Inference by Coincidence and the Extraction of Relational Information

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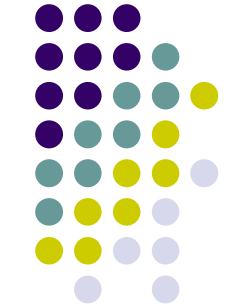
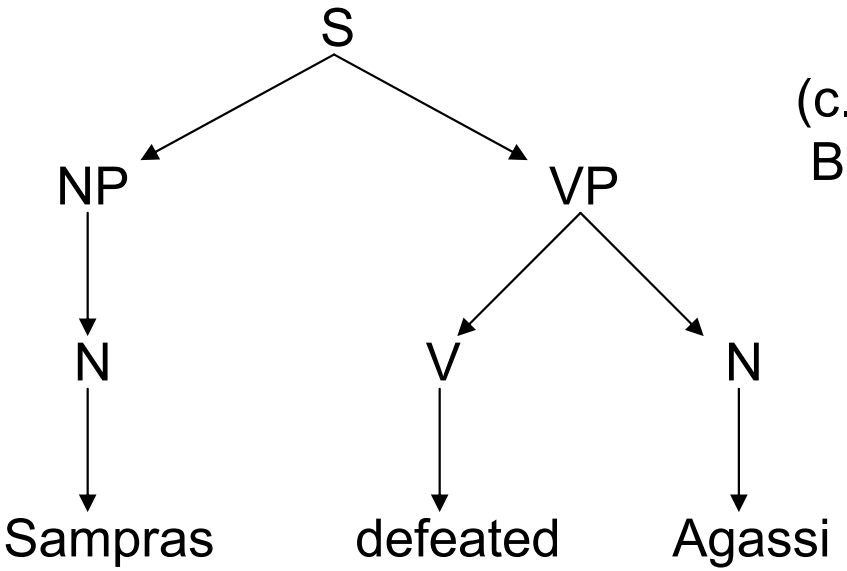
Current Approaches to Extracting Propositional Information from Text



Parse



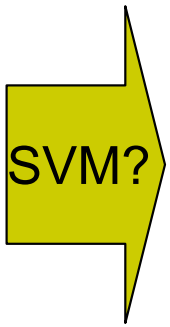
(c.f. Gildea & Jurafsky 2002
Blaheta & Charniak 2000)

Assign Roles

Verb (defeated)

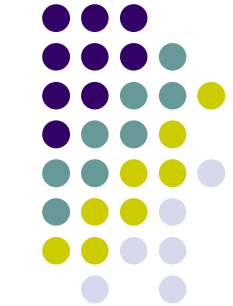
Head Noun (Sampras)

Structural Properties
(two up two down)



Role
(winner)

Problems

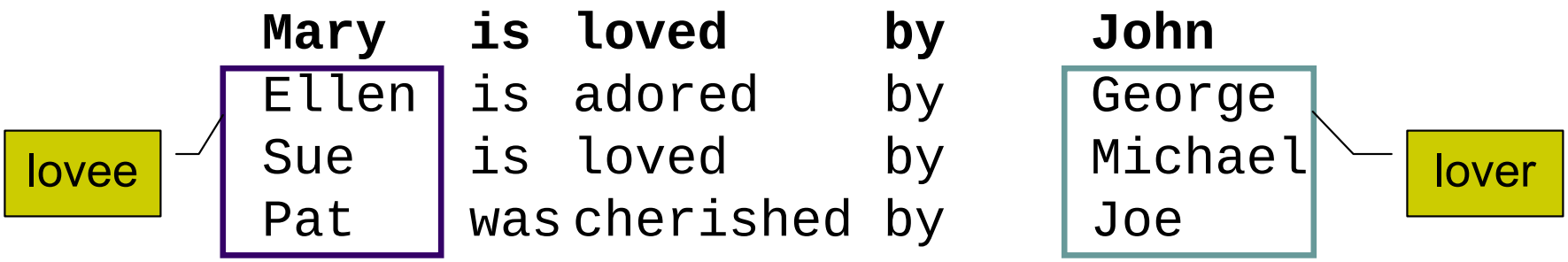


- Require large sets of parsed sentences for training
- Must predefine semantic roles
- Require large set of role labeled sentences for training
- Still don’t work well especially across corpora

The SP Model in a Nutshell

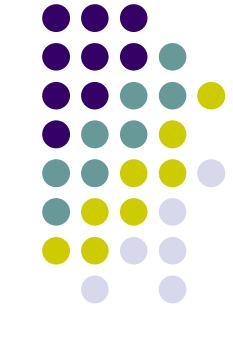
- Assumes that people store a large number of sentence instances (sequential traces).
- When trying to interpret a new sentence they retrieve similar sentences from memory and align these with the new sentence.
- The set of alignments is an interpretation of the sentence.
- Training involves adding new traces to memory and inducing word-to-word correspondences that are used to choose the optimal alignments.

SP Continued



- The set of words that aligns with each word from the target sentence represents the role that that word plays in the sentence.
- {Ellen, Sue, Pat} represents the lovee role and {George, Michael, Joe} the lover role.
- The model assumes that two sentences convey similar factual content to the extent that they contain similar words aligned with similar sets of words.
- Interpretations are entered into memory as relational traces and relational retrieval and resolution affect subsequent alignment.

The SP Architecture



Working Memory

Who	Who
did	did
Sampras	Sampras
beat	beat
?	?
#	#

Sequential Long-Term Memory

Sampras defeated Agassi
Kuerten defeated Roddick
Hewitt defeated Costa
Who did Kuerten beat? Roddick
Who did Hewitt beat? Costa

Relational Long-Term Memory

Sampras: Kuerten, Hewitt **Agassi**: Roddick, Costa
Kuerten: Sampras, Hewitt **Roddick**: Agassi, Costa
Hewitt: Sampras, Kuerten **Costa**: Agassi, Roddick
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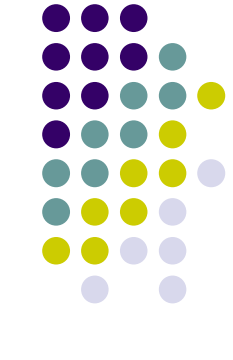
Hewitt: Kuerten **Costa**: Roddick

Sequential Retrieval



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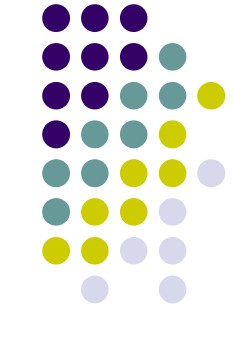
Sequential Resolution



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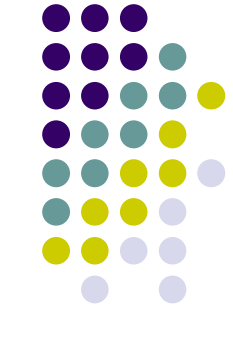
Relational Retrieval



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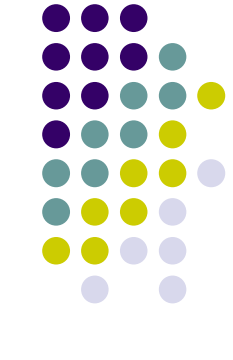
Relational Resolution



Working Memory

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did	did
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beat	beat
?	?
#	Agassi Roddick Costa

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String Edit Theory

- Characterize the similarity and alignment of strings by sequence of edit operations required to turn one string into another (matches, changes, insertions and deletions).

```
John    loves   Mary
|       |       |
Bert    loves   Ellen
```

- Deletes allow alignment of sentences of different lengths:

```
Little  John    loves   Mary
|       |       |       |
-       Bert    loves   Ellen
```

- or

```
John    loves   Mary    -
|       |       |       |
-       Bert    loves   Ellen
```

- 63 ways to align sentences not all equally likely
- Edit probabilities trained using a version of EM algorithm

The Bayesian Framework

- Calculate expected probability of substitution given the sentential context:

$$E_k\left[P(<W_m,T_i>|\,T)\right]=\sum_{k=1}^{N}\frac{P(S_k\mapsto T\,|\,T)}{\sum_{i=1}^{N}P(S_i\mapsto T\,|\,T)}P(<W_m,T_i>|\,S_k\mapsto T,T)$$

- Employs Bayesian likelihood framework:

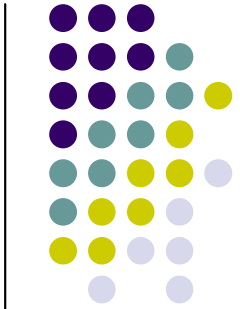
$$\frac{P(S_k\mapsto T\,|\,T)}{P(\overline{S_k\mapsto T}\,|\,T)}=\frac{P(T\,|\,S_k\mapsto T)P(S_k\mapsto T)}{P(T\,|\,\overline{S_k\mapsto T})P(\overline{S_k\mapsto T})}$$
$$=\frac{P(T\,|\,S_k\mapsto T)}{P(T\,|\,\overline{S_k\mapsto T})}$$

Relational Retrieval and Resolution

- Similar model to sequential case – assuming relational representation of target was generated by editing one of the relational traces in memory.

$$E_k\left[P(<W_m,T_i>|\,RT)\right]=\sum_{k=1}^{N}\frac{P(R_k\mapsto RT\,|\,RT)}{\sum_{i=1}^{N}P(R_i\mapsto RT\,|\,RT)}P(<W_m,T_i>|\,R_k\mapsto RT,RT)$$

Intentional vs Extensional Semantics



- Intentional Semantics
  - Defined by intended use

Defeated(Sampras, Agassi)

- Extensional Semantics
  - Defined by enumerating instances

Sampras: Kuerten, Hewitt
Agassi: Roddick, Costa

- Most systems employ intentional semantics
- SP uses extensional semantics:
  - Easier to make mapping from text to meaning representation
  - Allows system to take advantage of **inference by coincidence**

Inference by Coincidence

- Simple inference is an emergent property of the model as there is coherence between the fillers of different roles.

  e.g. Sampras claims 14th Grand Slam title.
  Sampras defeated Agassi at Flushing Meadows

- If Sampras won the tournament there is a good chance he won the match.
- There is overlap between the winner-of-match role and the winner-of-tournament role.
- No inference process needed – occurs as a consequence of the causality being expressed by the corpus.

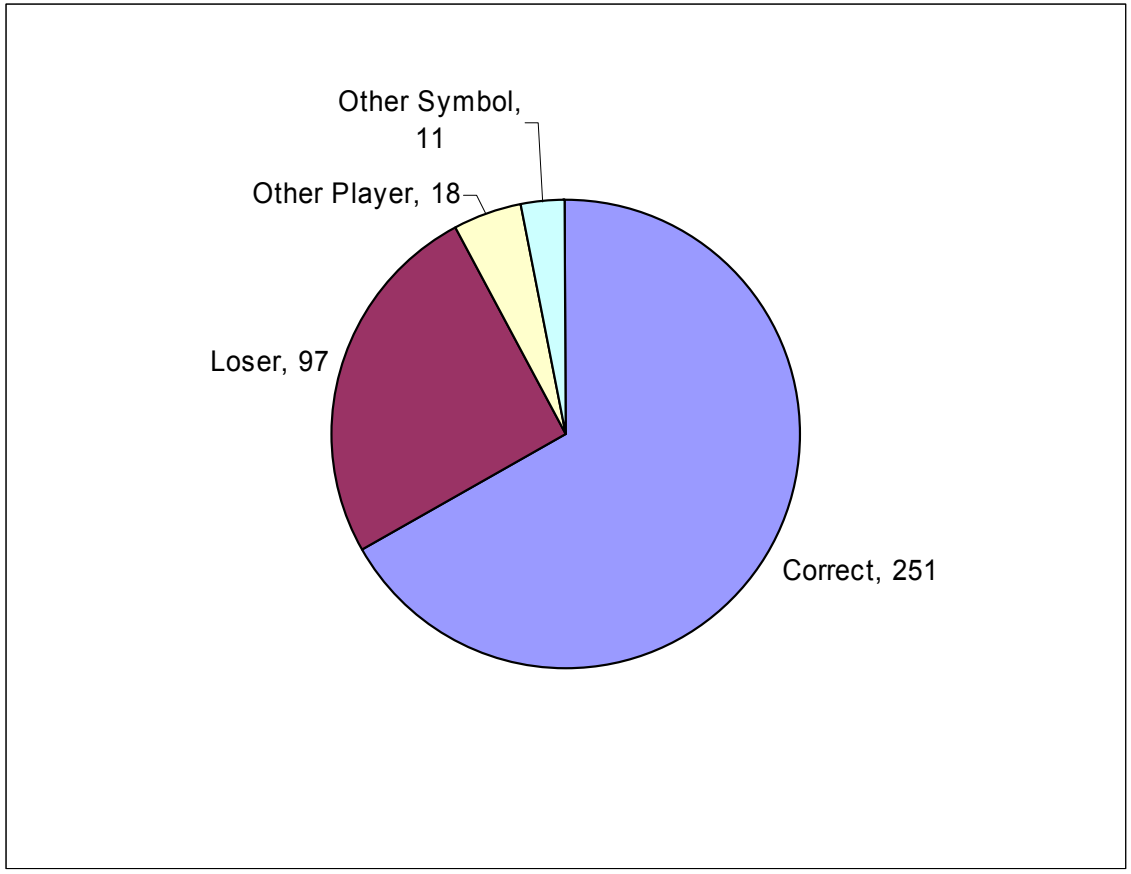
Question answering

- 69 articles were taken from the Association of Tennis Professionals (ATP) website at http://www.atptennis.com/.
- 377 questions of the form:

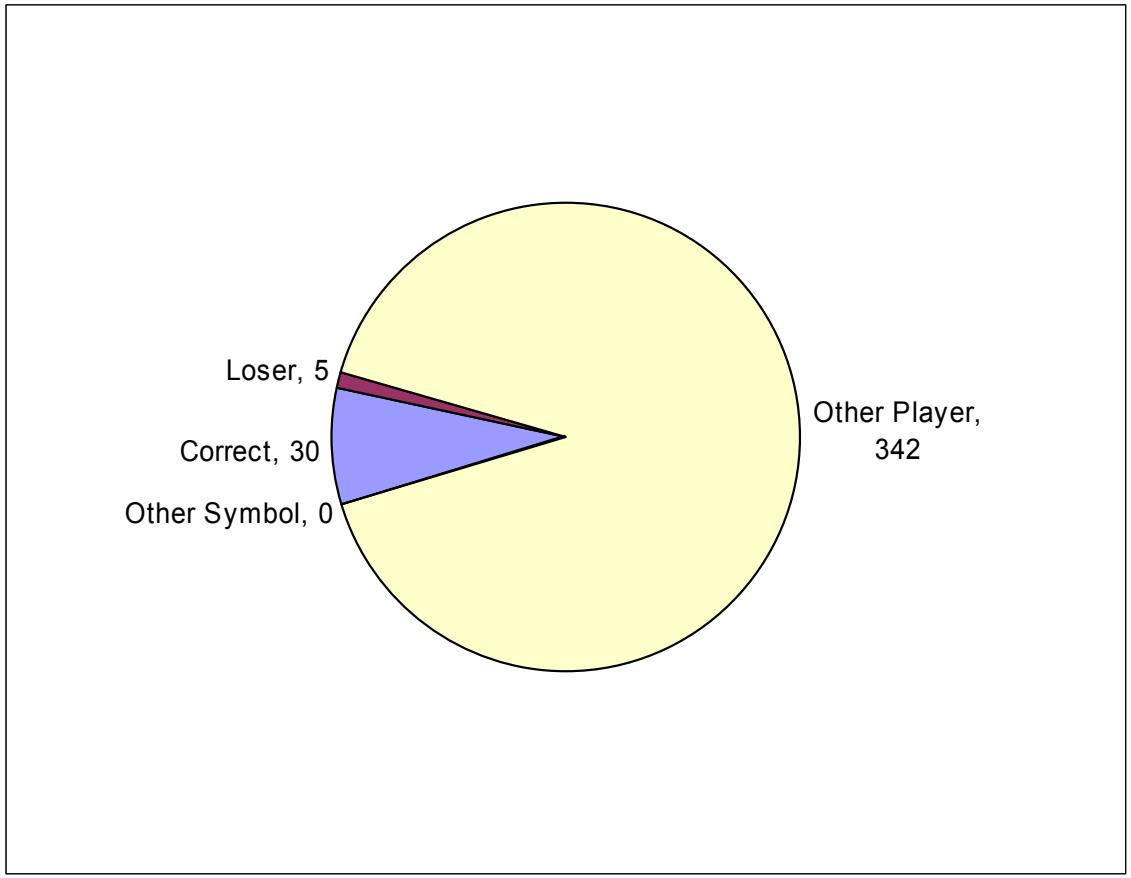
  Who won the match between X and Y? X

- Choice of Domain
  - Naturally occurring text available
  - Questions not susceptible to type heuristics
  - Opportunity for inference by coincidence

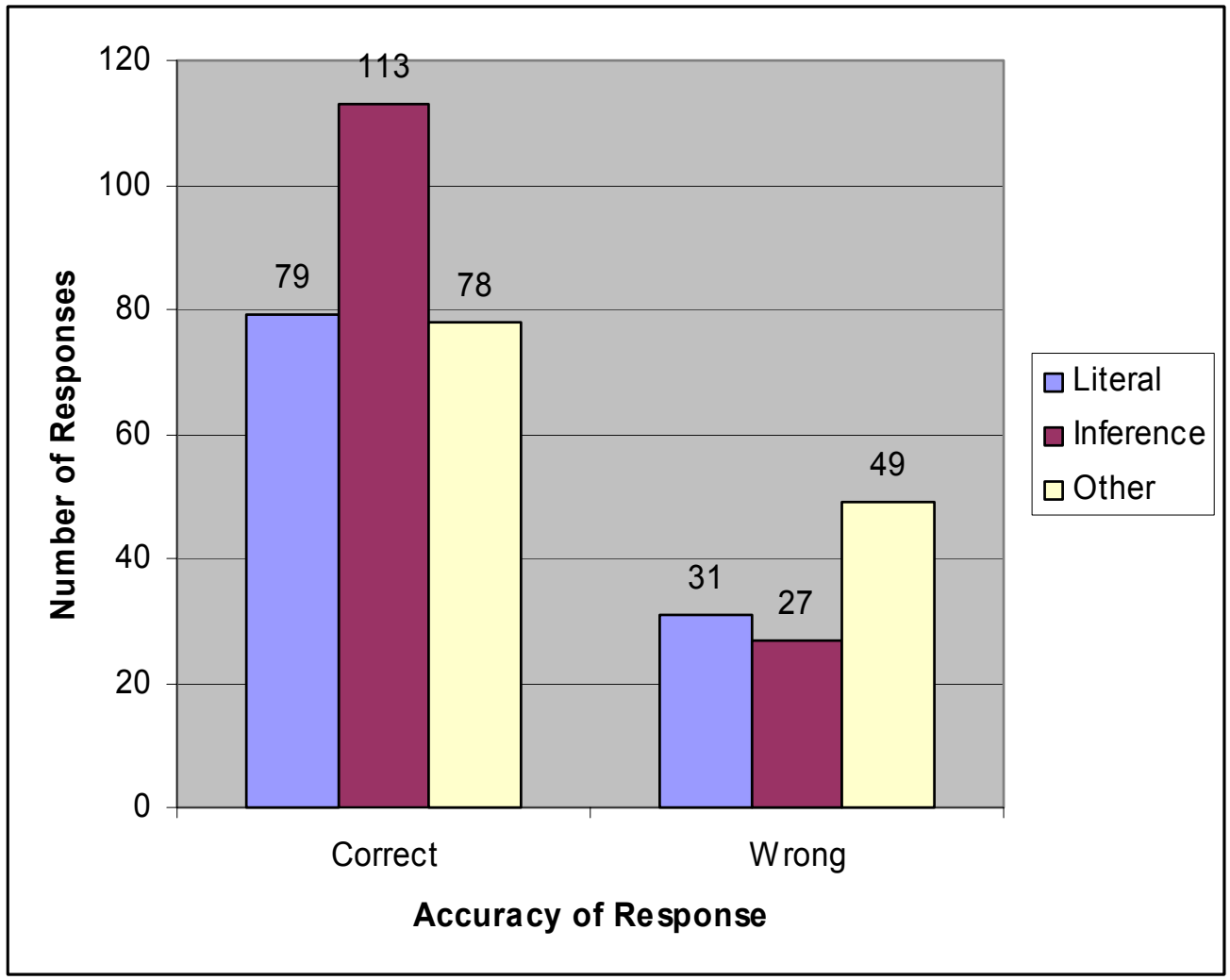
Results



Sequential Only



Inference by Coincidence Results



Conclusions

- No grammar
- No predefined semantic roles
- No conceptual schema

- Yet questions that require role information can be answered

- Automatic “inference by coincidence” can occur as an emergent property of retrieval without any inference process