# Semantic Kernels for Semantic Parsing


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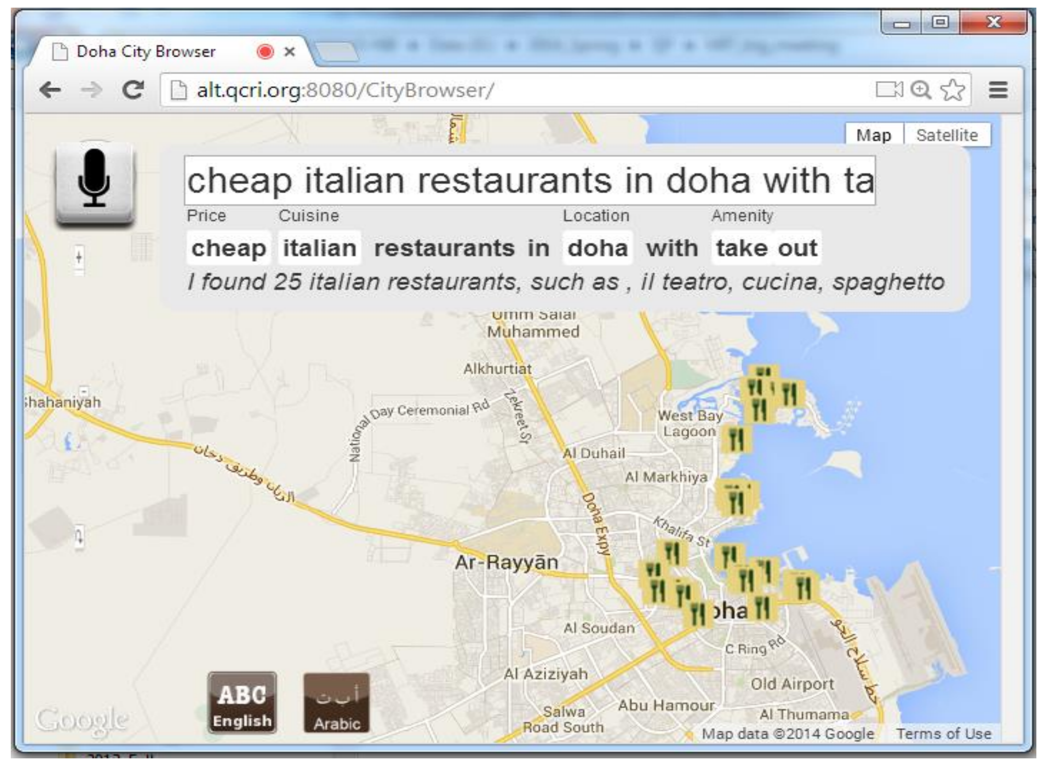
## 1. Motivation




How do we convert a spoken request like

***"cheap italian restaurants in doha with take out"***

into a database query?

### Processing Steps

Text/Speech

*"cheap italian restaurants in doha with take out"*

↓ ***semantic parser***

Semantically segmented text

*(cheap) (italian) restaurants in (doha) with (take out)*

`<Price> <Cuisine> <City> <Amenity>`

Semantic representation ↓ ***rule normalizer***

```
{"Price" : "low",
 "Amenity" : "take out",
 "City" : "doha",
 "Cuisine" : "italian"}
```

DB query ↓ ***query builder***

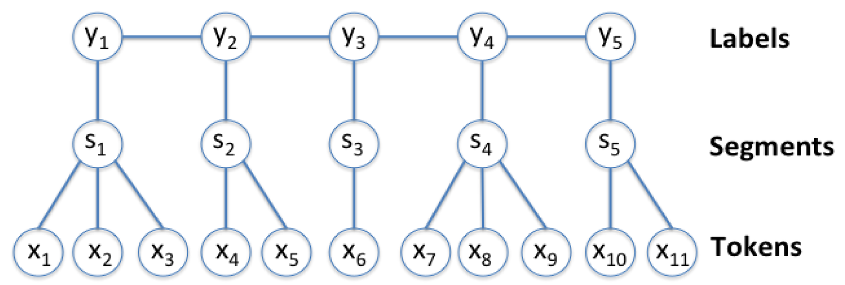
```
{$and[{"cuisine":{"$regex":"italian"}},
      {"city":{"$regex":"doha"}},
      {"price":{"$regex":"low"}},
      {"amenity":{"$regex":"carry out"}}]}
```

## 2. State-of-the-art Semantic Parser

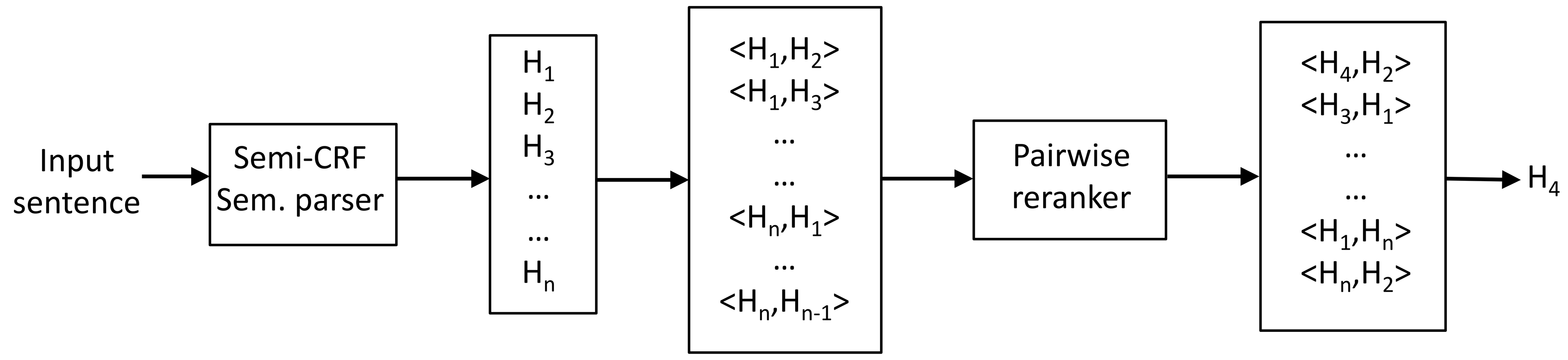
**Semi-Markov CRFs** (Sarawagi & Cohen 04)

- Joint sequential segmentation/classification
- Discriminative probabilistic sequential model
- Undirected graphical model

$$P(s \mid x) = \frac{1}{Z_\lambda(x)} \exp\{\textstyle\sum_j \lambda \cdot f(y_{j-1}, s_j, x)\}$$

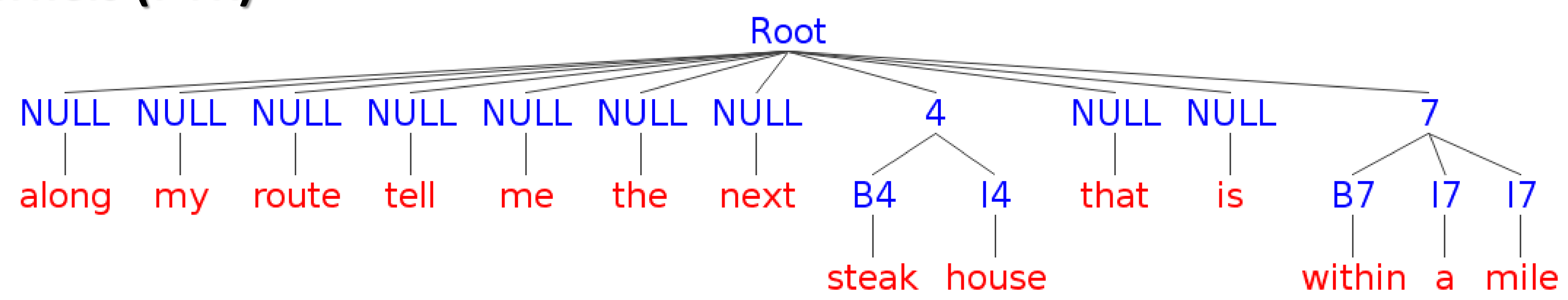



## 3. Our Approach: Reranking with Semantic Kernels



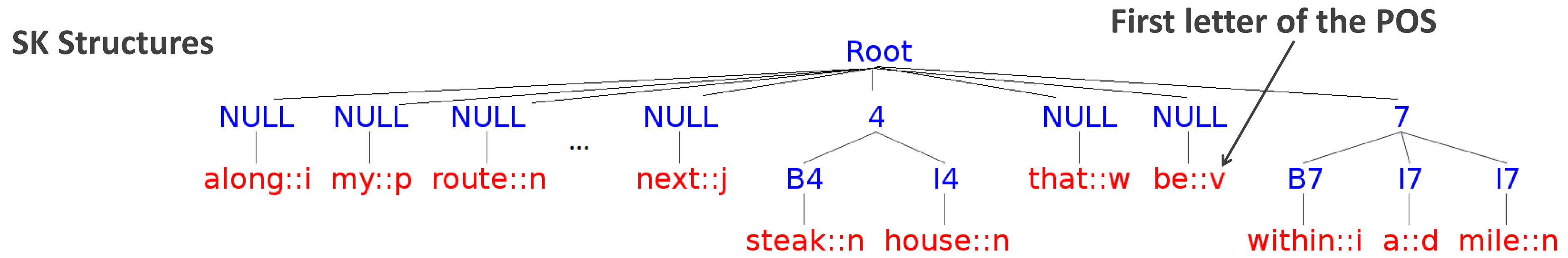

- Semi-CRF generates *n*-best hypotheses ($H_i$)
- Pairwise reranking function trained with SVMs with the preference reranking kernel
- Hypotheses are represented with tree-based structures (tree kernels are applied)
- **Focus on kernels using semantics: LSA-based smoothing lexical similarity and Brown clusters**

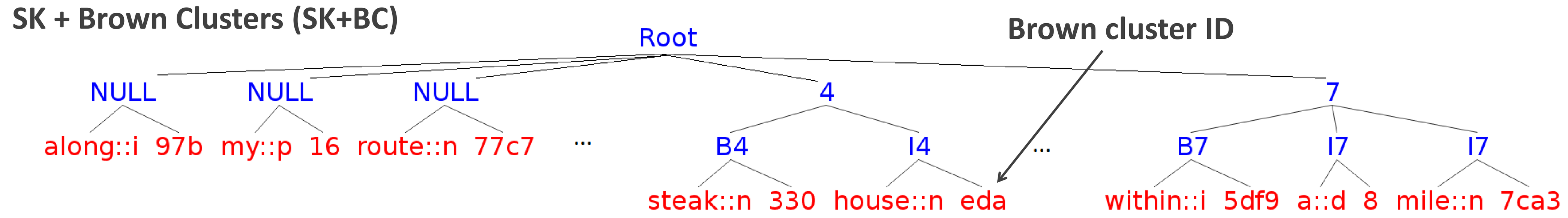
### Partial Tree Kernels (PTK)




### Smoothed PTK or Semantic Kernel (SK)

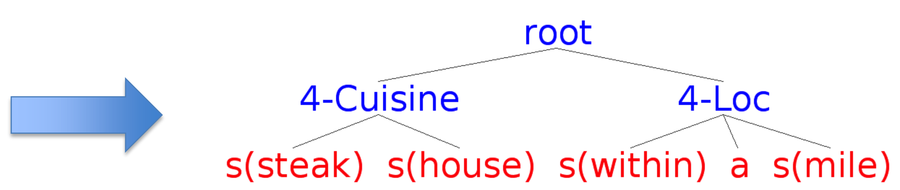
- Soft matching of tree fragments via similarity
- Node similarity derived using LSA




### Semantic Structures for CSL Reranking

- **Tree Kernels** capture structural similarities between trees
- **Brown cluster IDs** in the structures capture semantic dependencies between labels
- **LSA-smoothed SKs** enable to measure the similarity between tree fragments (based on LSA word similarity), thus powerful semantic patterns are generated




### Extra features in a flat vector (+all)

- From the semi-CRF: probability of label sequences, label sequence *n*-grams, DB-based, etc.

## 4. Experiments

- **Dataset:** human annotations (McGraw et al. 12)

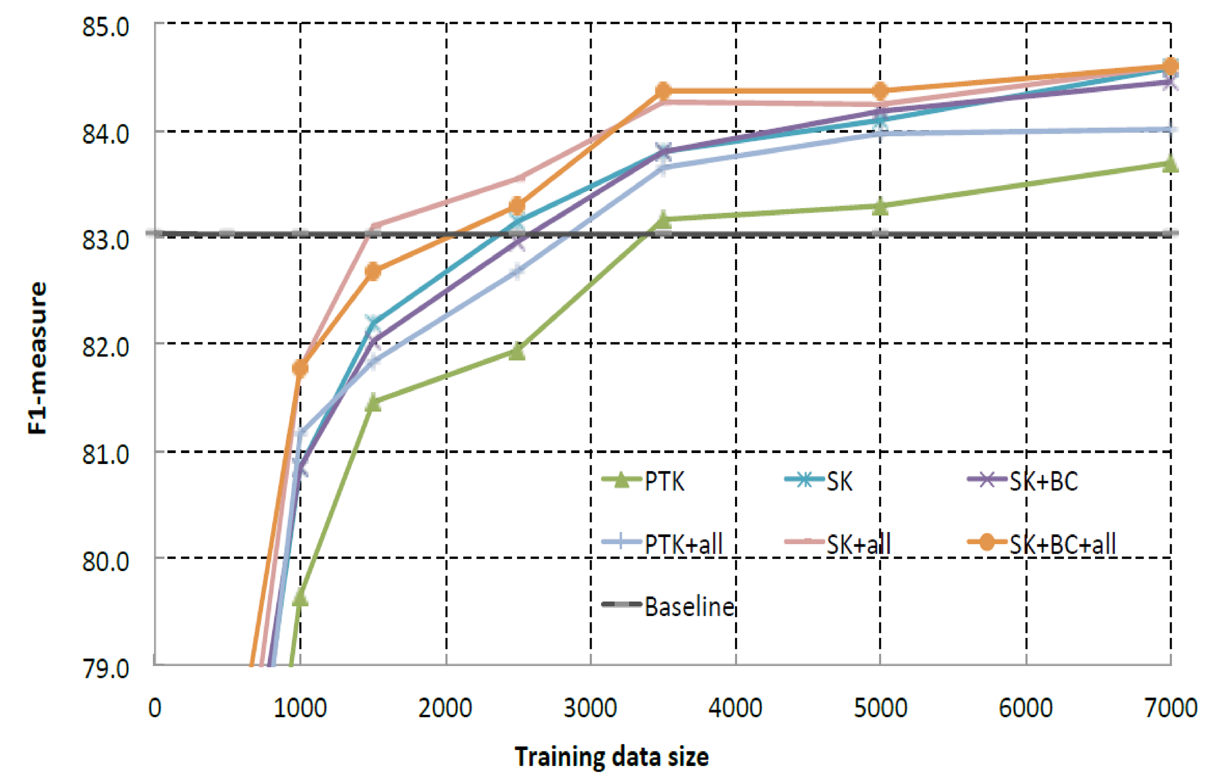
| Train | Test | Train Reranker | Test Reranker |
|---|---|---|---|
| 6,922 | 1,521 | 28,482 | 7,605 |

- **Oracle:** shows large room for improvement

| N | 1 | 2 | 5 | 10 | 100 |
|---|---|---|---|---|---|
| Oracle F1 | 83.03 | 87.76 | 92.63 | 95.23 | 98.72 |

- **Brown clusters:** from Yelp restaurants reviews
- **Lexical similarity for SK**: LSA on TripAdvisor reviews

**Main results**




## 5. Conclusions

- The LSA-smoothed semantic kernel (SK) improves significantly over the semi-CRF ("baseline") and over our previous state-of-the-art reranker, which uses shallow syntactic patterns and PTK (Saleh et al., COLING-2014; *equivalent* to PTK+all)
  - ✓ ~10% relative improvement
- BCs do not significantly improve any model
- PTK+all is better than PTK but its accuracy is lower than any SK
- *+all* helps SK only with small sizes of the training set

**Note**: the state of the art on the task is very hard to beat

## 6. Future Work

- Explore semantic similarity from distributional and other sources, e.g., Wikipedia, Wiktionary, WordNet, FrameNet, BabelNet, and LSA for different domains.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