Wrap-up
Statistical Relational AI
Tutorial at BTW 2019

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Mission for today

Providing an overview and a synthesis of StaRAI to identify links between StaRAI and DBs and prospects for collaboration for implementing scalable systems
What have we seen?

- Probabilistic relational models
  - Treat objects identically if they are indistinguishable
  - Different flavours available
  - Compactly represent objects, relations, uncertainties

- Semantics
  - Grounding semantics
  - Goal: avoid grounding!

- Lifted Algorithms
  - Exact: LVE, LJT
  - Approximate: Belief propagation, sampling
  - Lifted model from ground model: colour passing
Goal: scalable, easy-to-use systems

Needs probabilities, graphs, logic, and ... data bases
• Study and design intelligent agents that reason about and act in noisy worlds composed of objects and relations among the objects

[Getoor, Taskar MIT Press ’07; De Raedt, Frasconi, Kersting, Muggleton, LNCS’08; Domingos, Lowd Morgan Claypool ’09; Natarajan, Kersting, Khot, Shavlik Springer Brief’15; Russell CACM 58(7): 88-97 ’15, Gogate, Domingos CACM 59(7):107-115 ’16]
It works

Cardiovascular study
EHR
Alzheimer’s
RTS Games

Handwriting Recognition
Image Segmentation/Classification
Information Extraction
Recommendation System


This “Deep AI” can understand EHRs

Atherosclerosis is the cause of the majority of Acute Myocardial Infarctions (heart attacks)

[Circle of Nutrition; 92(8), 2157-62, 1995; JACC; 43, 842-7, 2004]

Plaque in the left coronary artery

Logical Variables (Abstraction)  Rule/Database view

Probability

Algorithm for Mining Markov Logic Networks

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Likelihood</th>
<th>AUC-ROC</th>
<th>AUC-PR</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boosting</td>
<td>0.81</td>
<td>0.96</td>
<td>0.93</td>
<td>9s</td>
</tr>
<tr>
<td>LSM</td>
<td>0.73</td>
<td>0.54</td>
<td>0.62</td>
<td>93 hrs</td>
</tr>
</tbody>
</table>

The higher, the better

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Accuracy</th>
<th>AUC-ROC</th>
</tr>
</thead>
<tbody>
<tr>
<td>J48</td>
<td>0.667</td>
<td>0.607</td>
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<tr>
<td>SVM</td>
<td>0.667</td>
<td>0.608</td>
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<td>AdaBoost</td>
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<tr>
<td>Bagging</td>
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<tr>
<td>RPT</td>
<td>0.667*</td>
<td>0.778</td>
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<tr>
<td>RFGB</td>
<td>0.667*</td>
<td>0.819</td>
</tr>
</tbody>
</table>

25%

This “Deep AI” can understand EHRs


[1] Kersting, Driessens ICML’08; Karwath, Kersting, Landwehr ICDM’08; Natarajan, Joshi, Tadepelli, Kersting, Shavlik. IJCAI’11; Natarajan, Kersting, Ip, Jacobs, Carr IAAI 13; Yang, Kersting, Terry, Carr, Natarajan. AIME 15; Khot, Natarajan, Kersting, Shavlik ICDM’13, MLJ’12, MLJ’15]
Today!

AI: intelligent systems in the real world

The world has things in it!
First-order logic

The world is uncertain!

First-order probabilistic languages

The world is uncertain!

Probabilistic graphical models

The world has things in it!
AI: intelligent systems in the real world

The world has things in it!
First-order logic

The world is uncertain!
Probabilistic graphical models

The world has things in it!
First-order open-universe probabilistic languages

The world has unknown things in it!
First-order probabilistic languages

Even more research, e.g.,
- First-order Open-universe POMDPs [Srivastava et al. 16]
- Open-world PDBs [Ceylan et al. 16]

Open Problems

• In any field, say Electronic Health Records or Robotics, there are many open problems
  • Open world learning – new diseases, drugs, indicators
  • Multi-modal learning
  • Large-scale lifted inference
  • Large-scale learning
  • Evolving dynamics
  • Heterogeneous data and hybrid models
  • Expert knowledge elicitation
  • Planning & actions
  • Interactive learning
  • ...

And there are popular science books about it.

In 2016, Bill Gates recommended the book, alongside Nick Bostrom’s *Superintelligence*, as one of the two books everyone should read to understand AI.
Slides

Statistical Relational AI

Tutorial at BTW 2019

https://www.ifis.uni-luebeck.de/index.php?id=597

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Logo: http://www.starai.org