Joint Parsing,
Named Entity Recognition,
(and Semantic Role Labeling)

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(joint work with Chris Manning)
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Motivation

• Core NLP tasks: part of speech tagging, named entity recognition, parsing, word sense disambiguation, semantic role labeling, coreference resolution

• Higher level NLP tasks: question answering, machine translation, textual entailment, semantics

• Goal: to bridge this divide
Motivation

• Different types of annotations should be able to help each other.
  • Named entities should correspond to constituents in the parse (or at least not have crossing brackets)
  • Named entities have distinct internal structure
  • Named entities are more likely to appear in certain structural contexts.
  • Named entities are more likely to be semantic arguments. Different kinds of entities are more likely to be different kinds of arguments
  • Semantic structure and syntactic structure are highly correlated and should be able to inform one another
Talk Outline

1. Motivation
2. Discriminative Parsing
3. Adding Named Entity Recognition
4. Adding Semantic Role Labeling (work in progress)
5. Conclusions / Future Work
Discriminative Parsing

Generative

\[
P(NP \rightarrow NN \ NNS) = \frac{\#(NP \rightarrow NN \ NNS)}{\#(NP)}
\]
Discriminative Parsing

\[ \phi(NP_{0,2} \rightarrow NN_{0,1} \ NNS_{1,2}) = f(NP_{0,2} \rightarrow NN_{0,1} \ NNS_{1,2}) \cdot \theta \]

Intuition: analogous to changing an HMM into a linear-chain CRF
Discriminative Parsing

\[ f(NP_{0,2} \rightarrow NN_{0,1}, NNS_{1,2}) \]

- **label**: NP
- **rule**: NP \( \rightarrow \) NN NNS
- **words**: NP/factory
- **dist sim tags**: NP/132
- **dist sim split**: NP/132/45

\[ f(NN_{4,5} \rightarrow September) \]

- **label/word**: NN/September
- **label/dist sim**: NN/24
- **prev word**: NN/in
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NER data

- Everything reported is with OntoNotes 2.0
- Only worked with the English data
- Collapsed the entity types down to person, GPE, organization, misc
- Made some small changes to the data for the sake of consistency – Chris will talk about this
The Basic Idea

\[
S \\
\text{NP} \rightarrow \text{VP} \\
\text{NN} \quad \text{NNS} \quad \text{VBD} \quad \text{PP} \\
\text{Factory} \quad \text{payrolls} \quad \text{fell} \quad \text{IN} \quad \text{NN-MISC} \\
\text{in} \quad \text{September} \\
\]

\[
f_{\text{parse}}(PP_{3,5} \rightarrow IN_{3,4} \; NN_{4,5})
\]

\[
f_{\text{NER}}(O_{3,5} \rightarrow O_{3,4} \; MISC_{4,5})
\]

\[
f_{\text{parse} / \text{NER}}(PP_{3,5} \rightarrow IN_{3,4} \; NN - MISC_{4,5})
\]
Joint Representation

```
NP
  /\   /
 /  \ /  \   /
DT NNP IN NNP
  \   \  /  /
   the [District of Columbia] GPE
```
Joint Representation

```
NP
  └── NamedEntity
      ├── DT
      │   └── NP
      │       └── NNP
      │           └── the
      └── NP
          └── NNP
              └── District
IN
 PP
  └── NP
      └── NNP
          └── Columbia
```
Joint Representation

```
NP
  /\  
DT  NamedEntity-GPE
     / \   / \  
    NP  PP  IN NP
      /   /   |   |
     NNP  IN  NNP
          /   |
           of  Columbia
           /
           the
```
Joint Representation

```
NP
  /   \
DT   NamedEntity-GPE *
     /       \
NP-GPE   PP-GPE
  /         /     \
NNP-GPE   IN-GPE NP-GPE
    /     /      /     \
  the   District of   Columbia
```
Grammar Smoothing

- Add rules, stripped of all entities
- If a rule has been seen with one type of entity, duplicate it with all kinds of entities
- If a rule has an NP for a child, allow that NP to be any kind of entity

- We tried adding other ones, but they mostly slowed it down without improving performance
Features

- *Parse features* – same as baseline parser

- *NER features* – same as baseline CRF named entity recognizer

- *Joint features* -
## Joint parse/NER Results (F-score)

<table>
<thead>
<tr>
<th></th>
<th>ABC</th>
<th>CNN</th>
<th>MNB</th>
<th>NBC</th>
<th>PRI</th>
<th>VOA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Just NER</strong></td>
<td>80.23</td>
<td>83.18</td>
<td>75.50</td>
<td>77.97</td>
<td>85.03</td>
<td>91.65</td>
</tr>
<tr>
<td><strong>Joint Model NER</strong></td>
<td>80.30</td>
<td>87.37</td>
<td>81.21</td>
<td>81.03</td>
<td>86.05</td>
<td>91.94</td>
</tr>
<tr>
<td><strong>Just Parse</strong></td>
<td>70.6</td>
<td>77.61</td>
<td>64.66</td>
<td>62.1</td>
<td>74.71</td>
<td>77.41</td>
</tr>
<tr>
<td><strong>Joint Model Parse</strong></td>
<td>70.71</td>
<td>78.79</td>
<td>67.26</td>
<td>62.79</td>
<td>76.49</td>
<td>79.38</td>
</tr>
<tr>
<td><strong># Train Sent</strong></td>
<td>1099</td>
<td>5220</td>
<td>592</td>
<td>555</td>
<td>1645</td>
<td>1485</td>
</tr>
<tr>
<td><strong># Test Sent</strong></td>
<td>295</td>
<td>1393</td>
<td>162</td>
<td>146</td>
<td>456</td>
<td>410</td>
</tr>
<tr>
<td><strong>Parse Train Time</strong></td>
<td>25 m</td>
<td>16.5 h</td>
<td>12 m</td>
<td>10 m</td>
<td>2.4 h</td>
<td>2.3 h</td>
</tr>
<tr>
<td><strong>Joint Train Time</strong></td>
<td>44 m</td>
<td>31.7 h</td>
<td>19 m</td>
<td>17 m</td>
<td>4.2 h</td>
<td>4.4 h</td>
</tr>
</tbody>
</table>
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Conclusions

• Jointly learning multiple levels of annotation can help all levels (at least with parsing and NER)
• Picking the correct model structure is key
  • Too simple and you can’t capture important aspects of the structure
  • Too complex and it becomes too expensive to do inference
  • Can be beneficial to restrict the model
• Separate and Joint features
  • Use all of your familiar single-task features
  • Add multi-task features to capture interactions between the different types of annotation
Future Work

- Finish getting SRL to work
- Multiple predicates at once
- Adding in the other levels of annotation in OntoNotes
- Require moving from exact inference to approximate inference
- Adding long distance dependencies for coreference resolution