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Construction of Minimized Deterministic Finite Automata for Finding the Equal Number of Input Characters

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Abstract— In this paper we analyze the equivalence of input characters for the given input string. The input string from the length two to five taken for the analysis. The counter concept used to check the equality. In each accepting state, a counter is fixed. The each input character has one accepting state. Initially, all counter value reset to zero. After processing the given input, the counter value for each input checked. The equal value of all counter value shows that the input has an equal number of input characters.

Keywords— Deterministic Finite Automata, Counter, Equality, Transition Diagram, Transition Table.

I. Introduction

Theory of computation is always a challenging subject for both the faculty and the students. This subject contains three abstract machines. The simple abstract machine is Finite Automata. It is simply a recognizer for accepting the string. The construction of Finite Automata has so many challenging problems. It is a mathematical subject. So it is possible to create even more than thousands of problems. One of the problems is checking the equality of the input character.

II. Related Work

Ezhilarasu et. al. [2014] categorized the Nondeterministic Finite Automata using a number of the loop [1],[2], and [3]. Those are Nondeterministic Finite Automata with 1. Single loop 2. Dual loop 3. More than two loops. In this three positions are used for placing the loop. Those are 1.Starting State 2. Final State 3. Intermediate State. Ezhilarasu and Krishnaraj [2015] categorized the Nondeterministic Finite Automata through a number of the substring in the given string [4], [5], and [6]. Those are 1. Single substring 2.Double Substring 3. More than double substring.

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III. Methodology

Based on, as in [7], [8], [9], [10], [11] Ezhilarasu et. al. [2014] and Ezhilarasu & Krishnaraj [2015] implemented the classification of Nondeterministic Finite Automata. This classification was also applicable to Deterministic Finite Automata. The construction of Minimized Deterministic Finite Automata for implementing the equality of input character for the given string comes under two categories. Those are 1. More than two loops 2. More than double substring.

IV. Construction Of Minimized Deterministic Finite Automata

A. Algorithm

1. Find the length of the string.
2. Divide the length of the string by a number of unique input characters.
3. If the reminder was not equal to zero, go to step 14.
4. A total number of states needed = String length + one.
5. A total number of accepting states = a total number of input characters.
6. Place counter at each final states.
7. Reset the counter value to zero.
8. Perform string processing character by character.
9. If an input character reaches its final state increase the counter value by one.
10. Continue step 8 and 9 if an input character remains.
11. Check the counter value in each final state.
12. If all the values are same print equality of input character, go to step 15.
13. Print unequal input characters. Go to step 15.
14. Print Equality of input characters not possible.
15. Stop the process.

B. Two Input Characters

Non-Minimized DFA

The Deterministic Finite Automata for accepting the equal input character for two input character has following tuples.

1. Starting state q0
2. Final States q1,q2,q3,q4.
3. Set of states {q0,q1,q2,q3, and q4}
4. Set of input characters {e,z}
5. Transition function

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$\delta(q_0,\{e,z\}) = \delta(q_0,e) + \delta(q_0,z)$
$= \{q_1\} + \{q_2\}$
$\delta(q_1,\{e,z\}) = \delta(q_1,e) + \delta(q_1,z)$
$= \{q_3\} + \{q_4\}$
$\delta(q_2,\{e,z\}) = \delta(q_2,e) + \delta(q_2,z)$
$= \{q_3\} + \{q_4\}$
$\delta(q_3,\{e,z\}) = \delta(q_0,e) + \delta(q_0,z)$
$= \{q_3\} + \{q_4\}$
$\delta(q_4,\{e,z\}) = \delta(q_0,e) + \delta(q_0,z)$
$= \{q_3\} + \{q_4\}$

The Transition Diagram of Non-Minimized DFA for checking the equality of two input characters is as given in Figure 1.

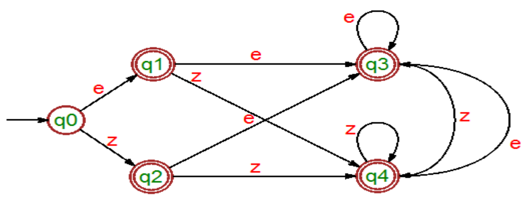

Fig.1.Transition Diagram of Non-Minimized DFA for checking the equality of two input characters.

The transition table for Figure 1 is as shown in Table 1.

Table.1. Transition Table of Non-Minimized DFA for checking the equality of two input characters.

STATES	INPUT	
	'e'	'z'
→q_0	q_1	q_2
*q_1	q_3	q_4
*q_2	q_3	q_4
*q_3	q_3	q_4
*q_4	q_3	q_4

Processing of input

Input: "ezeeezzzeezzze"

Table.2. Processing of input with the counter value.

States	Input Symbol	Transition Function	Counter			
			C1	C2	C3	C4
q_0	e	$\delta(q_0,e)=q_1$	1	0	0	0
q_1	z	$\delta(q_1,z)=q_4$	1	0	0	1
q_4	e	$\delta(q_4,e)=q_3$	1	0	1	1
q_3	e	$\delta(q_3,e)=q_3$	1	0	2	1
q_3	e	$\delta(q_3,e)=q_3$	1	0	3	1
q_3	z	$\delta(q_3,z)=q_4$	1	0	3	2
q_4	z	$\delta(q_4,z)=q_4$	1	0	3	3
q_4	z	$\delta(q_4,z)=q_4$	1	0	3	4
q_4	e	$\delta(q_4,e)=q_3$	1	0	4	4
q_3	e	$\delta(q_3,e)=q_3$	1	0	5	4
q_3	z	$\delta(q_3,z)=q_4$	1	0	5	5
q_4	z	$\delta(q_4,z)=q_4$	1	0	5	6
q_4	z	$\delta(q_4,z)=q_4$	1	0	5	7
q_4	e	$\delta(q_4,e)=q_3$	1	0	6	7

The value of counter C1 and C3 denotes the total occurrence of input character 'e'. Whereas the value of counter C2 and C4 denotes the total occurrence of input character 'z'.

C1+C3=C2+C4
1+6=0+7
7=7

Hence, the given input has an equal number of input characters.

Input: "ezeeezzzeezzz"

Table.3. Processing of input with the counter value.

States	Input Symbol	Transition Function	Counter			
			C1	C2	C3	C4
q_0	e	$\delta(q_0,e)=q_1$	1	0	0	0
q_1	z	$\delta(q_1,z)=q_4$	1	0	0	1
q_4	e	$\delta(q_4,e)=q_3$	1	0	1	1
q_3	e	$\delta(q_3,e)=q_3$	1	0	2	1
q_3	e	$\delta(q_3,e)=q_3$	1	0	3	1
q_3	z	$\delta(q_3,z)=q_4$	1	0	3	2
q_4	z	$\delta(q_4,z)=q_4$	1	0	3	3
q_4	z	$\delta(q_4,z)=q_4$	1	0	3	4
q_4	e	$\delta(q_4,e)=q_3$	1	0	4	4
q_3	e	$\delta(q_3,e)=q_3$	1	0	5	4
q_3	z	$\delta(q_3,z)=q_4$	1	0	5	5
q_4	z	$\delta(q_4,z)=q_4$	1	0	5	6
q_4	z	$\delta(q_4,z)=q_4$	1	0	5	7

C1+C3=C2+C4
1+5=0+7
6≠7

Hence, the given input has unequal input characters.

It is possible to add so many states to the existing transition diagram. But there is a need for an efficient solution. Hence, we need Minimized Deterministic Finite Automata.

C. Minimized Deterministic Finite Automata

The Deterministic Finite Automata for accepting the equal input character for two input character has following tuples.

1. Starting state q0
2. Final States q1,q2.
3. Set of states {q0,q1,q2}
4. Set of input characters {e,z}
5. Transition function

$\delta(q_0,\{e,z\}) = \delta(q_0,e) + \delta(q_0,z)$
$= \{q_1\} + \{q_2\}$
$\delta(q_1,\{e,z\}) = \delta(q_1,e) + \delta(q_1,z)$
$= \{q_1\} + \{q_2\}$
$\delta(q_2,\{e,z\}) = \delta(q_2,e) + \delta(q_2,z)$
$= \{q_1\} + \{q_2\}$

The Transition Diagram of Minimized DFA for checking the equality of two input characters are as given in Figure 2.

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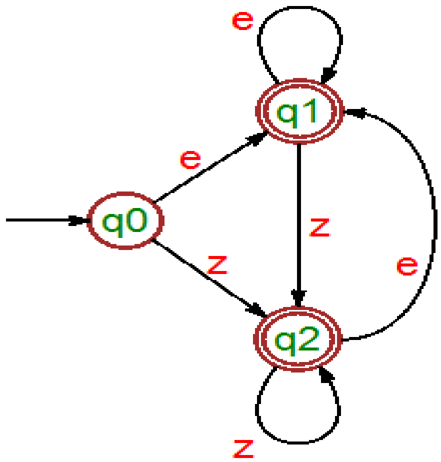

Fig.2.Transition Diagram of Minimized DFA for checking the equality of two input characters.

The transition table for Figure 2 is as shown in Table 4.

STATES	INPUT	
	'e'	'z'
→q_0	q_1	q_2
*q_1	q_1	q_2
*q_2	q_1	q_2

Table.4. Transition Table of Minimized DFA for checking the equality of two input characters.

Processing of input

Input: "ezeeezzzeezzze"

Table.5. Processing of input with the counter value.

States	Input Symbol	Transition Function	Counter	
			C1	C2
q_0	e	$\delta(q_0,e)=q_1$	1	0
q_1	z	$\delta(q_1,z)=q2$	1	1
q2	e	δ(q2,e)=q1	2	1
q1	e	δ(q1,e)=q1	3	1
q1	e	δ(q1,e)=q1	4	1
q1	z	δ(q1,z)=q2	4	2
q2	z	δ(q2,z)=q2	4	3
q2	z	δ(q2,z)=q2	4	4
q2	e	δ(q2,e)=q1	5	4
q1	e	δ(q1,e)=q1	6	4
q1	z	δ(q1,z)=q2	6	5
q2	z	δ(q2,z)=q2	6	6
q2	z	δ(q2,z)=q2	6	7
q2	e	δ(q2,e)=q1	7	7

The value of counter C1 denotes the total occurrence of input character 'e'. Whereas the value of counter C2 denotes the total occurrence of input character 'z'.

C1=C2

7=7

Hence, the given input has an equal number of input characters.

Input: "ezeeezzzeezzzz"

Table.6. Processing of input with the counter value.

States	Input Symbol	Transition Function	Counter	
			C1	C2
q_0	e	$\delta(q_0,e)=q_1$	1	0
q_1	z	$\delta(q_1,z)=q2$	1	1
q2	e	δ(q2,e)=q1	2	1
q1	e	δ(q1,e)=q1	3	1
q1	e	δ(q1,e)=q1	4	1
q1	z	δ(q1,z)=q2	4	2
q2	z	δ(q2,z)=q2	4	3
q2	z	δ(q2,z)=q2	4	4
q2	e	δ(q2,e)=q1	5	4
q1	e	δ(q1,e)=q1	6	4
q1	z	δ(q1,z)=q2	6	5
q2	z	δ(q2,z)=q2	6	6
q2	z	δ(q2,z)=q2	6	7
q2	z	δ(q2,z)=q2	6	8

C1=C2

6=8

6≠8

Hence, the given input has unequal input characters.

Input: "ezeeezzzeezzz"

Length of the string = 13

The number of input characters = 2.

Length of the string **mod** Number of input characters = 1

≠0

Therefore equality of input character not possible.

D.Three – Five Input Characters

The minimized DFA for the string length three, four, and five as shown in Figure 3, Table 7, and Table 8. The input taken here are {e,z,h},{e,z,h,i}, and {e,z,h,i,l} for three, four, and five input characters.

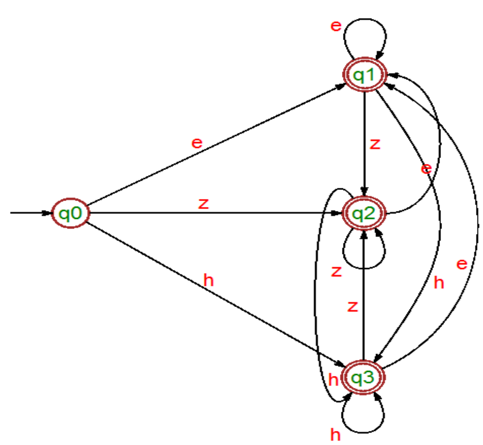

Fig.3.Transition Diagram of Minimized DFA for checking the equality of three input characters.

Table.7. Transition Table of Minimized DFA for checking the equality of four input characters.

STATES	INPUT			
	'e'	'z'	'h'	'i'
→q_0	q_1	q_2	q_3	q_4
*q_1	q_1	q_2	q_3	q_4
*q_2	q_1	q_2	q_3	q_4
*q_3	q_1	q_2	q_3	q_4
*q_4	q_1	q_2	q_3	q_4

Table.8. Transition Table of Minimized DFA for checking the equality of five input characters.

STATES	INPUT				
	'e'	'z'	'h'	'i'	'l'
→q_0	q_1	q_2	q_3	q_4	q_5
*q_1	q_1	q_2	q_3	q_4	q_5
*q_2	q_1	q_2	q_3	q_4	q_5
*q_3	q_1	q_2	q_3	q_4	q_5
*q_4	q_1	q_2	q_3	q_4	q_5
*q_5	q_1	q_2	q_3	q_4	q_5

The counter applied at the all final states. Then by checking the counter value it is possible to find equivalence of input characters for the given input string.

V.CONCLUSION

The Finite Automata cannot count the input characters for the given input string. Because it has some limitations. If we use the counter concept in final states, then it is possible to check equality of the input characters.

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