A Benchmark of Rule-Based and Neural Coreference Resolution in Dutch Novels and News

Corbèn Poot, Andreas van Cranenburgh
@andreascvc

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This talk:
Introduction
Setup and Results
Analysis

https://twitter.com/JenMsft/status/1132306345787568128
Coreference resolution is the task of clustering mentions in text that refer to the same persons or objects.
Definition

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+-----------+
|           |
|           |
"I voted for Obama because he was most aligned with my values", she said.
|           |
+--------------------------------------------------+------------+

Entity 1 = \{Obama, he\}
Entity 2 = \{I, my, she\}

http://nlpprogress.com/english/coreference_resolution.html
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Rule-based: deterministic, hand-written rules

Statistical: traditional (non-neural) machine learning

Neural: embeddings, CNN, recurrent nets etc.

BERT: contextual-word embeddings
- Rule-based: deterministic, hand-written rules
- Statistical: traditional (non-neural) machine learning
- Neural: embeddings, CNN, recurrent nets etc.
- BERT: contextual-word embeddings
State of the art: from rules to a neural arms race …

OntoNotes (English)
By the way ...

#BenderRule:

The rest of this talk is about Dutch!

https://thegradient.pub/the-benderrule-on-naming-the-languages-we-study-and-why-it-matters/
Research agenda/background

- Project The Riddle of Literary Quality (2012–2020)
- Next goal: Analyze plot, characters, dialogue of novels
- Domain-adaptation of NLP for literature

https://literaryquality.huygens.knaw.nl/
## Datasets

|                      | SoNaR-1          | RiddleCoref       |
|----------------------|-------------------|-------------------|
| Domain               | news, wiki, etc   | novels            |
| Docs                 | 861               | 33                |
| Tokens               | 1M                | 160k              |
| Tokens/doc           | \(\approx 1166\) | \(\approx 4900\) |
| Pron/Nom/Name %      | 11/71/18          | 40/47/13          |

- **SoNaR-1**: automatically extracted markables
- **RiddleCoref**: manually annotated mentions

Schuurman et al (LREC 2010). […] SoNaR, a reference corpus of contemporary written Dutch.
Van Cranenburgh (CLIN journal 2019). A Dutch coref. res. system w/evaluation on literary fiction.
|                      | dutchcoref                      | e2e-Dutch                       |
|----------------------|--------------------------------|--------------------------------|
| **Architecture**     | rule-based                     | neural                          |
|                      | entity-based                   | mention-ranking                |
|                      | knowledge-driven               | data-driven                     |
| **Features**         | Parse trees, NER, Gazetteer etc.| embeddings (fastText, BERT)    |
| **Based on**         | Stanford sieves                | e2e, higher-order, c2f         |
|                      | Lee et al 2013                  | Lee et al 2018                  |

https://github.com/andreasvc/dutchcoref/
https://github.com/Filter-Bubble/e2e-Dutch
Rule-based system: precision-ranked sieves

Lee et al (CL 2013). Deterministic coref. res. based on entity-centric, precision-ranked rules.
End-to-end neural system

Figure adapted from Lee et al (EMNLP 2017). **End-to-end neural coreference resolution.**

We use Lee et al (NAACL 2018). **Higher-order coref. resolution w/coarse- to-fine inf.**
## Results

|                | CoNLL score |
|----------------|-------------|
|                | RiddleCoref | SoNaR-1    |
| dutchcoref     | 69.9        | 55.9       |
| e2e-Dutch      | 63.6        | **68.5**   |

- Large coref. performance differences
## Results

|               | RiddleCoref | SoNaR-1 |
|---------------|-------------|---------|
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▶ Large coref. performance differences

|               | RiddleCoref | SoNaR-1 |
|---------------|-------------|---------|
| **Mention F1** |             |         |
| dutchcoref    | 89.2        | 74.2    |
| e2e-Dutch     | 85.3        | 87.9    |

▶ dutchcoref is limited by mention performance?
Detailed results (test set, predicted mentions, incl/singletons)

| System        | dataset       | Mentions |          | LEA        | CoNLL |
|---------------|---------------|----------|----------|------------|-------|
|               |               |          | R | P | F1 | R | P | F1 | R | P | F1 | R | P | F1 |
| dutchcoref    | RiddleCoref   | 87.7     | 90.8   | 89.2       | 50.8  | 64.8 | 57.0 | 69.9 |
| e2e-Dutch     | RiddleCoref   | 82.0     | 89.0   | 85.3       | 44.8  | 50.5 | 47.5 | 63.6 |
| dutchcoref    | SoNaR-1       | 65.3     | 85.9   | 74.2       | 37.9  | 52.6 | 44.0 | 55.9 |
| e2e-Dutch     | SoNaR-1       | 89.0     | 86.8   | 87.9       | 60.8  | 62.5 | 61.6 | 68.5 |

- RiddleCoref: Large LEA precision difference
- SoNaR-1: Large mention/LEA recall differences

Moosavi & Strube (ACL 2016). Which coreference evaluation metric do you trust?
https://github.com/ns-moosavi/coval/
e2e-Dutch performance on RiddleCoref dev set, as function of training data (initial segments of novels).
Learning curve (% training data)

e2e-Dutch performance on RiddleCoref dev set, as function of training data (initial segments of novels).

- need more training data to beat dutchcoref
- mention performance does reach plateau
### Coreference scores as a function of document length being evaluated.

- Gold and system output are truncated at different lengths (% of words);
- $r$ is correlation coefficient.
Singletons and gold mentions (dev set)

Dataset = RiddleCoref

Dataset = SoNaR-1

System
dutchcoref
e2e-Dutch

LEA F1

predicted, excluded
predicted, included
gold, included

Mentions, Singletons

System
dutchcoref
e2e-Dutch

predicted, excluded
predicted, included
gold, included

Mentions, Singletons
SoNaR-1 annotation issues

From a cursory inspection:

- Missing links for string matches: 5x “Amsterdam” etc.
- Missing anaphoric links
- Mention boundaries not corrected
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Remarks:

- Neural system adapts to all annotation conventions/issues
- Rule-based system is penalized for annotation differences
Conclusions

- Neural system struggles with long documents but needs more training data to reach full potential
- Singletons inflate the scores, esp. with e2e-Dutch on SoNaR-1
- Rule-based system is affected by annotation differences/issues
- Next steps: add classifiers to rule-based system (Lee et al 2017); BERT finetuning for neural system (Joshi et al 2019).

Lee et al (NLE 2017). *A scaffolding approach to coref. res. integrating statistical and rule-based models.*
Joshi et al (EMNLP 2019). *BERT for coreference resolution: Baselines and analysis.*
Recommendations:

▶ Evaluate on long(er) documents
▶ Exclude singletons for evaluation
▶ Use semi-automatic annotation

Open questions:

▶ Exclude singletons during training?
▶ Why is performance gap between datasets and systems so big?
▶ What has best return on investment:
  ▶ Rule-based system (add classifiers, harmonize annotation)
  ▶ Neural system (annotate more novel data, throw more compute at it)
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THE END

Models: https://github.com/andreasvc/crac2020

Paper: https://arxiv.org/abs/2011.01615

Thanks to my BSc thesis students for helping with annotation!

Dilbert cartoon, syndicated by Bruno Publications B.V.