Lecture 8 Scribble

09/17/2020

Topics for today:
- Finish CFG with closure
- Intro to Turing machines
- Formal def TMs
- TM examples
- Universal Turing Machines

CFLs/CFGs $L = \{a^n b^n \mid n \geq 0\}$ $\Sigma = \{a, b\}$

$P = \{S \to aSb \mid \varepsilon\}$ $V = \{S\}$ $S = S$

Closure CFGs: A set is closed under an operation if application of that operation on members of the set produces more members of that set.

$\overline{L}$ L^R

$L = \{a^n b^n c^n \mid n > 0\}$ is not CF Pumping Lemma

$L_1 \cap L_2$ is not CF $L_1 = a^n b^n c^*$ $L_2 = a^* b^n c^n$

Closed for CFL: $L_1 \cup L_2$ $S \to S_1 \mid S_2$

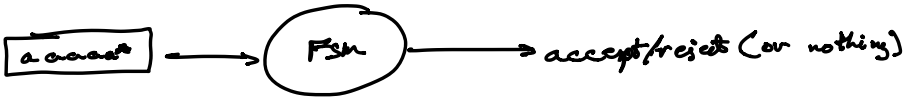
$L_1 \circ L_2$ $S \to S_1 \cdot S_2$

L_1^* $S \to S_1 S \mid \varepsilon$

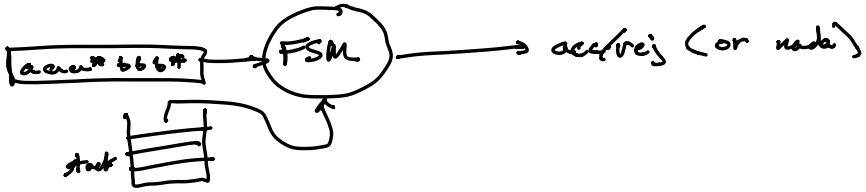
Turing Machine

RadioLab – The Turing Problem
(Jim) completely loopy

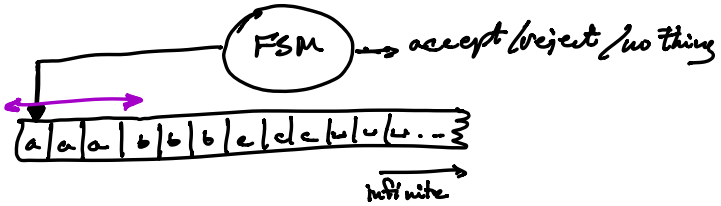
Finite States
(DFA / NFA)



Pushdown Automata



Turing Machine



Formal Definition of TM:

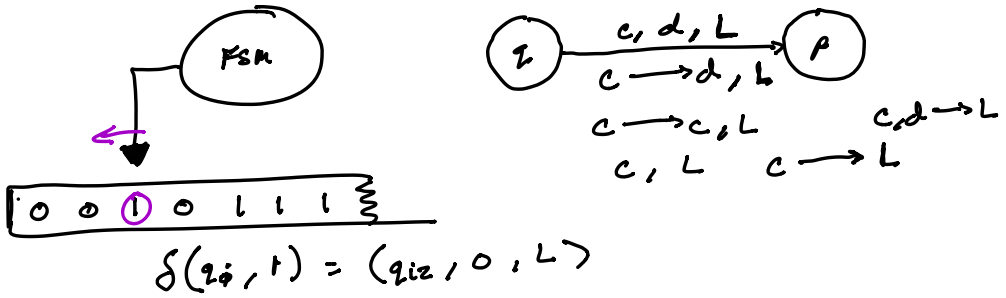
$M = (Q, \Sigma, \Gamma, \delta, q_0, q_{acc}, q_{rej})$

- Q: set of states FSM
- Σ: input alphabet
- Γ: tape alphabet
- δ: Transition function
- q_0: initial state
- q_{acc}: accepting state(s)
- q_{rej}: rejecting state

$\delta : Q \times \Gamma \longrightarrow Q \times \Gamma \times \{L, R, S\}$

$\delta(q, c) = (p, d, L/R/S)$

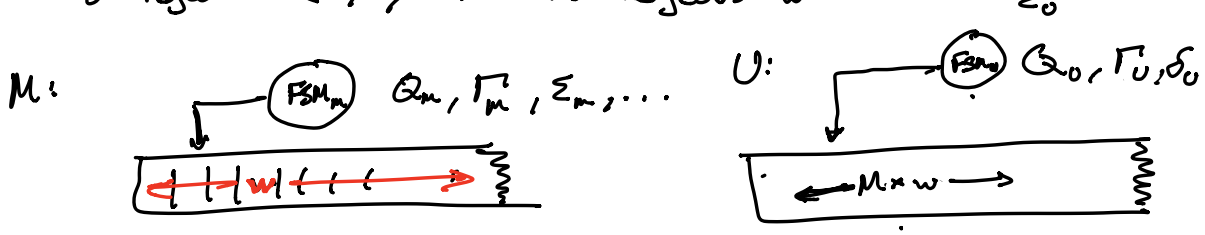
- q: old control state
- c: character under tape head
- p: new control state
- d: new character under tape
- $L/R/S$: movements of tape head



Universal Turing Machine:

Turing Machine that simulates Turing machines

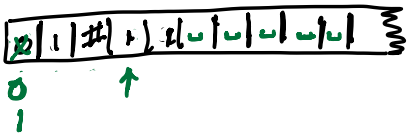
- U accepts $\langle M, w \rangle$ iff M accepts w
- U rejects $\langle M, w \rangle$ iff M rejects w

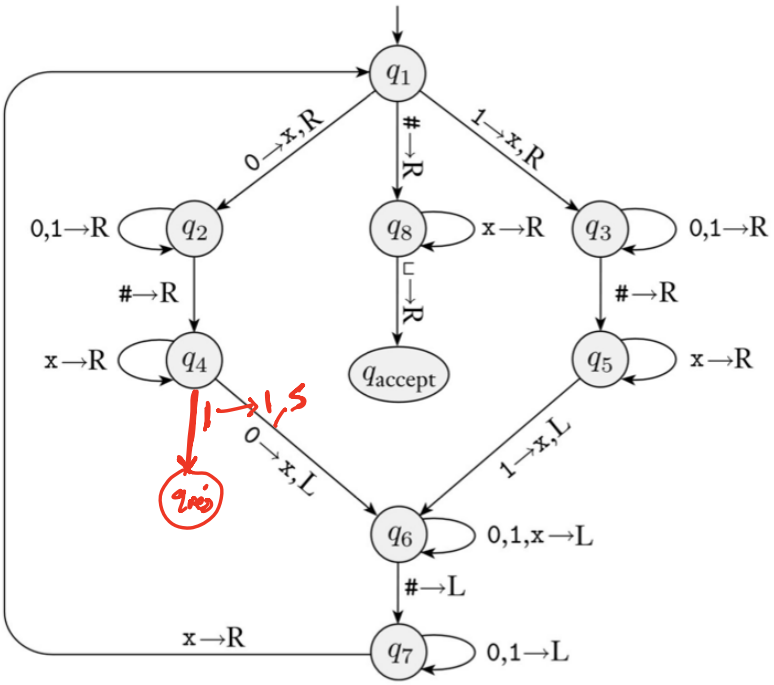


Lecture #8 Example #1

$L = \{ w \# w \mid w \in \{0,1\}^* \}$ 01#01 ~~01101~~

$\Sigma = \{0, 1, \#\}$ $\Gamma = \{x, \sqcup, \Sigma\}$

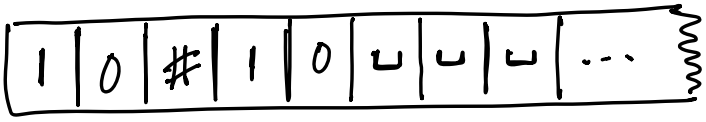




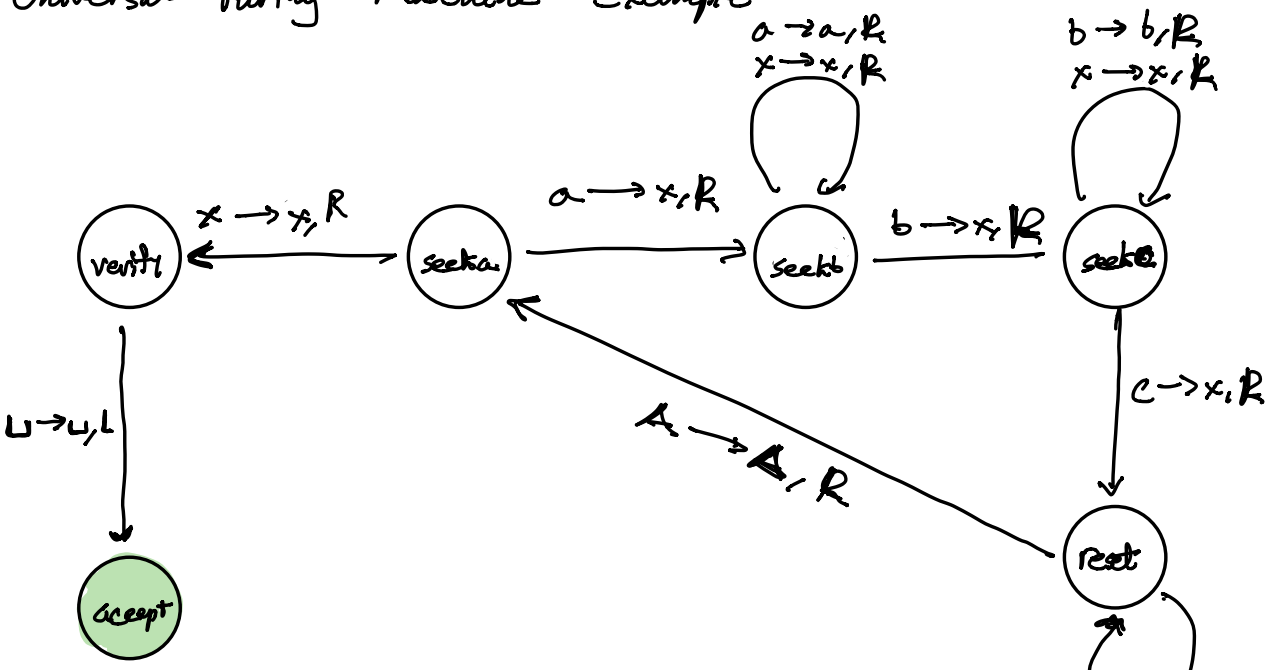
$\Sigma = \{a, b, c, d \ldots$

$\Gamma = \{A, B, C, D, \ldots, \Sigma\}$

Example



Universal Turing Machine Example



$Q = \langle$ start, seeka, seekb, seekc, verify, accept $\rangle$

start = 000

seeka = 001 seekb = 001 seekc = 010

$\Gamma = (a, b, c, \sqcup)$

0 0 0 0
0 0 1 1
0 1 0 1

$\delta(\text{seekc}, c) = (\text{seeka}, \text{d}, L)$

[010 . 010 | 001 . 001 . 1]

Input String = aa bb cc and ~~get~~ to

How do we indicate where the head is?

$w = a\,b\,c$