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Structured Prediction for Named Entity Recognition

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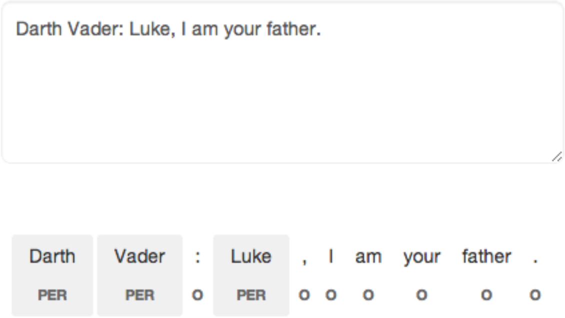
October 24th, 2012

Named Entity Recognition (NER)



Entity Classes in NER

- Enamex types
  - Person Names: `John Bateman`
  - Organisations: `Lavazza`
  - Locations: `France, Bristol`
- Miscellaneous (CoNLL)
  - proper names outside the classic *enamex*
- timex (Date & Time Expressions)
- numex Monetary Values & Percent

$\Rightarrow$ only specific entities; *in June* / *the prof* (undefined year/person)

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Training data

- CoNLL organized challenges
  - CoNLL 2002/2003: NER task
  - Languages: English, German, Spanish & Dutch
  - news data
  - data division: train, testA, testB
- POS-tagged, tokenized, NE-tagged (B-I-O)
- NE-labels: ORG, LOC, PER, MISC

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Approaches to NER

1. linguistic grammar-based techniques
   - hand-crafted rules may obtain a high precision, but at cost of low recall and extensive work by computational linguists
2. statistical models
   - Statistical NER systems usually require large amount of manually annotated training data

$\Rightarrow$ supervised methods most prominent

Issues in NER

- Ambiguity
  - **Polysemy:** `Location` vs. `Person`
    Paris (France) - Paris (Hilton)
  - **Metonymy:** (part-whole):
    "**Paris** has decided to introduce an increase in tax..."
    $\Rightarrow$ (the **government** not the **city**)
- mainly domain-specific systems - not readily portable to different domain/genre

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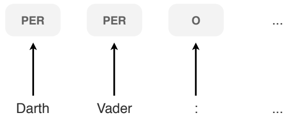
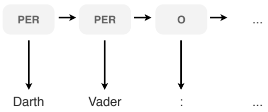
Structured Prediction

general framework for prediction $\mathbf{x} \rightarrow \mathbf{y}$ where $\mathbf{y}$ is structured (tree, sequence, etc.)



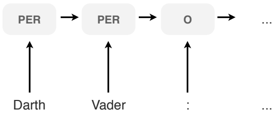
Local classifiers

- features
- no label interactions



HMM

- MLE over tokens
- label interaction



Structured Prediction

- features
- label interactions

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Our Implementation

- **Predicted structure:** NE label for each token in the sentence (O if none)
- **Learning:** Structured Perceptron with Averaging

  $$\mathbf{w} = \frac{\sum_{i=1 \ldots T} \mathbf{w}^i}{T}$$

  where $\mathbf{w}^i$ are the weights of epoch i
- **Decoding:** Viterbi algorithm (Markov assumption, only 1 prev. label)
- implemented in Python using the NumPy package

Features

- **Node features**:
  - token, suffixes and prefixes (2-4)
  - number patterns, contains '-', etc.
  - Capitalized?, UPPERCASE?
  - lemma, POS tag
- **Label interaction**:
  - current and prev. label
  - current token and last label for prepositions or possessive 's
- **Gazetteer**:
  - Mark entities from lists of known names. *Reliability* of each list is learnt by the Perceptron.
  - Lists are automatically created using a SPARQL query over DBpedia.

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Some Challenges

- **Marking gazetteer entries:**
  - Directed Acyclic Word Graph (Q: Do I know `New York .*` ?)
  - starting at each token, mark longest known entry
- **Headlines and irregular case:**

  `SOCCER - BELARUS BEAT ESTONIA IN WORLD CUP QUALIFIER .`

  - useful case information missing
  - restore most likely case before classification (*truecasing*)

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Evaluation

- **Training:** error on tokens
- **Evaluation:** Precision and Recall over full Named Entities
  - $precision = \frac{|\, gold\ \cap\ predicted\, |}{|\, predicted\, |}$
  - $recall = \frac{|\, gold\ \cap\ predicted\, |}{|\, gold\, |}$
  - $F_1 = \frac{2 * precision * recall}{precision + recall}$

Results and Conclusion

- **Results (English only)**

System	testA	testB
EN (full)	0.8109	0.7556
EN (no gazetteer)	0.7985	0.7156

- handling noisy input data important in NER
- SP is suitable and simple model for NER
- reasonable amount of work produces good results

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Thank You!

Questions?

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Structured Perceptron

- similar to vanilla Perceptron but different update rule:

  $\mathbf{z} = \arg\max_{\mathbf{z}} \sum_{i=1}^{n} \mathbf{f}(\mathbf{x}, i, \mathbf{z}_{i-1}, \mathbf{z}_i)$

  if $\mathbf{z} \neq \mathbf{y}$:

  $$\mathbf{w} \leftarrow \mathbf{w} + \sum_i \mathbf{f}(\mathbf{x}, i, \mathbf{y}_{i-1}, \mathbf{y}_i) - \sum_i \mathbf{f}(\mathbf{x}, i, \mathbf{z}_{i-1}, \mathbf{z}_i)$$