NLP

Introduction to NLP

Introduction to Parsing

Parsing Programming Languages

```
#include <stdio.h>

int main()
{
  int n, reverse = 0;

  printf("Enter a number to reverse\n");
  scanf("%d",&n);

  while (n != 0)
  {
    reverse = reverse * 10;
    reverse = reverse + n%10;
    n = n/10;
  }
  printf("Reverse of entered number is = %d\n", reverse);

  return 0;
}
```

Parsing Human Languages

- Rather different than computer languages
  - Can you think in which ways?

Parsing Human Languages

- Rather different than computer languages
  - No types for words
  - No brackets around phrases
  - Ambiguity
    - Words
    - Parses
  - Implied information

The Parsing Problem

- Parsing means associating tree structures to a sentence, given a grammar (often a CFG)
  - There may be exactly one such tree structure
  - There may be many such structures
  - There may be none
- Grammars (e.g., CFG) are declarative
  - They don’t specify how the parse tree will be constructed

Syntactic Ambiguities

- PP attachment
  - I saw the man with the telescope
- Gaps
  - Mary likes Physics but hates Chemistry
- Coordination scope
  - Small boys and girls are playing
- Particles vs. prepositions
  - She ran up a large bill
- Gerund vs. adjective
  - Frightening kids can cause trouble

Applications Of Parsing

- Grammar checking
  - I want to return this shoes.
- Question answering
  - How many people in sales make $40K or more per year?
- Machine translation
  - E.g., word order – SVO vs. SOV
- Information extraction
  - Breaking Bad takes place in New Mexico.
- Speech generation
- Speech understanding
- Interpretation

NLP

Introduction to NLP

Context-free grammars

Context-free Grammars

- A context-free grammar is a 4-tuple (N,Σ,R,S)
  - N: non-terminal symbols
  - Σ: terminal symbols (disjoint from N)
  - R: rules ($A \rightarrow \beta$), where β is a string from $(\Sigma \cup N)^*$
  - S: start symbol from N

Example

```
["the", "child", "ate", "the", "cake", "with", "the", "fork"]
```

```
S -> NP VP
NP -> DT N | NP PP
PP -> PRP NP
VP -> V NP | VP PP
DT -> 'a' | 'the'
N -> 'child' | 'cake' | 'fork'
PRP -> 'with' | 'to'
V -> 'saw' | 'ate'
```

Example

```
["the", "child", "ate", "the", "cake", "with", "the", "fork"]
```

```
S -> NP VP
NP -> DT N | NP PP
PP -> PRP NP
VP -> V NP | VP PP
DT -> 'a' | 'the'
N -> 'child' | 'cake' | 'fork'
PRP -> 'with' | 'to'
V -> 'saw' | 'ate'
```

Heads marked in bold face

Phrase-structure Grammars (1/2)

- Sentences are not just bags of words
  - Alice bought Bob flowers
  - Bob bought Alice flowers
- Context-free view of language
  - A prepositional phrase looks the same whether it is part of the subject NP or part of the VP
- Constituent order
  - SVO (subject verb object)
  - SOV (subject object verb)

Phrase-structure Grammars (2/2)

- Auxiliary verbs
  - The dog may have eaten my homework
- Imperative sentences
  - Leave the book on the table
- Interrogative sentences
  - Did the customer have a complaint?
- Negative sentences
  - The customer didn’t have a complaint

A Longer Example

```
S -> NP VP | Aux NP VP | VP
NP -> PRON | Det Nom
Nom -> N | Nom N | Nom PP
PP -> PRP NP
VP -> V | V NP | VP PP
Det -> 'the' | 'a' | 'this'
PRON -> 'he' | 'she'
N -> 'book' | 'boys' | 'girl'
PRP -> 'with' | 'in'
V -> 'takes' | 'take'
```

What changes were made to the grammar?

A Longer Example

```
S -> NP VP | Aux NP VP | VP
NP -> PRON | Det Nom
Nom -> N | Nom N | Nom PP
PP -> PRP NP
VP -> V | V NP | VP PP
Det -> 'the' | 'a' | 'this'
PRON -> 'he' | 'she'
N -> 'book' | 'boys' | 'girl'
PRP -> 'with' | 'in'
V -> 'takes' | 'take'
```

A Longer Example

```
S -> NP VP | Aux NP VP | VP
NP -> PRON | Det Nom
Nom -> N | Nom N | Nom PP
PP -> PRP NP
VP -> V | V NP | VP PP
Det -> 'the' | 'a' | 'this'
PRON -> 'he' | 'she'
N -> 'book' | 'boys' | 'girl'
PRP -> 'with' | 'in'
V -> 'takes' | 'take'
```

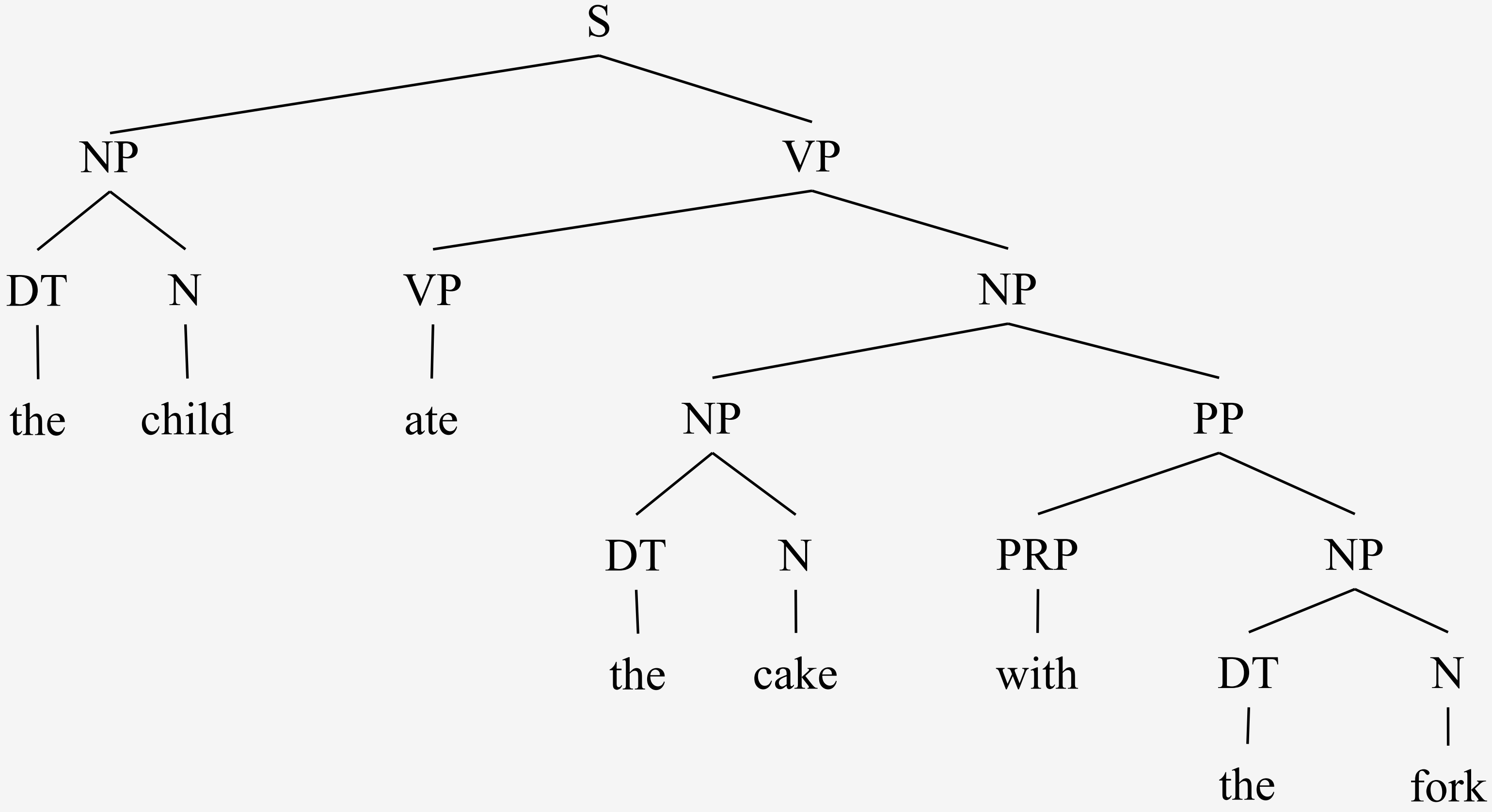
Penn Treebank Example

```
( (S
    (NP-SBJ
      (NP (NNP Pierre) (NNP Vinken) )
      (, ,)
      (ADJP
        (NP (CD 61) (NNS years) )
        (JJ old) )
      (, ,) )
    (VP (MD will)
      (VP (VB join)
        (NP (DT the) (NN board) )
        (PP-CLR (IN as)
          (NP (DT a) (JJ nonexecutive) (NN director) ))
        (NP-TMP (NNP Nov.) (CD 29) )))
    (. .) ))
( (S
    (NP-SBJ (NNP Mr.) (NNP Vinken) )
    (VP (VBZ is)
      (NP-PRD
        (NP (NN chairman) )
        (PP (IN of)
          (NP
            (NP (NNP Elsevier) (NNP N.V.) )
            (, ,)
            (NP (DT the) (NNP Dutch) (VBG publishing) (NN group) )))))
    (. .) ))
```

Leftmost Derivation

- A leftmost derivation is a sequence of strings s_1, s_2, …, s_n
  - $s_1 = S$, the start symbol
  - s_n includes only terminal symbols
- Example:
  - [S]
  - [S] [NP VP]
  - [S] [NP VP] [DT N VP]
  - …
  - [S] [NP VP] [DT N VP] … [the child ate the cake with the fork]

Leftmost Derivation



NLP