

# Automatic translator for mathematical Braille

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## Abstract

The Vickie Project aims at developing tools for the integration of impaired children in mainstream schools. We have in particular, developed an automatic translator for mathematical formulas: Latex, MathML presentation tag and French mathematical Braille are currently supported. In this document, we introduce the architecture and the use of our automatic translator for mathematical Braille. This translator accepts several inputs and output formats.

## 1 Introduction

### 1.1 The Vickie project

The Vickie project (Visually Impaired Children Kit for Integrated Education) is a European project whose goal is to give the tools for the integration of impaired children in mainstream schools. For this project, we need several tools which preserve the interaction between sighted and impaired children (teacher or sighted children/ impaired children).

Traditionally, in schools, Learning is based on writing. Blind students use a different writing mode: the Braille. For their integration, we need to translate all “traditional” documents in Braille and translate their works for the teacher. This action is easier if teachers or impaired child use automatics translators. In this study, we focus on the translation of mathematical documents.

### 1.2 Mathematics

There exist two Braille codes: the 6-dots Braille and the 8-dots Braille. Mathematical Braille code is based on the 6-dots Braille. With this code a Braille symbol is a matrix of three rows and two coulounes; it's can code only  $2^6 = 64$  different characters (including the space character).

Braille code – as normal text – is one-dimensional writing. But, mathematics uses two-dimensional writing (in case of using root square for instance). The Braille system needs to simulate the two-dimensional aspect of mathematics and edit all the mathematical symbols. In order to do that, it uses escape characters and translation rules. Escapes characters indicates that the next character will change of meaning. For instance, with these characters, we can change the writing mode (text, mathematics, ...) or build composed characters.

## 2 Mathematics Formats

## 2.1 Mathematical Braille code

Since the 80's, refreshable Braille displays allow blind people to access electronics documents, for browse instance web sites or edit a text file. This tool simplify the integration of impaired children in mainstream schools. The refreshable Braille display use Braille table to make a relation between electronic characters and Braille symbols. There are many Braille tables related to different alphabets. In French, two tables CBISF –for DOS System – and CBfr1252 – for the Windows system – are normally used. Moreover, blind people can create their personal tables. To translate correctly Braille file, we need to know the table whose the user use.

Contrarily to mathematical mainstream notation, the mathematical Braille notation is not international. There are many mathematical Braille notations; for instance, the American notation is called Nemeth, the German notation is called Marburg and two different notations exist for French.

## 2.2 Automatic translator for mathematical Braille

They exist automatics translator for mathematical Braille. For instance, there are:

- LaBraDoor [1] (Latex to Braille Door); it translate a formula write in Latex in the Marburg notation.
- BraMaNet [2] (Braille Mathématique sur Internet); it translate a formula write in MathML presentation tag (only) in French mathematical Braille notation
- The M.A.V.I.S [3] group have a translator whose translate a formula write in Latex in the Nemeth notation.

These translators have been develop in the goal to produce mathematical documents for blind students. As you can see, they works with a specific mathematical Braille notation.

## 2.3 Consequence

We can't impose one specific Braille table and one mathematical Braille code (Vickie is an European project). In consequence, we must produce automatic translation between several mathematical Braille codes and mainstream electronics mathematical formats. We decide to use MathML (presentation tag and semantic tag) and Latex formats because both are compatible with all mathematical equations and both are popular. These two formats are not so simple, but they can be generated by different software like Mathtype based on drag and drop interface. We have choose MathML because it is a recommendation of the W3C consortium to edit mathematics on the Internet.

# 3 Our translator

## 3.1 Central representation

### 3.1.1 Central language

To make an automatic translation, we need a dictionary which makes an association between the input and output format. In our case, we want to build a multi-directional translator.

Multitude of the formats requires building of many dictionaries. Moreover, if we add a new format for the input or the output, we need to add a new dictionary for every format we have.

To reduce the number of dictionary, we use a central language. Then, we have all the dictionaries whose the same structure: a word in a format and this transcription in our language. With these dictionaries to translate one formula, our translator must to do two translations:

- To translate the input format in the central language (a)
- To translate the central language in the output format (b)

Thanks to this method, to add a new format we must create only one dictionary.

### 3.1.2 Central representation

A central language is not enough. Those formats use several syntax to represent a mathematical equation. For instance, the MathML presentation tag represent an equation using the “traditional” equation while the MathML semantic use the polish notation. For example : (to simplify, we don’t write the MathML tag but only the structure of the equation)

$2+3=5$  for the presentation tag’s version

and

$= + 2 3 5$  for the semantic’s version

We can’t translate the two equations with the same translator. Then, we need a group of translators. Our tool is based on a central representation of the equation. The idea is to build the same central representation for a same formula indenpently of the input format.

For Analysis, our central representation should represent the mathematical equation structure. The polish notation shows this structure. The usual representation of the polish notation is a tree; the operator is a node and the “argument” is a leaf of the tree. Then, our tree is a semantic tree. All the nodes of our tree are written in our central language.

When we build the tree, we must follow the format rules. This stage run after the stage (a) and before the stage (b) of the 3.1.1. We call this stage the building module. The particularity of the tree structure is that we can change the equation notation changing our reading rules. Reading modules (stage (b)) are based of different reading rules of the tree. For instance, if we write up in the tree, we write mainstream notation.

## 3.2 Translator operation mode

To show the importance of the central representation, we show you the translator operation mode on translate one formula in two different translations :

- French mathematical Braille notation with the CBISF Braille table to MathML presentation tag (1)
- MathML presentation tag to Latex. (2)

We choose a simple formula to translate :

$$\sqrt[3]{a+b} \quad (3)$$

In French mathematical Braille notation, (3) is write :  $\wedge 3 @ < a ! b ;$  (1)

In MathML presentation tag, (3) is :  $\langle \text{mroot} \rangle \langle \text{mrow} \rangle \langle \text{mi} \rangle a \langle \text{mi} \rangle \langle \text{mo} \rangle + \langle \text{mo} \rangle \langle \text{mi} \rangle b \langle \text{mi} \rangle \langle \text{mrow} \rangle \langle \text{mn} \rangle 3 \langle \text{mn} \rangle \langle \text{mroot} \rangle$  (2)

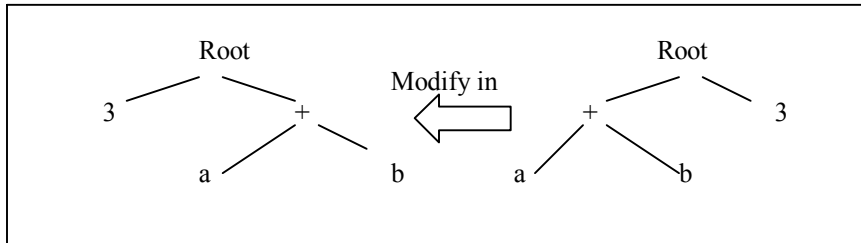
### 3.2.1 Input format to central language

We will use a pseudo-language for the central language is not our central language. This stage is different for the two translations. The Braille depends of one specific Braille table; it's for this reason we need to have a formula whose show the symbols indenpedently of the Braille table (4). We have :

|                  | (1)   | (2)  |
|------------------|---|--|
| (4)              | (6)(34)(146)(345)(56)(1)(235)(12)(23)         |  |
| Central language | <b>Init-root 3 init-square a!b end-square</b> | <b>Init-root init-square a!b end-square 3 end-root</b> |

### 3.2.2 Building module

With the formula in the central language, the translator build a central representation of the formula. The central representation must be the same for a same formula. To have the same representation we must to modify one of the two central representation. The first one is the tree of the (1) translation and the other it's the tree of (2).

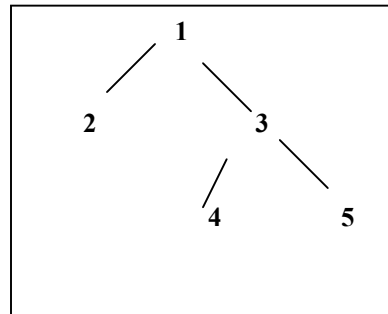


To have the same tree, we also change the order of the root children. For our translator we choose the first tree because Latex have the same structure.

### 3.2.3 Reading Module

We have said that reading module depend of the rules of reading the tree. We write the answer on the following table :

| Position on the tree | (1)  | (2)                        | Position On the tree |
|----------------------|--|----------------------------|----------------------|
| 1                    | $\langle \text{mroot} \rangle \langle \text{mrow} \rangle$ | $\backslash \text{sqrt} [$ | 1                    |
| 3                    |  | 3                          | 2                    |
| 4                    | $\langle \text{mi} \rangle a \langle \text{mi} \rangle$    | $] \{$                     | 1                    |
| 3                    | $\langle \text{mo} \rangle + \langle \text{mo} \rangle$    |                            | 3                    |
| 5                    | $\langle \text{mi} \rangle b \langle \text{mi} \rangle$    | a                          | 4                    |
| 3                    | $\langle \text{mrow} \rangle$                              | +                          | 3                    |
| 1                    |  | b                          | 4                    |



|          |                                     |   |          |
|----------|-------------------------------------|---|----------|
| <b>2</b> | <code>&lt;mn&gt;3&lt;/mn&gt;</code> |   | <b>3</b> |
| <b>1</b> | <code>&lt;/mroot&gt;</code>         | } | <b>1</b> |

To have the answer of the translation, we make the concatenation of all rows of this table. For Instance, for **(2)** we have the answer :

$\sqrt[3]{a+b}$

With this example, we know that the tag **init-root** is ‘^’ in French mathematical Braille notation with CBISF as Braille table, `<mroot><mrow>` for MathML presentation tag and `\sqrt[` for the Latex. As you can see, the output format is independ of the input format.

## 4 Current statement

The translator was developed on Java including major features and support of Latex and French Braille. Support MathML is currently under developing.

It will be included on software service for the vickie project. A simple interface was developed for demo purpose. A site whose allow testing the translator was create to. You can find the prototype in the following address : <http://inova.snv.jussieu.fr/math5>

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## References

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<sup>1</sup> The contents of this paper is the sole responsibility of the authors an in no way represents the view of the European Commission or its services.