A Dutch coreference resolution system with an evaluation on literary fiction

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https://twitter.com/JenMsft/status/1132306345787568128

Plan for today

1. Background
2. Annotating Dutch novels
3. The coreference system
4. Evaluation
5. Future work

Definition

Coreference resolution is a structured prediction task of partitioning detected mentions into entity clusters.

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

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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

Mentions

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NB: contrast with markable, a *potentially* referring expression.

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Pronouns I, he, my, his, that, [each other], himself, . . .

Names [John], [John Smith], [Mr. Smith], . . .

Nominals [the man], [the flowers on [the table]], . . .

But not:

► Events, actions, times

► Non-referring expressions: it rains

Coreference relations

Strict   [John]$_1$ sees [Mary]$_2$.
    [He]$_1$ waves at [her]$_2$ and takes [[his]$_1$ bike]$_3$.

Predicative   [John]$_1$ is [the director]$_1$.

Appositions   [John]$_1$, [the painter]$_1$. [Bond]$_2$, [James Bond]$_2$.

Relative clauses   [The man]$_1$ [who]$_1$ sold [the world]$_2$ ...

Bound anaphora   [Everyone]$_1$ has [his]$_1$ opinion about it.

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▶ No bridging relations (e.g., part-whole)
▶ Relation type not annotated

Winograd schemes

The [city councilmen]$_1$ refused [the demonstrators]$_2$ a permit because …
1. …[they]$_1$ feared violence.
2. …[they]$_2$ advocated violence.

"AI-complete" problem

Kehler (2002). Coherence, reference, and the theory of grammar, chapter 1.
http://web.stanford.edu/group/cslipublications/cslipublications/pdf/1575862166.pdf

History of coreference resolution

Various datasets, languages:

1996	MUC-6 shared task, English
2004	ACE shared task, English/Chinese/Arabic
2010	SemEval shared task, multilingual including Dutch
2011	CoNLL shared task, English
2012	CoNLL shared task, English/Chinese/Arabic

State of the art: from rules to a neural arms race …

Data: OntoNotes (English)   CoNLL score

  CoNLL 2011 shared task, winner: Lee et al., rule-based   58.3%

  CoNLL 2012 shared task, winner: Fernandes et al., perceptron   58.7%

  EMNLP 2017 end-to-end coref. resolution, deep learning   67.2%

  NAACL 2018 e2e + ELMO + c2f, deeper learning   73.0%

  EMNLP 2019 e2e + BERT Large, even deeper learning   76.9%

Evaluation metrics

Coreference evaluation is a mess!

Fatally flawed metrics:
1996 MUC
1998 B^3
2005 CEAFm, CEAFe
2011 CoNLL score (= avg of MUC, B^3, CEAFe)
2011 BLANC

No known issues (yet!):
2016 Link-based Entity-Aware metric (LEA)

Moosavi & Strube (ACL 2016) Which coreference evaluation metric do you trust?
A proposal for a link-based entity aware metric

By the way …

#BenderRule:

The rest of this talk is about Dutch!

I made a new annotation scheme …

I made a new annotation scheme …

https://xkcd.com/927/
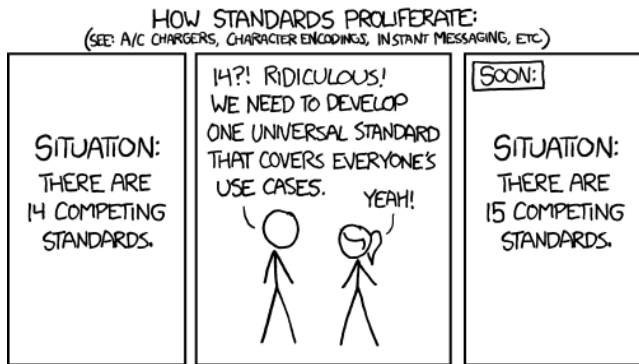
Annotation scheme

Simplified annotation scheme:

- ▶ Annotate mentions: include singletons,
  exclude non-referring expressions.

- ▶ Avoid difficult mention boundaries:
  no discontinuity, relative clauses

- ▶ Only annotate entity clusters,
  not directed anaphor-antecedent relations

https://github.com/andreasvc/dutchcoref/blob/master/annotationguidelines.pdf

Annotation workflow

1. Tokenize, parse with Alpino
2. Run coreference system
3. Manually correct output with CorefAnnotator
4. Optional: correction by second annotator

```
http://www.let.rug.nl/vannoord/alp/Alpino/
https://github.com/nilsreiter/CorefAnnotator/
```

Annotation workflow

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Result: tabular CoNLL 2012 file

```
#begin document (example); part 000
example 1    John        (0)
example 2    sees        -
example 3    Mary        (1)

#end document
```

http://www.let.rug.nl/vannoord/alp/Alpino/
https://github.com/nilsreiter/CorefAnnotator/

Annotated texts

	CLIN26 dev set	SemEval 2010 dev	Novels, dev set	Novels, test set
documents	30	23	10	11
tokens	4018	9164	19,051	88,092
sents per doc	7	21.4	100	491.5
avg sent len	19.3	18.4	19.0	16.3

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avg sent len	19.3	18.4	19.0	16.3
entities	273	424	1798	8337
mentions	663	1010	4243	20,873
% pronouns	7.69	14.45	43.3	36.5
% nominal	52.34	54.35	46.2	52.2
% names	39.97	31.20	10.5	11.2

107k tokens of annotated literary text!

Mention detection

1. Extract candidate constituents
2. Adjust spans
3. Filter with patterns
4. Detect features

- ▶ [John], [who], [the book on [the table]], . . .
- ▶ [Mr Smith], [San Jose, California], . . .
- ▶ Drop: yesterday, about two meters, . . .
- ▶ gender, animacy, number

Mention feature detection

parse features in the Alpino parse tree (HPSG-inspired)

NER part of Alpino; person/org/loc/misc

wordnet animacy & gender of head nouns (hand-corrected)

web text names extracted w/heuristics from 30GB parsed English text (Bergsma & Lin 2006; TODO: replicate for Dutch!)

Bergsma & Lin (COLING-ACL 2006). Bootstrapping path-based pronoun resolution.
http://aclweb.org/anthology/P06-1005

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	Pronouns	Nominals	Names
Number	parse	parse	web tekt
Gender	parse	wordnet	web text
Animacy	parse	wordnet	NER, web text

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Sieves: link mentions with deterministic rules

Quote attribution	find speaker & addressee of direct speech
String match	[The boy]$_1$ ... [The boy]$_1$ ...
Precise constructs	[the boy]$_1$ [who]$_1$ ...
Head match	[The clever boy]$_1$ ... [the boy]$_1$
Proper head noun match	[Bond]$_2$, [James Bond]$_2$
Pronoun resolution	[He]$_1$ ... [his]$_1$ ...

Muzny et al. (EACL 2017) A two-stage sieve approach for quote attribution
Heeyoung Lee et al. (CL 2013) Deterministic coreference resolution [...]

Demo

https://andreasvc.github.io/voskuil.html
http://haytabo.let.rug.nl:8888/ (RuG only)

Evaluation: shared tasks

CLIN26 shared task	Mentions	BLANC			
GroRef, Boeing test set	59.34	30.96			
This Work, Boeing test set	**59.49**	**31.48**			
GroRef, GM test set	**60.40**	**31.31**			
This Work, GM test set	59.26	31.07			
GroRef, Stock test set	53.70	25.40			
This Work, Stock test set	**54.68**	**26.09**			
SemEval 2010, Dutch, test set	Mentions	BLANC	MUC	B^3	CEAFm
SemEval 2010: Sucre	42.3	**46.9**	29.7	11.7	15.9
SemEval 2010: UBIU	34.7	32.3	8.3	17.0	17.0
This Work	**64.27**	41.48	**51.95**	**45.85**	**51.20**

Evaluation: novels

	mention			LEA
	F1	recall	precision	F1
SemEval 2010 (test set)	64.27	36.00	39.96	37.88
CLIN26 shared task (Boeing test set)	59.49	29.83	33.95	31.76
Literary texts (dev set)	87.05	57.13	61.71	59.33
Literary texts (test set)	87.10	49.27	57.45	53.05

Discussion

- ► High variance among novels; matter of style?
- ► Better performance on novels than news! Surprising?
  - ► More dialogue and pronouns in novels (some long chains)
  - ► Novels are longer documents
    (including our annotated fragments)
  - ► Not all errors are created equal . . .

Improve components

Components:
- ▶ Mention detection/spans
- ▶ Pleonastic pronoun detection
- ▶ Gender/animacy
- ▶ Quote attribution
- ▶ Pronoun resolution

Heeyoung Lee et al. (NLE 2017) A scaffolding approach to coreference resolution integrating statistical and rule-based models. https://doi.org/10.1017/S1351324917000109

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Procedure:
1. Acquire/annotate more data
2. Train supervised classifier
3. ???
4. Profit!

Heeyoung Lee et al. (NLE 2017) A scaffolding approach to coreference resolution integrating statistical and rule-based models. https://doi.org/10.1017/S1351324917000109

Neural coreference

- ► Create/convert more annotated data
- ► Train End-to-end coreference system
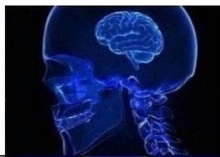- ► with BERT . . .

Neural coreference

- ▶ Create/convert more annotated data
- ▶ Train End-to-end coreference system
- ▶ with BERT . . .

Downsides:

- ▶ Huge memory (32GB GPU) & carbon footprint
- ▶ Long documents need to be split into paragraph chunks . . .

Kenton Lee et al. (EMNLP 2017) End-to-end neural coreference resolution

THE END

Code: https://github.com/andreasvc/dutchcoref

Paper: Coming soon[TM]

Thanks to my BSc thesis students for helping with annotation!

Dilbert cartoon, syndicated by Bruno Publications B.V.