Cheatography

Automata - CFG & PDA Cheat Sheet

by Vipera via cheatography.com/128346/cs/25668/

CFG Definition

Context-Free Grammar:	**G = (V,T,S,P)**
V: Set of variables	{S}
T: Set of terminal symbols	{a,b}
S: Start variable	S
P: Set of productions	{S→aSb, S→ε}

ONLY ONE variable → String of variables **and** terminals

Union of Two Languages

Example:	L={0^n1^n|n≥0} U {1^n0^n|n≥0}
Break problem in two	$\mathbf{S^1}$→0$S^1$1|ε $\mathbf{S^2}$→1$S^2$0|ε
Merge	**S→S^1|S^2** S^1→0$S^1$1|ε S^2→1$S^2$0|ε

Simplifications of CFG

Substitution *(B →y^1)*	A→xBz B→y^1	A→xBz|xy^1z
	A→xBBz B→y^1	A→xBBz|xBy^1z|xy^1Bz|xy^1y^1z
Removing ε *(B →ε)*	A→xBz B→ε	A→xBz|xz
Unit Production *(A →B)*	A→B B→bb	A→bb B→bb
Useless Productions	A→aA (infinite)	∴ remove
	Unreac-hable from S	∴ remove

Step 1: Remove Nullable Variables
Step 2: Remove Unit-Production
Step 3: Remove Useless Variables

DFA to CFG

1. Create variable $\mathbf{R^i}$ for every state $\mathbf{q^i}$
2. Create rule $\mathbf{R^i \rightarrow aR^j}$ for every transition $\mathbf{\delta(q^i,a) \rightarrow q^j}$
3. For accept states $\mathbf{q^i}$ create rule $\mathbf{R^i \rightarrow \varepsilon}$
4. For initial state $\mathbf{q^0}$ make $\mathbf{R^0}$ the start variable

Conversion to Chomsky Normal Form

Step 0:	If start symbol (S) is on the right hand side, change start symbol $S^0 \rightarrow S$
Step 1:	Remove Nullable variables ($A \rightarrow \varepsilon$) and Unit productions ($A \rightarrow B$)
Step 2:	For every symbol *a* add $T^a \rightarrow a$
Step 3:	Replace A→C^1C^2...C^n with A→C^1V^1 V^1→C^2V^2 ... V^{n-2}→$C^{n-1}C^n$

Chomsky form only has productions in forms
A→BC
A→a

Greibach Normal Form

All Productions have form:	A→aV^1V^2..V^k : k≥0
Example	
S→abSb S→aa	S→aT^bST^b S→aT^a T^a→a T^b→b

PDA

Transitions: **a, b → c** means when input is a, remove *b* from stack and add *c*

If the automaton attempts to pop from empty stack then it halts and rejects input.

A string is accepted if there is a computation such that:
All the input is consumed
The last state is an accepting state

PDA Formalities

PDA Representation	**M=(Q,Σ,Γ,δ,q0,z,F)**
Q: States	{q0,q1,q2}
Σ: Input Alphabet	{a,b}
Γ: Stack Alphabet	{a,b,$}
δ: Transition Functions	δ(q,a,w1)={(-q2,w2)}
q0: Initial State	q0
z: Stack Start Symbol	$
F: Accept States	{q2}

CFG to PDA

Start with PDA of q0 →$^{\varepsilon,\varepsilon\rightarrow S}$→q1 →$^{\varepsilon,\$\rightarrow\$}$→q2

For each CFG production *A→w* add **ε,A→w**

For each CFG terminal *a* add **a,a→ε**

"Easy" PDA to CFG

For the pair of transitions:
ⓟ→$^{a,\varepsilon\rightarrow t}$→ⓡ ⓢ→$^{b,t\rightarrow\varepsilon}$→ⓠ

Add the production: A^{pq}→aA^{rs}b
For each state **p** add: A^{pp}→ε
For each state-triple (p,q,r) add: A^{pr}→$A^{pq}A^{qr}$

For initial state and accept state:
→⓪ & □

Add the production: S→A^{0a}

Easy PDAs:
• Have only 1 accept state
• When accepting a string, the stack is empty (only inital symbol)
• Each transition pushes **or** pops

PDA to "Easy" PDA

1. The PDA has a single accept state	Create new accept state and make ε,ε→ε transitions from old accept states to the new

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PDA to "Easy" PDA (cont)

2. Use new initial stack symbol #	New initial state, that transitions to a new state with ε,ε→@ (auxiliary symbol) that transitions to the old initial state with ε,ε→$
3. On acceptance the stack contains only stack symbol #	Old accept state transitions to new to new accept state with ε,@→ε, αvδ self loops with ε,x→ε where ∀x∈Γ-{@,#}
4. Transitions can't push **and** pop	Replace any $ⓘ \rightarrow^{\sigma,a\rightarrow b} ⓙ$ with $ⓘ \rightarrow^{\sigma,a\rightarrow\varepsilon} ⓚ \rightarrow^{\varepsilon,\varepsilon\rightarrow b} ⓙ$
5. 4. Transitions can't neither push nor pop	Replace any $ⓘ \rightarrow^{\sigma,\varepsilon\rightarrow\varepsilon} ⓙ$ with $ⓘ \rightarrow^{\sigma,\varepsilon\rightarrow\partial} ⓚ \rightarrow^{\varepsilon,\partial\rightarrow\varepsilon} ⓙ$

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