Coreference & Coherence

Ling571
Deep Processing Techniques for NLP
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Roadmap

- Coreference algorithms:
  - Data-driven techniques
  - Deterministic sieves
- Discourse structure
  - Cohesion
    - Topic segmentation
  - Coherence
    - Discourse parsing

Data-driven Reference Resolution

- Prior approaches: Knowledge-based, hand-crafted
- Data-driven machine learning approach
  - Coreference as classification, clustering, ranking problem
    - Mention-pair model:
      - For each pair NPi,NPj, do they corefer?
      - Cluster to form equivalence classes
    - Entity-mention model
      - For each pair NP_k and cluster $C_{j,,}$ should the NP be in the cluster?
    - Ranking models
      - For each NP_k, and all candidate antecedents, which highest?

NP Coreference Examples

- Link all NPs refer to same entity

Queen Elizabeth set about transforming her husband, King George VI, into a viable monarch. Logue, a renowned speech therapist, was summoned to help the King overcome his speech impediment...

Example from Cardie&Ng 2004

Annotated Corpora

- Available shared task corpora
  - MUC-6, MUC-7 (Message Understanding Conference)
    - 60 documents each, newswire, English
  - ACE (Automatic Content Extraction)
    - Originally English newswire
    - Later include Chinese, Arabic; blog, CTS, Usenet, etc
- Treebanks
  - English Penn Treebank (OntoNotes)
  - German, Czech, Japanese, Spanish, Catalan, Medline

Feature Engineering

- Other coreference (not pronominal) features
  - String-matching features:
    - Mrs. Clinton <->Clinton
  - Semantic features:
    - Can candidate appear in same role w/same verb?
    - WordNet similarity
    - Wikipedia: broader coverage
  - Lexico-syntactic patterns:
    - E.g. X is a Y

Typical Feature Set

- 25 features per instance: 2NPs, features, class
  - lexical (3)
    - string matching for pronouns, proper names, common nouns
  - grammatical (18)
    - pronoun_1, pronoun_2, demonstrative_2, indefinite_2, ...
    - number, gender, animacy
    - appositive, predicate nominative
    - binding constraints, simple contra-indexing constraints, ...
    - span, maximalnp, ...
  - semantic (2)
    - same WordNet class
    - alias
  - positional (1)
    - distance between the NPs in terms of # of sentences
  - knowledge-based (1)
    - naïve pronoun resolution algorithm

Coreference Evaluation

- Key issues:
  - Which NPs are evaluated?
    - Gold standard tagged or
    - Automatically extracted
  - How good is the partition?
    - Any cluster-based evaluation could be used (e.g. Kappa)
    - MUC scorer:
      - Link-based: ignores singletons; penalizes large clusters
      - Other measures compensate

Clustering by Classification

- Mention-pair style system:
  - For each pair of NPs, classify +/- coreferent
    - Any classifier
  - Linked pairs form coreferential chains
    - Process candidate pairs from End to Start
    - All mentions of an entity appear in single chain
  - F-measure: MUC-6: 62-66%; MUC-7: 60-61%
    - Soon et. al, Cardie and Ng (2002)

Multi-pass Sieve Approach

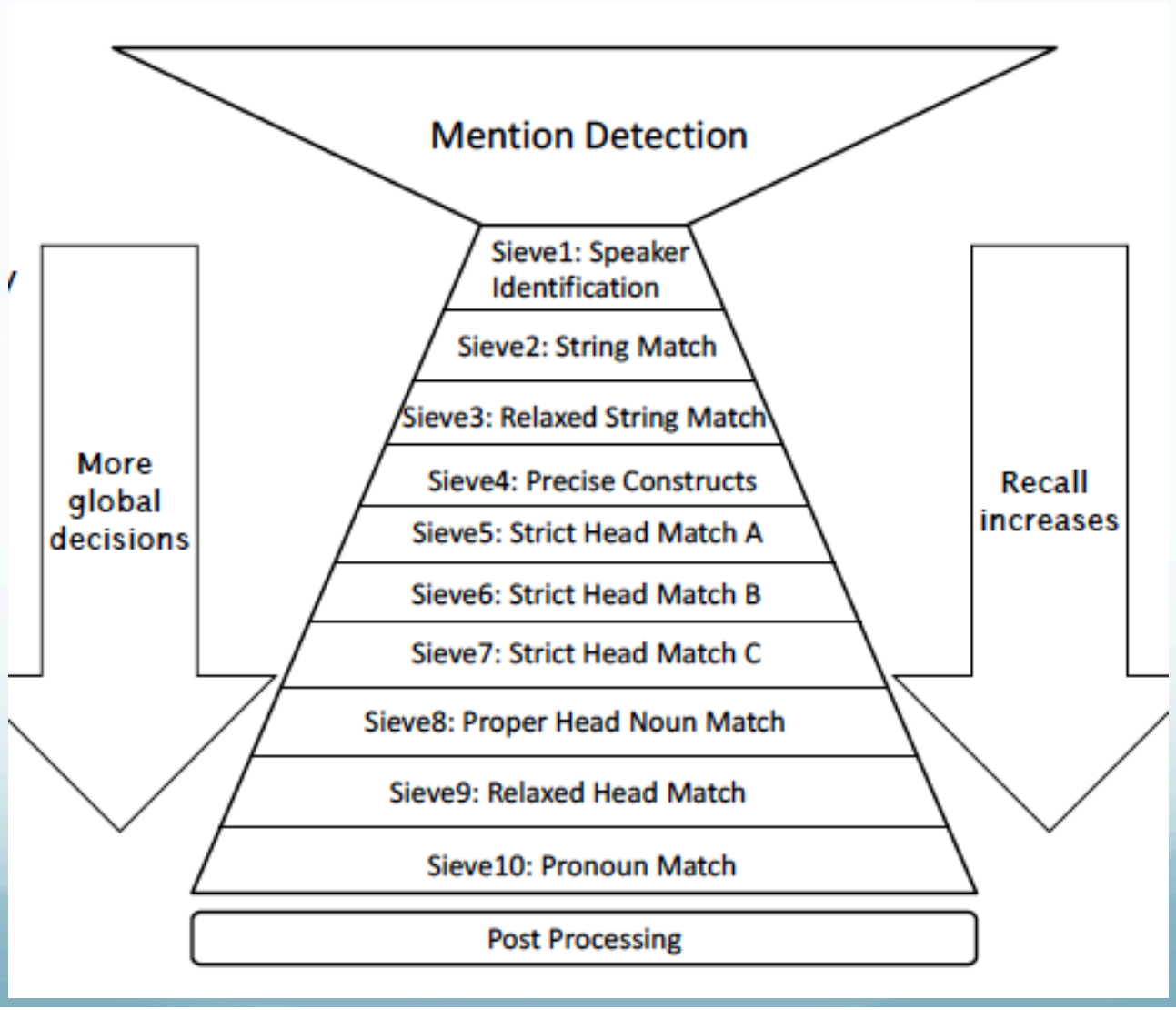
- Raghunathan et al., 2010

- Key Issues:
  - Limitations of mention-pair classifier approach
    - Local decisions over large number of features
      - Not really transitive
      - Can't exploit global constraints
      - Low precision features may overwhelm less frequent, high precision ones

Multi-pass Sieve Strategy

- Basic approach:
  - Apply tiers of deterministic coreference modules
    - Ordered highest to lowest precision
  - Aggregate information across mentions in cluster
    - Share attributes based on prior tiers
  - Simple, extensible architecture
    - Outperforms many other (un-)supervised approaches

Multi-Pass Sieve



Pre-Processing and Mentions

- Pre-processing:
  - Gold mention boundaries given, parsed, NE tagged
- For each mention, each module can skip or pick best candidate antecedent
  - Antecedents ordered:
    - Same sentence: by Hobbs algorithm
    - Prev. sentence:
      - For Nominal: by right-to-left, breadth first: proximity/recency
      - For Pronoun: left-to-right: salience hierarchy
    - W/in cluster: aggregate attributes, order mentions
    - Prune indefinite mentions: can't have antecedents

Multi-pass Sieve Modules

- Pass 1: Exact match (N): P: 96%
- Pass 2: Precise constructs
  - Predicate nominative, (role) appositive, re;. pronoun, acronym, demonym
- Pass 3: Strict head matching
  - Matches cluster head noun AND all non-stop cluster wds AND modifiers AND non i-within-I (embedded NP)
- Pass 4 & 5: Variants of 3: drop one of above

Multi-pass Sieve Modules

- Pass 6: Relaxed head match
  - Head matches any word in cluster AND all non-stop cluster wds AND non i-within-I (embedded NP)
- Pass 7: Pronouns
  - Enforce constraints on gender, number, person, animacy, and NER labels

Multi-pass Effectiveness

Passes	MUC P	MUC R	MUC F1
{1}	95.9	31.8	47.8
{1,2}	95.4	43.7	59.9
{1,2,3}	92.1	51.3	65.9
{1,2,3,4}	91.7	51.9	66.3
{1,2,3,4,5}	91.1	52.6	66.7
{1,2,3,4,5,6}	89.5	53.6	67.1
{1,2,3,4,5,6,7}	83.7	74.1	78.6

Sieve Effectiveness

- ACE Newswire

This work (sieve)	**83.8**	73.2	**78.1**
This work (single pass)	82.2	71.5	76.5
Haghighi and Klein (2009) +S	77.0	**75.9**	76.5
Poon and Domingos (2008)	71.3	70.5	70.9
Finkel and Manning (2008) +G	78.7	58.5	67.1

Questions

- Good accuracies on (clean) text. What about…
  - Conversational speech?
    - Ill-formed, disfluent
  - Dialogue?
    - Multiple speakers introduce referents
  - Multimodal communication?
    - How else can entities be evoked?
    - Are all equally salient?

More Questions

- Good accuracies on (clean) (English) text: What about..
  - Other languages?
    - Salience hierarchies the same
      - Other factors
    - Syntactic constraints?
      - E.g. reflexives in Chinese, Korean,..
    - Zero anaphora?
      - How do you resolve a pronoun if you can't find it?

Reference Resolution Algorithms

- Many other alternative strategies:
  - Linguistically informed, saliency hierarchy
    - Centering Theory
  - Machine learning approaches:
    - Supervised: Maxent
    - Unsupervised: Clustering
  - Heuristic, high precision:
    - Cogniac

Conclusions

- Co-reference establishes coherence
- Reference resolution depends on coherence
- Variety of approaches:
  - Syntactic constraints, Recency, Frequency,Role
- Similar effectiveness - different requirements
- Co-reference can enable summarization within and across documents (and languages!)

Discourse Structure

Why Model Discourse Structure? (Theoretical)

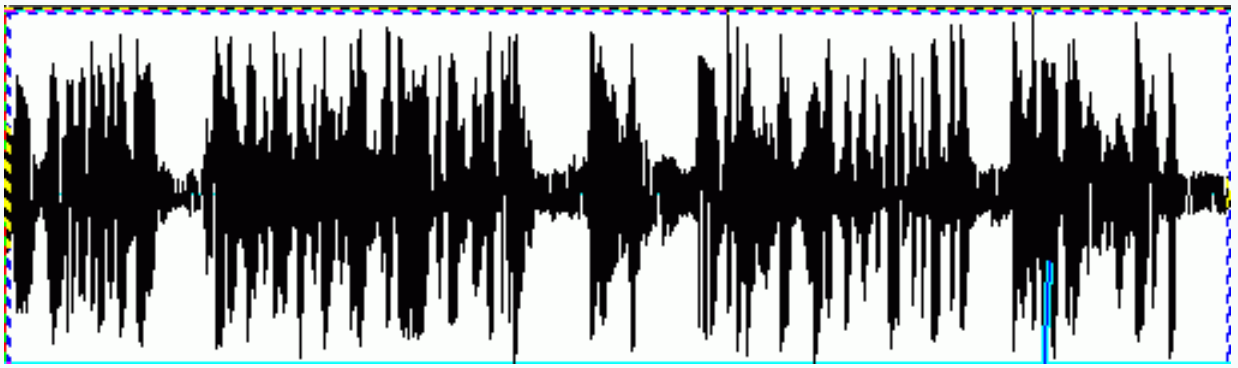
- Discourse: not just constituent utterances
  - Create joint meaning
  - Context guides interpretation of constituents
  - How????
    - What are the units?
    - How do they combine to establish meaning?
      - How can we derive structure from surface forms?
    - What makes discourse coherent vs not?
    - How do they influence reference resolution?

Why Model Discourse Structure?(Applied)

- Design better summarization, understanding
- Improve speech synthesis
  - Influenced by structure
- Develop approach for generation of discourse
- Design dialogue agents for task interaction
- Guide reference resolution

Discourse Topic Segmentation

- Separate news broadcast into component stories



On "World News Tonight" this Thursday, another bad day on stock markets, all over the world global economic anxiety. ||
Another massacre in Kosovo, the U.S. and its allies prepare to do something about it. Very slowly. ||
And the millennium bug, Lubbock Texas prepares for catastrophe, Bangalore in India sees only profit.||

Discourse Segmentation

- Basic form of discourse structure
  - Divide document into linear sequence of subtopics
- Many genres have conventional structures:
  - Academic: Into, Hypothesis, Methods, Results, Concl.
  - Newspapers: Headline, Byline, Lede, Elaboration
  - Patient Reports: Subjective, Objective, Assessment, Plan
- Can guide: summarization, retrieval

Cohesion

- Use of linguistics devices to link text units
  - Lexical cohesion:
    - Link with relations between words
      - Synonymy, Hypernymy
      - *Peel, core and slice the pears and the apples. Add the fruit to the skillet.*
  - Non-lexical cohesion:
    - E.g. anaphora
      - *Peel, core and slice the pears and the apples. Add them to the skillet.*
  - Cohesion chain establishes link through sequence of words
  - Segment boundary = dip in cohesion

TextTiling (Hearst '97)

- Lexical cohesion-based segmentation
  - Boundaries at dips in cohesion score
  - Tokenization, Lexical cohesion score, Boundary ID
- Tokenization
  - Units?
    - White-space delimited words
    - Stopped
    - Stemmed
    - 20 words = 1 pseudo sentence

Lexical Cohesion Score

- Similarity between spans of text
  - b = 'Block' of 10 pseudo-sentences before gap
  - a = 'Block' of 10 pseudo-sentences after gap
  - How do we compute similarity?
    - Vectors and cosine similarity (again!)

$$sim_{\cos ine}(\vec{b},\vec{a}) = \frac{\vec{b} \bullet \vec{a}}{\left|\vec{b}\right|\left|\vec{a}\right|} = \frac{\sum_{i=1}^{N} b_i \times a_i}{\sqrt{\sum_{i=1}^{N} b_i^2}\sqrt{\sum_{i=1}^{N} a_i^2}}$$

Segmentation

- Depth score:
  - Difference between position and adjacent peaks
  - E.g., $(y_{a1}\text{-}y_{a2})+(y_{a3}\text{-}y_{a2})$