

## Homework 7

Please submit your solutions via email. Please submit only PDFs! Every solution should be preceded by the corresponding question text, like:

**Q<sub>n</sub>:**     ...a difficult question from me...  
**A:**        ...an answer from you ...  
**Q<sub>n+1</sub>:**   ...another difficult question...  
**A:**        ...another brilliant answer from you...

Solutions will only be accepted until 20th December! Please send only one homework per email.

1. Suppose the context-sensitive grammar

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

where  $S$  is the starting symbol of the grammar. Give a derivation of the string "aaabaaabb". 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

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

into Chomsky normal form.

4. Consider the following grammar  $G$

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

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