Theory of Automata and Formal Language

Lecture-26

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Greibach Normal Form (GNF)

A CFG is said to be in Greibach normal form if all the production rules are of the following form:

A$\rightarrow$ $a\gamma$, where $\gamma \in V^*$, a $\in \Sigma$ and A$\in$V.

Lemma-1

Let A$\rightarrow$ $B\gamma$ be an A-production and let B-productions are B$\rightarrow$ $\beta_1|\beta_2|$...........$|\beta_n$. Then A$\rightarrow$ $B\gamma$ production is replaced by the following rules:-

A$\rightarrow$ $\beta_1\gamma|\beta_2\gamma|$..........$|\beta_n\gamma$.

Context Free Grammar

Lemma-2

Let the set of A-productions be A$\rightarrow A\alpha_1|A\alpha_2|$...........$|A\alpha_m|\beta_1|\beta_2|$.......$|\beta_n$

(β_i's do not start with A). Then we replace the rules A$\rightarrow A\alpha_1|A\alpha_2|$...........

by the following procedure:-

Add new variable Z to the grammar. And the set of A-production are

A$\rightarrow \beta_1|\beta_2|$.......$|\beta_n$

A$\rightarrow \beta_1 Z|\beta_2 Z|$.......$|\beta_n Z$

The set of Z-productions are

Z$\rightarrow \alpha_1|\alpha_2|$.......$|\alpha_m$

Z$\rightarrow \alpha_1 Z|\alpha_2 Z|$.......$|\alpha_m Z$

Reduction to Greibach Normal Form

Step-1: Construct the given grammar into CNF. Next, we rename the variables as $A_1, A_2, \ldots\ldots\ldots, A_n$ with S $= A_1$.

Step-2: Consider the production rules which are of the following form

$A_i \rightarrow A_j\gamma$, where j¡i and $\gamma \in V^*$

Apply the lemma-1 in these rules until j$\geq$i.

Step-3: Consider the production rules which are of the following form

$A_i \rightarrow A_j\gamma$, where j $=$ i and $\gamma \in V^*$

Apply the lemma-2 in these rules until j$\geq$i.

Step-4: Consider the production rules which are not in GNF. Apply lemma-1 in all these rules. After this, the resultant grammar will be in GNF.

Example: Convert the following grammar into GNF.

1. S$\rightarrow$AB, A$\rightarrow$BS/b, B$\rightarrow$SA/a.
2. S$\rightarrow$AA/a, A$\rightarrow$SS/b.
3. E$\rightarrow$E+T/T, T$\rightarrow$T*F/F, F$\rightarrow$(E)/a,
4. S$\rightarrow$ABb/a, A$\rightarrow$aaA, B$\rightarrow$bAb.
5. S$\rightarrow$SS, S$\rightarrow$0S1/01, B$\rightarrow$SA/a.

Exercise

1. Eliminate the useless production from the following grammar
   $S \rightarrow a/aA/B/C$, $A \rightarrow aB/\epsilon$, $B \rightarrow aA$, $C \rightarrow cCD$, $D \rightarrow ddd$,.
2. Eliminate all the ϵ-productions from the following grammar:-
   $S \rightarrow AaB/aaB$, $A \rightarrow \epsilon$, $B \rightarrow bbA/\epsilon$
3. Remove all unit productions, all useless productions and all ϵ-productions from the grammar
   $S \rightarrow aA/aBB$, $A \rightarrow aaA/\epsilon$, $B \rightarrow bB/bbC$, $C \rightarrow B$.
4. Transform the following grammar into CNF
   $S \rightarrow abAB$, $A \rightarrow bAB/\epsilon$, $B \rightarrow BAa/A/\epsilon$.
5. Transform the following grammar into CNF
   $S \rightarrow AB/aB$, $A \rightarrow aab/\epsilon$, $B \rightarrow bbA$.

Context Free Grammar

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