# COL776: Probabilistic Graphical Models
# Assignment #2

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**Message Passing Over a Junction Tree**

- Construct graph as per given model type
- Obtain variable elimination ordering from min-fill heuristics
- Generate Clique Tree
- Run two-way message passing algorithm on clique tree

**Loopy Belief Propagation**

- Construct graph as per given model type
- Construct BetheGraph
- Run loopy belief propagation

## 1. Sum-Product Inference

### Comparing Inference Algorithms

We can observe that LBP and MP give almost similar accuracy in sum-product inference. But time taken by LBP is greater compared to MP.

| **data-tree.dat** | Ch-Acc | Wd-Acc | LL | Time (ms) |
|---|---|---|---|---|
| MP | 0.675603 | 0.166667 | -6.606466 | 7.071033 |
| LBP | 0.678284 | 0.166667 | -6.629327 | 90.941630 |

| **data-treeWS.dat** | Ch-Acc | Wd-Acc | LL | Time (ms) |
|---|---|---|---|---|
| MP | 0.666667 | 0.163043 | -7.208698 | 40.382173 |
| LBP | 0.669978 | 0.179348 | -7.248585 | 295.473828 |

| **data-loops.dat** | Ch-Acc | Wd-Acc | LL | Time (ms) |
|---|---|---|---|---|
| MP | 0.568345 | 0.071429 | -7.545382 | 18.437528 |
| LBP | 0.539568 | 0.071429 | -7.563060 | 60.083693 |

| **data-loopsWS.dat** | Ch-Acc | Wd-Acc | LL | Time (ms) |
|---|---|---|---|---|
| MP | 0.675926 | 0.138462 | -6.919762 | 61.277259 |
| LBP | 0.705247 | 0.207692 | -6.866533 | 876.623621 |

**Adding Sophistication in Factors**

We can observe that as we increase the complexity of the model (i.e ocr -> transition -> skip -> pair-skip), the accuracy increases.
It is because higher complex model is able to capture the dependence between two words (pairs).

| **data-loopsWS.dat** | Ch-Acc | Wd-Acc | LL | Time (ms) |
|---|---|---|---|---|
| OCR | 0.600309 | 0.084615 | -7.816212 | 0.225974 |
| OCR+T | 0.660494 | 0.115385 | -7.524869 | 11.448129 |
| OCR+T+S | 0.662037 | 0.115385 | -7.331848 | 30.138350 |
| OCR+T+S+PS | 0.675926 | 0.138462 | -6.919762 | 61.277259 |

## 2. Max-Product Inference

We observe that MAP inference improve the results considerably. The word accuracy is very high compared to Sum-Product inference.
Also we note that LBP accuracy are significantly lower that corresponding the MP ones.

**Comparing Inference Algorithms**

| **data-tree.dat** | Ch-Acc | Wd-Acc | LL | Time (ms) |
|---|---|---|---|---|
| MP | 0.772118 | 0.523810 | -6.171370 | 8.497049 |
| LBP | 0.739946 | 0.440476 | -6.145515 | 58.308981 |

| **data-treeWS.dat** | Ch-Acc | Wd-Acc | LL | Time (ms) |
|---|---|---|---|---|
| MP | 0.764901 | 0.500000 | -6.483239 | 48.986065 |
| LBP | 0.749448 | 0.440217 | -6.443796 | 247.207710 |

| **data-loops.dat** | Ch-Acc | Wd-Acc | LL | Time (ms) |
|---|---|---|---|---|
| MP | 0.553957 | 0.178571 | -7.055558 | 21.898050 |
| LBP | 0.568345 | 0.071429 | -7.241011 | 73.157841 |

| **data-loopsWS.dat** | Ch-Acc | Wd-Acc | LL | Time (ms) |
|---|---|---|---|---|
| MP | 0.800926 | 0.623077 | -6.266185 | 77.575922 |
| LBP | 0.802469 | 0.561538 | -6.541588 | 273.674670 |

**Adding Sophistication in Factors**

| **data-loopsWS.dat** | Ch-Acc | Wd-Acc | LL | Time (ms) |
|---|---|---|---|---|
| OCR | 0.600309 | 0.084615 | -7.816212 | 0.366633 |
| OCR+T | 0.743827 | 0.346154 | -7.317031 | 14.476091 |
| OCR+T+S | 0.768519 | 0.507692 | -6.789455 | 36.895441 |
| OCR+T+S+PS | 0.800926 | 0.623077 | -6.266185 | 77.575922 |