
1 CFL

Let $G = (\{S, A, B, a, b\}, \{a, b\}, S, P)$ where P consists of:

G1 $S \rightarrow AB, A \rightarrow ab, B \rightarrow bb$

G2 $S \rightarrow AB, S \rightarrow aA, A \rightarrow a, B \rightarrow ba$

G3 $S \rightarrow AB, S \rightarrow AA, A \rightarrow aB, A \rightarrow ab, B \rightarrow b$

G4 $S \rightarrow aS, S \rightarrow Sb, S \rightarrow$

G5 $S \rightarrow aS, S \rightarrow A, A \rightarrow bA, A \rightarrow$

- find the languages generated by G1, G2, G3.
- Construct a derivation of a^2b^4 using G4 and G5.
- Build the parse trees of a^2b^4 using G4 and G5.

2 CFG

Construct CFGs generating each of the following languages:

- $L_1 = a^n b^m a^n$ ($0 \leq n, 1 \leq m$)
- $L_2 = a^n b^n a^m b^m$ ($1 \leq n, m$)

3 CFG and NL

Write a grammar that recognizes the language (viz. all the sentences) below.

- Jonh left
- Jonh knows Mary
- They know Mary
- They know her
- She knows them
- I will leave Boston in the morning
- Everybody likes Boston
- A student likes Boston

9. John read a book
10. John gave Mary a red shirt
11. A student read a book
12. John saw a man with a telescope
13. The woman saw a man last Thursday
14. Mary knows old men and women

Construct their derivations.

4 CFG and NL structures

a) Give the CFG rewriting rules missing in the previous grammar to recognize the structures listed below starting from the following lexicon

Lexicon:

```
pn --> carlos ; maarten ; patrick
det --> some ; every
n --> student ; lecturers
p --> to
adv --> always
iv --> laughs
tv --> helps ; knew
dtv --> introduced
```

Sentences

- | | |
|---|---|
| 1. Carlos laughs | 2. [Carlos [laughs always]] |
| 3. [Carlos [helps Maarten]] | 4. [Patrick [[introduced Carlos] to Maarten]] |
| 5. [Some student] [[helps Carlos] always] | 6. [[Every lecturer] [helps [some student]]] |

- b) Construct the derivation trees for sentences 4 and 5.
- c) Extend the grammar so that sentences can be conjoined by "and".
- d) Add further words to the lexicon and give new sentences the grammar can parse.
- e) Pick a language of your choice (different from English) and write a CFG for a fragment of this language.

5 PP

Which rule do we need to generate the phrases below?

1. the flight to Boston
2. the nice flight to Boston

3. the flight to Boston from Miami
4. the flight to Boston from Miami in February
5. the flight to Boston from Miami in February on Friday

6 Ambiguities

(a) Complete the grammar below with the missing re-writing rules to build the sentences below and build their parse trees.

Lexical rules:

```

PN --> vincent | mia | marsellus
Det --> a |the
N --> gun | robber
RPR01 --> who
RPR02 --> that
P --> to
IV --> died | fell
TV --> loved |shot | knew
DTV --> gave
SV --> knew | believed

```

Grammatical rules:

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S --> NP VP
NP --> PN
VP --> IV
NP --> Det N
VP --> TV NP
VP --> VP PP
VP --> DV NP PP
PP --> P NP
NP --> NP PP

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1. The robber knew Vincent shot Marsellus
2. Vincent knew who shot Marsellus
3. The robber believed that Vincent shot Marsellus

Have you encountered cases of local ambiguity?

(c) Extend the lexicon of the grammar above with the lexical entries to parse the sentence below.

- John saw the man in the park with the telescope.