Approximate Knowledge Compilation by Online Collapsed Importance Sampling

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Motivation

Factor Graphs:
Motivation

Factor Graphs:

Great! But asking queries is hard
Motivation

Factor Graphs:
Motivation: Arithmetic Circuit

- Exact inference: Use Knowledge Compilation (e.g. BDD, SPN)

- **Tractable** form: easy queries + operations
- Take advantage of further independence properties, logical structure
But they don’t scale!
Knowledge Compilation

Exact

Independence Properties

Logical Structure

This work

Sampling

Scalable

Anytime

This work
Collapsed Sampling (Rao-Blackwell)

Sampling on some variables, exact inference conditioned on sample
Collapsed Sampling (Rao-Blackwell)

Sampling on some variables, exact inference conditioned on sample
Collapsed Sampling (Rao-Blackwell)

Sampling on some variables, exact inference conditioned on sample

Sample A, B
Collapsed Sampling (Rao-Blackwell)

Sampling on some variables, exact inference conditioned on sample

Observe sampled values
Collapsed Sampling (Rao-Blackwell)

Sampling on some variables, exact inference conditioned on sample

Compute exactly $P(C|A,B)$
What to Sample?

• Is it even possible to pick a correct set a priori?
• Consider a network of potential smokers, with friendships sampled

Sample 1

Sample 2
Online Collapsed Sampling

Choose *on-the-fly* which variable to sample next, based on result of sampling previous variables

**Theorem:** Still unbiased
How?

1. What/when do we sample?
How?

1. What/when do we sample?
2. How do we sample?
How do we Sample?

• Importance Sampling
• Need a proposal for any variable conditioned on any other variables
How?

1. What/when do we sample?
2. How do we sample?
3. How do we do exact inference?
Exact Inference

How do we do exact inference conditioned on different variables?
Exact Inference

• How do we do exact inference conditioned on different variables?
Collapsed Compilation

Result: A circuit for factor graph with some sampled variables
Collapsed Compilation

1. What/when do we sample?
2. How do we sample?
3. How do we do exact inference?
Collapsed Compilation

1. What/when do we sample?
2. How do we sample?
3. How do we do exact inference?
What/when do we sample?

*When*: Circuit too big

*What*: Heuristic on current circuit
Collapsed Compilation

1. What/when do we sample?
2. How do we sample?
3. How do we do exact inference?
Motivation: Arithmetic Circuit

- Exact inference: Use Knowledge Compilation (e.g. BDD, SPN)

- **Tractable** form: easy queries + operations

- Take advantage of further independence properties, logical structure
How do we sample?

Compute the marginal of the variable in the current circuit!
1. What/when do we sample?
2. How do we sample?
3. How do we do exact inference?
Conditional Exact Inference

Result is a circuit: any joint can be computed efficiently & exactly
Approximate any query!
Experiments

• Approximate marginal in factor graph
• Algorithmically limit exact inference
# Experiments

## Table 2: Hellinger distances across methods with internal treewidth and size bounds

<table>
<thead>
<tr>
<th>Method</th>
<th>50-20</th>
<th>75-26</th>
<th>DBN</th>
<th>Grids</th>
<th>Segment</th>
<th>linkage</th>
<th>frust</th>
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</thead>
<tbody>
<tr>
<td>EDBP-100k</td>
<td>2.19e-3</td>
<td>3.17e-5</td>
<td>6.39e-1</td>
<td>1.24e-3</td>
<td>1.63e-6</td>
<td>6.54e-8</td>
<td>4.73e-3</td>
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<td>EDBP-1m</td>
<td>7.40e-7</td>
<td>2.21e-4</td>
<td>6.39e-1</td>
<td>1.98e-7</td>
<td>1.93e-7</td>
<td>5.98e-8</td>
<td>4.73e-3</td>
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<td>SS-10</td>
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<td>2.22e-3</td>
<td>6.37e-1</td>
<td>3.10e-1</td>
<td>3.11e-7</td>
<td>4.93e-2</td>
<td>1.05e-2</td>
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<tr>
<td>SS-12</td>
<td>6.96e-3</td>
<td>1.02e-3</td>
<td>6.27e-1</td>
<td>2.48e-1</td>
<td>3.11e-7</td>
<td>1.10e-3</td>
<td>5.27e-4</td>
</tr>
<tr>
<td>SS-15</td>
<td>9.09e-6</td>
<td>1.09e-4</td>
<td>(Exact)</td>
<td>8.74e-4</td>
<td>3.11e-7</td>
<td>4.06e-6</td>
<td>6.23e-3</td>
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<tr>
<td>FD</td>
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<td>5.96e-6</td>
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<tr>
<td>MinEnt</td>
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<td>1.83e-2</td>
<td>3.61e-3</td>
<td>3.40e-7</td>
<td>6.16e-5</td>
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<tr>
<td>RBVar</td>
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<td>4.39e-1</td>
<td>6.27e-3</td>
<td>1.20e-1</td>
<td>3.01e-7</td>
<td>2.02e-2</td>
<td>2.30e-3</td>
</tr>
</tbody>
</table>
Thanks!

Poster: Room 210 #5

Code: github.com/UCLA-StarAI/Collapsed-Compilation