Lecture 1 : Introduction - What is Theory of Automata and why we study it?

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Automation -> Automatic machine / self controlled

Example: Computer, ATM, any machine that has automatic mechanism

Is an area of computer science that deals with the study of abstract machines (mathematical models) as well as the computational problems that can be solved using them

Why we study it?

- It allows us to think systematically about what machine do without going into hardware details
- Learning of Languages and Computational techniques.
- Designing of theoretical models for machines
- Course Requirement → **Abstract machines**

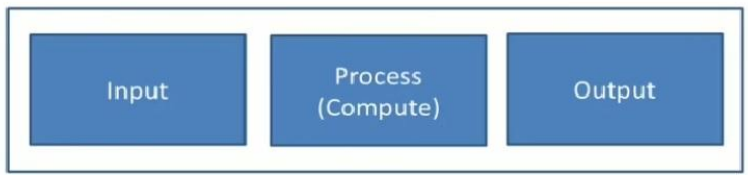
States

Different names;

- Theory of Automata
- Automata Theory
- Theory of Computer Science
- Theory of Computation
- Computer Theory

Fundamental / Core subject of computer science

(Computer)



Lecture 2: Language, alphabet, string, word

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Letters	Characters/Symbols out of which we build languages for machine	a, b, c, d , .. 0, 1, 2, 3,..
Alphabet	a set of letters , denoted by Greek letter sigma **Σ**	**Σ** = {a,b} **Σ** = {0,1}
String	Concatenation of letters Or a Sequence of letters	aa, bb, ab

Language: a set of strings with rules

Concatenation
Sath Jorna

Example: Make a language for a machine in which strings start with 'a' and ends with 'a' from Alphabet {a,b}

L1= {aa,aba,..}

Word String that is permissible in language

String
ڈوری
رسی

aa bb
ab ba
aab aba
baa aba

Why ATM can't perform other tasks of general purpose computer?

why machine language is easier for Computer to understand ?

Lecture 3

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Empty String, Length of String, reverse of String, Power of alphabet, Power of String

Σ = {a,b} ∧ a b aa ab

Empty String	string that has no letter, also known as **Null string**, denoted by ∧, **λ** or ε It's length is Zero (0)
Length of String	is the number of letters in a string, denoted by **|s|** Example: s = abab **|s| = 4** or **length(s) = 4** or **length(abab) = 4**
Reverse of String	Is obtained by writing letters of string in reverse order, denoted by Rev(s) or s^r Or Reverse(s) Example: s = abab **Rev(s)** = baba **Reverse(s)** = baba
Power of Alphabet	Determines that the strings made from alphabet will be of length equal to power of alphabet **Σ = {a,b}**^{2} {aa, ab, ba, bb} Total number of letters in alphabet → n^m $2^2 = 4$ (Length/power)
Power of string	Determines the length of string $(bab)^2$ = babbab ba^2b = baab

Lecture 4

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Practice Problem

Consider the language S*, where S = {a b}.
How many words does this language have of length 2? of length 3? of length n?

Solution:

$2^2 = 4$
$2^3 = 8$
$2^n = 2^n$

Total number of letters = 2

Total number of letters in alphabet → n^m (length/power)

Lecture 5

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Kleene Star/ Closure/Operator VS Kleener Closure/Plus/Positive , Lexicographic Order

Kleene Star
Kleene Closure
Kleene Operator

It is undermined power, represent infinite number of terms can be made including empty string

Denoted by *

Kleene Plus
Kleene Positive
Positive Closure

It is undermined power, represent infinite number of terms can be made except empty string

Denoted by +

Lexicographic order Method of Sequencing a language in which strings are grouped by their length (i.e. strings of shortest length first)

Power of Alphabet Determines that the strings made from alphabet will be of length equal to power of alphabe

$\Sigma = \{a,b\}$

$\Sigma^2 = \{a,b\}^2$ $\quad \Sigma^2$ {aa, ab, ba, bb}

$\Sigma^* = \{a,b\}^*$ $\quad \Sigma^*$ { ^ , a, b, aa, ab, ba, bb, aaa, aab, ... }

$\Sigma^+ = \{a,b\}^+$ $\quad \Sigma^+$ { a, b, aa, ab, ba, bb, aaa, aab, ... }

Power of string Determines the length of string

ba^2b = baab

ba^*b = bb or bab or baab or baaaaaab

Lecture 6

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Formal Language VS Informal Language

Language

Set of strings with rules

Language of strings that starts
With a and end with a
L1= {aa, aba, aaa, abba, ababa, ...}

English Language

work wkro ✗

Concerned with rules and meaning

Informal Language
or
Semantic Languages
معنی سے متعلق

Language1: Starts with **w** and ends with **o**

✗work wkro

Concerned with just rules/syntax
not with meaning

Formal Language
or Syntactic language
قوانین سے متعلق

Automata focus on Formal Languages

Lecture 7: Descriptive Definition in Automata, define a Palindrome language

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There are different methods with which we can define language.

Descriptive Definition.

- ✓ It is one of the language defining methods
- ✓ In this method, we simply describe the condition imposed on its strings/words

How do automata accept or reject the input?

how can automata know given string is valid or not?

Example:

L1 = {any finite string of letters that does not start with letter 0}

languageName = {Definition}

Example:

L1 = {set of all strings of letters that starts with a and ends with a}

X = 12321
Reverse(x) = 12321

Important Question: Define a Palindrome language with Descriptive Definition

reverse(x) = x

Palindrome = {∧, and all strings x such that reverse (x) = x }

e.g. Palidrome = { a, b, aa, bb, aaa, aba ... }

Lecture 8: Recursive Definition, Positive Even Numbers/Integers, Palindrome

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Recursive Definition

دہرانا

- ✓ It is one of the language defining methods
- ✓ In this method, we simply describe the language with three steps/rules

1. First, we specify some basic objects in the set. The number of basic objects specified must be finite.
2. Second, we give a finite number of rules for constructing more objects in the set from the ones we already know.
3. Third, we declare that no objects except those constructed in this way are allowed in the set.

Example: Recursive Definition for Positive Even Numbers / Positive Even Integers

P-Even = {2,4,6,8,10,..}

Rule 1: 2 is in P-EVEN.
Rule 2: If x is in P-EVEN, then so is x + 2.
Rule 3: The only elements in the set P-EVEN are those that can be produced from the two rules above.

Example: Recursive definition for palindrome

Reverse(X) = X

12321

Rule 1: ∧, a, and b are in PALINDROME.
Rule 2: If w ∈ PALINDROME, then so are awa and bwb.
Rule 3: No other string is in PALINDROME unless it can be produced by rules 1 and 2.

Lecture 9: Regular Expression, how to make RE (Power, Concatenation, Union) alisoomro666@gmail.co

There are different methods with which we can define language.

Regular Expression

- ✓ It is one of the language defining methods
- ✓ In this method, language is represented in terms of strings

String → ڈوری / رسی

Concatenation of letters
or Sequence of letters

aabaaba

Saath Jorna

^
a
ab
ababa

Example: string contains only a letters
L={^, a,aa,aaa,aaaa,aaaaa,.....}

R = a*

Example: string contains only a letters
L={a,aa,aaa,aaaa,aaaaa,.....}

R = a^+

Power of String

ba^2b = baab
ba^*b = bb or bab or baab or baaaaaaab
ba^+b = bab or baab or baaaaaaab

Fixed Power:
Kleene star(Can contain null):
Kleene plus(Can't contain null):

Example: string starts with a and contains any b letters
L= {a, ab, abb, abbb,abbbb}

R= ab* → **Concatenation of Strings . AND**

a.ab = aab

Lecture 9: Regular Expression, Power, Concatenation, Union alisoomro666@gmai

Example: string contains a or b
L={a,b}

R=a+b → **Union of Strings + OR**

a + b

Example: string contains any a or any b

R=(a+b)*

Example: string starts with a and ends with a
L={aa,aaa,aba,aaaa,aaba,abaa,abba,...}

R = a(a+b)*a

Lecture 10: Regular Expression for a language with Substring, examples alisoomro666@gmail.com

It is one of the language defining methods by which language is represented in terms of strings (Power, Concatenation, Union)

Substring?

aababababa

Smaller
chotaa

R = a*	L={^, a,aa,aaa,aaaa,.....}
R = a^+	L={a,aa,aaa,aaaa,aaaaa,.....}
R= ab*	L= {a, ab, abb, abbb,abbbb}
R=a+b	L={a,b}
R=(a+b)*	
R = a(a+b)*a	L={aa,aaa,aba,aaaa,aaba,...}

Q: Define a RE for language that contains the substring ba

(a+b)*ba (a+b)*

Power

Fixed Power: ba^2b = baab
Kleene star(Can contain null): ba^*b = bb or bab or baab or baaaaaaab
Kleene plus(Can't contain null): ba^+b = bab or baab or baaaaaaab

Concatenation (AND)
A.B
AB

Union (OR)
A+B
A|B

Q: All strings which do not contain the substring ba.

b*a* ✗ a*b* ✓

Lecture 10: Regular Expression for a language with Substring, examples alisoomro666@gmail.com

Q: Define a RE for language that contains the substring 00

(0+1)*00(0+1)*

Q: All strings which do not contain the substring 00.

0+1* +1*01*

Q: All strings which do not contain the substring 101.

0*(1*000*)* 1* 0*