Statistical Relational AI
Exploiting Symmetries
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Agenda

1. Introduction [Tanya]
2. Exploiting Symmetries in Probabilistic Graphical Models [Marcel]
3. Exploiting Symmetries in Conditional Knowledge Bases [Marco]
4. Summary [Tanya]
Statistical Relational Artificial Intelligence (StaRAI)

The world has things in it!
The world is uncertain!
The world has things in it!
The world is uncertain!

First-order logic

Probabilistic graphical models

AI: intelligent systems in the real world

Statistical Relational Artificial Intelligence

Probabilistic relational models

Figure based on a figure by Stuart Russell
Exploiting Symmetries

- Exchangeable random variables in the full joint probability distribution
  → Inference using representatives
  → Tractability in terms of domain sizes

\[\text{10, Presents}(alice, p_1, ijcai) \Rightarrow \text{Attends}(alice, ijcai)\]
\[\text{10, Presents}(alice, p_1, kr) \Rightarrow \text{Attends}(alice, kr)\]
\[\text{10, Presents}(alice, p_2, ijcai) \Rightarrow \text{Attends}(alice, ijcai)\]
\[\text{10, Presents}(alice, p_2, kr) \Rightarrow \text{Attends}(alice, kr)\]

10 Presents \((X, P, C) \Rightarrow \text{Attends}(X, C)\)
The Larger Scope

Statistical Relational Learning & AI

• Study and design
• intelligent agents
• that reason about and
• act in noisy worlds
• composed of objects and relations among the objects
Some Things We Did Not Talk About Today: 
More on Lifted Inference

• Approximate inference, e.g.,
  • Lifted belief propagation [Ahmadi et al. 13]
  • Lifted importance sampling [Gogate et al. 12]
  • Lifted MCMC [Niepert 12]
• Lifted evidence [Van den Broeck & Davis 12]
• Lifted queries [B & Möller 18]
• Assignment queries: Lifted inference for MPE [de Salvo Braz et al. 06, Apsel & Brafman 12, B & Möller 19] and MAP queries [B 20]
• Continuous inference [Choi et al. 10, Hartwig et al. 23]
• Lifted variational inference in hybrid models [Choi & Amir 12]
Some Things We Did Not Talk About Today:
Decision Making

• Models:
  • Decision-theoretic ProbLog [Van den Broeck et al. 10]
  • First-order (partially observable) Markov decision processes (FO (PO)MDPs) [Boutelier et al. 01]
  • Markov logic decision networks [Nath & Domingos 09]
  • (Temporal) decision parfactor models [Gehrke et al. 19b, c]
  • Lifting the agent set in decentralised POMDPs (multi-agent setting) [B et al. 22]

• Solution methods:
  • Symbolic dynamic programming for FO POMPDs [Sanner & Kersting 10]
  • L(D)JT for decision parfactor models [Gehrke et al. 19b, c]
Some Things We Did Not Talk About Today:
Description Logics / Infinite Domains

• Probabilistic Description Logics, e.g.:
  • Tractable Probabilistic DLs [1]
  • Expressive Probabilistic DLs [2]

• Maximum Entropy and Infinite Domains:
  • Entropy Limit Approach [3]
  • Maximum Entropy Approach [4]
  • Entropy Limit Conjecture [5]

• Maximum Entropy and Description Logics:
  • Probabilistic DL ALCP [6]
  • Probabilistic DL ALC\(^{\text{ME}}\) [7]
What Else Is There To Do?

• Enhance lifting applicability, e.g., approximating symmetries
• Develop more robust learning algorithms
• Incorporate additional requirements such as
  • Privacy
  • Ethics
  • Explainability
  • Human-awareness
• And so much more...

Thank you!

• For slides, please go to (QR code goes to this address):
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Ordered alphabetically
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