Natural Language Processing
CMSC 723 (spring, 2001)

March 28, 2001

- Syntax
- Context Free Grammars
- Chomsky Hierarchy
- Grammar Development
- Grammar Equivalence and Normal Form
- Intro to Parsing

HOMEWORK #6:
(1) Jurafsky and Martin, 9.6
(2) Jurafsky and Martin, 9.7
(3) Convert this grammar to CNF:
   \[ S \rightarrow aXY, \quad X \rightarrow aX \mid b, \quad Y \rightarrow Ya \mid b \]

Syntax

Who cares?

- Grammar checkers
- Question answering/database access
- Information extraction
- Generation
- Translation

What is Syntax?

- How words and phrases are strung together
- Childrens’ language
- Not meaning

Context Free Grammars

- Captures constituency and ordering
- Need something else!
- Used in modern linguistic theories of grammar?
Context Free Grammars

Consist of:

- Sets of terminals.
- Sets of non-terminals
- Sets of rules of the form $A \rightarrow \alpha$ where $\alpha$ is a string of zero or more terminals and non-terminals.
- Notation: $X \rightarrow aX \mid b$
- The use of "context" in CFG?
- Backus-Naur form grammars.

Derivations and Trees

[Figure 9.4]

Sample Grammar

[Figure 9.3]

As opposed to what?

- Regular expressions
- Context sensitive grammars
- Turing machines
### Chomsky Hierarchy

[Figure 13.1]

### Note!

The use of the term “context free” in the description of this formalism has nothing to do with the ordinary use of the word context.

### Grammar Development

- **S** → **NP** **VP**
- **NP** → **Det** **Nominal**
- **NP** → **Pronoun**
- **Nominal** → **Noun** **Nominal**
- **Nominal** → **Noun**
- **VP** → **V**
- **VP** → **V** **NP**
- **Pronoun** → **I**
- **Det** → **a**
- **Noun** → **morning**
- **Noun** → **flight**
- **V** → **want** | **fly**
Key Constituents

- Sentences
- Noun phrases
- Verb phrases
- Prepositional phrases

Recursive Structures

NP → NP PP The flight to Boston
VP → VP PP departed Miami at noon

Sentence Types

- Declaratives: John left.
- Imperatives: Leave!
- Yes-No Questions: Did John leave?
- WH Questions: When did John leave?
### Conjunctions

\[
\begin{align*}
S &\rightarrow S \text{ and } S \\
NP &\rightarrow NP \text{ and } NP \\
VP &\rightarrow VP \text{ and } VP
\end{align*}
\]

### Agreement

- This dog
- Those dogs
- *Those dog
- *This dogs

- Do [any flights] stop in Chicago?
- Does [NP Delta] stop in Chicago?

### Some Difficulties

- Agreement
- Subcategorization
- Movement

### How do we deal with agreement?

\[
\begin{align*}
Sg_{\text{Nominal}} &\rightarrow Sg_{\text{Noun}} \mid Sg_{\text{Noun}} \ Sg_{\text{Noun}} \\
P1_{\text{Nominal}} &\rightarrow P1_{\text{Noun}} \mid P1_{\text{Noun}} \ P1_{\text{Noun}}
\end{align*}
\]

Problems?
Subcat

VP → Verb disappear
VP → Verb NP prefer a morning flight
VP → Verb NP PP leave Boston in the morning
VP → Verb PP leaving on Thursday

*I disappeared the cat.

Movement

• I looked up his grade.
  I looked his grade up.

• John put the book on the table.
  What did John put on the table?

• Long distance dependencies.

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Grammar Equivalence and Normal Form

Weak equivalence:

Strong equivalence:

It is sometimes useful to have a normal form for grammars.

Chomsky Normal Form (CNF): $A \rightarrow BC$ or $A \rightarrow a$

Any grammar can be converted into a weakly-equivalent CNF grammar.
### Parsing

Parsing with a CFG is the task of assigning a correct tree (or derivation) to a string given some grammar.

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### A Note on the Input

**Assumptions:**

- The input is not tagged
- The input consists of unanalyzed word tokens
- All the words in the input are known
- All the words in the input are available simultaneously

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### Parsing as Search

As with finite-state recognition and transduction, parsing can be viewed as a search.

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### Example Context-Free Grammar and Example sentence

[Figure 10.2]
Example Context-Free Grammar and Example sentence

[Figure 10.1]