Homework 1: Regular Languages: Automata and Expressions

CS 212 Nature of Computation
Habib University

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General instructions

- For drawing finite automata, see this TikZ guide or the JFLAP tool. Hand drawn diagrams will not be accepted.
- Please ensure that your solutions are neatly formatted and organized, and use clear and concise language.
- Please consult Canvas for a rubric containing the breakdown of points for each problem.
- For all the problems below, $\Sigma = \{a, b\}$.
- Some of the problems below make use of the following count function.

$$n_a(w) = \text{the number of occurences of } a \text{ in } w, \text{ where } a \in \Sigma, w \in \Sigma^*.$$

Problems

1. [15 points] List 2 members and 2 non-members of the language, $(a \cup ba \cup bb)\Sigma^*$.

Solution:

2. [20 points] Provide the state diagram of a simplified DFA that recognizes the language,

$$A = \{w \in \Sigma^* \mid n_a(w) \geq 2, n_b(w) \leq 1\}.$$

Solution:

3. [30 points] Given the languages, A and B, we derive the language, $C = \{w \in A \mid w \in B\}$.

   Prove or disprove the following claim.

   Claim 1. *If A and B are regular languages, then so is C.*

Solution: We have to prove a language C has members : w is member of A given that it is member of B, where A and B are some regular languages then so is C. To accomplish this we can construct a DFA that accepts language C to complete the proof.

let $C' = (Q, \sigma, \delta, q_0, F)$ be a DFA that accepts language C. Language A is accepted by DFA A' and language B is accepted by DFA B' Let $A' = (Q_A, \sigma, \delta_A, q_{0A}, F_A)$ and $B' = (Q_B, \sigma, \delta_B, q_{0B}, F_B)$

We can construct C as follows:

- $Q = (q_A, q_B) \mid q_A \in Q_A, q_B \in Q_B$ so the new state set Q is the cartesian product of the state sets of A and B.
- $\sigma = \sigma_A = \sigma_B$ (since w $\in \Sigma*$ and $\Sigma = \{a, b\}$ which is same for A and B)
- $\delta((q_A, q_B), a) = (\delta_A(q_A, a), \delta_B(q_B, a))$
- $q_0 = (q_{0A}, q_{0B})$
- $F = F_A \times F_B$ the start states and end states of C' will be pair of start states and end states of A' and B' respectively.

Now we have to prove that C' is a DFA that accepts language C.

- C is a DFA because it has a finite set of states, a finite set of input symbols, a transition function, a start state, and a set of end states.
- C accepts language C because it accepts all strings w that are accepted by A and B.

Therefore, C is a DFA that accepts language C, so the claim is true.

4. [35 points] Given the languages, A and B, we define the following operation.

$$A \smile_a B = \{u \in A \mid \exists v \in B \ni n_a(u) = n_a(v)\}$$

   Prove or disprove the following claim.

   Claim 2. *The class of regular languages is closed under $\smile_a$.*

Solution: