Syntactic Theories

CS 672

Why is Syntax Important?

- Statistical ***bag of words*** approaches work well for a number of NLP applications:
  - Information Retrieval (IR)
  - Text Categorization
- Bag of words approaches, however, exhibit asymptotic behavior
- For other applications, bag of word approaches don't work well at all

Syntax is Important

- To improve the performance, NLP applications need to consider the structure of the text
  - Bob hit John.
  - John hit Bob.
  - Bob was hit by John.
  - Q: Who hit John?

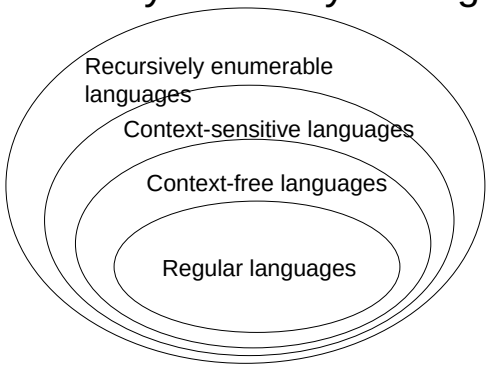
Bob	John	hit	was	by	…
1	1	1	0	0	0
1	1	1	0	0	0
1	1	1	1	1	0

Some Background

- Two notions of grammar equivalency
  - Weak
  - Strong
- Lexical grammars

Complexity of Natural Languages

- The Chomsky hierarchy of languages



Complexity of Natural Languages

- Where do Natural Languages (NLs) fit?
  - It is universally agreed that NLs are not regular
  - Many theorists believe that NLs are not Context-Free
    - Evidence: cross constructs in German have the form $wu^mv^nxy^mz^np$
  - NLs are believed to be ***Mildly Context Sensitive***

Mildly Context Sensitive Languages (MCSLs)

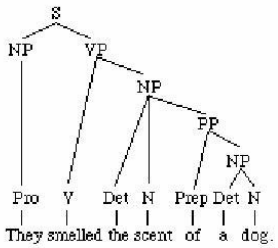
- A formalism introduced to deal with NL
- Defined by the following properties:
  - CFL are properly contained in MCSL
  - Languages in MCSL can be parsed in polynomial time
  - MCSG can only capture certain dependencies (e.g. nested dependencies)
  - Languages in MCSL have the linear growth property

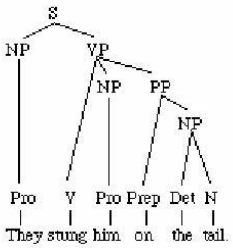
Syntactic Theories in Linguistics and Psychology

- Classical linguistics
- New directions in syntax

the reigning metaphor:
language as

S → NP VP
NP → { (Det) N (PP) / Pro }
VP → V (NP) (AdvP) (PP)
PP → Prep NP
AdvP → (Intens) Adv

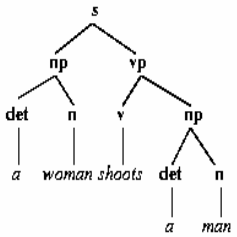




(Slide taken from Shimon Edelman's presentation)

Classical Linguistics

- Syntax described by CFG
- Semantic and other considerations expressed in terms of constraints
- Theory of movement and tra
- Innate grammar hypothesis



Classical Syntax in NLP

- Penn Treebank
- Parsers have been used successfully in NLP:
  - Stochastic and symbolic parsers; partial parsers
  - Parsers used in many NLP applications
    - Question Answering, Coreference Resolution, Machine Translation, etc
- Grammars typically hand-crafted

Classical Syntax in NLP Cont'd

- Attempts to learn the structure empirically from data:
  - Stolcke & Omohundro (1994) attempted to induce the structure of probabilistic grammars
    - Used HMM's, Class-based n-gram Models, Stochastic CFGs
  - Clark (2001) - Unsupervised induction of Stochastic Context-Free Grammars

Classical Linguistics - Problems

- No comprehensive transformational generative grammar for any language
- Imperfections of performance and competence
- Lack of empirical support for traces and movement
- Limited defacto language productivity

Example

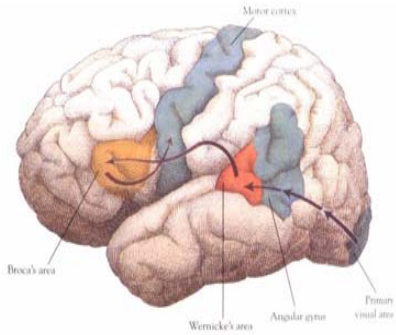
You already know what it's hittin for
Ma I got whatever outside and you know what I'm sittin on
50/50 venture with them S dots kickin off
Armadale poppin now, only bring a brotha more
Only thing missin is a Missus
You ain't even gotta do the dishes, got two dishwashers
Got one chef, one maid, all I need is a partner
to play spades with the cards up, ALL TRUST
Who else you gon' run with, the truth is us
Only dudes movin units - Em, Pimp Juice and us
.. it's the Roc in here!
(Jay-Z - Excuse me miss)

New Approaches to Syntax

- Cognitive Grammar
- Construction Grammars
- Tree-Adjoining Grammars

Cognitive Grammar

- Langacker, Taylor
- Linguistic cognition simply is cognition; it is an inextricable phenomenon of overall human cognition.



•Therefore, patterns of cognition observed by psychologists, neurologists, and the like should be observed in language.

Cognitive Grammar Cont'd

- "Grammar is not a distinct level of linguistic representation, but reduces instead to the structuring and symbolization of conceptual content..."
- "Lexicon, morphology, and syntax form a continuum of symbolic units, divided only arbitrarily into separate "components"---it is ultimately as pointless to analyze grammatical units without reference to their semantic value as it is to write a dictionary which omits the meanings of its lexical units. "

Construction Grammar

- Constraint based system; syntactic and semantic information represented within single feature structure (attribute value matrix)
- Jackendoff (2002): "[...] we must explicitly deny that conceptual structures [...] mean anything. Rather, we want to say that they are meaning: they do exactly the things meaning is supposed to do, such as support inference and judgment"

Construction Grammar Cont'd

- Constructions – stored pairings of form and function
- Elements vary in complexity and in the degree in which they are specified

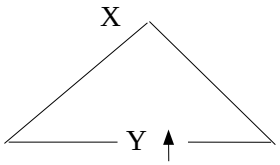
Morpheme	e.g., *anti-, pre-, -ing*	
Word	e.g., *Avocado, anaconda, and*	
Complex word	e.g., *Daredevil, shoo-in*	
Idiom (filled)	e.g., *Going great guns*	
Idiom (partially filled)	e.g., *Jog* <someone's> *memory*	
Covariational Conditional construction [10]	Form: The Xer the Yer (e.g., *The more you think about it, the less you understand*)	Meaning: linked independent and dependent variables; see text
Ditransitive (double object) construction	Form: Subj [V Obj1 Obj2] (e.g., *He gave her a Coke; He baked her a muffin.*)	Meaning: transfer (intended or actual); see text.
Passive	Form: Subj aux VPpp (PP_{by}) (e.g., *The armadillo was hit by a car*)	Discourse function: to make undergoer topical and/or actor non-topical

Tree-Adjoining Grammars (TAGs)

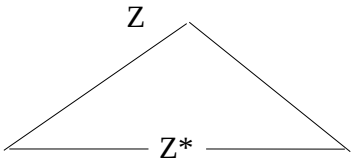
- Joshi, Schabes, Vijay-Shanker, Wier, Rambow...
- Work on TAGs motivated by linguistics considerations
- TAGs, however, of interest in formal languages and automata
  - Mildly context sensitive
  - Can be parsed in polynomial time by embedded push-down automata
  - Derive from the lexicalyzation of CFG

TAG elements

- Initial tree

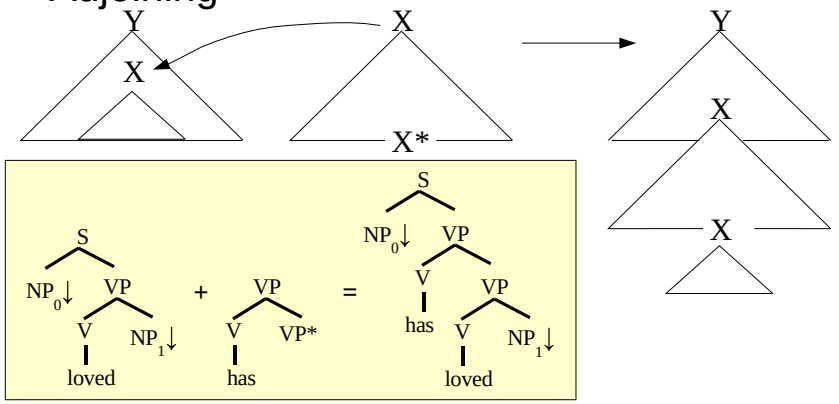


- Auxiliary tree



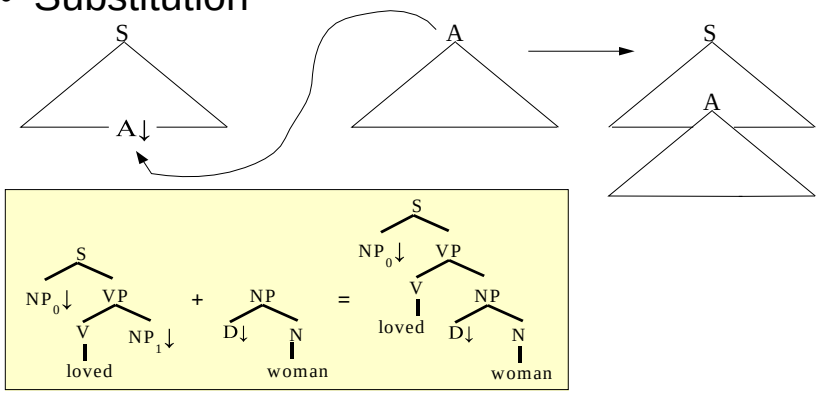
LTAG composition operations

- Adjoining



LTAG composition operations

- Substitution



LTAG linguistic relevance

- Extended domain of locality
- Factoring recursion from the domain of locality
  - Dependencies such as agreement and subcategorization stated over elementary structures of TAGs
  - Long-distance behavior follows from adjoining

Other approaches

- Stochastic Tree Substitution Grammars (STSGs)
  - Bod (1998); Scha, Bod, and Sima'an (1999)
- Split and Merge Pattern Learning
  - Wolff (1988)
- ADIOS
  - Shimon Edelman et al

New Approaches - Connections to NLP

- Information Extraction – Extraction Patterns
  - <victim> was murdered
- Question answering
- A challenge:
  - Develop methods to automatically identify semantic units from (un/weakly) supervised training data
  - Take advantage of the vast amount of unsupervised data (untagged text) available