Discourse: Reference

Ling571
Deep Processing Techniques for NLP
March 2, 2011
What is a Discourse?

- Discourse is:
  - Extended span of text
  - Spoken or Written
  - One or more participants
  - Language in Use
  - Goals of participants
    - Processes to produce and interpret
Why Discourse?

- Understanding depends on context
  - Referring expressions: it, that, the screen
  - Word sense: plant
  - Intention: Do you have the time?

- Applications: Discourse in NLP
  - Question-Answering
  - Information Retrieval
  - Summarization
  - Spoken Dialogue
  - Automatic Essay Grading
Reference Resolution

U: Where is *A Bug’s Life* playing in *Summit*?
S: *A Bug’s Life* is playing at the Summit theater.
U: When is *it* playing *there*?
S: *It’s* playing at 2pm, 5pm, and 8pm.
U: I’d like 1 *adult* and 2 *children* for the first show. How much would *that* cost?

- Knowledge sources:

From Carpenter and Chu-Carroll, Tutorial on Spoken Dialogue Systems, ACL ‘99
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- Knowledge sources:
  - Domain knowledge
  - Discourse knowledge
  - World knowledge

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Coherence

- *First Union Corp. is continuing to wrestle with severe problems. According to industry insiders at PW, their president, John R. Georgius, is planning to announce his retirement tomorrow.*
- **Summary:**
  - *First Union President John R. Georgius is planning to announce his retirement tomorrow.*
- **Inter-sentence coherence relations:**
  - Second sentence: main concept (nucleus)
  - First sentence: subsidiary, background
Different Parameters of Discourse

- Number of participants
  - Multiple participants -> Dialogue

- Modality
  - Spoken vs Written

- Goals
  - Transactional (message passing) vs Interactional (relations, attitudes)
  - Cooperative task-oriented rational interaction
Spoken vs Written Discourse

- **Speech**
  - Paralinguistic effects
    - Intonation, gaze, gesture
  - Transitory
  - Real-time, on-line

- **Less “structured”**
  - Fragments
  - Simple, Active, Declarative
  - Topic-Comment
  - Non-verbal referents
  - Disfluencies
    - Self-repairs
    - False Starts
    - Pauses

- **Written text**
  - No paralinguistic effects
  - “Permanent”
  - Off-line. Edited, Crafted

- **More “structured”**
  - Full sentences
  - Complex sentences
  - Subject-Predicate
  - Complex modification
  - More structural markers
  - No disfluencies
Spoken vs Written: Representation

- Spoken “text” “same” if:
  - Recorded (Audio/Video Tape)
  - Transcribed faithfully
    - Always some interpretation
  - Text (normalized) transcription
    - Map paralinguistic features
    - e.g. pause = -,+;++
    - Notate accenting, pitch

- Written text “same” if:
  - Same words
  - Same order
  - Same punctuation (headings)
  - Same lineation
Agenda

- Coherence: Holding discourse together
  - Coherence types and relations

- Reference resolution
  - Referring expressions
  - Information status and structure
  - Features and Preferences for resolution
  - Knowledge-rich, deep analysis approaches
    - Lappin&Leass,
    - Hobbs
Coherence Relations

- John hid Bill’s car keys. He was drunk.
- ?? John hid Bill’s car keys. He likes spinach.

Why odd?
- No obvious relation between sentences
  - Readers often try to construct relations

How are first two related?
- Explanation/cause

Utterances should have meaningful connection
- Establish through coherence relations
Entity-based Coherence

- John went to his favorite music store to buy a piano.
- He had frequented the store for many years.
- He was excited that he could finally buy a piano.

VS

- John went to his favorite music store to buy a piano.
- It was a store John had frequented for many years.
- He was excited that he could finally buy a piano.
- It was closing just as John arrived.

Which is better? Why?
- ‘about’ one entity vs two, focuses on it for coherence
Reference Resolution

- Match referring expressions to referents
- Syntactic & semantic constraints
- Syntactic & semantic preferences
- Reference resolution algorithms
Reference Resolution

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Reference Resolution: Global Focus/Task

- (From Grosz “Typescripts of Task-oriented Dialogues”)
- E: Assemble the air compressor.
- .
- .
- ... 30 minutes later...
- E: Plug it in / See if it works
- (From Grosz)
- E: Bolt the pump to the base plate
- A: What do I use?
- ....
- A: What is a ratchet wrench?
- E: Show me the table. The ratchet wrench is [...]. Show it to me.
- A: It is bolted. What do I do now?
Relation Recognition: Intention

- A: You seem very quiet today; is there a problem?
  - B: I have a headache.

- Answer

- A: Would you be interested in going to dinner tonight?
  - B: I have a headache.

- Reject
Reference

- 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...

Referring expression: (refexp)
Linguistic form that picks out entity in some model
That entity is the “referent”
  When introduces entity, “evokes” it
  Set up later reference, “antecedent”
2 refexps with same referent “co-refer”
Reference (terminology)

- 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...

Anaphor:
- Abbreviated linguistic form interpreted in context
  - Her, his, the King
- Refers to previously introduced item (“accesses”)
  - Referring expression is then anaphoric
Referring Expressions

- Many alternatives:
  - Queen Elizabeth, she, her, the Queen, etc
  - Possible correct forms depend on discourse context
    - E.g. she, her presume prior mention, or presence in world

- Interpretation (and generation) requires:
  - Discourse Model with representations of:
    - Entities referred to in the discourse
    - Relationships of these entities
  - Need way to construct, update model
  - Need way to map refexp to hearer’s beliefs
Reference and Model

Discourse Model

refer (evoke)

"John"
corefer

"he"

refer (access)
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...

Coreference resolution:
Find all expressions referring to same entity, ‘corefer’
Colors indicate coreferent sets

Pronominal anaphora resolution:
Find antecedent for given pronoun
Referring Expressions

- Indefinite noun phrases (NPs): e.g. “a cat”
  - Introduces new item to discourse context

- Definite NPs: e.g. “the cat”
  - Refers to item identifiable by hearer in context
    - By verbal, pointing, or environment availability; implicit

- Pronouns: e.g. “he”, “she”, “it”
  - Refers to item, must be “salient”

- Demonstratives: e.g. “this”, “that”
  - Refers to item, sense of distance (literal/figurative)

- Names: e.g. “Miss Woodhouse”, “IBM”
  - New or old entities
Information Status

- Some expressions (e.g. indef NPs) introduce new info
- Others refer to old referents (e.g. pronouns)

- Theories link form of refexp to given/new status

The givenness hierarchy:

<table>
<thead>
<tr>
<th>in focus &gt;</th>
<th>activated &gt;</th>
<th>familiar &gt;</th>
<th>uniquely identifiable &gt;</th>
<th>referential &gt;</th>
<th>type identifiable</th>
</tr>
</thead>
<tbody>
<tr>
<td>{it}</td>
<td>{that}</td>
<td>{that N}</td>
<td>{the N}</td>
<td>{indef. this N}</td>
<td>{a N}</td>
</tr>
</tbody>
</table>

- Accessibility:
  - More salient elements easier to call up, can be shorter
  - Correlates with length: more accessible, shorter refexp
Complicating Factors

- Inferrables:
  - Refexp refers to inferentially related entity
    - *I bought a car today, but the door had a dent, and the engine was noisy.*
    - E.g. car -> door, engine

- Generics:
  - *I want to buy a Mac. They are very stylish.*
  - General group evoked by instance.

- Non-referential cases:
  - *It’s raining.*
Syntactic Constraints for Reference Resolution

- Some fairly rigid rules constrain possible referents
- Agreement:
  - Number: Singular/Plural
  - Person: 1st: I, we; 2nd: you; 3rd: he, she, it, they
  - Gender: he vs she vs it
Syntactic & Semantic Constraints

- **Binding constraints:**
  - Reflexive (x-self): corefers with subject of clause
  - Pronoun/Def. NP: can’t corefer with subject of clause

- **“Selectional restrictions”:**
  - “animate”: The cows eat grass.
  - “human”: The author wrote the book.
  - More general: drive: John drives a car....
Syntactic & Semantic Preferences

- Recency: Closer entities are more salient
  - The doctor found an old map in the chest. Jim found an even older map on the shelf. It described an island.

- Grammatical role: Saliency hierarchy of roles
  - e.g. Subj > Object > I. Obj. > Oblique > AdvP
  - Billy Bones went to the bar with Jim Hawkins. He called for a glass of rum. [he = Billy]
  - Jim Hawkins went to the bar with Billy Bones. He called for a glass of rum. [he = Jim]
Syntactic & Semantic Preferences

- Repeated reference: Pronouns more salient
  - Once focused, likely to continue to be focused
    - Billy Bones had been thinking of a glass of rum. He hobbled over to the bar. Jim Hawkins went with him. He called for a glass of rum. [he=Billy]

- Parallelism: Prefer entity in same role
  - Silver went with Jim to the bar. Billy Bones went with him to the inn. [him = Jim]
  - Overrides grammatical role

- Verb roles: “implicit causality”, thematic role match,...
  - John telephoned Bill. He lost the laptop.
  - John criticized Bill. He lost the laptop.
Reference Resolution Approaches

- Common features
  - “Discourse Model”
    - Referents evoked in discourse, available for reference
    - Structure indicating relative salience
  - Syntactic & Semantic Constraints
  - Syntactic & Semantic Preferences

- Differences:
  - Which constraints/preferences? How combine? Rank?
A Resolution Algorithm
(Lappin & Leass)

- Discourse model update:
  - Evoked entities:
    - Equivalence classes: Coreferent referring expressions
  - Salience value update:
    - Weighted sum of salience values:
      - Based on syntactic preferences

- Pronoun resolution:
  - Exclude referents that violate syntactic constraints
  - Select referent with highest salience value
Salience Factors (Lappin & Leass 1994)

- Weights empirically derived from corpus
  - Recency: 100
  - Subject: 80
  - Existential: 70
  - Object: 50
  - Indirect Object/Oblique: 40
  - Non-adverb PP: 50
  - Head noun: 80
  - Parallelism: 35, Cataphora: -175

- Divide by 50% for each sentence distance
Example

- John saw a beautiful Acura Integra in the dealership.
- He showed it to Bob.
- He bought it.
Example

- John saw a beautiful Acura Integra in the dealership.

<table>
<thead>
<tr>
<th>Referent</th>
<th>Phrases</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>John</td>
<td>{John}</td>
<td>310</td>
</tr>
<tr>
<td>Integra</td>
<td>{a beautiful Acura Integra}</td>
<td>280</td>
</tr>
<tr>
<td>Dealership</td>
<td>{the dealership}</td>
<td>230</td>
</tr>
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He showed it to Bob.

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<td>210</td>
</tr>
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<td>135</td>
</tr>
<tr>
<td>Dealership</td>
<td>{the dealership}</td>
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Hobbs’ Resolution Algorithm

- Requires:
  - Syntactic parser
  - Gender and number checker

- Input:
  - Pronoun
  - Parse of current and previous sentences

- Captures:
  - Preferences: Recency, grammatical role
  - Constraints: binding theory, gender, person, number
Hobbs Algorithm

- Intuition:
  - Start with target pronoun
  - Climb parse tree to S root
  - For each NP or S
    - Do breadth-first, left-to-right search of children
      - Restricted to left of target
      - For each NP, check agreement with target
  - Repeat on earlier sentences until matching NP found
Hobbs Algorithm Detail

- Begin at NP immediately dominating pronoun
- Climb tree to NP or S: X=node, p = path
- Traverse branches below X, and left of p
  - Breadth-first, Left-to-Right
  - If find NP, propose as antecedent
    - If separated from X by NP or S
- Loop: If X highest S in sentence, try previous sentences.
- If X not highest S, climb to next NP or S: X = node
- If X is NP, and p not through X’s nominal, propose X
- Traverse branches below X, left of p: BF, LR
  - Propose any NP
- If X is S, traverse branches of X, right of p: BF, LR
  - Do not traverse NP or S; Propose any NP
  - Go to Loop
Hobbs Example

Lyn’s mom is a gardener. Craige likes her.
Another Hobbs Example

P. Denis
Hobbs Algorithm

- Results: 88% accuracy; 90+% intrasential
  - On perfect, manually parsed sentences
- Useful baseline for evaluating pronominal anaphora
- Issues:
  - Parsing:
    - Not all languages have parsers
    - Parsers are not always accurate
  - Constraints/Preferences:
    - Captures: Binding theory, grammatical role, recency
    - But not: parallelism, repetition, verb semantics, selection
Reference Resolution: Agreements

- Knowledge-based
  - Deep analysis: full parsing, semantic analysis
  - Enforce syntactic/semantic constraints
  - Preferences:
    - Recency
    - Grammatical Role Parallelism (ex. Hobbs)
    - Role ranking
    - Frequency of mention

- Local reference resolution
- Little/No world knowledge
- Similar levels of effectiveness
Questions

- 80% 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

- 80% 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
Reference Resolution: Extensions

- Cross-document co-reference
  - (Baldwin & Bagga 1998)
  - Break “the document boundary”
  - Question: “John Smith” in A = “John Smith” in B?
- Approach:
  - Integrate:
    - Within-document co-reference
    - with
      - Vector Space Model similarity
Cross-document Co-reference

- Run within-document co-reference (CAMP)
  - Produce chains of all terms used to refer to entity

- Extract all sentences with reference to entity
  - Pseudo per-entity summary for each document

- Use Vector Space Model (VSM) distance to compute similarity between summaries
Cross-document Co-reference

• Experiments:
  • 197 NYT articles referring to “John Smith”
    • 35 different people, 24: 1 article each
  • With CAMP: Precision 92%; Recall 78%
  • Without CAMP: Precision 90%; Recall 76%
  • Pure Named Entity: Precision 23%; Recall 100%
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!)