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Design of Minimal States Deterministic Finite Automaton to recognize Braille Language Pattern using the concept of Regular Expression

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Abstract: The research contribution focuses on designing of a minimal state deterministic finite automaton for Braille language pattern by using the conception of regular expression. Deterministic finite automaton is a very common and useful approach for designing machine or language. In this research automata technique is used for designing a Braille Pattern DFA. Further constructed DFA of Braille Pattern is minimized using the concept of contraction (or merging) of equivalent states algorithm.

Key words: Braille Language pattern, Deterministic Finite Automata (DFA).

INTRODUCTION

Automata theory provides the methods and techniques to construct abstract machines for any problem. Based on this concept automaton of Braille Language pattern can be developed. This research work proposes an approach to relate the deterministic finite automata with the Braille Pattern. The proposed method is cheap and less complex than many other systems that are currently in use by different local and international organizations.

Deterministic Finite Automata:

A deterministic finite automata (DFA) is a quintuple M= (Q,∑, δ, q_0, F), where Q is a finite set of states, ∑ a finite set called alphabet, $q_0 \in Q$, a distinguished state known as the start state, F a subset of Q called the final or accepting states, and $\delta: Q \times \sum \rightarrow Q$, known as the transition function.

The extended transition function can be defined. Let M= (Q∑, δ, q_0, F) be a DFA, we define the function $\delta^*: QX\sum^* \rightarrow Q$ as follows:

1. For any q∈ Q , $\delta^*(q,\lambda) = q$.
2. For any q∈ $Q, y \in \sum^* and a \in \sum \quad then \delta^*(q,ya) = \delta(\delta^*(q,ya))$.

A string is accepted by M if$\delta^*(q_0,x) \in F$. Thus the language recognized by the DFA M is the set we have referred to as a deterministic finite automata as an abstract machine. The operation of a DFA is described in terms of components that are present in many familiar computing machines. A computation of an automaton consists of the execution of a sequence of instructions where the execution of an instruction alters the state of the machine to some new state. The objective of a computation of an automaton is to determine the acceptability of the input string. An input string is accepted if the computation terminates in an accepting state; otherwise it is rejected. At any point during the computation, the result depends only on the current state and the unprocessed input. This combination is called a machine configuration and is represented by the ordered pair [q_i, w], where qi is the current state and $w \in \sum^*$ (John C., 2007; Thomas Sudkamp, 2006).

Braille Pattern Literacy:

Braille is a system of printing and writing for the blind created in 1824 by Louis Braille (1809–1852), a French inventor who went blind from an accident when he was three. Each character in Braille is made up of an arrangement of one-to-six raised points used in 64 possible combinations (Figure 1,2 & 3). Braille is read by passing the fingers over the raised characters. Braille is a series of raised dots that can be read with the fingers by people who are blind or whose eyesight is not sufficient for reading printed material.

Braille symbols are formed within units of space known as Braille cells. A full Braille cell consists of six raised dots arranged in two parallel rows each having three dots. The dot positions are identified by numbers from one through six. Sixty-four combinations are possible using one or more of these six dots. A single cell can be used to represent an alphabet letter, number, punctuation mark, or even a whole word. The enclosed Braille alphabet and numbers card illustrates what a cell looks like and how each dot is numbered.

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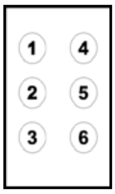

Fig. 1: The Braille Cell

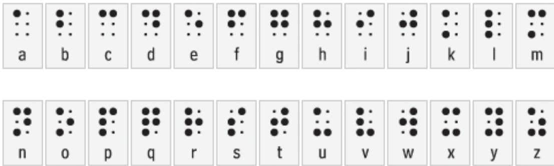

Fig. 2: Braille Alphabets

The Braille Language is used worldwide. For mostly all of the blind and many partially sighted persons, the Braille Language represents the only possibility to use a written language in order to communicate and coordinate their actions with other individuals.

Information technology offers the users of the Braille Language and others a previously unimaginable liberty of communication. The users of the Braille Language who communicate and coordinate with other individuals using other languages seem to meet certain obstructions and hindrances especially when Braille printed on paper is used (Standard English Braille Grades; Urdu Braille Guide Published 1989).

MATERIALS AND METHODS

DFA to Recognize Braille Pattern:

Abstract computing devices usually known as finite-state machines and the computations of such machines determine whether a string satisfies a set of conditions or matches a prescribed pattern. Finite State Machines share properties common too many real life mechanical machines when given input; they process input and generate output. The set of strings that are accepted as input defines the language of machine or input-out system. We are interested in introducing a class of abstract machines computations that can be used to determine the acceptability of input strings of Braille and Sign language (Urdu Braille Guide Published, 1989; S.M. Lucas, T.J. Reynolds, 2005).

Concept of regular expression can be used to express pattern/token in a language. In Automata theory machine receive regular expression in stream (on-by-one) and checks its validity on the basis of their syntax and semantic analysis and then accepts it.

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L (r.e) = {1, 2, 3, 4, 5, 6} (1)

In constructing the regular expression for Braille Language pattern the following combinations are taken using pattern matching techniques for software development and packet pattern matching for voice patterns , and related technologies can be referred in (Lucas, S.M.; Reynolds, T.J. 2005; Hardware acceleated; D.A. Fisher, C.W. Bond, *et al.*, 1992).

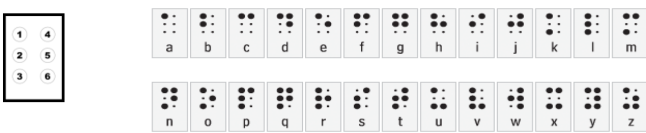

Fig. 3: Braille Alphabets Pattern

Table 1

Alphabets	Braille code	Alphabets	Braille code
A	1	N	1345
B	12	O	135
C	14	P	1234
D	145	Q	12345
E	15	R	1235
F	124	S	234
G	1245	T	2345
H	125	U	136
I	24	V	1236
J	245	W	2456
K	16	X	1346
L	123	Y	13456
M	134	Z	1356

It can be seen in Figure 2 that **‘a’** is on **‘1’** and in the same way for **‘b’**, **‘1’** and **‘2’** dots are used so one can say b is made of 12 in the same way all combination can be written in the following table:

$$\sum = 1 + 12 + 14 + 145 + 15 + 124 + 1245 + 125 + 24 + 245 + 13 + 123 + 134 + 1345 + 135 + 1234 + 12345 + 1345 + 234 + 2345 + 136 + 1236 + 2456 + 1346 + 13456 + 1356 \quad (2)$$

There is a facility of representing Capital letters and as well as digits in the Braille language. Braille language also includes the number sign and capital letters formed on those six dots.

For writing uppercase alphabets in Braille pattern a capital sign pattern is used in concatenation with lowercase characters. E.g. if capital ‘A’ is required then we use capital sign in which dots arise at position six along with lowercase ‘a’. To get the capital letters in Braille capital sign is used in a unique sequence of dots.

When writing numbers in Braille pattern, a number sign (left cell) along with lowercase characters (right cell) is used for **e.g**. if one is required then we use number sign in which dots arise at position 3456 along with lowercase ‘a’.

Now at this stage it is also necessary to add the regular expression to match the pattern if any capital or number occurs. The regular expression for capital sign is 6 and 2456 for number sign

$$L\ (r.e2) = \{6 + 3456\} \quad (3)$$

can’t be complete without the special characters so for special characters we have shown in table below:

Table 2:

Alphabets	Braille code
Capital Letter	1
Number Sign	12
.	256
,	2
‘	3
!	235
?	236
-	36

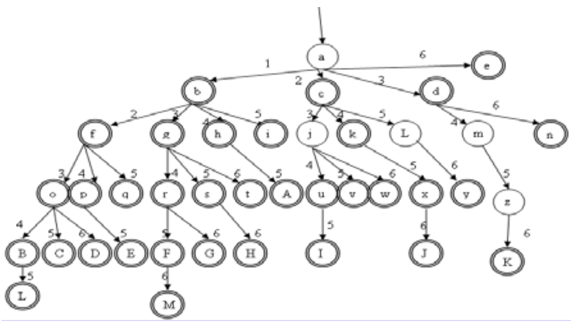

Fig. 4: Automata of Braille

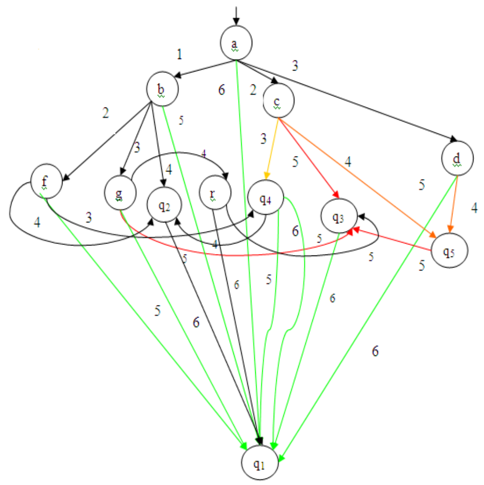

Fig. 5: Deterministic Finite Automata for Sin Language after minimization

V Result:

After minimization of Braille Automata (Figure 4) The minimized Deterministic Finite Automata (Table3 and Figure 5) contain total number of states Q= 12, which work faster than actual automata

VI Conclusion:

Modern technologies play an important part and for communicating deaf persons with normal persons. Assistive technology is important because, without assistive technology they will not have access or be able to benefit from their educational program and other matter of their life.

By the use of ICT, it is easy to develop an interactive communication system for them. Automata concept provides us the methods and techniques to construct abstract machines for Braille Language pattern .Based on this, I have developed an automaton that takes the English text as input and converts this into Braille language pattern using the concept of minimization which reduces the size of actual automata.

In proposed DFA of Braille language pattern, I used the position of fingers instead of complete hand. The proposed approach is cheap and less complex than many other systems that are currently in use by different local and international platform.

Table 3: Transition table of Braille Automata Figure 4

	1	2	3	4	5	6
a	b	c	d	⊥	⊥	e
b	⊥	f	g	h	i	⊥
c	⊥	⊥	j	k	l	⊥
d	⊥	⊥	⊥	m	⊥	n
e	⊥	⊥	⊥	⊥	⊥	⊥
f	⊥	⊥	o	p	q	⊥
g	⊥	⊥	⊥	r	s	t
h	⊥	⊥	⊥	⊥	A	⊥
i	⊥	⊥	⊥	⊥	⊥	⊥
j	⊥	⊥	⊥	u	v	w
k	⊥	⊥	⊥	⊥	x	⊥
l	⊥	⊥	⊥	⊥	⊥	y
m	⊥	⊥	⊥	⊥	z	⊥
n	⊥	⊥	⊥	⊥	⊥	⊥
o	⊥	⊥	⊥	B	C	D
p	⊥	⊥	⊥	⊥	E	⊥
q	⊥	⊥	⊥	⊥	⊥	⊥
r	⊥	⊥	⊥	⊥	F	G
s	⊥	⊥	⊥	⊥	⊥	H
t	⊥	⊥	⊥	⊥	⊥	⊥
u	⊥	⊥	⊥	⊥	I	⊥
v	⊥	⊥	⊥	⊥	⊥	⊥
w	⊥	⊥	⊥	⊥	⊥	⊥
x	⊥	⊥	⊥	⊥	⊥	J
y	⊥	⊥	⊥	⊥	⊥	⊥
z	⊥	⊥	⊥	⊥	⊥	K
A	⊥	⊥	⊥	⊥	⊥	⊥
B	⊥	⊥	⊥	⊥	L	⊥
C	⊥	⊥	⊥	⊥	⊥	⊥
D	⊥	⊥	⊥	⊥	⊥	⊥

	1	2	3	4	5	6
a	b	c	d	⊥	⊥	q_1
b	⊥	f	g	q_2	q_1	⊥
c	⊥	⊥	q_4	q_5	q_3	⊥
d	⊥	⊥	⊥	q_5	⊥	q_1
f	⊥	⊥	q_4	q_2	q_1	⊥
g	⊥	⊥	⊥	r	q_3	q_1
q_1	⊥	⊥	⊥	⊥	⊥	⊥
q_2	⊥	⊥	⊥	⊥	q_1	⊥
q_4	⊥	⊥	⊥	q_2	q_1	q_1
q_5	⊥	⊥	⊥	⊥	q_3	⊥
q_3	⊥	⊥	⊥	⊥	⊥	q_1
r	⊥	⊥	⊥	⊥	q_3	q_1

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