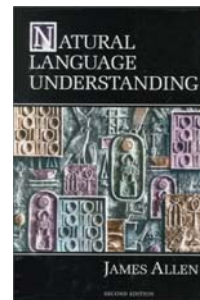


Natural Language Processing

- **Phonology and phonetics:** structure of the sounds of language, how words are realized as speech
- **Morphology:** structure of words, how words are formed from prefixes, suffixes and other components
- **Syntax:** structure of sentences, how words combine into phrases, how phrases combine into sentences
- **Semantics:** meaning, how to represent the meaning of words and sentences, how to derive the meaning of complex phrases from the meaning of its subparts
- **Pragmatics:** use of language, how sentences are used to convey information, make requests, etc.
- **Discourse:** structure of extended, multiple-sentence language, such as in text and dialogs

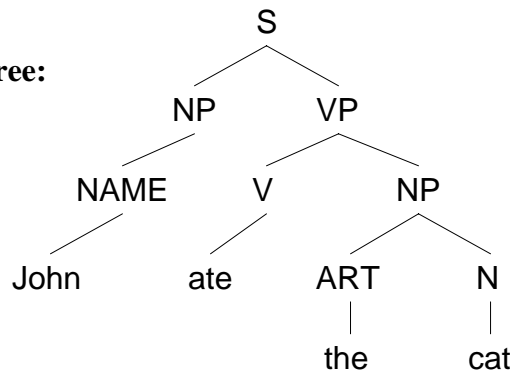
Applications of Natural Language Processing

- Text-based applications:
 - Information retrieval from document databases
 - Document translation
 - Text summarization
 - Automatic database construction
- Applications of speech recognition:
 - Spoken language control of a machine
 - Dialog-based applications:
 - Question-answering systems
 - Automated customer service over the telephone
 - Tutoring systems



Syntactic Processing

parse tree:



**simple
context-free
grammar:**

- | | |
|---------------------------|----------------------------|
| 1. $S \rightarrow NP VP$ | 5. $NAME \rightarrow John$ |
| 2. $VP \rightarrow V NP$ | 6. $V \rightarrow ate$ |
| 3. $NP \rightarrow NAME$ | 7. $ART \rightarrow the$ |
| 4. $NP \rightarrow ART N$ | 8. $N \rightarrow cat$ |

Top-down vs. Bottom-up Parsing

bottom-up strategy:

John ate the cat
 \Rightarrow NAME ate the cat
 \Rightarrow NAME V the cat
 \Rightarrow NAME V ART cat
 \Rightarrow NAME V ART N
 \Rightarrow NP V ART N
 \Rightarrow NP V NP
 \Rightarrow NP VP
 \Rightarrow S

top-down strategy:

S
 \Rightarrow NP VP
 \Rightarrow NAME VP
 \Rightarrow John VP
 \Rightarrow John V NP
 \Rightarrow John ate NP
 \Rightarrow John ate ART N
 \Rightarrow John ate the N
 \Rightarrow John ate the cat

- | | |
|---------------------------|----------------------------|
| 1. $S \rightarrow NP VP$ | 5. $NAME \rightarrow John$ |
| 2. $VP \rightarrow V NP$ | 6. $V \rightarrow ate$ |
| 3. $NP \rightarrow NAME$ | 7. $ART \rightarrow the$ |
| 4. $NP \rightarrow ART N$ | 8. $N \rightarrow cat$ |

Top-down parse of $_1$ *The* $_2$ *dogs* $_3$ *barked* $_4$

Step	Current State	Backup States	Comment
1	((S) 1)		initial position
2	((NP VP) 1)		rewrite S by rule 1
3	((ART N VP) 1)	((ART ADJ N VP) 1)	rewrite NP by rules 2 & 3
4	((N VP) 2)	((ART ADJ N VP) 1)	match ART with <i>the</i>
5	((VP) 3)	((ART ADJ N VP) 1)	match N with <i>dogs</i>
6	((V) 3)	((V NP) 3) ((ART ADJ N VP) 1)	rewrite VP by rules 4 & 5
7	(() 4)		match V with <i>barked</i> done!

- | | |
|----|----------------------------|
| 1. | $S \rightarrow NP VP$ |
| 2. | $NP \rightarrow ART N$ |
| 3. | $NP \rightarrow ART ADJ N$ |
| 4. | $VP \rightarrow V$ |
| 5. | $VP \rightarrow V VP$ |

Top-down parse of $_1$ *The* $_2$ *old* $_3$ *man* $_4$ *cried* $_5$

Step	Current State	Backup States	Comment
1	((S) 1)		initial position
2	((NP VP) 1)		rewrite S by rule 1
3	((ART N VP) 1)	((ART ADJ N VP) 1)	rewrite NP by rules 2 & 3
4	((N VP) 2)	((ART ADJ N VP) 1)	match ART with <i>the</i>
5	((VP) 3)	((ART ADJ N VP) 1)	match N with <i>old</i>
6	((V) 3)	((V NP) 3) ((ART ADJ N VP) 1)	rewrite VP by rules 4 & 5
7	(() 4)		match V with <i>man</i> stuck!
8	((V NP) 3)	((ART ADJ N VP) 1)	choose first backup state
9	((NP) 4)	((ART ADJ N VP) 1)	match V with <i>man</i>
10	((ART N) 4)	((ART ADJ N) 4) ((ART ADJ N VP) 1)	rewrite NP by rules 2 & 3 stuck!
11	((ART ADJ N) 4)	((ART ADJ N VP) 1)	stuck!
12	((ART ADJ N VP) 1)		choose next backup state
13	((ADJ N VP) 2)		match ART with <i>the</i> continue to success...