CSCE 5400 Formal Languages, Automata, and Computability - Fall 2024

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Assignment-3

1. Find grammar for the following languages:
   - $L = \{a^n b^m c^k \mid n = k + m \text{ and } n \geq 0, m \geq 0, k \geq 0\}$ (3 points)
   - $L = \{(ab)^n (cd)^n : n \geq 1\}$ (3 points)
   - Language whose 3^{rd} symbol from last is b. over {a, b} (3 point)

Ans:

a.

$$\begin{cases} S \rightarrow aSc \mid B \\ B \rightarrow aBb \mid \text{epsilon} \end{cases}$$

b.

$$\{ S \rightarrow abScd \mid abcd$$

c.

$$\begin{cases} S \rightarrow AbBB \\ A \rightarrow aA \mid bA \mid \text{epsilon} \\ B \rightarrow a \mid b \end{cases}$$

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2. What is the language of the following CFG? (5 points)

$$\begin{cases} S \rightarrow AB \mid \varepsilon \\ A \rightarrow 1A \mid S \\ B \rightarrow 0B \mid S \end{cases}$$

Ans: This grammar can generate any combination of 0 and 1 including epsilon.

L(G) = {0,1}*

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3. Remove the ε-Productions: (3 points)

$$\begin{cases} S \rightarrow AaB \mid aaB \\ A \rightarrow \varepsilon \\ B \rightarrow aaA \mid \varepsilon \end{cases}$$

Ans:

$$\begin{cases} S \rightarrow aB \mid aaB \mid a \mid aa \\ B \rightarrow aa \end{cases}$$

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4. Convert the following CFG into an equivalent CFG in Chomsky Normal Form: (3 points)

$$\begin{cases} A \rightarrow BAB \mid B \mid \varepsilon \\ B \rightarrow 00 \mid \varepsilon \end{cases}$$

Ans:

Remove epsilon productions:

$$\begin{cases} A \rightarrow BAB \mid B \mid BB \mid AB \mid BA \mid A \mid epsilon \\ B \rightarrow 00 \end{cases}$$

Remove unit productions

$$\begin{cases} A \rightarrow BAB \mid 00 \mid BB \mid AB \mid BA \mid epsilon \\ B \rightarrow 00 \end{cases}$$

$$\begin{cases} A \rightarrow BAB \mid XX \mid BB \mid AB \mid BA \mid epsilon \\ B \rightarrow XX \\ X \rightarrow 0 \end{cases}$$

A → BY | XX | BB | AB | BA | epsilon

B → XX

X → 0

Y → AB

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5. i) Find the grammar for the following language. (5 points)

$L = \{ a^n b^n c^m d^m \mid n \geq 1, m \geq 1 \} \cup \{ a^n b^m c^m d^n \mid n \geq 1, m \geq 1 \}$

ii) Convert the generated Context Free Grammar to Greibach Normal Form. (3 points)

iii) Is the grammar for language L ambiguous? Why? (2 points)

Ans:

i.

S → A | B

A → XY

X → aXb | ab

Y → cYd | cd

B → aBd | aKd

K → bKc | bc

ii.

S → A | B

A → XY

X → aXM | aM

Y → cYN | cN

B → aBN | aKN

K → bKO | bO

M → b

N → d

O → c

S → aXMY | aMY | aBN | aKN

A → aXMY | aMY

X → aXM | aM

Y → cYN | cN

B → aBN | aKN

K → bKO | bO

M → b

N → d

O → c

iii. Yes, the grammar for language L is ambiguous because we can derive a string by different ways.

Ex: String “abcd” can be derived in 2 ways.

Method 1: S → A → XY → Xcd → abcd

Method 2: S → B → aKd → abcd