International Institute of Information Technology Bangalore

CS 704: Topics in Computability and Learning

Practice Questions: Regular Languages

1. Let $\Sigma = \{a, b\}$. Give a DFA for the language that contains all strings that have at least three positions where 3 consecutive b's occur. For e.g., *abbbbbba* and *bbbbaabbbaa* should be accepted by the DFA but, not *abbb*.

2. Give an NFA for the language of binary strings with alternating 0s and 1s. Give an equivalent DFA (either using subset construction or directly). How many states will the minimal DFA for this language have?

3. Prove or disprove: The regular expression $(ab^*a + b)^*$ describes the language of all strings over $\{a, b\}$ that contain an even number of 'a's.

4. Give a DFA for the language of all strings over $\{a, b\}$ which *don't* contain the substring *bab*.

5. Describe a DFA for the language $a^*b^* + b^*a^*$.

6. Consider the sentence $\varphi = \exists x((\forall y \neg(y < x) \wedge Q_a(x)))$ over the alphabet $\{a\}$. Describe the language of words that satisfy φ in English. Also give a regular expression for the language.

7. Consider the formula $\varphi(x) = \exists x((x < y) \wedge Q_a(y))$. List the free and the bound variables in φ. Also describe the alphabet over which the automaton that will be constructed for accepting all the models of φ will run on. Assume that Σ is just $\{a\}$.

8. Describe the language defined by the sentence below, as a regular expression over the alphabet $\{a, b\}$.

$$\forall x(Q_b(x) \Rightarrow \exists y(y < x \wedge Q_a(y))).$$

9. Give a regular expression which describes the language defined by the MSO sentence below over the alphabet $\{a, b\}$.

$$\begin{aligned}\exists X(\quad & (\exists x(zero(x) \wedge x \in X)) \wedge \\ & (\exists x(last(x) \wedge \neg x \in X)) \wedge \\ & (\forall x \forall y(succ(x, y) \Rightarrow (x \in X \Leftrightarrow \neg y \in X))) \wedge \\ & \forall x(x \in X \Rightarrow Q_a(x))).\end{aligned}$$

10. Give a finite state automaton that accepts all binary representations of i, j and k such that $i + j = k$.

11. Construct an automaton that accepts all binary representations of x, y such that $y = 2x + 1$.

12. While using projection operation for the existential quantifiers during the inductive construction of the automaton for a given a linear inequality in Presburger's algorithm, briefly explain why we have to make a few extra states as final states.

13. Consider the alphabet $\Sigma = \{a, b\}$ and the following observation table with the learner while running L^* algorithm.

	ϵ	a
ϵ	0	0
b	0	1
ba	1	0
a	0	0
bb	1	1
baa	0	0
bab	0	1

Check if the table is closed and consistent. Justify your answer.

14. Assume that the teacher's regular language is $L = \{w \in \{0,1\}^* \mid \#0s$ is a multiple of $3\}$. Describe the working of Angluin's algorithm for this language.

15. Assume that the teacher's regular language is $L = \{w \in \Sigma^* \mid$ second last letter from the right is a $b\}$. Describe the working of Angluin's algorithm for this language.

16. While running Angluin's L^*-algorithm to learn a particular regular language, describe how the learner constructs an automaton from a closed and consistent table. In particular, describe how the states and transitions of the automaton are defined from the table and which are the initial and final states.