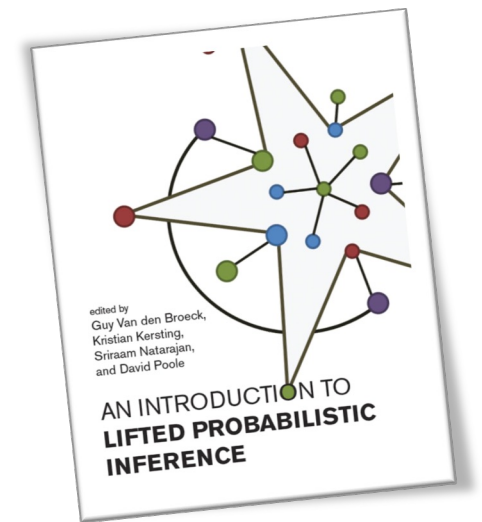
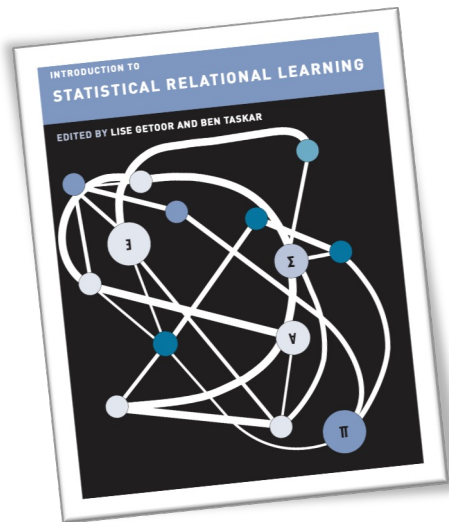




UNIVERSITÄT ZU LÜBECK  
INSTITUT FÜR INFORMATIONSSYSTEME

# Dynamic Probabilistic Relational Models

## Overview



Marcel Gehrke

IM FOCUS DAS LEBEN

# Administrative Stuff: Lecture

- Module: Lectures on Data Science and KI
  - Module numbers: **CS5070-KP04**
  - 2+1 SWS
- Lecture:

## Dynamic Probabilistic Relational Models

- More specifically, *probabilistic relational models* and *lifted probabilistic inference*
- Seminar: [tdb](#)
- Room
  - Lecture hall ITSC 2021



# Administrative Stuff: Exam

---

- Oral exam
  - Date: *probably 31.07-4.08*
- Conditions for participation
  - Registration in Moodle
  - Seminar presentation



# Contents (*preliminary*)

## 1. Introduction

- StaRAI: Agent, context, motivation

## 2. Foundations

- Logic
- Probability theory
- Probabilistic graphical models (PGMs)

## 3. Probabilistic Relational Models (PRMs)

- Parfactor models, Markov logic networks
- Semantics, inference tasks

## 4. Exact Lifted Inference

- Lifted Variable Elimination
- Lifted Junction Tree Algorithm
- First-Order Knowledge Compilation

## 5. Lifted Sequential Models and Inference

- Parameterised models
- Semantics, inference tasks, algorithm

## 6. Lifted Decision Making

- Preferences, utility
- Decision-theoretic models, tasks, algorithm

## 7. Approximate Lifted Inference

## 8. Lifted Learning

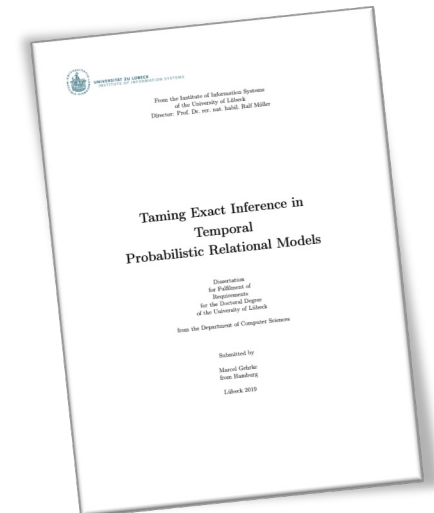
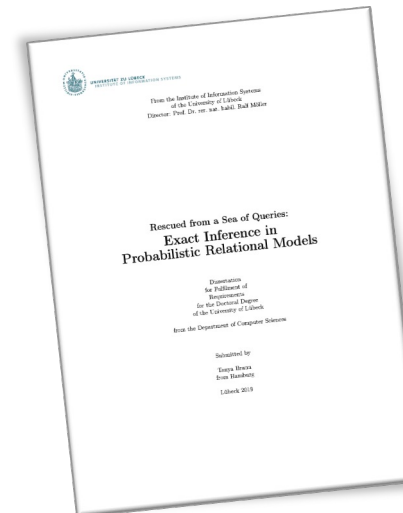
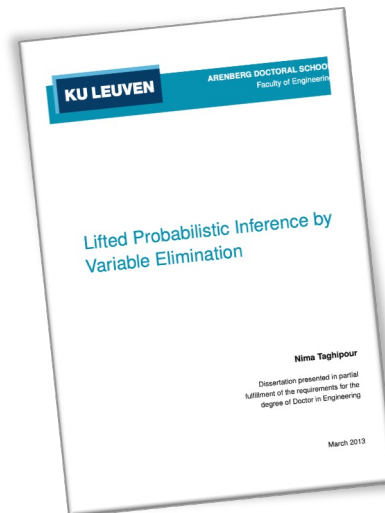
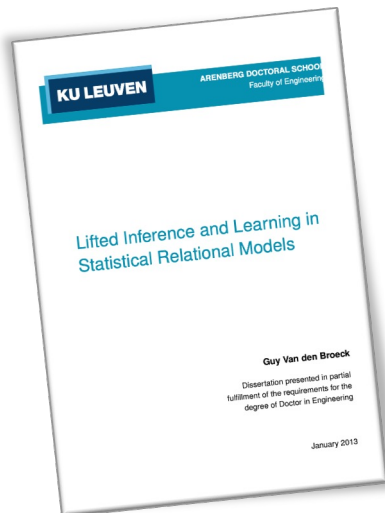
- Parameter learning
- Relation learning
- Approximating symmetries

# Goals

- On a technical level
  - Understand and explain the modelling, algorithm, solution approach, ... in terms of
    - Main idea
    - Use cases
    - Advantages / disadvantages
  - Understand and explain the connection between the different models and algorithms
- On a more general level
  - Assess problems and current research in the context of artificial intelligence
  - Insight into combining apparently diametrically opposed disciplines (here logic & probability)
- Get a well-rounded overview of different aspects of lifted inference up to state-of-the-art research (we should get up to at least 2020)

# Main Sources

- **Lifted Inference and Learning in Statistical Relational Models**
  - Guy Van den Broeck, PhD thesis, 2013
- **Lifted Probabilistic Inference by Variable Elimination**
  - Nima Taghipour, PhD thesis, 2013
- **Rescued from a Sea of Queries: Exact Inference in Probabilistic Relational Models**
  - Tanya Braun, PhD thesis, 2020
- **Taming Exact Inference in Temporal Probabilistic Relational Models**
  - Marcel Gehrke, PhD thesis, 2022



<http://web.cs.ucla.edu/~quyvdb/phd/quyvdb-phdthesis.pdf>

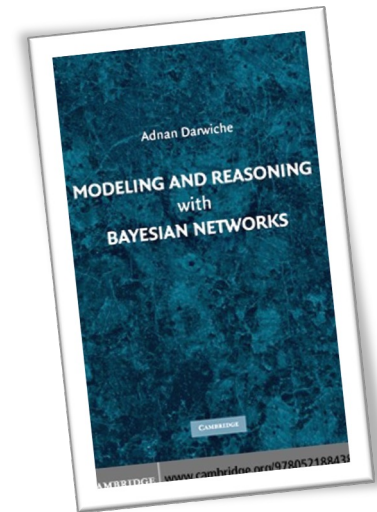
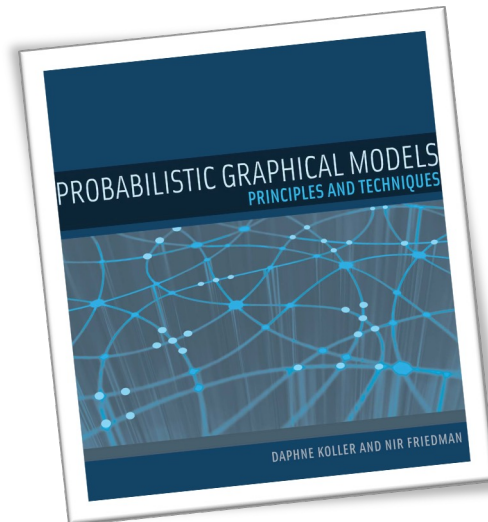
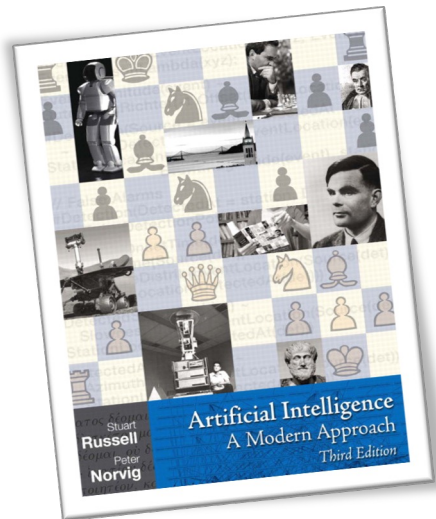
<https://lirias.kuleuven.be/1656026?limo=0>

[https://www.ifis.uni-luebeck.de/~braun/Diss/Braun\\_diss.pdf](https://www.ifis.uni-luebeck.de/~braun/Diss/Braun_diss.pdf)

[https://www.ifis.uni-luebeck.de/uploads/tx\\_wapublications/Diss\\_Gehrke\\_public\\_02.pdf](https://www.ifis.uni-luebeck.de/uploads/tx_wapublications/Diss_Gehrke_public_02.pdf)

# Literature: Introductory Books & Books on Foundations

- **Artificial Intelligence – A Modern Approach** (3<sup>rd</sup> ed.)
  - Stuart Russell, Peter Norvig
  - Basics on agents, logic, reasoning under uncertainty
- **Probabilistic Graphical Models**
  - Daphne Koller, Nir Friedman
  - General PGMs for reasoning under uncertainty
- **Modelling and Reasoning with Bayesian Networks**
  - Adnan Darwiche
  - BNs for reasoning under uncertainty



<http://aima.cs.berkeley.edu>

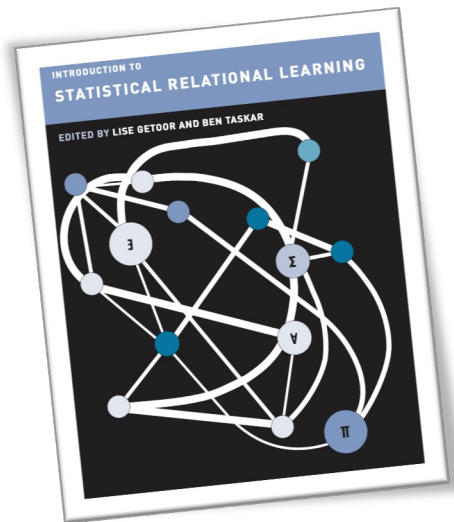
<https://mitpress.mit.edu/books/probabilistic-graphical-models>

<https://www.cambridge.org/core/books/modeling-and-reasoning-with-bayesian-networks/8A3769B81540EA93B525C4C2700C9DE6>

# Literature: Books on StaRAI

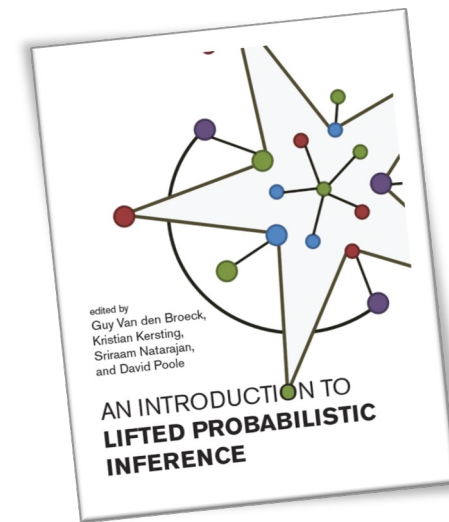
- Introduction to Statistical Relational Learning

- Editors:  
Lise Getoor, Ben Taskar



- An Introduction to Lifted Probabilistic Inference

- Editors:  
Guy Van den Broeck, Kristian Kersting,  
Sriram Natarajan, David Poole





# Note

- *The lecture is new in this format (and with that, the slides and seminar)!*
  - The slides are based on two different versions of this lecture by Tanya Braun
    - One focusing on the PGM part (<https://www.ifis.uni-luebeck.de/index.php?id=703> )
    - The other focusing more on the bigger picture and agents as a 3+1 lecture (<https://www.uni-muenster.de/Informatik.AGBraun/teaching/wise22/starai.html>)
- What does that mean for this lecture?
  - There might be changes in the structure
    - Current structure is coherent but there might be other interesting things coming up or time runs out
  - There most certainly will be typos, although we try our best to eliminate them
  - Graphs or examples that appeared reasonable at the time might actually not be, which we might find out during the lecture

If you find errors or have suggestions, please do not hesitate to tell us!

# Contents (*preliminary*)

## 1. Introduction

- StaRAI: Agent, context, motivation

## 2. Foundations

- Logic
- Probability theory
- Probabilistic graphical models (PGMs)

## 3. Probabilistic Relational Models (PRMs)

- Parfactor models, Markov logic networks
- Semantics, inference tasks

## 4. Exact Lifted Inference

- Lifted Variable Elimination
- Lifted Junction Tree Algorithm
- First-Order Knowledge Compilation

## 5. Lifted Sequential Models and Inference

- Parameterised models
- Semantics, inference tasks, algorithm

## 6. Lifted Decision Making

- Preferences, utility
- Decision-theoretic models, tasks, algorithm

## 7. Approximate Lifted Inference

## 8. Lifted Learning

- Parameter learning
- Relation learning
- Approximating symmetries