CS 4705

Algorithms for Reference Resolution

Anaphora resolution

- Finding in a text all the referring expressions that have one and the same denotation
  - Pronominal anaphora resolution
  - Anaphora resolution between named entities
  - Full noun phrase anaphora resolution

Review: What Factors Affect Reference Resolution?

- Lexical factors
  - Reference type: Inferability, discontinuous set, generics, one anaphora, pronouns,…
- Discourse factors:
  - Recency
  - Focus/topic structure, digression
  - Repeated mention
- Syntactic factors:
  - Agreement: gender, number, person, case
  - Parallel construction
  - Grammatical role

  - Selectional restrictions
- Semantic/lexical factors
  - Verb semantics, thematic role
- Pragmatic factors

Reference Resolution

- Given these types of constraints, can we construct an algorithm that will apply them such that we can identify the correct referents of anaphors and other referring expressions?

Issues

- Which constraints/features can/should we make use of?
- How should we order them? I.e. which override which?
- What should be stored in our discourse model? I.e., what types of information do we need to keep track of?
- How to evaluate?

Three Algorithms

- Lappin & Leas ‘94: weighting via recency and syntactic preferences
- Hobbs ‘78: syntax tree-based referential search
- Centering (Grosz, Joshi, Weinstein, ‘95 and various): discourse-based search

Lappin & Leass ‘94

- Weights candidate antecedents by recency and syntactic preference (86% accuracy)
- Two major functions to perform:
  - Update the discourse model when an NP that evokes a new entity is found in the text, computing the salience of this entity for future anaphora resolution
  - Find most likely referent for current anaphor by considering possible antecedents and their salience values
- Partial example for 3P, non-reflexives

Saliency Factor Weights

- Sentence recency (in current sentence?) 100
- Subject emphasis (is it the subject?) 80
- Existential emphasis (existential prednom?) 70
- Accusative emphasis (is it the dir obj?) 50
- Indirect object/oblique comp emphasis 40
- Non-adverbial emphasis (not in PP,) 50
- Head noun emphasis (is head noun) 80

- Implicit ordering of arguments:

subj/exist pred/obj/indobj-oblique/dem.advPP

On the sofa, the cat was eating bonbons.

sofa: 100+80=180

cat: 100+80+50+80=310

bonbons: 100+50+50+80=280

- Update:
  - Weights accumulate over time
  - Cut in half after each sentence processed
  - Salience values for subsequent referents accumulate for equivalence class of co-referential items (exceptions, e.g. multiple references in same sentence)

The bonbons were clearly very tasty.

sofa: 180/2=90

cat: 310/2=155

bonbons: 280/2 +(100+80+50+80)=450

- Additional salience weights for grammatical role parallelism (35) and cataphora (-175) calculated when pronoun to be resolved
- Additional constraints on gender/number agrmt/syntax

They were a gift from an unknown admirer.

sofa: 90/2=45

cat: 155/2=77.5

bonbons: 450/2=225 (+35) = 260….

Reference Resolution

- Collect potential referents (up to four sentences back): {sofa,cat,bonbons}
- Remove those that don't agree in number/gender with pronoun {bonbons}
- Remove those that don't pass intra-sentential syntactic coreference constraints

  The cat washed it. (it≠cat)
- Add applicable values for role parallelism (+35) or cataphora (-175) to current salience value for each potential antecedent
- Select referent with highest salience; if tie, select closest referent in string

A Different Aproach: Centering Theory

- (Grosz et al 1995) examines interactions between local coherence and the choice of referring expressions
  - A pretty woman entered the restaurant. She sat at the table next to mine…
  - A woman entered the restaurant. They like ice cream.

Centering theory: Motivation

- (Grosz et al 1995) examine interactions between local coherence and the choice of referring expressions
  - Pronouns and definite descriptions are not equivalent with respect to their effect on coherence
  - Different inference demands on the hearer/reader.

Centering theory: Definitions

- The centers of an utterance are discourse entities serving to link the utterance to other utterances
  - **Forward looking centers:** a ranked list
  - A **backward looking center:** the entity currently 'in focus' or salient
- Centers are semantic objects, not words, phrases, or syntactic forms but
  - They are realized by such in an utterance
  - Their realization can give us clues about their likely salience

More Definitions

- More on discourse centers and utterances
  - U_n: an utterance
  - Backward-looking center $C_b(U_n)$: current focus after U_n interpreted
  - Forward-looking centers $C_f(U_n)$: ordered list of potential focii referred to in U_n
    - $C_b(U_{n+1})$ is highest ranked member of $Cf(U_n)$
    - C_f may be ordered subj<exist. Prednom<obj<indobj-oblique<dem. advPP (Brennan et al)
    - $C_p(U_n)$: preferred (highest ranked) center of $C_f(U_n)$

Transitions from Un to Un+1

	Cb(Un+1)=Cb(Un) or Cb(Un) undef	Cb(Un+1)≠Cb(Un)
Cb(Un+1)= Cp(Un+1)	Continue	Smooth-Shift
Cb(Un+1)≠ Cp(Un+1)	Retain	Rough-Shift

Rules

- If any element of $C_f(U_n)$ is pronominalized in U_{n+1}, then $C_b(U_{n+1})$ must also be
- Preference: Continue > Retain > Smooth-Shift > Rough-Shift
- Algorithm
  - Generate C_b and C_f assignments for all possible reference assignments
  - Filter by constraints (syntactic coreference, selectional restrictions,…)
  - Rank by preference among transition orderings

Example

U_1:George gave Harry a cookie. U_2:He baked the cookie Thursday. U_3: He ate the cookie all up.

- One
  - $C_f(U_1)$: {George,cookie,Harry}
  - $C_p(U_1)$: George
  - $C_b(U_1)$: undefined
- Two
  - $C_f(U_2)$: {George,cookie,Thursday}
  - $C_p(U_2)$: George
  - $C_b(U_2)$: George
  - Continue ($C_p(U_2)=C_b(U_2)$; $C_b(U_1)$ undefined

- Three
  - $C_f(U_3)$: {George?,cookie}
  - $C_p(U_3)$: George?
  - $C_b(U_3)$: George?
  - Continue ($C_p(U_3)=C_b(U_3)$; $C_b(U_3)= C_b(U_2)$)
- Or, Three
  - $C_f(U_3)$: {Harry?,cookie}
  - $C_p(U_3)$: Harry?
  - $C_b(U_3)$: Harry?
  - Smooth-Shift ($C_p(U_3)=C_b(U_3)$; $C_b(U_3) \neq C_b(U_2)$)

The winner is…..George!

Centering Theory vs. Lappin & Leass

- Centering sometimes prefers an antecedent Lappin and Leass (or Hobbs) would consider to have low salience
  - Always prefers a single pronominalization strategy: prescriptive, assumes discourse coherent
  - Constraints too simple: grammatical role, recency, repeated mention
  - Assumes correct syntactic information available as input

Evaluation

- Centering only now being specified enough to be tested automatically on real data
  - Specifying the Parameters of Centering Theory: A Corpus-Based Evaluation using Text from Application-Oriented Domains (Poesio et al., ACL 2000)
- Walker ‘89 manual comparison of Centering vs. Hobbs ‘78
  - Only 281 examples from 3 genres
  - Assumed correct features given as input to each
  - Centering 77.6% vs. Hobbs 81.8%
  - Lappin and Leass’ 86% accuracy on test set from computer training manuals

Rule-based vs. Statistical Approaches

- Rule-based vs statistical
  - (Kennedy & Boguraev 1996), (Lappin & Leass 1994) vs (Ge, Hale & Charniak 1998)
- Performed on full syntactic parse vs on shallow syntactic parse
  - (Lap 1994), (Ge 1998) vs (Ken 1996)
- Type of text used for the evaluation
  - (Lap 1994) computer manual texts (86% accuracy)
  - (Ge 1998) WSJ articles (83% accuracy)
  - (Ken 1996) different genres (75% accuracy)