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Theory of Computation
CS F315

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Some Examples of Turing Machine

Let L1 = {“M” “w” | M is a Turing Machine that accepts string w}. Answer the following.

- Is L1 a Recursive language?
- Is L1 a Recursively Enumerable language?
- Is complement of L1 a Recursively Enumerable language? Why ?

Some Examples of Turing Machine

"Decidable languages are closed under UNION operation". TRUE/FALSE.

What is wrong with the following proof for above theorem?

Let T1 = (K1, ∑1, δ1, s1, {Y1, N1}) and T2 = (K2, ∑2, δ2, s2, {Y2, N2}) be two single tape Turing Machines that decide languages L1 and L2, respectively. Y1 and Y2 are accepting halting states. Similarly, N1 and N2 are non-accepting halting states. Assuming both T1 and T2 starts in initial configuration, we need to design a single tape Turing Machine T = (K, ∑, δ, s, H) that decides L = L1 U L2.

Is the following construction of T correct? Justify your answer briefly.

- T = (K, ∑, δ, s, H), where
- K = K1 U K2 U {qn} , ∑ = ∑1 U ∑2 , s = s1 , H = H1 U H2
- **∀x ∈ ∑1, ∀y ∈ ∑1 – {⊳},**
- δ = **δ1** U **δ2** U **{(N1, x)(qn, x)}** U **{(qn, y)(qn, ←)}** U **{(qn, ⊳)(s2, →)}**
- [**Note**: Transition of the form (q, x)(p, y) means in state q if the symbol read is x, write y in place of x and move to state p.]

Some Examples of Turing Machine

- Let L = {“M” | M is a Turing Machine which decides its respective language}. Give a high level description of Turing Machine U_{TM} which takes “M” $\in$ L (i.e. encoding of M) as input and outputs all halting states of M.
- Also, is $L(U_{TM})$ decidable?

Problem

Let G1 be a CFG and string $x \in L(G1)$. Also, let G2 be a CFG such that $L(G2) = L(G1) - \{x\}$. Prove that (by giving an algorithm) computing grammar G2 from grammar G1 is decidable.

Problem

- Let G1 be a CFG and string $x \in L(G1)$. Also, let G2 be a CFG such that $L(G2) = L(G1) – \{x\}$. Prove that (by giving an algorithm) computing grammar G2 from grammar G1 is decidable.
- Let L = {G | G is a CFG and G generates at least 51 strings}. Prove that L is decidable. You can give an algorithm here as a high-level description of corresponding TM.

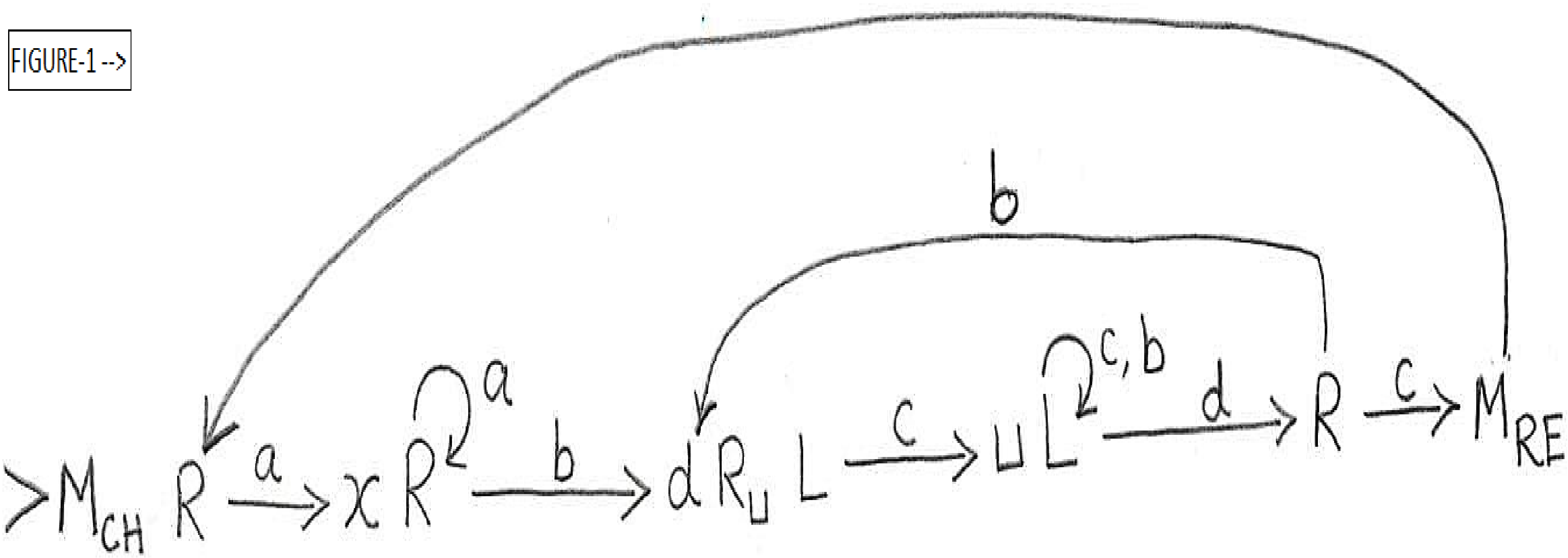
[**<u>Hint</u>**: Think about the outcome of the question just before this one.]

Some Examples of Turing Machine

- Let L = $\{a^i b^j c^k \mid i \times j = k \text{ and } i, j, k > 0\}$. Consider the single tape Turing Machine (FIGURE-1) to accept L. Its initial configuration is $\blacktriangleright \underline{\sqcup} w$ and final configuration is $\blacktriangleright \underline{\sqcup} w1$, where w1 is any string. It uses machine M_{CH} (which accepts if all a's are followed by all b's and all b's are followed by all c's; otherwise it rejects). Also it uses machine M_{RE} to restore all b's (understand yourself why it is required). Attempt the following:
- Make TM's for M_{CH} and M_{RE} so that they are meaningful in deciding language L by TM in FIGURE-1.
- Modify FIGURE-1 so that it semi-decides the language L.
- Finally, modify FIGURE-1 so that it decides the language L.

Some Examples of Turing Machine

FIGURE-1 -->



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Thank You