Motivation & Background

Most probabilistic inference algorithms are too slow for online inference (changing evidence).

Want to reuse computation from one frame to the next.

Applications:
- Utility maximization
- MAP inference with partial evidence
- Interactive inference
- Parameter and structure learning
- Etc., etc.

A Markov logic network (MLN) [Richardson & Domingos 06] is a set of weighted first-order logic formulas

An MLN acts as a first-order template for a Markov network:
- One node per ground atom
- One feature per ground clause

\[ P \propto \exp(\text{sum of weights of satisfied formulas}) \]

Lifted belief propagation [Singla & Domingos 08] is an inference algorithm for Markov logic that takes advantage of repeated dependency patterns.

Step 1: Lifted Network Construction (LNC)
- Identify sets of indistinguishable objects

Step 2: Belief Propagation (BP)
- Message-passing algorithm to infer marginals

This work:
- \( \Delta \text{LNC} \): online version of LNC
- \( \text{EFBP} \): online version of BP

\[ \text{EFBP} \text{ receives one LNC update; no loss of utility} \]

Standard LNC:
- Simulate BP; group together nodes that send and receive the same messages.

\( \Delta \text{LNC} \):
- First step: standard LNC
- Subsequent steps: retrace LNC’s steps, but only move changed tuples

Video segmentation experiments:
- Segmenting video into background and foreground
- First frame labeled by hand
- Simple MLN model for subsequent frames

LBP-4: four iterations of LNC (approximate lifting)

<table>
<thead>
<tr>
<th></th>
<th>Shuttle takeoff</th>
<th>Cricket</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial number of nodes</td>
<td>76800</td>
<td>2992</td>
</tr>
<tr>
<td>Initial number of factors</td>
<td>306080</td>
<td>13564</td>
</tr>
<tr>
<td>Initial LNC time (s)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Average ( \Delta \text{LNC} ) time (s)</td>
<td>-</td>
<td>6.95</td>
</tr>
<tr>
<td>Average BP time (s)</td>
<td>394.46</td>
<td>39.91</td>
</tr>
<tr>
<td>Total time (s)</td>
<td>3900.92</td>
<td>558.3</td>
</tr>
</tbody>
</table>

Viral marketing experiments: (Epinions)

| \( 0 \rightarrow 0.6 \) | \( \text{Buys}(x_j) \land \text{Trusts}(x_j, x_j) \Rightarrow \text{Buys}(x_j) \) | 29X |
| \( 0 \rightarrow 0.8 \) | \( \text{MarketTo}(x) \Rightarrow \text{Buys}(x) \) | 48X |
| \( 20 \rightarrow -1 \) | \( \text{Buys}(x) \) | |
| \( -1 \rightarrow \text{MarketTo}(x) \) | | |

- Goal: choose set of users to market to, taking advantage of word-of-mouth
- Epinions dataset: 75,888 users 500k edges

\( \Delta \text{LNC} \) for utility max:
Each flip is more informative!

Future work:
- Tighter combination of \( \Delta \text{LNC} \) and \( \text{EFBP} \)
- \( \text{EFXX} \)
- More applications

Further reading: