A SYSTEM FOR TRANSCRIBING MATHEMATICS INTO BRAILLE

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ABSTRACT:

Transcribing Mathematical documents into braille requires a knowledge and a mastery of mathematical braille which is very complex. Consequently editions of scientific books are very few in this area. This paper describes a system for transcribing automatically mathematical text into braille.

CONTENTS:

I. INTRODUCTION

Mathematical expressions are represented, in ink print, multilinearly, as for example:

$$\sum_{i=0}^{n} f(x)$$

The Braille transcription of this expression is realized linearly, which is the best adapted form for tactile reading. We may observe that the sighted person reads that expression in the following linearized way:

" $\sum$ for i=0 to n f(i)", which is similar to the one used by the blind:

" $\sum$ i=0,n,f(i)".

In this paper, we present the three different steps which are necessary to produce a Braille document:

1) acquisition of the scientific text.

2) linearization of the text,

3) Braille transcription of the linearized text.

These three steps are illustrated in Figure 1.

II. THE ACQUISITION OF SCIENTIFIC TEXTS.

Different acquisition methods exist for scientific texts. The purpose of most methods is to code mathematical texts in a linear form and to reproduce the original text on an output peripheral (graphic terminal, phototypesetter) (Badr78, Cher75, Knut78). This supposes the use of a mathematical text editor and a good knowledge of mathematics.

In a first step, to simplify acquisition, we preferred an off-line data acquisition with a display terminal, provided with a mathematical generator and tape cartridge units. The mathematical text is directly recorded on a tape cartridge by an operator who does not need any mathematical knowledge, the operator simply reproduces an exact image of the original on the screen. The terminal used is a HP2644A, it permits document acquisition on tape cartridge. The mathematical character generator implemented includes 255 mathematics symbols in the form of:

- keyboard for subscripts and superscripts,
- a keyboard for logical, relational and functional operators,
- a Greek alphabet.

Another possibility is the use of the photocomposition tapes. The use of photocomposition tapes is illustrated in Figure 2.

The common point of these methods is to produce a file of mathematical data in a multilinear form to be used by the sighted person.

We have not developed a special method to acquire scientific text for the blind. On the contrary, to simplify this acquisition and decrease its cost we use the same methods: a same file may be out in ink print and be useful for input data of our system.

III. MATHEMATICAL TEXT LINEARIZATION

In order to be transcribed the text must be linearized. To make this step easy, an acquisition convention is imposed. The group of lines of a mathematical text are separated by a white line in order to isolate a set of interrelated data (such as a matrix or integral elements).

Mathematical text linearization is realized in the same order as reading: the text is read from left to right following the main line, and linearized step by step.

III.1 Main line determination

Each data group has a main line. For instance, in the formula

$$\sum_{i=0}^{n} f(x)$$

$\sum f(x)$ is the main line.

"n" and "i=0" are in adjacent lines.

This main line is determined by a set of definite rules which correspond to the different possible cases. The rules have been ordered according to the frequency of their utilization, the intention is that they are more adequate than exhaustive (we need, for each possible case to have one determination rule and only one).

The text is scanned vertically from top to bottom and from left to right, until the meeting of a determination case.

FIGURE 1. The three steps necessary to produce a Braille document.

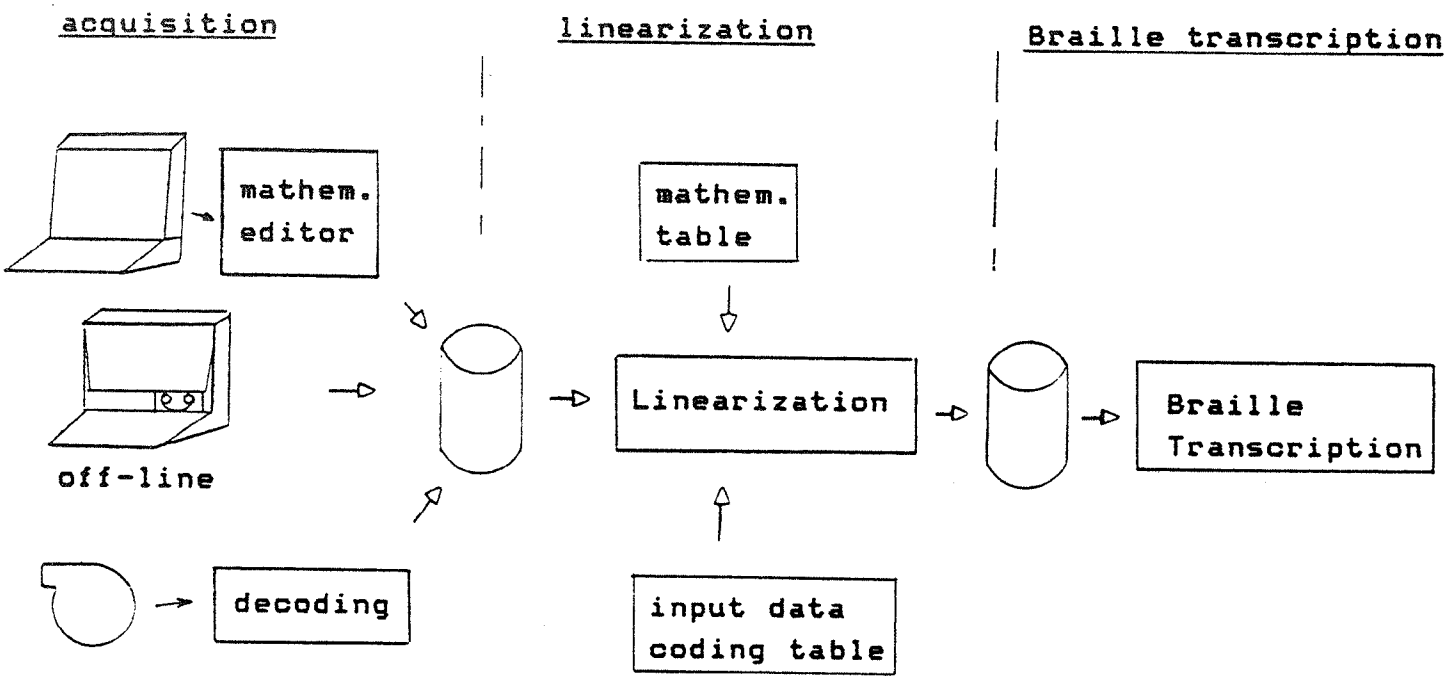
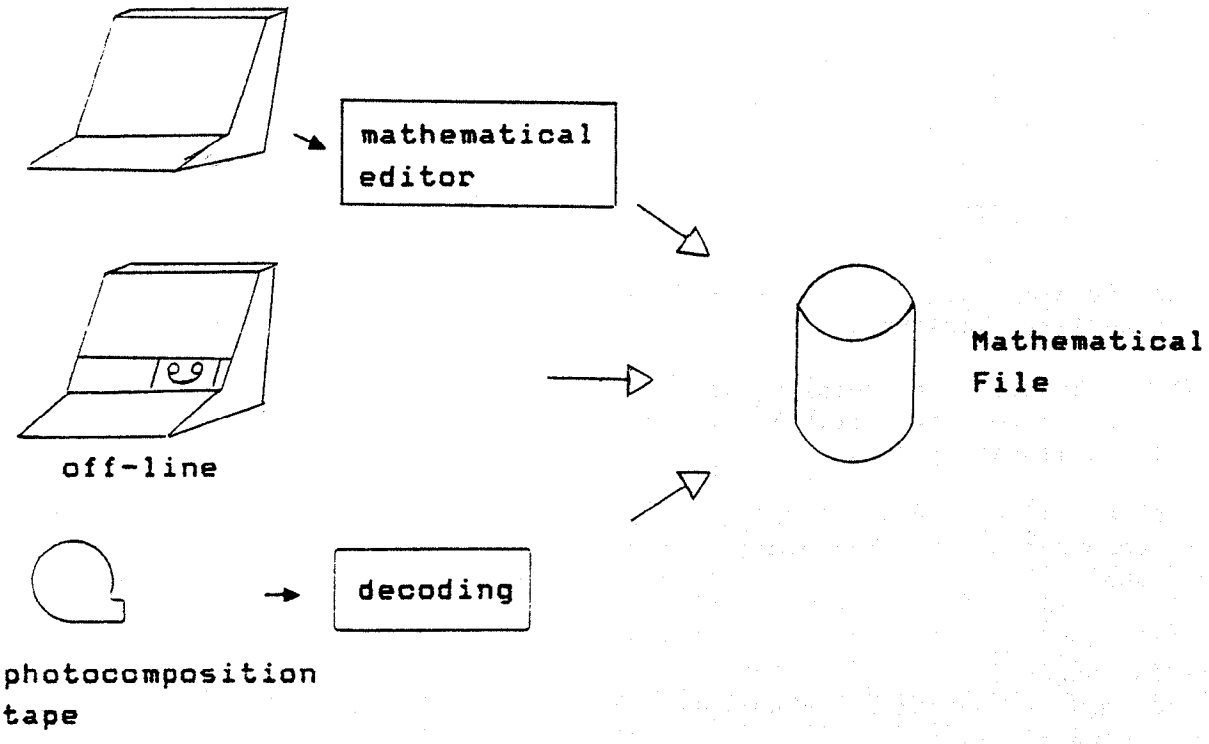


FIGURE 2. The use of photocomposition tapes.



III.2 Linearization

When the main line is determined, linearization is realized by scanning, from left to right, the mathematical expression along this line and cutting up the expression into different horizontal data groups. For instance,

$$f(x) = x^4 + \frac{4x^2 + 1}{x/2}$$

will be divided into three horizontal data groups

$$\boxed{f(x)} = \boxed{x^4} + \boxed{\frac{4x^2 + 1}{x/2}}$$

with "=" and "+" as intermediary characters. These data groups will be themselves subdivided, according to the cases, into vertical data groups.

$$\frac{4x^2 + 1}{x/2}$$

will be broken up into

$$\frac{\boxed{4x^2 + 1}}{\boxed{x/2}}$$

with the division sign "----------" as the intermediary character.

The mathematical expression is thus broken up into increasingly simpler expressions, linear or not.

The non-linear minimal expressions are a combination of elementary expressions, like

- a fraction,
- an integral,
- an expression with subscripts or superscripts,
- a matrix

For each elementary expression, linearization rules have been prepared which produce the Braille equivalent. The linearization of

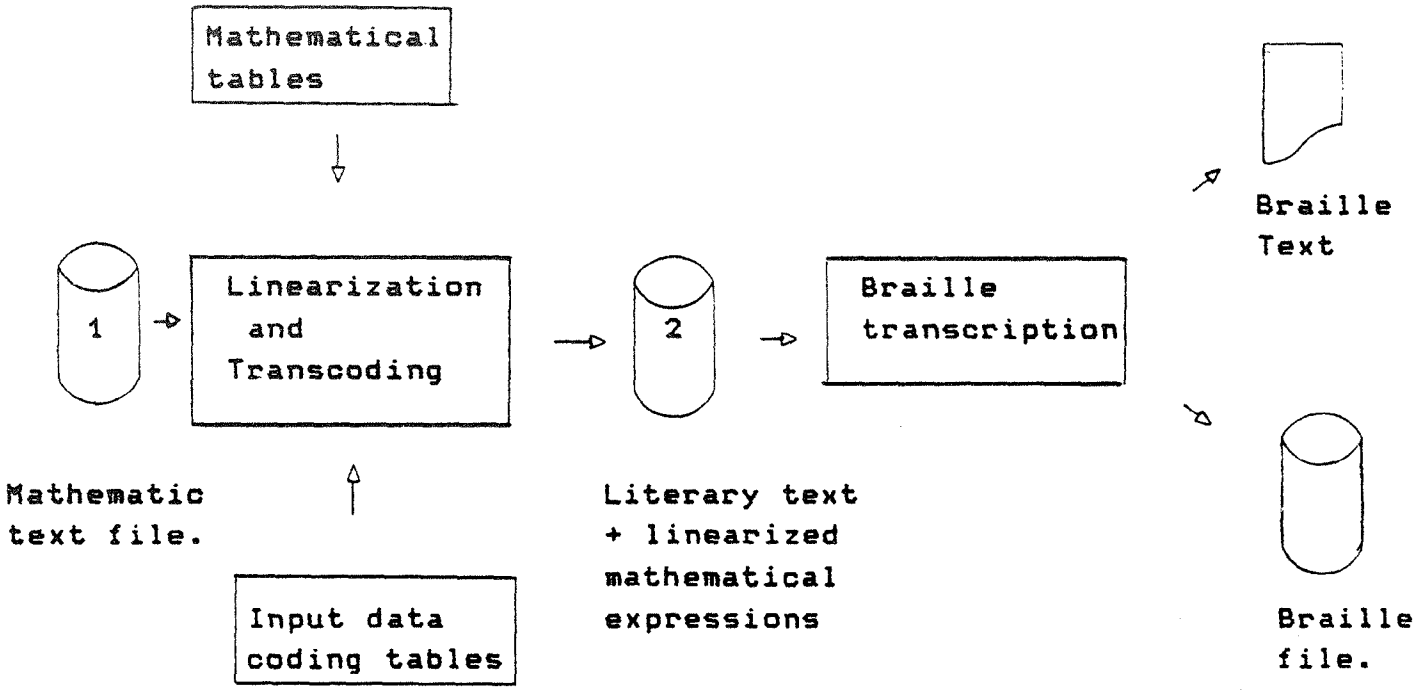
" $\int_b^a f(x)dx$" will be "Sum,a,b,f(x)dx"

The result of each linearization is concatenated with the results of previous linearizations according to the expression order.

The following algorithm represents the general process of linearization:

```
WHILE(not end of text)
DO BEGIN
     determine next data group;
     determine the main line of this
     group;
     WHILE(not end of line)
     DO BEGIN
          determine next horizontal group;
          linearize this horizontal group;
          concatenate the linearized text
     END
END
```

FIGURE 3. Transcribing literary text into Braille grade II.



IV. BRAILLE TRANSCRIPTION

A mathematical text includes literary text and mathematical formulae. For mathematical text acquisition we differentiate text from formulae by a special character.

In a first step, we consider only the mathematical expressions of the original text: they are linearized, then transcribed into Braille. The expression

$$I = \begin{vmatrix} a & b \\ c & d \end{vmatrix}$$

will be transcribed "I=det a b change of line c d det".

In a second step the literary text is transcribed into Braille grade II, and the transcription result is formatted by the Braille text editor. The entire process is illustrated in Figure 3.

This system can transcribe a general or specialized scientific text. For each specialization we only have to change the mathematical table in order to obtain the associated Braille text, because one symbol may have different meaning in different areas (and therefore a different transcription): the symbol "∧" indicates a vectorial product in geometry and a logical "AND" in Boolean calculus.

V. CONCLUSIONS

This system will allow the Braille transcription of scientific texts to be made on an international level (except the Braille grade II which is particular to each language), even if a different coding prevails in each country for the mathematical symbols. Yet, it seems necessary, to standardize the Braille mathematical notation on an international level, to give the blind a universal access to scientific Braille documents.

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