Facilitating visually impaired learners of Mathematics in ODL

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***Abstract*—Mathematics is a common and important subject for all in their schooling. Developing insight in Mathematics is difficult in the absence of visualization of the concepts / illustrations. This particular requirement prohibits visually challenged ones (VC) from learning mathematics.**

The trained human readers are scarcely available and screen reader applications are inadequate for mathematical text. The main reason is that several times mathematics text cannot be completely read linearly.

There are attempts to make elementary mathematics readable for VC. Aim of this paper is to extend such efforts for learning higher mathematics and add value to it by employing ICT.

We have developed syntax for unambiguous linear reading of a mathematics text. Also, we have developed MathX, an Android application that reads mathematical text for VC. The results of the software form the core of this paper. They are comparable with Braille. We hope this special tool in the category of assistive technology will receive a good response from VC.

Keywords—Assisitive Technology, Visual Handicapped, Mathematical Expression, Education.

I. INTRODUCTION

Visually challenged (VC) term categorized as low vision, functionally blind and totally blind refers to the greatly reduced vision, value of which may vary from dim-sighted to unsighted [18].

From an infant to an old age citizen, a person of any age can be a VC. In the world 285 million people are estimated to be visually impaired of which 13.6% are completely visually impaired (i.e., blind) [17].

The special needs of blind students are addressed in the subject "Blindness and Education" [17]. It is believed that up to 80% of what a normal child learns is through visual cues.

In this paper, we are reviewing available assistive technologies and building a model which will read mathematical text and will provide output in sound format.

II. RELATED WORK

We are dividing assistive technology into three categories: (i) Used for ICT and Communication, (ii) Used in web navigation, (iii) Used along with Braille Devices and (iv) Used for physical navigation. We are discussing the categories below :

A. Used for ICT and Communication

[3] elaborates the basis of the operator precedence (BODMAS) in an arithmetic expression. A normal eyesight person recognizes priorities in solving an arithmetic equation by its visual inspection which the VC is deprived of. Optical Character Recognition could be employed for reading a pdf or an image text file [8].

Findings of a survey on use of technology by learner-VC at different courses are compiled in Table 1 below.

Table 1: Use of Technology by VC

Sr no	Application domain	% use
1	ICT and Communication	70
2	Romanian Language	63

3	foreign language study	50
4	History	20
5	Mathematics	1

An impact of using ICT over Braille has been studied by asking the Subjects to extract grammar and semantics of a written text and execute it [9, 14, 7]. Musibraille transcribes notations of a musical composition into Braille [8, 15]. Screen readers like Orca are very familier to VC[11, 5]. They are 10 times cheaper than Braille interfaces and more accessible in general. Interactive robots have been employed to assist the brain-impaired children [6, 12].

B. Used in Web Navigation

The use of Assistive technology differs in every nation as requirement varies according to government guidelines [10]. Firefox, Google chrome add-ons are organized in three group viz. themes, plug-ins and extensions. [9] proposed the stability issues should be addressed while developing accessible web applications.

C. Used Along with Braille Devices:-

An Arabic Braille bi-directional and bi-lingual translation/editor system is used to convert English and Arabic words in Braille format [13] . “SingleTapBraille” is a model which will accept input from user with single tap [1]. An online service “RoboBraille” is available which will convert printed text or scanned text in Braille format [16].

III. CHALLENEGES FACED BY VC IN LEARNING MATHEMATICS

The Survey gives clear indication that the assistive technology is rarely used as educational-ads. VC can be assisted by human or technology but with some pros and cons given below.

A. Challenges in Human Assistance:-

Human assistance can be defined as assistive technology which can perform all category assistive work like education, navigation etc. Still, calling Human Assistance a perfect technology is not good. The Main issue is availability. As other assistive technology one cannot assure human availability. Even human can defined meaning of a statement in it own

way which may be wrong at some instances. In the case of mathematics if priority is not given human can change the equation priority according to his requirement unlike machine does. This may mislead the information.

B. Challenges in Machine Assistance:-

A technology like screen reader can allow VC to read the normal text. In case of Mathematical text non-linear structure leads an ambiguity. The priority in mathematical text is defined by Non-Linear structure. Due to non-linear nature screen reader cannot read mathematics according to priority. They read it as normal text. Screen readers NVDA, JAWS cannot read images. We are listing out which characters can be read in screen readers in following table.

Table 2: Symbols available in Screen-Reader

Sr No	**Symbol**	**Verbalization in Screen Reader**	**Pronunciation**
1	A	Not Possible	Alpha
2	B	Not Possible	Beta
3	Δ	Not Possible	Delta
4	∂	Not Possible	Derive
5	÷	Not Possible	Divided by
6	∈	Not Possible	Epsilon
7	Γ	Not Possible	Gamma
8	∞	Not Possible	Infinity
9	∫	Not Possible	Start Integration
10	Λ	Not Possible	Lambda
11	{	Not Possible	StarCurlyBracket
12	*(	Not Possible	Startbracket
13	[	Not Possible	Startsqaurebracket
14	-	Not Possible	Minus

15	π	Not Possible	Pi
16	+	Not Possible	Plus
17	∏	Not Possible	Startprod
18	}	Not Possible	EndcurlyBracket
19	*)	Not Possible	EndBracket
20	]	Not Possible	endSquareBracket
21	∑	Not Possible	StartSummation
22	/	Not Possible	Divided by
23	√	Not Possible	Square root of
24	*	Not Possible	Multiplied by
25	Θ	Not Possible	Theta
26	A - Z	Possible	A – Z
27	a-z	Possible	a-z
28	0-9	Possible	0-9

Images can be worked out with Character recognition software. The OCR like Google Docs, OnlineOCR.net are very good in performance but they are not able to scan non-linear mathematical symbols like summation, derivation, prod. Normally OCR is application for all characters in the range [A-Z],[a-z] and [0-9].

IV. MATHSPEAK

Mathspeak is a website defined for VC to give access to study materials in the field of Science, Engineering, Mathematics, and Technology. It works on inserting simple token in mathematical text and it converts non-linear mathematical structure into linear mathematical structure [42]. The some examples of Mathspeak statements are given below:-

Table 3: Math-Speak rules

Sr No	Mathematical Text	Mathspeak Conversion
1	$102 + 2,214 + 15 = 2,331$	02 plus 2,214 plus 15 equals 2,331

2	$59 \times 0 = 0$	59 times 0 equals 0
3	$0x15FF + 0x2B01 = 0x4100$	Number 0x15FF plus Number 0x2B01 equals Number 0x4100
4	1/x	StartFraction 1 Over x EndFraction

V. MATHX :-

We are proposing a novel idea of combining OCR techniques and Screen reader by considering Math-Speak rules. We found Math-speak provides a way of converting Non-Linear mathematical text into linear text and later on we can pass this to screen reader to get verbal output.

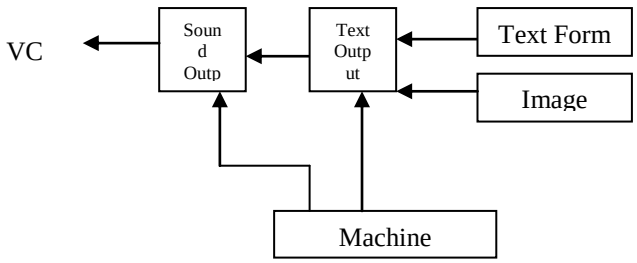

Figure 1:- General Idea of MathX

Here, Figure 1 specifies general idea of MathX in which input will be either in Text format or Image format. With the help of Machine Assistance we will linearize the text and it will be passed to screen reader for verbal output

Figure 2 briefly shows our model for reading mathematical text. The output is passed to mathematical text generator and it inserts token according to Math-speak rules. Thus we are getting linear mathematical statement which we can pass to any screen reader and can get required result.

The upper layer have three blocks namely Math text i.e. input to the system which will be either in linear format or non-linear format. After performing image processing, symbols and text will be retrieved by scanning line by line based on symbols database and Math heuristics. At this stage, we have linear mathematical text which can be passed to our screen reader which is based on Math-Speak rules.

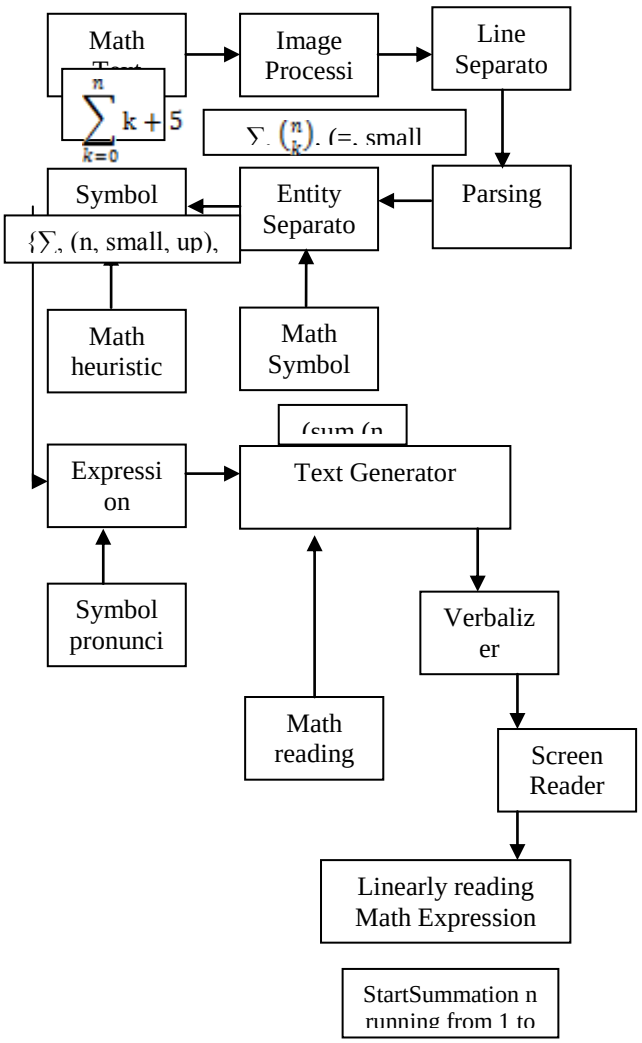

Figure 2 :- MathX Model

VI. CONCLUSION

We feel that the logic of MathX works for reading the mathematical symbols and is generalizable for the reading of any academic mathematics book as it covers most of the mathematical symbols. We also claim MathX will be novel, low cost and portable solution for assisting VC.

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