Linguistic Essentials

Berlin Chen 2003

References:
1. Speech and Language Processing, chapter 3
2. Foundations of Statistical Natural Language Processing, chapter 3
3. Natural Language Understanding, chapter 2
Introduction

• Basic linguistic concepts
  – Word
    • Part-of-speech (word categories)
    • Morphology
  – Phrase and Syntax
    • Rewrite rules, parsing
  – Sentences and Discourse
  – Semantics and Pragmatics
Word Classes or Categories

• Words are fundamental building block of languages
• Classify words into different classes (categories) based on their uses
• Two related areas of evidence
  – **Semantic behavior**
    • The word’s contribution to the phrase that contains it
  – **Syntactic or grammatical behavior**
    • The actual syntactic structures in which the word may play a role
    • Traditionally named part-of-speech (POS)
    • Four important part-of-speech are nouns, verbs, adjectives, and adverbs
Word Classes or Categories

• The syntactic classes of words (part-of-speech) are traditionally divided into about 8 classes
  – E.g. noun, verb, adjective, adverbs, prepositions, conjunctions, determiners, pronouns,…

  – There are well-established sets of abbreviations for naming these classes, referred as POS tags
    • E.g.: noun (N), verb (V), adjective (A) ...
    • Brown tags
Important Syntactic Classes of Words

• Nouns (名詞)
  – Used to identify the basic types of objects (people and animal, etc.), things, concepts, or places being discussed
  – mass nouns or count nouns

• Verb (動詞)
  – Used to express the action in a sentence

• Adjectives (形容詞)
  – Used to describe the properties of nouns
    • Qualify the object, thing, concept, or place
      The anger man waves his hands.
  – Noun modifiers: nouns used to modify another noun
    The cook book is just over there.
Important Syntactic Classes of Words

• Adverbs (副詞)
  – Modify a verb in the same way that adjectives modify nouns
  – Specify place (here, everywhere), time (then, yesterday), manner (never, rarely), or degree (very, rather, too)

• Pronouns (代名詞)
  – A small class of words (it, he, she, they,...) that act like variables in that they refer to a person or thing that is somewhat salient in the discourse context
  – They are the only words in English which appear different forms (cases) being used as the subject (nominative) and object (accusative) of a sentence
Important Syntactic Classes of Words

• Pronoun Forms in English

<table>
<thead>
<tr>
<th>Tag(s)</th>
<th>Nominative</th>
<th>Accusative</th>
<th>Possessive</th>
<th>2nd Possessive</th>
<th>Reflexive</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPS (3SG)</td>
<td>PPO</td>
<td>PP$</td>
<td>PP$$</td>
<td>PPL (PPLS for PL)</td>
<td></td>
</tr>
<tr>
<td>PPSS (1SG, 2SG, PL)</td>
<td>me</td>
<td>my</td>
<td>mine</td>
<td>myself</td>
<td></td>
</tr>
<tr>
<td>1SG</td>
<td>I</td>
<td>me</td>
<td>my</td>
<td>mine</td>
<td>myself</td>
</tr>
<tr>
<td>2SG</td>
<td>you</td>
<td>you</td>
<td>yours</td>
<td>yours</td>
<td>yourself</td>
</tr>
<tr>
<td>3SG MASC</td>
<td>he</td>
<td>him</td>
<td>his</td>
<td>his</td>
<td>himself</td>
</tr>
<tr>
<td>3SG FEM</td>
<td>she</td>
<td>her</td>
<td>her</td>
<td>hers</td>
<td>herself</td>
</tr>
<tr>
<td>3SG NEUT</td>
<td>it</td>
<td>its</td>
<td>its</td>
<td>itself</td>
<td></td>
</tr>
<tr>
<td>1PL</td>
<td>we</td>
<td>us</td>
<td>our</td>
<td>ours</td>
<td>ourselves</td>
</tr>
<tr>
<td>2PL</td>
<td>you</td>
<td>you</td>
<td>yours</td>
<td>yours</td>
<td>yourselves</td>
</tr>
<tr>
<td>3PL</td>
<td>they</td>
<td>them</td>
<td>theirs</td>
<td>theirs</td>
<td>themselves</td>
</tr>
</tbody>
</table>

Table 3.2 Pronoun forms in English. Second person forms do not distinguish number, except in the reflexive, while third person singular forms distinguish gender.

– Relative pronouns
  • who, which, that
Important Syntactic Classes of Words

• **Prepositions** (介系詞) *(in, on over, about, …)*
  – Small words that express **spatial** or **temporal** relationships
  – Prepositions can also be used as **particles** in the formation of phrasal verbs (片語動詞)
    
    He looks over the paper.

• **Conjunctions** (連接詞) *(or, and, but, if, because, …)*
  – Conjoin or coordinate (or subordinate) two words or phrases of (usually) the same category
  – Coordinating conjunctions (對等連接詞) *(or, and, but, …)*, subordinating conjunctions (從屬連接詞) *(if, because, …)*
Important Syntactic Classes of Words

• Determiners (定詞)
  – Determiners describe the particular reference of a noun
  – Articles (冠詞) (the, a/an) are a subtype of determiners
    • The article the indicates that we are talking about something or someone that we already known about or can uniquely determined
    • The article a (or an) indicates that thing or person we are talking about was not previously mentioned
  – Demonstratives (指示代名詞) (this, that) are another kind of determiners
Other Syntactic Classes of Words

• **Interrogative pronouns/determiners** (疑問代名詞/疑問定詞)
  • Used for questions and relative clauses
  • Interrogative pronouns:
    – Subject cases: who, which, what
    – Object cases: whom, which, what
  • Interrogative determiners:
    – E.g.: what, which
Other Syntactic Classes of Words

• Proper Nouns (Proper Names 專有名詞)
  – Are names refer to particular persons, things, or places, which are usually capitalized
  – E.g.: George W. Bush, 911 Attack on America, Unite States

• Compound Words: merge two or more words into a new word
  • In English: noun-noun compound words, or other combination
    – E.g.: college degree (N), disk driver (N), downmarket (A), overtake (V), mad cow disease (PN)
An Example Sentence

*Children ate sweet candy.*

- The noun *children* refer to a group of people
- The noun *candy* refer to a particular type of food
- The verb *ate* describes what children do with candy
- The adjective *sweet* tells us about the property of candy
Substitution Test and Multiple POS

• Substitution test
  – The most basic test for word belong to the same class

• Multiple part-of-speech of words
  – E.g.: a noun can be a verb or a modifier, a adjective can be a noun

Too much boiling will **candy** the molasses. (**candy**: verb)
There is a **book** worm. (**book**: noun modifier)
That **green** is lighter than the color. (**green**: noun)
Substitution Test and Multiple POS

• Multiple part-of-speech of words (cont.)
  – Adjectives: can be further divided into
    • Those that can also used to describe a concept or quality directly
      – E.g.: The hot are on the table. (the hot plates are on the table)
    • Those that can’t
      – E.g.: green
Open and Close Word Classes

• Open or lexical classes (categories)
  – Words like nouns, verbs, and adjectives (adverbs), which have a large number of members, and to which new words are commonly added as language evolves
  – Used to form the basis of a phrase
    • The head of the phrase

• Closed or functional classes (categories)
  – Words such as prepositions (e.g. in, on, over, …) and determiners (e.g. a, an, the, …), which have only a few members, and members of which normally have a clear grammatical use
  – New words in these classes are rarely introduced
Morphology

• What is morphology (構詞學)？
  – Study the way words are built up from smaller meaning-bearing units, morphemes (詞素)
  • A morpheme is the minimal meaning-bearing unit in a language, e.g.,
    – *fox* consists of a single morpheme *fox*
    – *cats* consists two: *cat* and *-s* (singular → plural)
      \[\text{stem} \quad \text{affix}\]
  – Many new words are morphologically related to known words
    • We can infer a lot about the syntactic and semantic properties of new words if we understand the morphological process
Morphology

• Two broad categories of morphemes
  – Stems (詞幹)
    • The main morpheme of the word, supplying the main meaning
  – Affixes (詞綴)
    • Add additional meanings of various kinds
    • Can be further divided into prefixes, suffixes, infixes, and circumfixes
      – prefixes, suffixes: concatenative morphology

• Concatenative morphology vs. non-concatenative morphology
  – Concatenative: English,
  – Non-concatenative: Arabic, Hebrew, Tagalog, …
Two basic ways to form words from morphemes

- **Inflection**
  - The combination of a word stem with a grammatical morpheme, usually resulting in a word of the *same syntactic class* as the original stem (does not change word class or meaning significantly), e.g.:
    - The plural on English nouns, “dog” → “dogs”
    - The past tense on English verbs, “walk” → “walked”
  - Systematic, relatively simple in English

- **Derivation**
  - The combination of a word stem with a grammatical morpheme, usually resulting in a word of *different syntactic classes*, e.g.:
    - “computerize” → “computerization”
  - Less systematic, quite complex in English
Inflectional Morphology

• Only nouns, verbs, and sometimes adjectives can be inflected in English

• Nominal inflection
  – Inflections for nouns: number, case, gender
  – Only two kinds of inflections first discussed here:
    • plural (number)
    • possessive/genitive (case)
  – The plural suffixes can be regular or irregular

<table>
<thead>
<tr>
<th></th>
<th>Regular Nouns</th>
<th>Irregular Nouns</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Singular</strong></td>
<td>cat</td>
<td></td>
</tr>
<tr>
<td></td>
<td>thrush</td>
<td>butterfly</td>
</tr>
<tr>
<td></td>
<td>(-sh, -ch, -x)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>mouse</td>
<td>ox</td>
</tr>
<tr>
<td><strong>Plural</strong></td>
<td>cats</td>
<td>butterflies</td>
</tr>
<tr>
<td></td>
<td>thrushes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>mice</td>
</tr>
<tr>
<td></td>
<td></td>
<td>oxen</td>
</tr>
</tbody>
</table>
Inflectional Morphology

• Nominal inflection (cont.)
  – Possessive/genitive suffix:
    • Realized by apostrophe (’) plus -s for regular nouns and plural nouns not ending in -s
      – Singular noun: llama’s
      – Irregular plural noun: children’s
    • Realized by a lone apostrophe after regular plural nouns and some names ending in –s or –z
      – Regular plural noun: llamas’
      – Names ending in -s: Euripides’ comedies
Inflectional Morphology

• Verbal inflection
  – More complicated than nominal inflection
    • Three kinds of verbs
      – Main verbs (eat, sleep, impeach, ...)
      – Primary verbs (be, have, do)
      – Modal verbs (can, will, should, ...)
  – Main verbs (can be regular or irregular)
    • Regular verbs: with three predictable endings

Quirk et al., 1985
Inflectional Morphology

<table>
<thead>
<tr>
<th>Morphological Form Classes</th>
<th>Regularly Inflected Verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>stem</td>
<td>walk</td>
</tr>
<tr>
<td>-s form</td>
<td>walks</td>
</tr>
<tr>
<td>-ing participle (分詞)</td>
<td>walking</td>
</tr>
<tr>
<td>past form or -ed participle</td>
<td>walked</td>
</tr>
</tbody>
</table>

- The regular class is **productive**: new words can be automatically included, e.g., fax
Inflectional Morphology

- Irregular verbs: have some more or less idiosyncratic forms of inflection (3~8 forms)
  - In general, the most frequent a word form, the most likely it’s to have idiosyncratic properties

<table>
<thead>
<tr>
<th>Morphological Form Classes</th>
<th>Regularly Inflected Verbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>stem</td>
<td>eat, catch, cut</td>
</tr>
<tr>
<td>-s form</td>
<td>eats, catches, cuts</td>
</tr>
<tr>
<td>-ing participle</td>
<td>eating, catching, cutting</td>
</tr>
<tr>
<td>(also for a gerund)</td>
<td></td>
</tr>
<tr>
<td>past form (preterite)</td>
<td>ate, caught, cut</td>
</tr>
<tr>
<td>-ed participle</td>
<td>eaten, caught, cut</td>
</tr>
<tr>
<td>(prefect construction, passive construction)</td>
<td></td>
</tr>
</tbody>
</table>
Derivational Morphology

A very common kind of derivation in English is the formation of new nouns, often from verbs or adjectives.

<table>
<thead>
<tr>
<th>Suffix</th>
<th>Base Verb/Adjective</th>
<th>Derived Noun</th>
</tr>
</thead>
<tbody>
<tr>
<td>-ation</td>
<td>computerize (V)</td>
<td>computerization</td>
</tr>
<tr>
<td>-ee</td>
<td>appoint (V)</td>
<td>appointee</td>
</tr>
<tr>
<td>-er</td>
<td>kill (V)</td>
<td>killer</td>
</tr>
<tr>
<td>-ness</td>
<td>fuzzy (A)</td>
<td>fuzziness</td>
</tr>
</tbody>
</table>

Adjectives derived from nouns and verbs:

<table>
<thead>
<tr>
<th>Suffix</th>
<th>Base Noun/Verb</th>
<th>Derived Adjective</th>
</tr>
</thead>
<tbody>
<tr>
<td>-al</td>
<td>computation (N)</td>
<td>computational</td>
</tr>
<tr>
<td>-able</td>
<td>embrace (V)</td>
<td>embraceable</td>
</tr>
<tr>
<td>-less</td>
<td>clue (N)</td>
<td>clueless</td>
</tr>
</tbody>
</table>

Generally less productive!
Morphological Comparatives and Superlatives

• In English, only some, mainly short, adjectives form morphological comparatives and superlatives by suffixing `-er` or `-est`, e.g.:
  – rich, richer, richest
  – trendy, trendier, trendiest

• For the rest adjectives, periphrastic form are used
  – Intelligent, more intelligent, most intelligent
Case Inflection

- **Case:**
  - Nouns or pronouns appear in different forms when they different functions (subject, object, etc.) in a sentence, and these forms are called cases
    - Nominative (subject case) personal pronouns
      - E.g.: he, she
    - Accusative (object case) personal pronouns
      - E.g.: him, her
    - Genitive (possessive case)
      - Have a systematical indication
      - Explained previously
Word Order and Phrase Structure

• Word do not occur in just any old order, but language have constraints on word order
  – Words in a sentence are organized into phrases
    • Phrases: groupings of words (called constituents) that clumped as a unit
  – E.g.:
    I put the bagels in the freezer
    The bagels, I put in the freezer.
    I put in the freezer the bagels.
Syntax

• Meanings
  – From the Greek: “setting out together or arrangement”
  – The way words are arranged together
    • Study the regularities and constraints of word order and phrase structure

• Things to deal with
  – Constituency
    • Group of words may behave as a single unit or phrase
  – Grammatical Relations
    • E.g.: subjects and objects
  – Sub-categorization and dependencies (e.g. verbs)
    • Certain kinds of relations between words and phrases
Phrase Structure and Syntax

• Paradigmatic Relationship (範例關係)
  – All elements that can be replaced for each other in a certain syntactic position, e.g. the following noun phrase constituents

  \[
  \begin{align*}
  \text{She} & \quad \text{The woman} \\
  \text{The woman} & \quad \text{The woman with sad eyes} \\
  \text{...} & \\
  \text{him} & \quad \text{the man} \\
  \text{the man with red hair} & \quad \text{...}
  \end{align*}
  \]

• Syntagmatic Relationship (結構體關係)
  – Two words are syntagmatic relationship in can form a phrase like clothes in *sewed clothes* and a dress in *sewed a dress*
    • *sewed wood?*
Typical English Sentence Structure

• A sentence normally rewrites as a subject noun phrase and a verb phrase

```
(S)
   / \  
  NP   VP
  / \  /  
That man VBD NP
    /   /  
   caught the butterfly IN NP
       /   /
      with a net
```
Noun Phrases (NP)

• Noun phrase is a syntactic unit of the sentence in which information about the noun is gather
  – A noun is usually embedded in a noun phrase (NP)
  – The noun is the head of the noun phrase, the central constituent that determines the syntactic character of the phrase

• Noun phrases usually exist along with verbs

• Determiners, adjectives, post-modifiers, prepositional phrases may occurred in noun phrases

The homeless old man in the park that I tried to help yesterday goes away.
Verb Phrases (VP)

• The verb phrase organize all elements of the sentence that depend syntactically on the verb
  – The verb is the head of the verb phrase
    *Getting to school on time was a struggle.*
    *He was trying to keep his temper.*
    *That woman quickly showed me the way to hide.*

• Subject-verb agreement
  – The subject and verb of a sentence agree in number and person
Verb Phrases (VP)

• Sub-categorization
  - Transitive and Intransitive
    • Transitive: the verb with a following noun phrase (or a complement)  
      
      John loves Mary.
    • Intransitive: the verb may stand alone  
      The women walked.
  - Arguments and Complements (補語)
    • Subject (NP) and (direct/indirect) objects (NP), PP, etc., are arguments of a verb  
      We deprived him of food.
    - Centrally involved in the action of the verb
    • All non-subject arguments are complements
  - Adjuncts (附加語)
    • Phrases that have a less tight link to the verb
    • Specify time, place, manner of the action
      She saw a Woody Allen movie in Paris.
      She saw a Woody Allen movie with a couple of friends.
Prepositional Phrases (PP)

• Headed by a preposition and contain a noun phrase complement
  – Express spatial and temporal locations and other attributes

• Can appear within other major phrase types
  - Nominal modifier prepositional phrases
  - Verbal modifier prepositional phrases

Jack put the book inside the box.

Jack gave the book inside the box to me.
Adjective Phrases (AP)

• Adjectives can be grouped into a phrase
  – Can have an adverb before the adjective

• Complex adjective phrases are less common

  It is the least expensive fare.
  She is very sure of herself.
  He seemed (a man who was) quite certain to succeed.

  – But most commonly found as the complements of verbs such as be or seem
  – May take a degree modifier preceding the head
Phrase Structure Grammars

- A syntactic analysis (parsing) of a sentence tells us how to determine the meaning of the sentence from meaning of words
  
  Mary gave Peter a book.
  Peter gave Mary a book.

- In English, the basic word orders are
  
  - **Declaratives** (直述句): Subject -Verb -Object
    
    The children (subject) should (auxiliary verb) eat spinach (object).

  - **Interrogatives** (詢問句): (question) Yes/No question
    
    Did he cry?

  - **Imperatives** (祈使句): (requests/commands)
    
    Eat spinach!
Showing Syntactic Constituency

• Three ways to show the syntactic constituency
  – Rewrite rules
  – Parsing trees
  – (Labeled) Bracketing
Rewrite Rules

• The regularities of word order are often captured by means of rewrite rules
  - *Generate sentences*
  - *Parsing*: the process of reconstructing the derivation(s) or phrase structure tree(s) for a particular sequence of words
    • A phrase structure tree is called a “*parse*”
    • Multiple parses → “syntactic ambiguity”

• A rewrite rules has the form:
  \[ \text{Category} \rightarrow \text{category}^* \]
  – The symbol on the left side can be rewritten as the sequence of symbols on the right side
Rewrite Rules

• To produce a language
  – We can start with the start symbol ‘S’ (for a sentence)

• A property of the most formalizations of natural language in terms of rewrite rules is recursive
Rewrite Rules

• A simple set of rewrite rules

\[
\begin{align*}
S & \rightarrow NP \ VP \\
NP & \rightarrow \{AT \ NNS, \ AT \ NN, \ NP \ PP\} \\
VP & \rightarrow \{VBD, \ VBD \ NP\} \\
PP & \rightarrow IN \ NP
\end{align*}
\]

- The rules on the righthand side rewrite one of the syntactic categories (part-of-speech symbols) into a word of the corresponding category

• The lexicon: words with pronunciations and POS tags

\[
\begin{align*}
AT & \rightarrow \text{the} \\
NNS & \rightarrow \{\text{children}, \ \text{students}, \ \text{mountains}\} \\
VBD & \rightarrow \{\text{slept}, \ \text{ate}, \ \text{saw}\} \\
IN & \rightarrow \{\text{in}, \ \text{of}\} \\
NN & \rightarrow \text{cake}
\end{align*}
\]
Rewrite Rules and Context-Free Grammar

• Examples:

<table>
<thead>
<tr>
<th>S</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>→ NP VP</td>
<td>→ NP VP</td>
</tr>
<tr>
<td>→ AT NNS VBD</td>
<td>→ AT NNS VBD NP</td>
</tr>
<tr>
<td>→ The children slept.</td>
<td>→ AT NNS VBD AT NN</td>
</tr>
<tr>
<td></td>
<td>→ The Children ate the cake.</td>
</tr>
</tbody>
</table>

• Context-free grammar
  – The possibilities for rewriting depend solely on the category, not the surrounding context
Representing Phrase Structures as a Tree

- The tree has a single root node which is the start symbol of grammar

\[
\begin{array}{c}
S \\
\text{NP} & \text{VP} \\
\text{AT} & \text{NNS} & \text{VBD} \\
\text{The} & \text{Children} & \text{slept}
\end{array}
\]

- Nonterminal/Terminal nodes
  - Each nonterminal node and its immediate children (known as a local tree) corresponds to the application of a rewrite rule

\[
\begin{array}{c}
S \\
\text{NP} & \text{VP} \\
\text{AT} & \text{NNS} & \text{VBD} & \text{NP} \\
\text{The} & \text{Children} & \text{ate} & \text{AT} & \text{NN} \\
& & \text{the} & \text{cake}
\end{array}
\]
Representing Phrase Structures as a Tree

- Two words that were generated by a common rewrite rules and syntactically linked can become separated by intervening words as the derivation of a sentence proceeds
  - Non-local dependencies

![Figure 3.1 An example of recursive phrase structure expansion.](image)
Representing Phrase Structures as a Tree

• Non-local dependencies
  – Two words can syntactically dependent even though they occur far apart
  – Two examples
    • Subject-verb agreement
      
      \[
      \text{The women who found the wallet \textbf{were} given a reward.}
      \]

    • Long-distance dependence
      
      \[
      \text{Should Peter \textbf{buy a book}?} \\
      \text{\textbf{Which book} should Peter \textbf{buy}?}
      \]

      An argument of “buy”
Representing Phrase Structures via a Bracketing

• Bracketing
  – Sets of brackets delimit constituents and may be labeled to show the categories of tree nonterminal nodes

\[
[S[NP[AT The][NNS children]][VP[VBD ate][NP[AT the][NN cake]]]]
\]
Dependency: Arguments and Adjuncts

- Frequently, **noun phrases** are arguments of **verbs**, which can be described at various levels
  - Semantic roles
    - **Agent**: the person or thing that is doing something
    - **Patient**: the person or thing that is having something done to it
  - Syntactic roles (grammatical relations)
    - **Subject**: the noun phrase that appears before the verb
    - **Object**: the noun phrase that normally appears immediately after the verb
Dependency: Arguments and Adjuncts

• Examples

Children **eat** sweet candy.

She **gave** him the book.

She **gave** the book *to* him.

Bill **received** a package *from* the mailman.

Candy is eaten *by* children.

---

Active voice

Passive voice
Phrase Structure Ambiguity

- Example: “Our company is training workers” has 3 syntactic analyses (parses)
- “List the sales of the products produced in 1973 with the products produced in 1972” has 455 syntactic analyses (parses)
- Therefore, a practical NLP system must be good at making disambiguation decisions of word sense, word category, syntactic structure, and semantic scope
Phrase Structure Ambiguity

a. S
   NP  VP
   Our company  Aux  VP
   is  V  NP
   is  training  workers

b. S
   NP  VP
   Our company  V  NP
   is  V  training  workers

(Cf. Our problem is training workers.)
Phrase Structure Ambiguity

Our company training is workers.

(Cf. Those are training wheels.)

* The last two parses (b. and c.) are semantic anomalous!
Phrase Structure Ambiguity

Figure 3.2 An example of a prepositional phrase attachment ambiguity.
Semantics

• The meaning of words, constructions and utterances
  – The study of individual words (lexical semantics)
    • Lexical hierarchy
  – The study of how meanings of individual words are combined into the meaning of sentences (or even larger units)

• In most current systems semantic analysis is done only after syntactic analysis!
Lexical Semantics

- **WordNet** defines the lexical hierarchy
  - **Hypernyms** (上義詞) and **hyponyms** (下義詞)
    - Hypernym: a word with a more general sense, e.g., animal is a hypernym of cat
    - Hyponym: a word with more specialized meaning
  - **Antonyms** (反義詞): words with opposite meanings
  - **Synonyms** (同義詞): Words have the same (very similar) meanings
  - **Homonyms** (同形異譯詞): Words are written the same way but have different meanings which seems unrelated (e.g.: bank, suit, bass,…)
    - Homophones (同形同音異譯詞): two word are not only written the same way but also same pronunciation (bank, suit, …)
Lexical Semantics

Figure 1 shows an example of a poset representing geographic locations and sub-locations using a tree structure to show the partial ordering relation.

\[ a \rightarrow b : b \leq_F a \]

\[ \text{M(AFRICA)} \]

\[ \text{M(ALGERIA)} \]

\[ \text{M(ALGIERS)} \]

\[ \text{M(WORLD)} \]

\[ \text{M(OCEANIA)} \]

\[ \text{M(WESTERN-SAMOA)} = \text{M(SAMOA-I-SISIFO)} \]

\[ \text{sempos(AFRICA)} \]

**Figure 1: Example of Geographic Semantic Poset**
Discourse

• Elucidate the covert between sentences in a text
  - The anaphoric relations
    – How the immediately preceding sentences affect the interpretation of the next sentence

• Model the relationship between turns and the kinds of speech acts involved
  - Speech acts: questions, statements, requests, acknowledges
    – Important for interpreting pronouns and for interpreting temporal aspects of information conveyed

Hurricane Hugo destroyed 20,000 Florida homes. At an estimated cost of one billion dollars, the disaster has been the most costly in the state’s history.

Which hurricanes caused more than a billion dollars worth of damage?
Pragmatics

- The study of how knowledge about the world and language conventions interact with literal meaning
  - How sentences are used in different situations
  - How use affects the interpretation of the sentence
Other Areas

• **Phonetics (語音學)**
  – The study of speech sounds and their production, classification, and transcription
  – Include the phenomena like consonants, vowels and intonation

• **Phonology (音韻學)**
  – The structure of the sound systems
  – The tacit rules governing the speech pronunciation

• **Language acquisition**
  – Investigate how children learn language

• **Psycholinguistics**
  – Focus on issues of real-time production and perception of language and the way language is presented in the brain