Topics for Today

- Last class: Pragmatics
  - problem of inference
  - knowledge-based methods for inferring text cohesion
    - knowledge about action and causality
  - scripts
- Today: Pragmatics of discourse context
  - reference resolution
  - noun phrase coreference resolution
  - machine learning approach to NP coreference resolution

The problem of reference resolution

Gracie: Oh yeah...and then Mr. And Mrs. Jones were having matrimonial trouble, and my brother was hired to watch Mrs. Jones.

George: Well, I imagine she was a very attractive woman.

Gracie: She was, and my brother watched her day and night for six months.

George: Well, what happened?

Gracie: She finally got a divorce.

George: Mrs. Jones?

Gracie: No, my brother’s wife.

George Burns and Gracie Allen in The Salesgirl

Reference resolution

- **Reference**: the process by which speakers use expressions like “John Simon” and “his” to denote a real-world entity
  - **Referring expressions**: NL expression used to perform reference
  - **Referent**: the entity that is referred to
  - **Shorthand form**: *his* refers to John Simon

Coreference

- **Coreference**: two referring expressions that are used to refer to the same entity are said to corefer
- *John Simon* is the **antecedent** of *his*.
- Reference to an entity that has been previously introduced into the discourse is called **anaphora**; and the referring expression used is said to be **anaphoric**.

John Simon, Chief Financial Officer of Prime Corp. since 1986, saw his pay jump 20%, to $1.3 million, as the 37-year-old also became the financial-services company’s president...
Types of referring expressions

- **Indefinite noun phrases**
  - Introduce entities that are new to the hearer into the discourse context
    » I saw a Subaru WRX today.
    » I saw this awesome Subaru WRX today.

- **Definite noun phrases**
  - Refer to an entity that is identifiable to the hearer
    » It has already been mentioned in the discourse
    » It is contained in the hearer's set of beliefs about the world
    » The uniqueness of the object is implied by the description itself
    - I saw a Subaru WRX today. *The WRX* was blue and needed a wash.
    - *The Indy 500* is the most popular car race in the US.
    - *The fastest car in the Indy 500* was a Subaru WRX.

- **Pronouns**
  - Another form of definite reference
  - Referent must have a high degree of activation or salience in the discourse model
    » John went to Bob's party, and parked next to a beautiful Subaru WRX. He went inside and talked to Bob for more than an hour. Bob told him that he recently got engaged.
      (a) He also said that he bought *it* yesterday.
      (a') He also said that he bought *the WRX* yesterday.
  - Cataphora: referring expression is mentioned before its referent
    » Before he bought *it*, John checked over the WRX carefully.

- **Demonstrative pronouns**
  - Behave somewhat differently than simple definite pronouns
    » Can appear alone or as determiners
    » Choice of *this* or *that* depends on some notion of spatial or temporal proximity
      - I bought a WRX yesterday. It's similar to the one I bought a year ago. *That one* was really nice, but I like *this one* even better.

- **One-anaphora**
  - Blends properties of definite and indefinite reference
    » I saw no fewer than 6 Subaru WRX's today. Now I want *one*.
  - May introduce a new entity into the discourse, but it is dependent on an existing referent for the description of this new entity.

Types of referring expressions

- **Noun Phrase Coreference Resolution**
  - Identify all phrases that refer to each real-world entity mentioned in the text

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John Simon, Chief Financial Officer of Prime Corp. since 1986, saw his pay jump 20%, to $1.3 million, as the 37-year-old also became the financial-services company’s president...
Why It’s Hard

Many sources of information play a role
- head noun matches
  » IBM executives = the executives
  » Microsoft executives

- syntactic constraints
  » John helped himself to...
  » John helped him to...

- discourse focus, recency, syntactic parallelism, semantic class, agreement, world knowledge, ...

Why It’s Hard

No single source is a completely reliable indicator
- semantic preferences
  » Mr. Callahan = president =? the carrier

- number and gender
  » assassination (of Jesuit priests) = these murders
  » the woman = she = Mary =? the chairman

Why It’s Hard

Coreference strategies differ depending on the type of referring NP
- definiteness of NPs
  » ... Then Mark saw the man walking down the street.
  » ... Then Mark saw a man walking down the street.

- pronoun resolution alone is notoriously difficult
  » resolution strategies differ for each type of pronoun
  » some pronouns refer to nothing in the text

I went outside and it was snowing.

Types of referents: complications

- Inferrables
  » A referring expression does not refer to an entity in the text, but to one that is inferentially related to it.
    » I almost bought a WRX today, but a door had a dent and the engine seemed noisy.
    » Mix the flour, butter, and water. Stir the batter until all lumps are gone.

- Discontinuous sets
  » Referents may have been evoked in discontinuous phrases
    » John has a Volvo, and Mary has a Mazda. They drive them all the time.

- Generics – refer to a class of entities
  » I saw no fewer than 6 WRX’s today. They are the coolest cars.
Topics for today

- Pragmatics of discourse
  - reference resolution
  - noun phrase coreference resolution
- Machine learning approach to NP coreference resolution
  - a high-performing machine learning solution
  - two extensions (if time)

Traditional Knowledge-Based Approaches

Lappin and Leass [1994]

- Hand-crafted heuristics and filters
  - syntactic filters [Lappin and McCord 1990a]
  - morphological filter
  - pleonastic pronoun filter (“It was raining.”)
  - procedure for identifying possible antecedents [Lappin and McCord 1990b]
  - salience assignment w.r.t. grammatical role, proximity, parallelism, etc.

- Decision procedure

Problems

- Portability
- Robustness
- Few large-scale evaluations
- Evaluations make a number of simplifying assumptions
  - perfect parse
  - omit many difficult cases, e.g. pleonastic pronouns
- Impose coreference resolution strategies rather than learn them empirically

A Machine Learning Approach

Classification

- Given a description of two noun phrases, \( NP_i \) and \( NP_j \), classify the pair as coreferent or not coreferent

\[
\text{[John Simon], [Chief Financial Officer] of [Prime Corp.]} \quad ? \quad \text{?}
\]

Since 1986, saw his pay jump 20%, to $1.3 million, as the 37-year-old also became the ....

Aone & Bennett [1995]; Connolly et al. [1995]; McCarthy & Lehnert [1995]; Soon, Ng & Lim [2001]; Ng & Cardie [2002]
A Machine Learning Approach

- Clustering
  - coordinates pairwise coreference decisions

John Simon
Chief Financial Officer
the 37-year-old president
of Prime Corp.
since 1986

Singletons
- pay
- 20%
- $1.3 million

Evaluation

- MUC-6 and MUC-7 coreference data set
- documents annotated w.r.t. coreference
- 30 + 30 training texts (dry run)
- 30 + 20 test texts (formal evaluation)
- scoring program
  - recall
  - precision
  - F-measure: 2PR/(P+R)

Baselines...

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<tr>
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<th>MUC-6</th>
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<tr>
<td></td>
<td>R</td>
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<tr>
<td>Match Any Word</td>
<td>41.3</td>
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<tr>
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<td>Single Cluster</td>
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Issues

- Training data
- Instance representation
- Learning algorithm
- Clustering approach

Will learn about these in the critique paper…