Coreference Resolution

Different German & English Coreference Resolution Models for Multi-Domain Content Curation Scenarios

Ankit Srivastava, Sabine Weber, Peter Bourgonje, and Georg Rehm

DFKI GmbH – Forschungsbereich Sprachtechnologie, Berlin

GSCL 2017, 14th September, Berlin

Deutsches Forschungszentrum für Künstliche Intelligenz GmbH

DKT

WK · POTENZIAL UNTERNEHMEN REGION Die BMBF-Innovationsinitiative Neue Länder

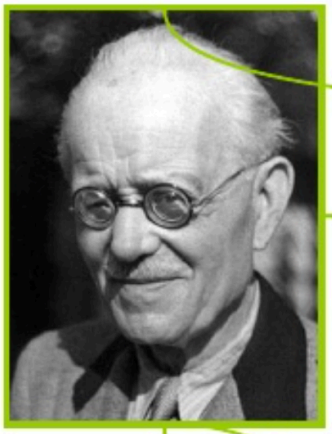
GEFÖRDERT VOM Bundesministerium für Bildung und Forschung

About this Presentation

- Introduction to Coreference Resolution
- Coreference Resolution for English
- Coreference Resolution for German
- Our Approaches: $\text{Coref}_{\text{rule}}$, $\text{Coref}_{\text{stat}}$, $\text{Coref}_{\text{proj}}$
- Coreference Resolution for Digital Curation
- Endpoint

Digitale
Kuratierungs-
technologien

COREFERENCE RESOLUTION



Audi is an automaker that makes luxury cars and SUVs. The company was born in Germany .

It was established by August Horch in 1910. Horch had previosly founded another company and his models were quite popular. Audi started with four cylinder models. By 1914, Horch 's new cars were racing and winning.

August Horch left the Audi company in 1920 to take a position as an industry representative for the German motor vehicle industry federation.

Currently Audi is a subsidiary of the Volkswagen group and produces cars of outstanding quality.

Source: Coreference Resolution presentation by Shumin Wu and Nicolas Nicolov of J.D. Power and Associates

What is Coreference Resolution?

- Process of identifying all words & phrases in a document that refer to the same entity
- Core of Natural Language Understanding (NLU) since 1960s
- Documents usually contain the full named entity once or a few times. For full NLU, coreference resolution is essential
- Can be meaningfully applied in Question Answering, Named Entity Recognition, Machine Translation, Summarisation

Coreference & Co.

Anaphora

*The **music** was so loud **it** couldn't be enjoyed.*

Cataphora

*Despite **her** difficulty, **Wilma** came to understand the point.*

Split antecedents

***Carol** told **Bob** to attend the party. **They** arrived together.*

Coreferring noun phrases

***Some of our colleagues** will help us. **These people** will earn our trust.*

Motivation

- Digital Curation Platform for Knowledge Workers
  - Named Entity Recognition, Entity & Relation Extraction, Translation, Summarisation, Timelining, Clustering

- Benefit from Coreference: Disambiguation
  - Explore tools available for both German & English
  - Build our own… evaluate

DKT

Digitale
Kuratierungs-
technologien

SUMMARY OF APPROACHES

Approaches to Coreference

- 3 Paradigms
  - Rule-based (Heuristics)
  - Machine Learning (Mention-Rank Model)
  - Knowledge-based (Crosslingual Projections)

- Coreference Resolution for English
  - [Raghunathan et al., 2010] [Clark & Manning, 2015 | 2016]

- Coreference Resolution for German
  - [Verseley et al., 2008] [Krug at al., 2015] [Roesiger & Riester, 2015] [Tuggener, 2016]

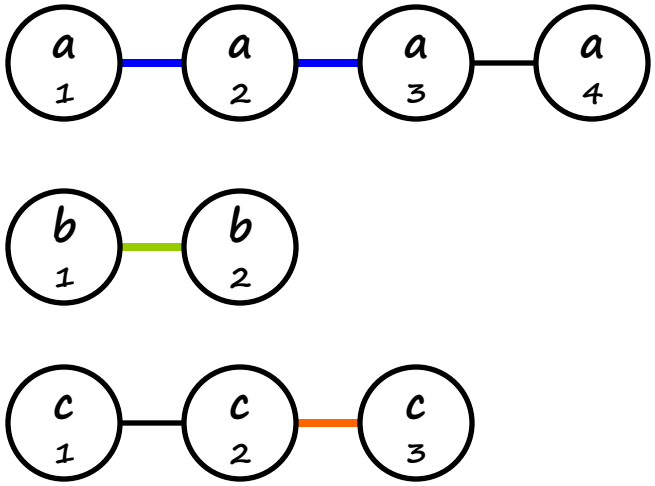
Evaluation of Coreference

- Benchmarking Shared Tasks on Standard datasets
  - Message Understanding Conference (MUC)
  - Automatic Content Extraction (ACE)
  - Computational Natural Language Learning (CoNLL)
  - Semantic Evaluation (SemEval)
  - Coreference Resolution beyond OntoNotes (CORBON)

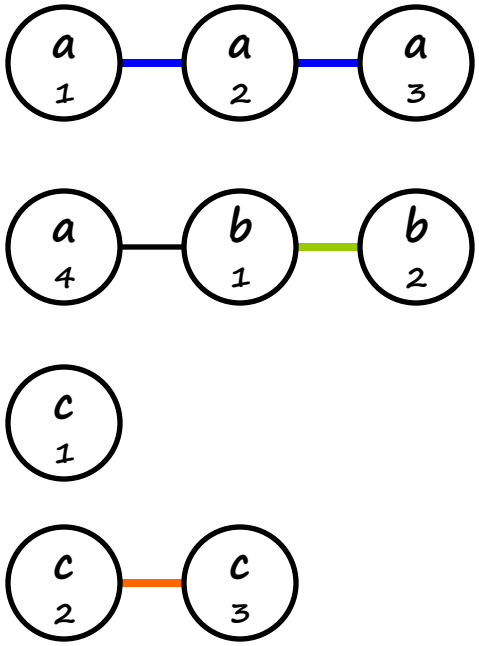
- Evaluation Metrics
  - Message Understanding Conference F-measure (MUC6)
  - Bagga, Baldwin, Biermann (B^3)
  - Constrained Entity-Alignment F-Measure (CEAF)

Evaluation: MUC-6 F-Measure

Reference:



System output:



Count the number of corresponding links between mentions

Precision = 4/5

Recall = 4/6

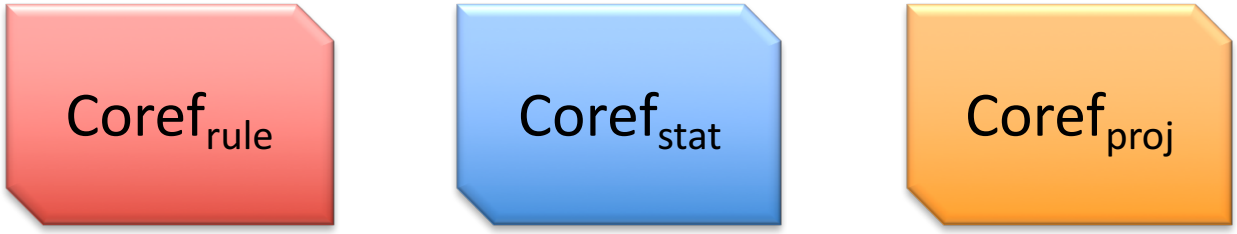
F-measure = 2* Precision * Recall/(Precision + Recall) = 0.727

Evaluation Metrics Summary

- MUC6 F-measure
  - Ignores single mention entities
  - Potentially biased toward large clusters
  - No one-to-one entity mapping guarantee
- B^3
  - Set view of mentions in an entity
  - Based on number of corresponding mentions between entities averaged over total number of mentions
  - Does not provide one-to-one entity mapping
- CEAF
  - One-to-one entity mapping
  - Optimal mapping can be tuned to a different similarity measure

DKT

Digitale
Kuratierungs-
technologien

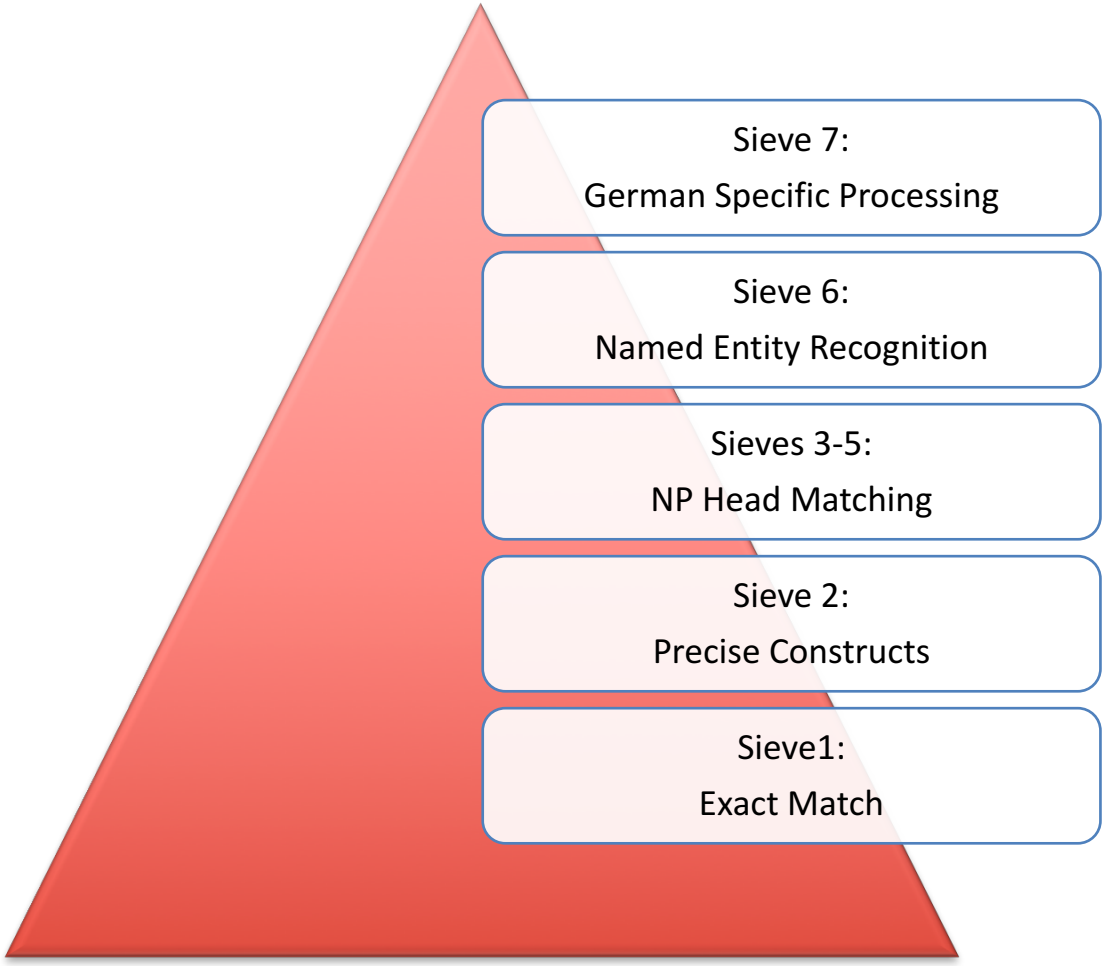


THREE IMPLEMENTATIONS

Rule-based (Multi-Sieve)

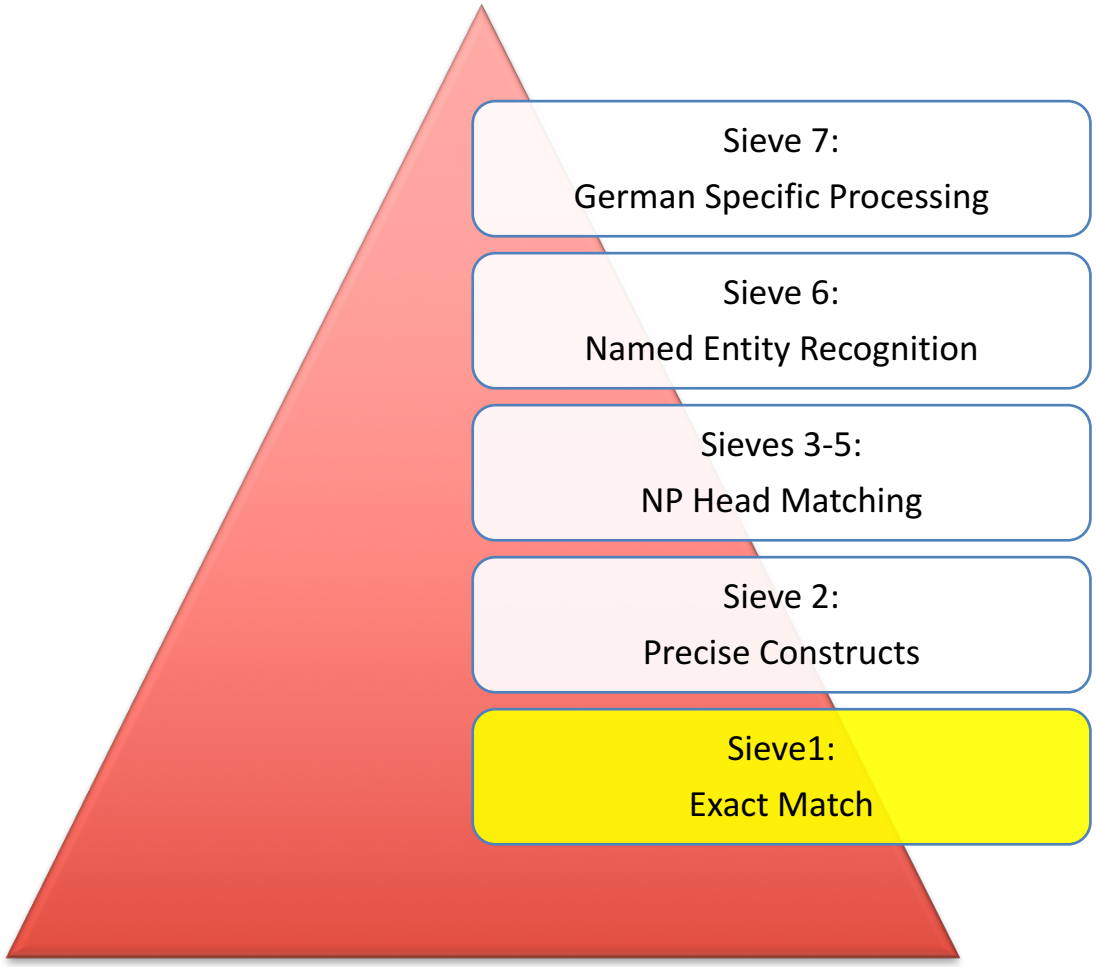
- English version Based on Stanford CoreNLP
  - https://nlp.stanford.edu/software/dcoref.html
- German version: in-house implementation
  - https://github.com/dkt-projekt/e-NLP/ecorenlp/modules
- Idea of an annotation pipeline
  - Sentence splitting, tokenisation, parsing, morphology

Multi-Sieve Coreference



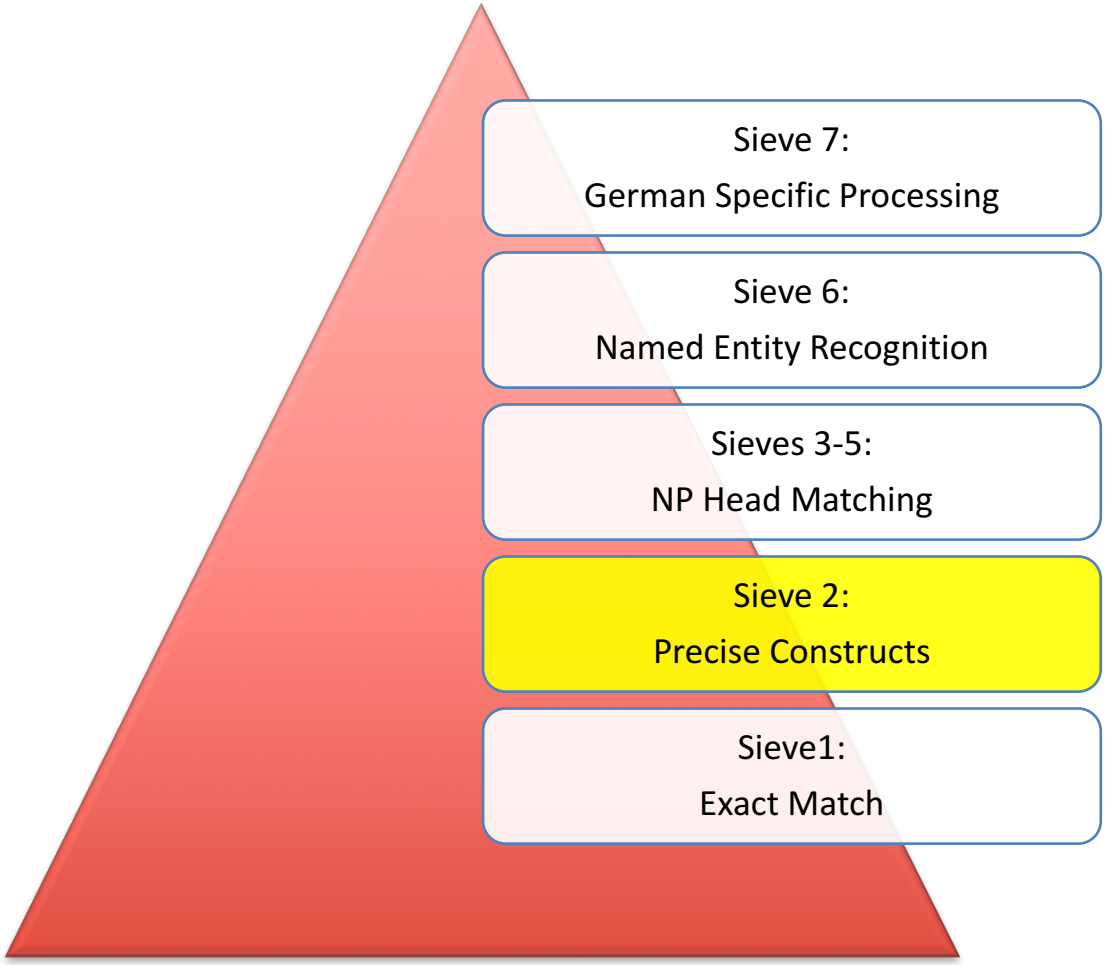
Multi-Sieve Coreference

- Parse a document
- Get Noun Phrases, Pronominal Phrases
- Cluster them via sieve heuristics
- **Exact Match**: If NPs match each other in a context window of 5 (with stemming), then link them
- “Der Hund” / “Des Hundes”



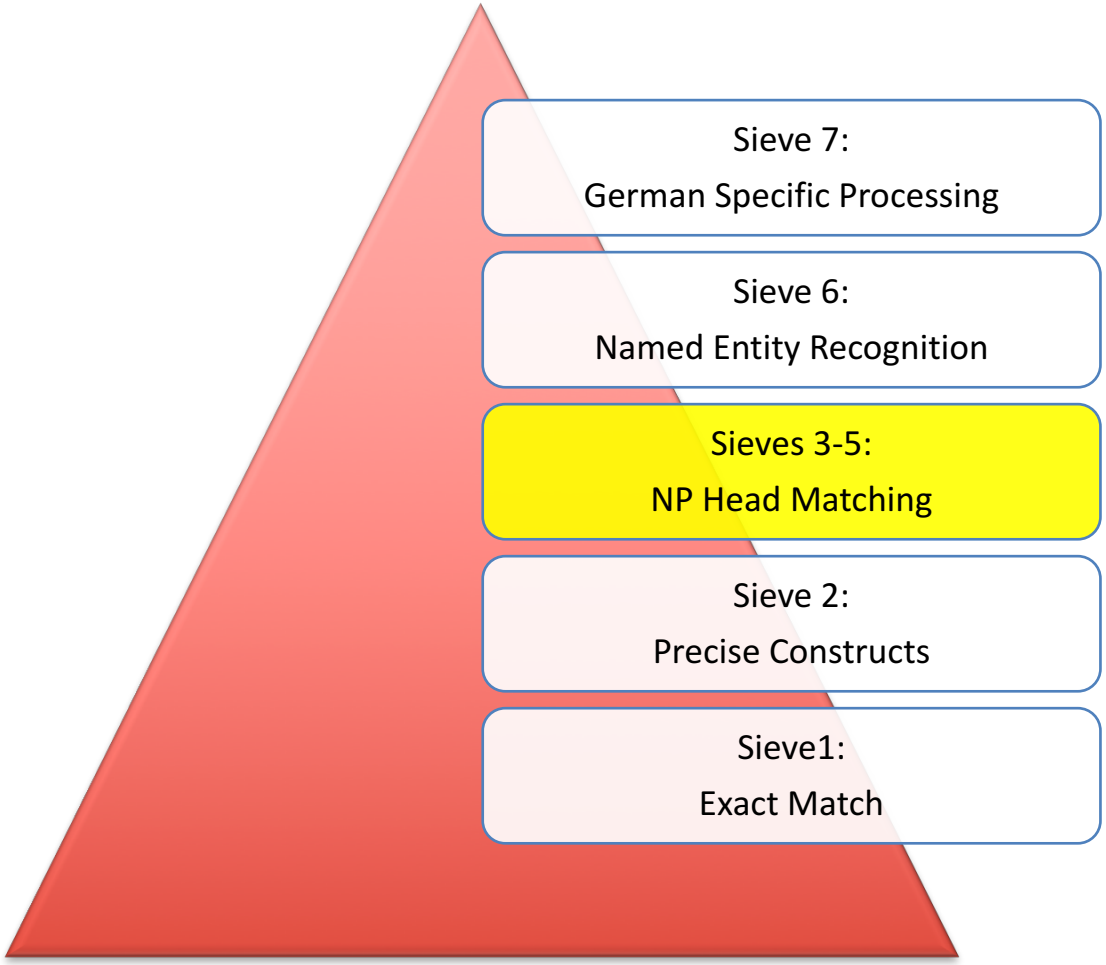
Multi-Sieve Coreference

- Models linked if appositive or predicative nominative constructs are detected
- Appositive: "Donald Trump, President of USA"



Multi-Sieve Coreference

- If head word of two NPs is same, they are coreferrent
- Some Relaxations and Rules



Examples of Match Heuristics

- Compatible mentions:
  - Exact string match of capitalized mentions
    “Trump” & “Trump”
  - Exact string match of mentions within a sentence
    “car” & “car”
  - Acronyms
    “USA” & “United States of America”
  - First person / Second person / Third person pronoun
    “I” & “me”, “you” & “yours”, “he” & “him”, “she” & “her”

- Incompatible mentions:
  - Different acronyms
    “USA” & “UK”
  - Personal, gender, number disagreement
    “I” & “you”, “he” & “she”, “car” & “cars”

Evaluation: Sieve Settings

1. All Sieves in place
2. All mentions but no coreference links
3. {1} after deletion of clusters with no mentions
4. {1} with insertion of clusters with no mentions added last

System	MUC	B-Cube
Setting 1	54.4	11.2
Setting 2	70.5	23.1
Setting 3	58.9	15.0
Setting 4	56.1	12.0

Statistical (Mention-Ranking)

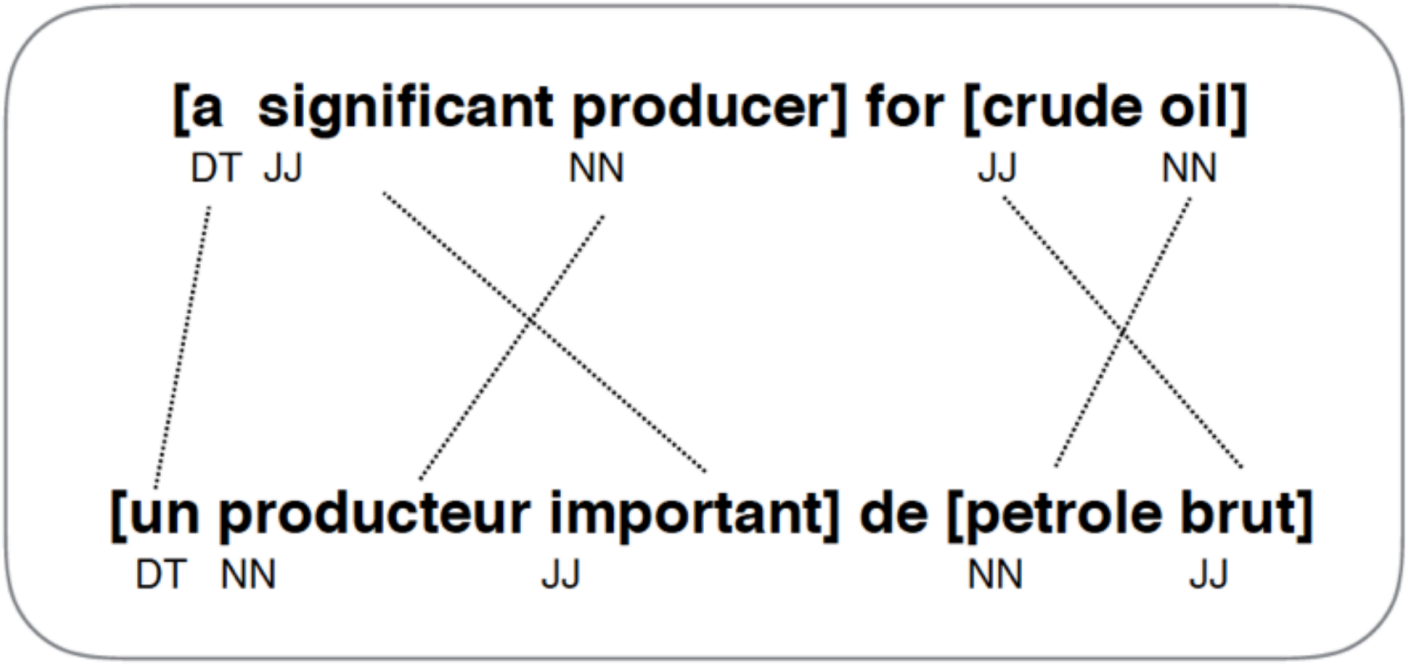
- Based on Stanford CoreNLP (English & German)
  - English trained and evaluated on CoNLL ’11, ‘12
  - German trained on TüBa/D-Z, evaluated on SemEval ’10
- 4 Types of Features learned using Dagger [Ross 2011]
  - Distance
  - Syntactic
  - Semantic
  - Lexical
- Issues in out-of-domain adaptation

Features

- Distance features: the distance between the two mentions in a sentence, number of mentions
- Syntactic features: number of embedded NPs under a mention, Part-Of-Speech tags of the first, last, and head word (based on the German parsing models included in the Stanford CoreNLP (Rafferty and Manning, 2008)
- Semantic features: named entity type, speaker identification
- Lexical Features: the first, last, and head word of the current mention

Projection (Crosslingual)

- Coreference for German based on English models
- Transferring Models Vs Transferring Data
- Corbon 2017 English—German Data



Comparative Evaluation

English: CoNLL 2012

System	MUC	B-Cube
BART	45.3	64.5
CorZu	60.1	58.9
Sieve	49.2	45.3
Statistical	56.3	50.4
Neural	60.0	56.8

German: SemEval 2010

System	MUC	B-Cube
CoRefGer-rule	50.2	63.3
CoRefGer-stat	40.1	45.3
CoRefGer-proj	35.9	40.3

Digitale
Kuratierungs-
technologien

MULTI DOMAIN CONTENT CURATION SCENARIOS

Curation Case Studies

Corpora	Language	Documents	Words	Domain
Mendelsohn	DE	2,501	699,213	Personal letters
Mendelsohn	EN	295	21,226	Personal letters
Vikings	EN	12	298,577	Wikipedia and E-books
News	DE	1,037	716,885	News articles and summaries

Coreference for Curation

- Applied English & German coreference models on different datasets
- $\text{Coref}_{\text{rule}}$ outperforms $\text{Coref}_{\text{stat}}$, $\text{Coref}_{\text{proj}}$ in terms of number of mentions

Dataset	SENTS.	WORDS	MENTIONS
Mendelsohn EN	21K	109K	48%
Mendelsohn DE	34K	681K	26%
Vikings EN	39K	310K	49%
News Stories DE	53K	369K	25%

About this Presentation

- Introduction to Coreference Resolution
- Coreference Resolution for English
- Coreference Resolution for German
- Our Approaches: $\text{Coref}_{\text{rule}}$, $\text{Coref}_{\text{stat}}$, $\text{Coref}_{\text{proj}}$
- Coreference Resolution for Digital Curation
- **Endpoint**

Conclusions

- Performed Coreference Resolution
  - In both English & German
  - On a variety of text types
  - For competing approaches (sieve, mention-rank, projection)

- Successful in coreference resolution for curation datasets such as an archive of letters, research materials for exhibition, news articles & downstream applications

- Currently, best choice is Multi Sieve (Rule-based) approach for out-of-domain processing

Thank You!

Email: ankit.srivastava@dfki.de

DKT

Digitale
Kuratierungs-
technologien

EXTRA SLIDES