TOC Final Exam (Maisha maam)

Group - A

1. Context Free Language
   - → Formal definition
   - → Ambiguity
   - → chomsky Normal form
2. push down automata
   - → formal definition
   - → Equivalence with CFG
3. Non CFL
   - → pumping lemma for CFL

Group - B

4. Computability Theory
   - → The church Turing thesis
   - → Turing machine
   - → Non deterministic Turing machine
   - → Hilberts problem

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⑤ Decidability

- Decidable Languages
- The Halting problem
- with diagonalization method

⑥ Complexity Theory

- The classes NP, P
- Examples of problems
- The P Vs NP Question
- NP completeness
- polynomial Time reducibility
- Hamilton path problem
- Subset problem

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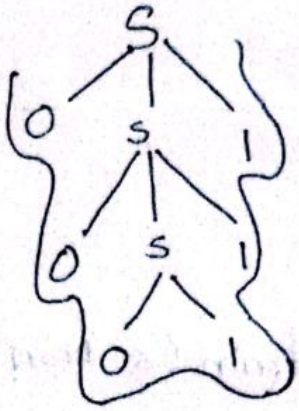
Context Free Languages

CFG: CFG is a set of rules/productions used to generate pattern of strings

$S \rightarrow 01 \mid 0S1 \longrightarrow 0S1$ সমান 0, সমান 1 থাকতে হবে।



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Formal def of CFG

CFG এর ৪টি tuple থাকে। যেমন:

(V, Σ, R, S) where
$N \quad T \quad P$

1) 'V' ⟶ Finite set called "Variable"
   ↳ "N" ⟶ Another name "Non-terminals"

2) "Σ" is a finit set disjoint from "V"
   ↳ "T" ⟶ set of Terminals

3) "R" / "P" ⟶ Finite set of rules/productions

④ "S" ⟶ start variable

$S \in V$

Ex If $S \longrightarrow 01 \mid 0S1$

$V = \{S\}$

$\Sigma = \{0, 1\}$

$S = \{S\}$

$R = S \longrightarrow 01 \mid 0S1$

Question Identify the Terminals, Non-terminals start variable from the following grammar

① $E \Rightarrow F+T \mid T$

$T \Rightarrow T*F \mid F$

$F \Rightarrow (E) \mid id$

Ans $V = \{E, T, F\}$

$\Sigma = \{"+", "*", "(", ")", "id"\}$

$S = \{E\}$

② $S \Rightarrow (L) \mid a$

$L \Rightarrow L, S \mid S$

Ans $V = \{L, S\}$

$\Sigma = \{"(", ")", "a", ","\}$

$S = \{S\}$

CFG

String acceptence

- Derivation
- parsing format

$S \rightarrow 01 \mid 0S1$

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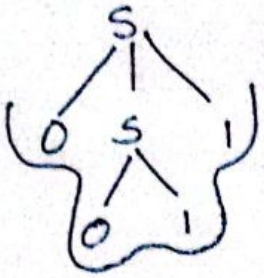


CFG Design

Example-1

$L = \{a^n \mid n \geq 0\}$

$\Downarrow$ RE

a^*

$= \{\epsilon, a, aa, aaa \ldots\}$

DFA

CFG $A \Rightarrow aA \mid \epsilon$

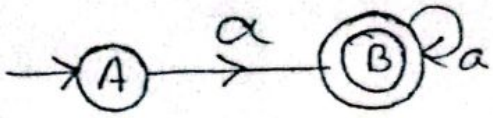
$\epsilon \rightarrow$ non-terminal

② $L = \{a^n | n \geq 1\}$

⇓ RE

a^+

$= \{a, aa, aaa \cdots\}$



CFG $A \Rightarrow aA|a$

aaa $A \Rightarrow aA$

$\Rightarrow aaA$

$\Rightarrow aaa$

③ $L = \{$set of all strings over $\{a,b\}\}$

⇓

$(a+b)^*$

"a" $A \Rightarrow aA|\epsilon$

"b" $A \Rightarrow bA|\epsilon$

$A \Rightarrow aA|bA|\epsilon$

aab $A \Rightarrow aA$

$\Rightarrow aaA$

$\Rightarrow aabA$ ($A \to \epsilon$)

$\Rightarrow aab$

(4) L = {set of all strings over {a, b} which length at least $|w| \geq 2$}

= {aa, bb, ab, ba, bbb...}

$\underbrace{(a+b)}_{A}\underbrace{(a+b)}_{A}\underbrace{(a+b)^*}_{B}$

$S \Rightarrow AAB$

aa

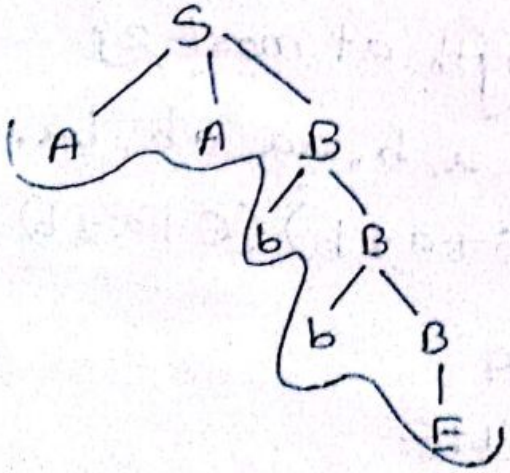
$S \Rightarrow AAB$
$\Rightarrow aAB$
$\Rightarrow aaB$
$\Rightarrow aa\epsilon$

abbb

$S \Rightarrow AAB$
$\Rightarrow aAB$
$\Rightarrow abB$
$\Rightarrow abbB$
$\Rightarrow abbb\epsilon$

$A \Rightarrow a \mid b$

$B \Rightarrow aB \mid bB \mid \epsilon$



H.W (1) {set of strings for at least 3 0's}

~~{01, 011}~~ $S = \underbrace{(0+1)}_{E}{}^*0\underbrace{(0+1)}_{E}{}^*0\underbrace{(0+1)}_{E}0\underbrace{(0+1)}_{E}{}^*$

3रा 0 fixed position

0 or 1 or ~~किछु~~ ε ना।

$S \Rightarrow EOEOEOE$

$E \Rightarrow OE \mid 1E \mid \epsilon$

1000

$S \Rightarrow \underline{E}OEOEOE$

$\Rightarrow 1\underline{E}OEOEOE$

$\Rightarrow 1\epsilon O\epsilon O\epsilon O\epsilon$

$\Rightarrow 1000$

(2) $S = \{$length at most 2$\}$

$= \{\epsilon, a, b, aa, ab, ba, bb\}$

$= (\epsilon + a + b)(\epsilon + a + b)$

$S \Rightarrow AA$

$A \Rightarrow a \mid b \mid \epsilon$

(3) $\{$starts with a ends with b$\}$

$a(a+b)^* b$

$S \Rightarrow aAb$

$A \Rightarrow aA \mid bA \mid \epsilon$

④ {starts with and ends with different symbol}

$$a(a+b)^* b + b(a+b)^* a$$

$S \Rightarrow aAb + bAa$

$A \Rightarrow aA + bA \mid \epsilon$

⑤ {start and ends with same symbol}

$$a(a+b)^* a + b(a+b)^* b + \epsilon + a + b$$

$S \Rightarrow aAa + bAb \mid a \mid b \mid \epsilon$

$A \Rightarrow aA \mid bA \mid \epsilon$

⑥ {even length string}

$$((a+b)(a+b))^*$$

$T \Rightarrow ST \mid \epsilon$

$S \Rightarrow AA$

$A \Rightarrow a \mid b$

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Ambiguity in CFG

If a grammar generates the same string in several different ways we say that the derived string is "Ambiguous"

Example: $S \Rightarrow S+S \mid S*S \mid a$

$S \Rightarrow S+S$

$S \Rightarrow S*S$

$a+a*a$

$S \Rightarrow S+S$

$\Rightarrow a+S$

$\Rightarrow a+S*S$

$\Rightarrow a+a*a$

$S \Rightarrow S*S$

$\Rightarrow S+S*S$

$\Rightarrow a+S*S$

$\Rightarrow a+a*a$

Ex-1

S =

A

B

C

Remo

Re

Ex:

(2)

Remove null Productions from CFG

Ex-1

$S \Rightarrow ABC$
$A \Rightarrow aA \mid \epsilon$
$B \Rightarrow bA \mid \epsilon$
$C \Rightarrow c$

$A \Rightarrow \epsilon$
$B \Rightarrow \epsilon$

Removing $A \Rightarrow \epsilon$

$S \Rightarrow ABC \mid BC$
$A \Rightarrow aA \mid a$
$B \Rightarrow bB \mid \epsilon$
$C \Rightarrow c$

$A \Rightarrow aA$
$\Rightarrow a\epsilon$
$\Rightarrow a$

Removing $B \Rightarrow \epsilon$

$S \Rightarrow AB \mid BC \mid AC \mid C$
$A \Rightarrow aA \mid a$
$B \Rightarrow bB \mid b$
$C \Rightarrow c$

Ex:

(2) $S \Rightarrow ABAC$
$A \Rightarrow aA \mid \epsilon$
$B \Rightarrow bB \mid \epsilon$
$C \Rightarrow c$

$A \Rightarrow \epsilon$
$B \Rightarrow \epsilon$

Removing $A \Rightarrow \epsilon$

$S \Rightarrow ABAC|BAC|ABC|BC$

$A \Rightarrow aA|a$

$B \Rightarrow bB|\epsilon$

$C \Rightarrow C$

Removing $B \Rightarrow \epsilon$

$S \Rightarrow ABAC|BAC|ABC|BC|$
$AAC|$
$AC|C$

$A \Rightarrow aA|a$

$B \Rightarrow bB|b$

$C \Rightarrow C$

(3) $S \Rightarrow aS|A$

$A \Rightarrow \epsilon$

Removing $A \Rightarrow \epsilon$

$S \Rightarrow aS|\epsilon$

$S \Rightarrow \epsilon$ $S \Rightarrow aS|\epsilon|a$

Remove Unit Productions from CFG

① $A \to AB$
$A \to a$
$B \to c \mid b$
$C \to D$
$D \to E$
$E \to a$

$B \to C$
$C \to D$
$D \to E$

step:1

$E \to a$

as $D \to E$
$D \to a$

$B \to C$
$B \to a$

$C \to D$
$C \to a$

$A \Rightarrow A \mid B$
$A \Rightarrow a$
$B \Rightarrow a \mid b$
$C \Rightarrow a \mid b$

X $C \Rightarrow a$, $D \Rightarrow a$, $E \Rightarrow a$

Ex-2

$S \Rightarrow aA \mid B$
$A \Rightarrow ba \mid bb$
$B \Rightarrow A \mid bba$

$S \Rightarrow B$
$B \Rightarrow A$

X B ⇒ ba | bbl bb a

S ⇒ aA | ba | bb | bba

A ⇒ ba | bb

CFG → CNF

chomsky Normal Formal

A context free grammar is in "chomsky Normal form if every rule of the form

A ⇒ a

A ⇒ BC

where a = any terminals

A, B, C = any non-terminals

B, C ⇒ start variable

CFG to CNF

→ chomsky rules

① $S \Rightarrow ASA \mid aB$ अनुसारी right side में start variable नहीं था।

$A \Rightarrow B \mid S$

$B \Rightarrow b \mid \epsilon$

Step-1 :

$S_0 \Rightarrow S$

$S \Rightarrow ASA \mid aB$

$A \Rightarrow B \mid S$

$B \Rightarrow b \mid \epsilon$

Step-2 :

Remove Null productions

$S_0 \rightarrow S$

$S \rightarrow ASA \mid aCa$

$A \rightarrow B \mid S \mid \epsilon$

$B \rightarrow b$

$A \rightarrow \epsilon$

$S_0 \rightarrow S$

$S \rightarrow ASA \mid aB \mid a \mid SA \mid AS \mid S$

$A \rightarrow B \mid S$ $B \rightarrow b$