Bayesian Networks

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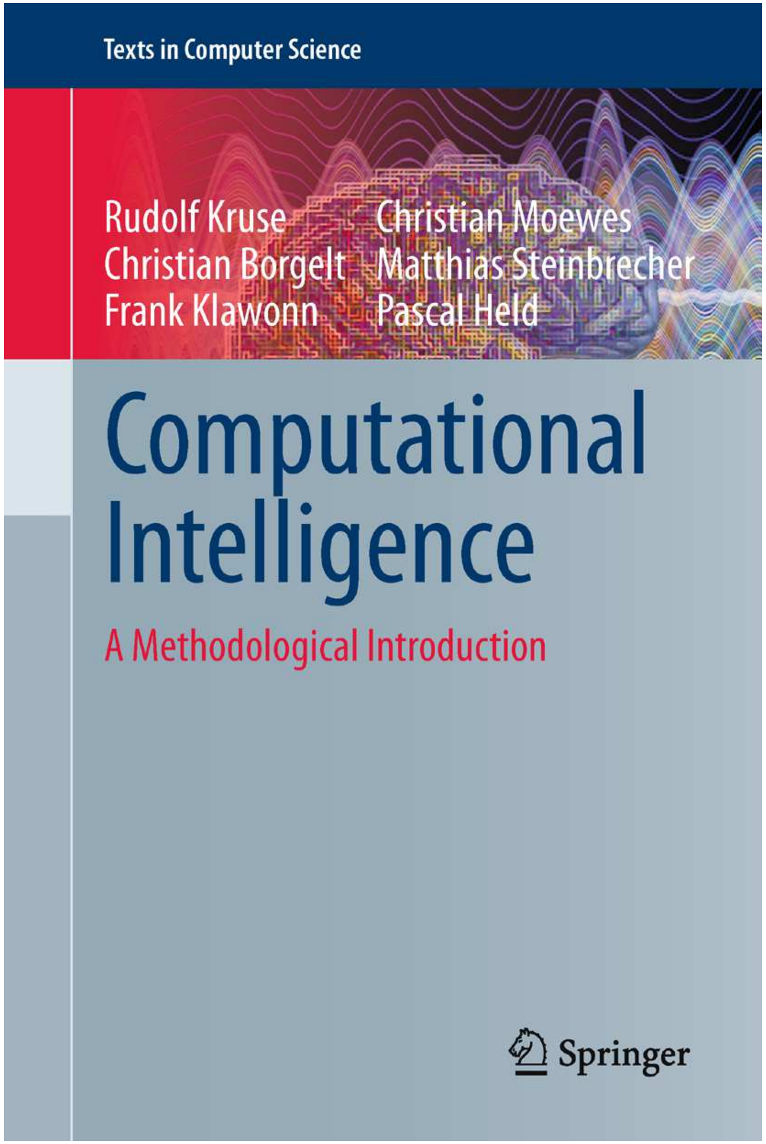
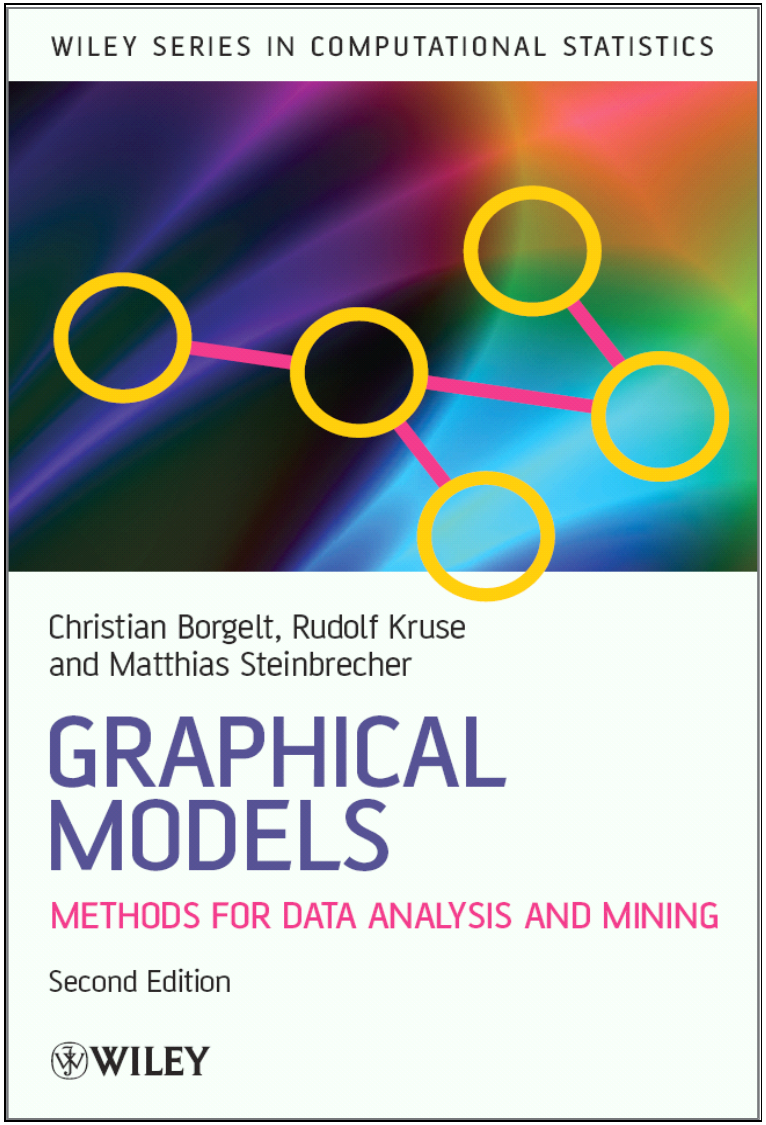
Books about the course





http://www.computational-intelligence.eu/

Human Expert

A human *expert* is a specialist for a specific differentiated application field who creates solutions to customer problems in this respective field and supports them by applying these solutions.

Requirements

- Formulate precise problem scenarios from customer inquiries
- Find correct and complete solution
- Understandable answers
- Explanation of solution
- Support the deployment of solution

Knowledge Based Systems (2)

“Intelligent” System

An intelligent system is a program that models the knowledge and inference methods of a human expert of a specific field of application.

Requirements for construction:

- Knowledge Representation
- Knowledge Acquisition
- Knowledge Modification

Qualities of Knowledge

In most cases our knowledge about the present world is

incomplete/missing (knowledge is not comprehensive)

- e. g. "I don't know the bus departure times for public holidays because I only take the bus on working days."

vague/fuzzy/imprecise (knowledge is not exact)

- e. g. "The bus departs roughly every full hour."

uncertain (knowledge is unreliable)

- e. g. "The bus departs probably at 12 o'clock."

We have to decide nonetheless!

Reasoning under Vagueness

Reasoning with Probabilities

. . . and Cost/Benefit

Example

Objective: *Be at the university at 9:15 to attend a lecture.*

There are several plans to reach this goal:

- P_1: Get up at 8:00, leave at 8:55, take the bus at 9:00 ...
- P_2: Get up at 7:30, leave at 8:25, take the bus at 8:30 ...
- ...

All plans are *correct*, but

- they imply different *costs* and different *probabilities* to *actually* reach that goal.
- P_2 would be the plan of choice as the lecture is important and the success rate of P_1 is only about 80–95%.

Question: *Is a computer capable of solving these problems involving uncertainty?*

Example:

We would like to support a robot's localization by fixed landmarks.
From the presence of a landmark we may infer the location.

Problem:

Sensors are imprecise!

- We cannot conclude definitely a location simply because there was a landmark detected by the sensors.
- The same holds true for undetected landmarks.
- Only probabilities are being increased or decreased.

Degrees of Belief

We (or other agents) are only believing facts or rules to some extent.

One possibility to express this *partial belief* is by using *probability theory*.

“The agent believes the sensor information to 0.9” means:
In 9 out of 10 cases the agent trusts in the correctness of the sensor output.

Probabilities gather the “uncertainty” that originates due to ignorance.

Probabilities $\neq$ Vagueness/Fuzziness!

- The predicate “large” is fuzzy whereas “This might be Peter’s watch.” is uncertain.

Rational Decisions under Uncertainty

Choice of several *actions* or *plans*

These may lead to different results with different *probabilities*.

The *actions* cause different (possibly subjective) *costs*.

The *results* yield different (possibly subjective) *benefits*.

It would be rational to choose that action that yields the largest total benefit.

$$\text{Decision Theory} = \text{Utility Theory} + \text{Probability Theory}$$

Decision-theoretic Agent

input perception
output action

$K \leftarrow$ a set of probabilistic beliefs about the state of the world

calculate updated probabilities for current state based on available evidence including current percept and previous action

calculate outcome probabilities for actions, given action descriptions and probabilities of current states

select action A with highest expected utility given probabilities of outcomes and utility information

return A

Decision Theory: An agent is rational if and only if it chooses the action yielding the largest utility averaged over all possible outcomes of all actions.