

## Homework 7

1. Suppose the context-sensitive grammar

$$\begin{aligned} S & ::= bSAA \mid \epsilon \\ A & ::= a \\ bA & ::= Ab \end{aligned}$$

where  $S$  is the starting symbol of the grammar. Give a derivation of the string "aaabaaaabb". What can you say about the number of as and bs in the strings recognised by this grammar.

2. Consider the following grammar

$$\begin{aligned} S & ::= N \cdot P \\ P & ::= V \cdot N \\ N & ::= N \cdot N \\ N & ::= A \cdot N \\ N & ::= \text{student} \mid \text{trainer} \mid \text{team} \mid \text{trains} \\ V & ::= \text{trains} \mid \text{team} \\ A & ::= \text{The} \mid \text{the} \end{aligned}$$

where  $S$  is the start symbol and  $S, P, N, V$  and  $A$  are non-terminals. Using the CYK-algorithm, check whether or not the following string can be parsed by the grammar:

The trainer trains the student team

3. Transform the grammar

$$\begin{aligned} A & ::= 0A1 \mid BB \\ B & ::= \epsilon \mid 2B \end{aligned}$$

into Chomsky normal form.

4. Consider the following grammar  $G$

$$\begin{aligned} S & ::= \text{if } 0 \cdot E \cdot \text{then } \cdot S \\ S & ::= \text{print } \cdot S \\ S & ::= \text{begin } \cdot B \cdot \text{end} \\ B & ::= S \cdot ; \\ B & ::= S \cdot ; \cdot B \\ S & ::= \text{num} \\ E & ::= \text{num} \\ B & ::= \text{num} \end{aligned}$$

where  $S$  is the start symbol and  $S$ ,  $E$  and  $B$  are non-terminals.

Check each rule below and decide whether, when added to  $G$ , the combined grammar is ambiguous. If yes, give a string that has more than one parse tree.

- (i)  $S ::= \text{if } 0 \cdot E \cdot \text{then } \cdot S \cdot \text{else } \cdot S$
- (ii)  $B ::= B \cdot B$
- (iii)  $E ::= (\cdot E \cdot)$
- (iv)  $E ::= E \cdot + \cdot E$

5. Suppose the string "9 - 5 + 2". Give all parse trees that the following two grammars generate for this string.

Grammar 1, where List is the starting symbol:

$$\begin{aligned} \text{List} & ::= \text{List} + \text{Digit} \mid \text{List} - \text{Digit} \mid \text{Digit} \\ \text{Digit} & ::= 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9 \end{aligned}$$

Grammar 2, where String is the starting symbol:

$$\begin{aligned} \text{String} & ::= \text{String} + \text{String} \mid \text{String} - \text{String} \mid \\ & 0 \mid 1 \mid 2 \mid 3 \mid 4 \mid 5 \mid 6 \mid 7 \mid 8 \mid 9 \end{aligned}$$