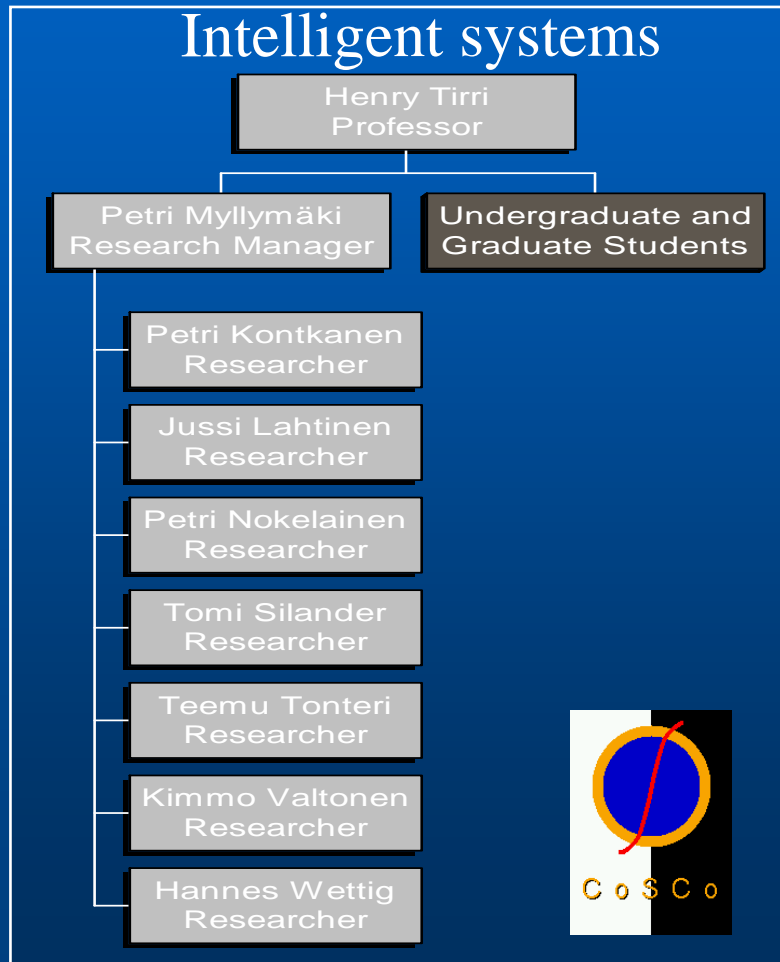


Deep Computing

Petri Myllymäki
Complex Systems Computation Group
Department of Computer Science
University of Helsinki



Complex Systems Computation Group



Example problem I

General tools for probabilistic modeling

ICE Browser - [Bayda main]

BAYDA

Welcome to the guided journey through the Bayesian predictive discriminant analysis. The whole procedure consists of five simple steps from loading the data to the analysis of the results.

You can start immediately, but if you are a first time user, you might be interested in browsing the answers to some frequently asked questions.

What is Bayesian predictive discriminant analysis?
In discriminant analysis (classification) the aim is to build a model for predicting the value of one discrete variable using other variables. In the analysis one also considers the question, which of the variables should be used for prediction.

What does Bayesian mean in this analysis?
The predictions use infinitely many models weighted by their probabilities to do the prediction. Using *many models* and using *probabilities of the models*, is an essential feature of Bayesian modeling.

Why should I use this analysis?
To put it pragmatically: it works, it is simple to use, theoretically sound, and above all, it is easy to understand. One does not have to use the concepts such as p-values, Wilks' lambdas, the fundamental notion of probability is enough. The analysis has its assumptions of independence and assumptions of the distributions of the data, but most importantly, it is based on the theory that explicitly acknowledges these assumptions (also called *prior knowledge* in Bayesian terminology).




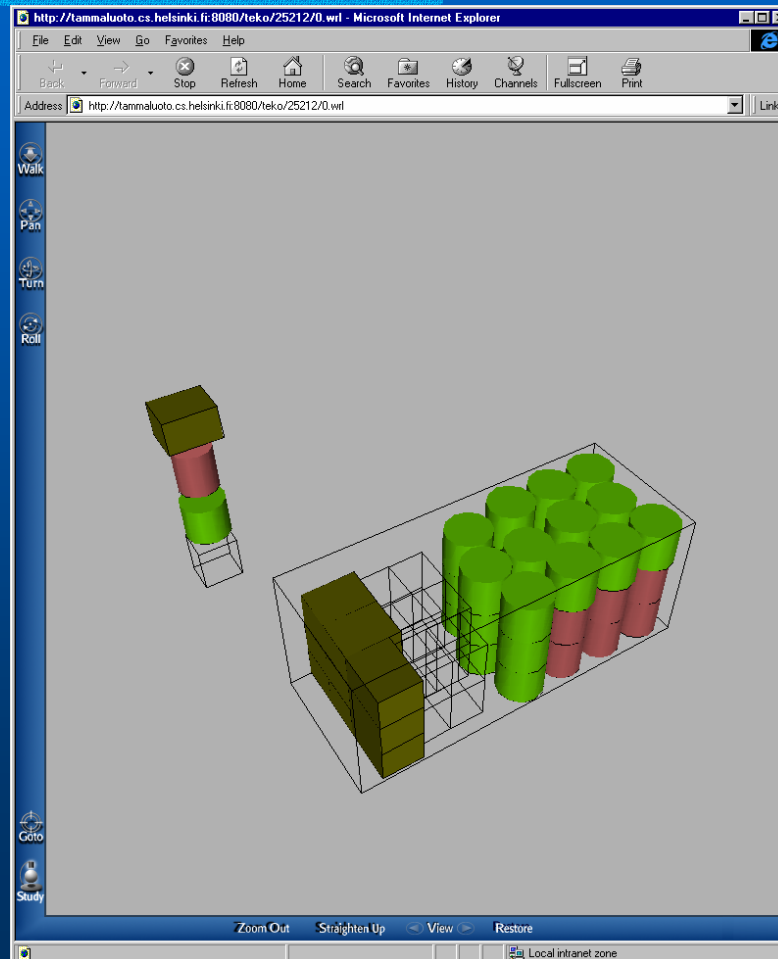
Figure 1. Reverent Thomas Bayes (1702-1761)

Next
Info
Save
Exit

<http://www.cs.Helsinki.fi/research/cosco/>

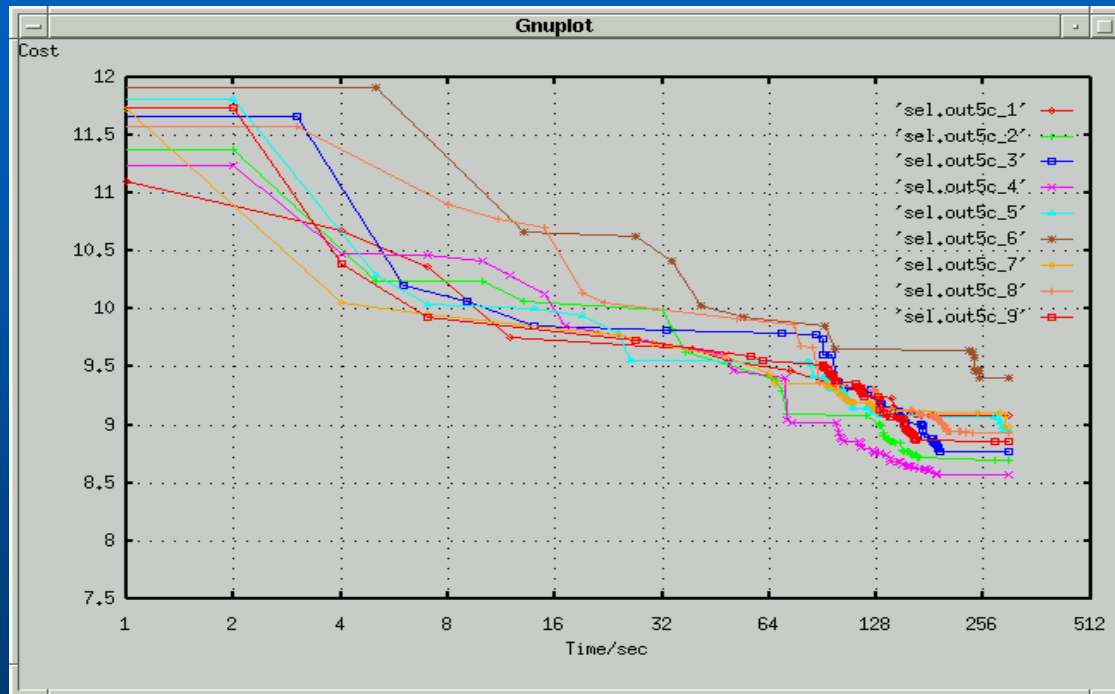
Example problem II

A 3D bin-packing problem with a lot of physical constraints and tight time constraints



Example problem III

Frequency allocation for mobile networks



Previous

Next

Example problem IV

A complex configuration problem, solved by combining expert knowledge with statistical data

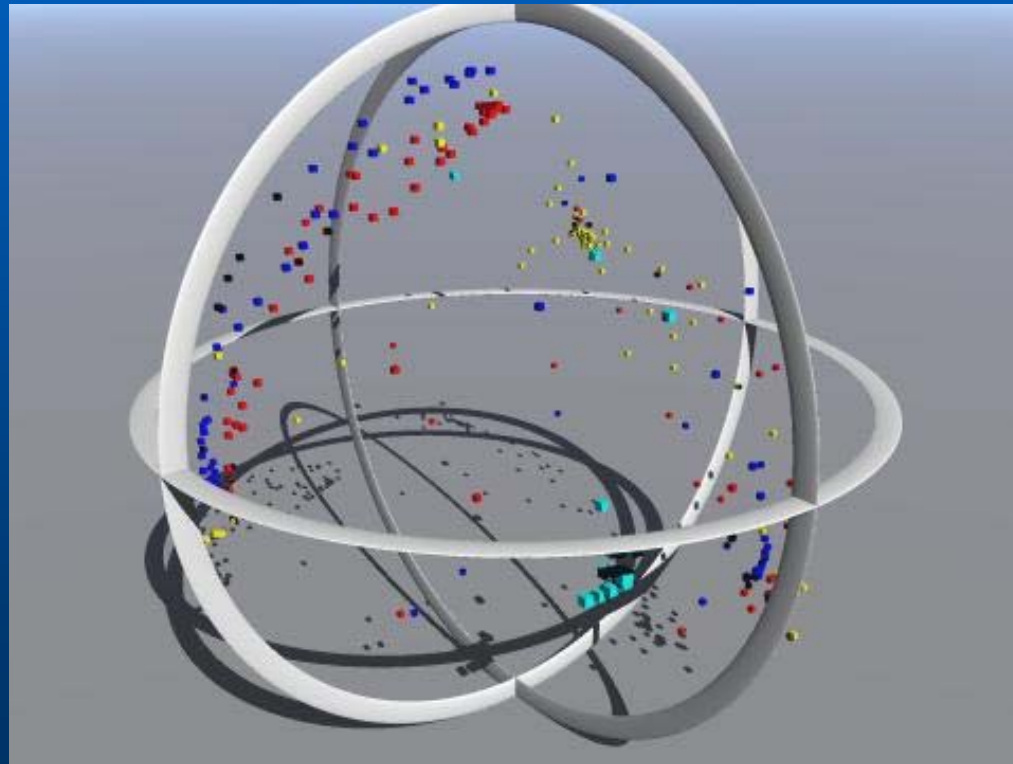
The screenshot displays the BRASS software interface, which is used for solving complex configuration problems. The interface is divided into several sections:

- Utility Functions:** A horizontal bar chart at the top left shows the relative weight of the utility function in percentage, ranging from 0 to 100. Below it, three utility functions are displayed: TOTAL UTILITY (green bar), UTILITY (red bar), and CUSTOMER UTILITY (green bar).
- RECOMMENDATION:** A list of recommendations with their corresponding utility values:
 - "Brushed Laquered" -0.425
 - "Brushed Waxed" -0.367
 - "Mirror Laquered" -0.390
 - "Mirror Waxed" -0.372
 - "Mirror Natural" -0.320
 - "TIN" +0.004
 - "(standard materials)" -0.299
- LIST SORTING METHOD:** Two options are available: "Worst-case" (selected with a diamond icon) and "Best-case" (selected with a downward arrow icon).
- CHOICES MADE SO FAR:** A list of choices with their utility values:
 - "Color": "Tinted" -0.423
 - "Finishing surface": "Super Mirror polished" -0.350
 - "Finishing style": "Super Mirror finish" -0.343
 - "material used": "TIN" -0.330
 - "Elevator load": "2000" -0.319
 - "Visual consistency": "All parts must be same material" -0.229
 - "vandal scatching": "high" -0.229
 - "Material": "TIN" +0.000
- A SPECIFIC CHOICE:** A list of specific choices with their utility values:
 - "Color" (selected with a diamond icon): "Distinct brass" -0.423
 - "Color": "Tinted" +0.000
 - "Color": "Patinated" -0.373
- OPEN QUESTIONS:** A list of open questions with their utility values:
 - "Customer given risks" -0.353
 - "Passenger" -0.322
 - "Hotel" -0.317
 - "waxing is ensured" -0.315
 - "No. of elements" -0.311
 - "Wall elements" -0.311
 - "Wall elements" -0.311
 - "Serv. & Med." -0.306
 - "Residential" -0.306
 - "Office" -0.303
- PERSPECTIVE:** A list of perspectives with their utility values:
 - Functionality -0.423
 - Customer profile -0.353
 - Walls -0.350
 - Style profile -0.343
 - Elevator use profile -0.32
 - Main specifications -0.316
 - Segment profile -0.317
 - Durability requirements -0.298
 - Supply profile -0.298
 - Cost and price -0.295
- A SPECIFIC QUESTION:** A list of specific questions with their utility values:
 - "Customer given risks" (selected with a downward arrow icon): "Low" -0.241
 - "Customer given risks": "Medium" -0.265
 - "Customer given risks": "High" -0.294
 - "Customer given risks": "Extra High" -0.353

At the bottom of the interface, there are "Reset" and "Quit" buttons.

Example problem V

Model-based visualization of high-dimensional data



Example problem VI

Analysis and prediction of web browsing behavior

The screenshot shows the Sonera Plaza website in Microsoft Internet Explorer. The browser's address bar displays `http://fi.soneraplaza.net/`. The page features a navigation menu on the left with sections like 'KANAVAT', 'LINKKIHAKEMISTO', and 'INFO'. The main content area is titled 'MEILTÄ KAIKKI MATKAT.' and includes sections for 'Kanavissa tänään', 'Uutiset', and 'Sää tänään'. The 'Uutiset' section contains several news items with links to articles about travel and current events. The 'Sää tänään' section includes a weather map of Finland. The right sidebar contains advertisements for 'PLAZALLA mm.', 'kauppakeskus Ostella', 'SYYSENERGIA!', and 'messi'.

Maanantai 20.09.1999 Ummittelemme: Varpu, Vauva

Hae tietoa Suomesta:

KANAVAT

- **Dome** pelien maailma
- **Elit** aktiivisille naisille
- **Kaista** nuorison kohtaamispaikka
- **Stadion** urheilufanin ykkösareena
- **Viinitupa** viinystävien yhteisö

LINKKIHAKEMISTO

- **Palvelut**
- **Uutiset ja sää**
- **Pankkipalvelut**
- **Yritykset**
- **Työpaikat**
- **Urheilu**
- **Yhteiskunta**
- **Vapaa-aika**

INFO

- **Neuvonta**
- **Palaute**
- **Mediakortti**

VEIKKAUS

Mahdoton tehtävä

SUOMEN MATKATOIMISTO

MEILTÄ KAIKKI MATKAT.

Kanavissa tänään

Kaista

Kaistan channelhost Apulannan Tuukka kertoo omista kokemuksistaan veroviraston lasiovista viikon kolumnissaan.

Brittipopin kuuma nimi Gay Dad vieraili Suomessa keikalla Tavastiällä ja kuultuaan Kaista-hemmojen olevan paikalla, he tahtoivat välttämättä antaa eksklusiivisen haastattelun toimittajallemme.

Viikon videona Samuli Edelmannin tähdittämä Häjyt.

Ajankohtaista verkossa

Tutustu ensi-iltansa saaneen [Lapin kullan kimallus](#) -elokuvan taustoihin. Perjantaina ehdit vielä osallistua kultakilpiaan testaamalla [kultatietämyksesi](#).

Viikon mittaiset [Rakkautta ja anarkiaa](#) -filmifestivaalit pidetään Helsingissä 17.-26. syyskuuta. Tutustu filmeihin ja osallistu vuoden paras elokuva -äänestykseen.

[Aurajoki-sivut](#) tarjoavat paljon tietoa joen suojelusta, virkistyskäytöstä ja jokikulttuurista. Sivut tehneen

Uutiset

[Yäestötietojen päivityksessä kahden viikon tauko](#) (17.9.1999 16:02)

[Hallituksen mustat viikot Saksassa](#) (20.9.1999 06:47)

[Hallituksen mustat viikot Saksassa](#) (20.9.1999 06:26)

Lisää uutisia: [Kotimaa](#), [Ulkomaat](#), [Talous](#), [Viihde](#), [Urheilu](#)

Sää tänään

PLAZALLA mm.

DINE & WINE

Wanhan Tallinnan tunnelmaa Bonapartessa.

kauppakeskus Ostella

Yli sata kauppiasta, yli tuhat tuotetta. Tutustul

SYYSENERGIA!

Vauhtia päivään: tee testi, osallistu kilpailuun ja aivojumppaa!

Kaista

Nuoria kiinnostava sisältö yhdessä paketissa.

KLUBISSA

10 ilmaista tekstiviestiä kuukaudessa

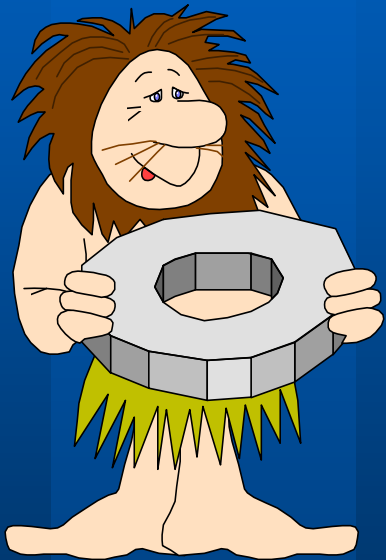
messi

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

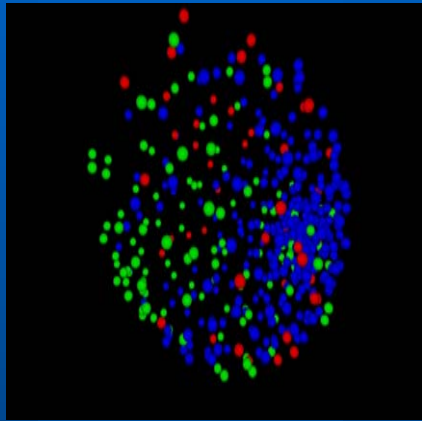
What is Deep Computing?



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, keskittynyt, läpituokeva, syvällekäyvä, vaikea, monimutkainen, vaikeatajuinen, selittämätön, arvoituksellinen, epämääräinen, kauas menevä, älykäs, järkevä

Deep modeling



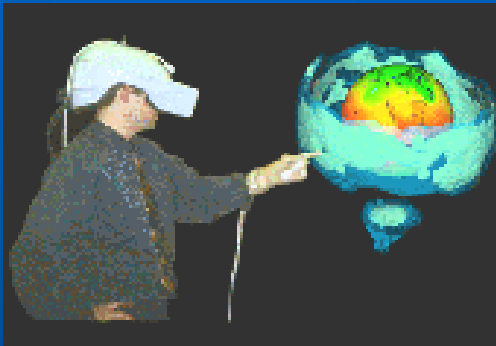
- **Challenges**
 - building models from very large data streams
 - automatic discovery of features
 - universal modeling
- **Techniques (multi-disciplinary)**
 - computer science
 - information theory
 - mathematical statistics
- **Application areas**
 - **Business Intelligence**
 - “super modeling” 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

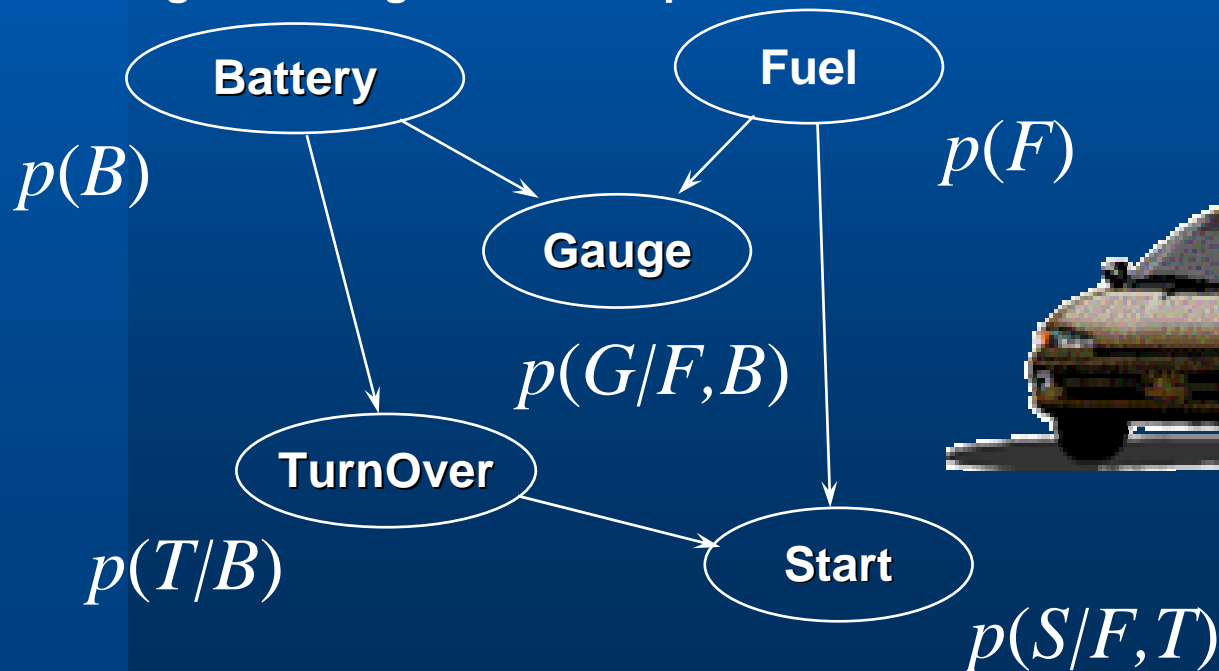


“Microsoft’s competitive advantage, he [Gates] responded, was its expertise in “Bayesian networks”. Ask any other software executive about anything “Bayesian” and you’re liable to get a blank stare. Is Gates onto something? Is this alien-sounding technology Microsoft’s new secret weapon?”

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

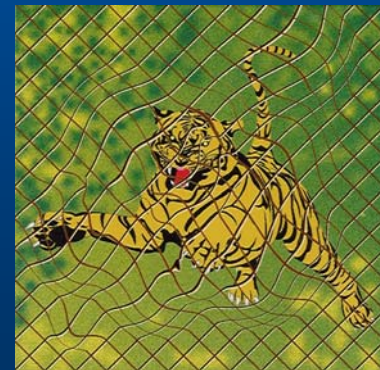
Bayesian (belief) networks

- 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
 - Myllymäki, Tirri: Bayes-verkkojen mahdollisuudet. Teknologiaakatsaus 58/98, Teknologian kehittämiskeskus (TEKES) 1998.



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, ...)**

