A Study of using Syntactic and Semantic Structures for Concept Segmentation and Labeling

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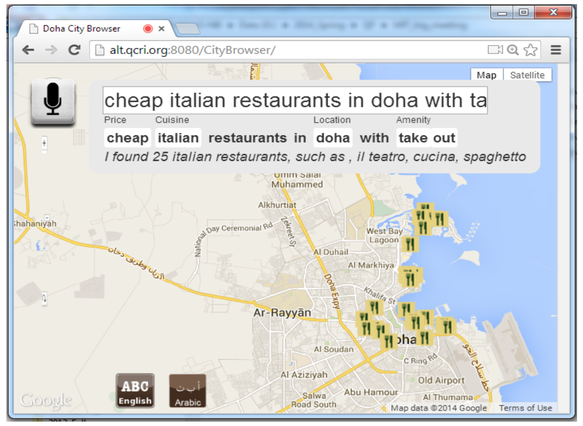
Motivation



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 tagger

Semantically segmented text

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

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

↓ Rule normalizer

Semantic representation

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

↓ Query builder

DB query

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

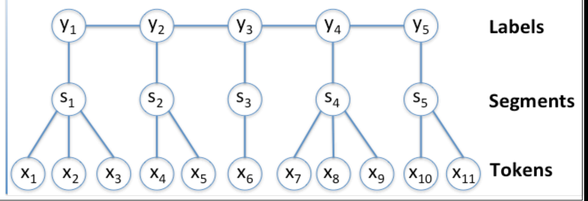
Computation Models for Semantic Tagging

State-of-the-art system

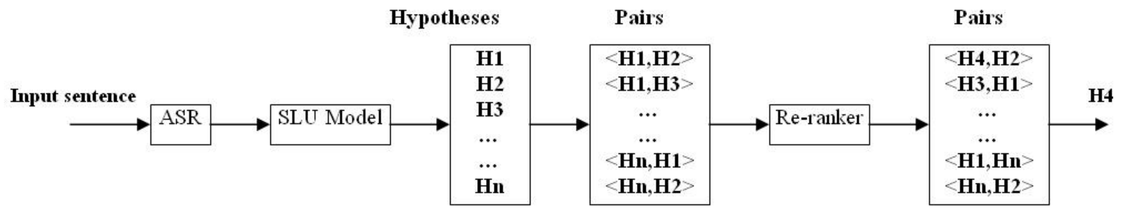
Joint sequential segmentation/classification

- **Semi-Markov CRFs** (Sarawagi & Cohen 04)
- Discriminative probabilistic sequential model
- Undirected graphical model

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

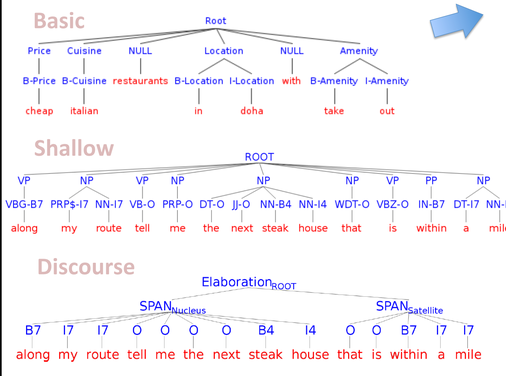


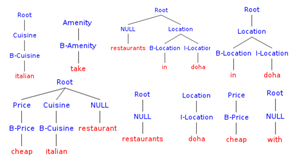
Our Approach: Reranking with Kernel Machines



- Semi-CRF generates *n*-best hypotheses
- SVMs and convolution tree kernels are then used to learn a reranking function
- Such function can choose the best hypothesis by exploiting structural representations

Hypothesis representations in form of semantic trees





Classification function with kernels

SVM: $H(\vec{x}) = \vec{w} \cdot \vec{x} + b = 0$

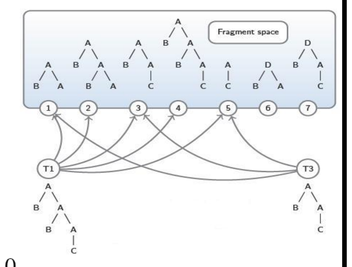
Dual: $\sum_{i=1..l} y_i \alpha_i \phi(o_i) \cdot \phi(o) + b = 0$

$K(o_i, o) = \langle \phi(o_i) \cdot \phi(o) \rangle$

Re-ranking Kernel:

$K(\langle H_1, H_2 \rangle, \langle H_1', H_2' \rangle) = S(H_1, H_1') + S(H_2, H_2') - S(H_1, H_2') - S(H_2, H_1')$

Common Tree Fragment Set



Dataset

Amazon Mechanical Turk was used to collect a corpus of sentences and gold-standard human annotations: 7,661 sentences (McGraw et al. 12)

Train	Test	Train RR	Test RR
6,922	1,521	28,482	7,605

Acknowledgements

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Experiments

- N-best Oracle accuracy shows great headroom for improving on the CRF baseline

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

- F1 scores for different tree kernels on basic tree

Subtree kernel	Syntactic tree kernel	Syntactic tree kernel + BOW	Partial tree kernel	Sequence kernel
84.08	83.19	83.20	**84.61**	82.93

- F1 scores for different feature combinations

	CRF Feat.	All Feat.	All Feat. + Basic Tree	All Feat. + Shallow Tree	All Feat. + Discourse Tree
F1	83.44	83.86	84.76	84.79	84.55
Rel. Imp	2.4%	4.8%	10.2%	10.3%	8.9%

Error analysis

	Other	Rating	Restaurant	Amenity	Cuisine	Dish	Hours	Location	Price
Other	8260	35	43	110	15	19	55	113	9
Rating	29	266	0	**14**	3	6	0	0	8
Restaurant	72	6	657	**20**	19	15	0	5	0
Amenity	117	9	10	841	**27**	**27**	7	12	7
Cuisine	36	2	12	**26**	543	**44**	3	1	0
Dish	23	0	4	**20**	**33**	324	1	4	0
Hours	61	0	1	2	6	1	426	9	1
Location	104	1	14	**20**	2	1	1	1457	0
Price	22	1	0	7	0	2	0	1	204

- Inaccuracies and inconsistencies in human annotations
- Requires lexical semantics and more coverage

Conclusions

- Structural kernels yield significant improvements.
- Partial tree kernel gives best results.
- Shallow tree is more helpful than other deep structures.
- Still large room for further improvement in the future.

References

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[2] M. Dinarelli, A. Moschitti, and G. Riccardi. Discriminative Reranking for Spoken Language Understanding. IEEE Transaction on Audio, Speech and Language Processing, 2012.

[3] S. Sarawagi, W. W. Cohen, Semi-Markov Conditional Random Fields for Information Extraction, in proceedings of NIPS, 2004 .