Short presentation

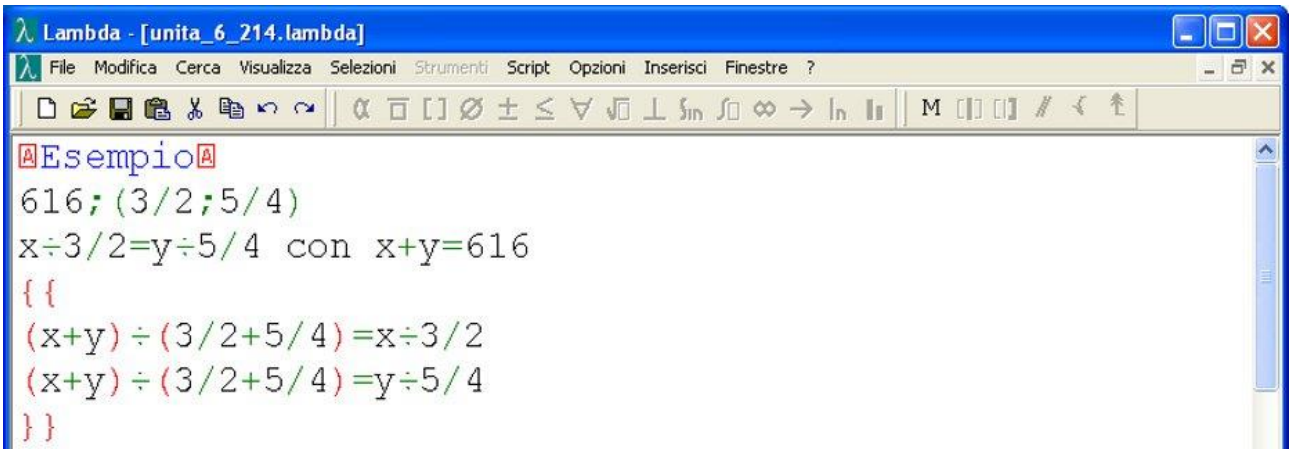
Blind people have always considered the study of Mathematics as a difficult problem to solve, that strongly hindered the chance to approach scientific studies for generations of visually impaired people. The use of computer is very large among blind students, who appreciate more and more its advantages (speed, efficiency, access to a large quantity of papers, almost unlimited), yet in the field of Mathematics, the benefits are still limited, due to its complex symbols and its bi-dimensional writing.
LAMBDA is system based on the functional integration of a linear mathematical code and an editor for the visualization, the writing and the manipulation of the text.

The code (Lambda Mathematical Code) directly derives from MathML and it was designed to be used with Braille peripherals and the vocal synthesis. It is automatically convertible, in real time and without mistakes, into an equivalent MathML version and, through it, into the most popular mathematical formats (LaTeX, MathType, Mathematica...), both input and output.

The editor allows to write and to manipulate mathematical expressions in a linear way and provides a series of compensatory functions. In fact, the user is supplied with some aids to reduce the difficulties in understanding and managing the text, due to the visual handicap and to the need to use a linear code to manage the formulas. LAMBDA was meant for secondary-school to university students; some basic skills in computer science are necessary

Longer presentation

The LAMBDA System



The LAMBDA team designed a system based on the functional integration of a linear mathematical code and an editor to display, write and manipulate a text.
A new code has been created (the LAMBDA code), which is strictly connected with MathML: it is always possible to automatically convert the LAMBDA code into MathML and vice versa, without ambiguities. Then, using one of the available conversion systems, it is possible to turn the text into LaTeX. Therefore through LAMBDA, it is always possible to access these formats, that cover most of the scientific papers, both input and output.
The LAMBDA code is designed to be presented to the user through the editor and it is easy and compact to be used with Braille peripherals.
The LAMBDA editor has a very important function. As the visualization programs of LaTeX and MathMl, it transforms the source code, so it appears in a very simple and immediate way to the user, and for the visually impaired users it is a linear code easy to be read on the screen and, through the vocal synthesis. However, another fundamental difference is that the LAMBDA software is an editor and not only a simple browser, so it allows the user to write and manipulate the formula, not only to read it as the displays for LaTeX and MathMl do.
The LAMBDA source code is hidden to the user: he does not need to enter it, because it can be easily managed through the editor.
The compactness of the LAMBDA code is mainly due to mathematical symbols and markers, that are represented by a very small number or characters, often a single one. The risk of misunderstanding and the difficulty in comprehension are overcome thanks to the management system, that provides various methods for reading: the vocal synthesis can spell the name of the element or reading the whole formula in a natural language, moreover the entire name of the element, on which the cursor is positioned, always appears on the status bar, that can be read whether through the Braille display or the vocal synthesis.

Braille
The LAMBDA special symbols and markers have been designed on the basis of the 8-dot Braille combinations representing them: all the most common operators, markers and symbols will be represented by a single character, chosen as much as possible like the corresponding 6-dot Braille character, used in the various national codes, so to facilitate the initial training and memorization process.
Even if LAMBDA source code is unique (and then the LAMBDA documents do not depend on local choices), the Braille code, applied to it, changes according to the various countries, to adapt as much as possible to national traditions and customs.
For example, a compound fraction, whose numerator and denominator are made of more elements or expressions, needs three markers for the LAMBDA code: one indicating the beginning of the fraction, another for the fraction bar, that separates the numerator from the denominator, the third one to show the end of the fraction.
Those symbols will be managed by the programme and saved on files through a code, that identifies them univocally, yet they will appear on the Braille display in different ways, according to the country where they are used. Moreover, the textual descriptions and the voices associated to the vocal synthesis are translated into the various languages.
As for the Italian version, for example, the compound fraction needs three Braille symbols; for each of them there will also be the Italian text for the name of the marker and one indicating the words, to be pronounced by the synthesis, to have a natural and smooth reading.

Braille dots	Marker name	Text read by the vocal synthesis
12467	Open compound fraction	Open fraction (or simply "fraction" for the skilled users)
47	Intermediate compound fraction	Fraction sign
13458	Close compound fraction	End fraction

For example, the formula a+b divided by a-b corresponding to dots 12467, 1, 235,12, 48,36,12,13458

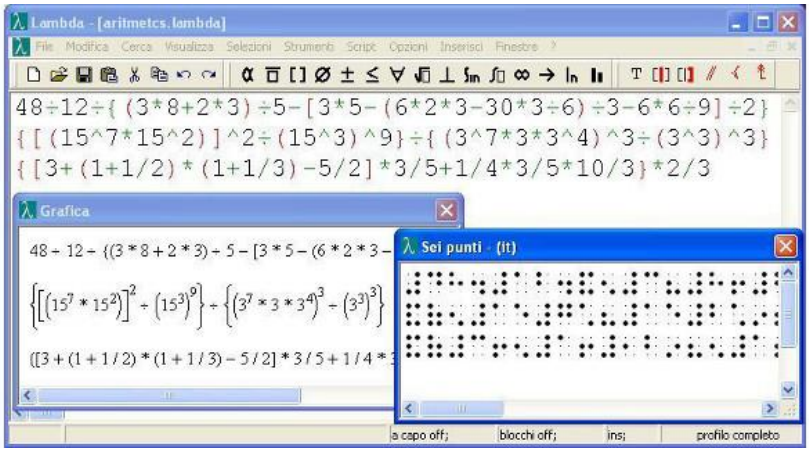
As you can see, the couple open/close is very similar to open and close numerator in the Italian 6-dot Braille (it was not possible to use the same symbols because, in the 8-dot code, the combination 1246 is already assigned to number 6).
The intermediate, the fraction sign, is very similar to the 6-dot bar (dots 34).
In other countries, there are various rules (also very different) to indicate the compound fraction in 6-dot Braille, therefore other combinations of Braille dots will be chosen to represent the three LAMBDA markers.
As the available Braille combinations are less than the needed symbols, sometimes it is necessary to use combinations of Braille dots (a sequence of two or more symbols to define a single element). In the definition of the 8-dot Braille code for Mathematics, the Braille characters used are much less than the 256 (28) available ones. A too elevated number of new symbols would create issues tied to discrimination, memorization and training. The learning-by-heart process can be performed for a limited number of cases; generally, when it is not possible arguing by analogy with the 6-dot code, as the example above, it is better to exploit logical or mnemonic links. To define a prefix to indicate the specific use of a symbol, in set theory for example, we could use a series of symbols already known and memorized. In this table, there are some LAMBDA symbols with the set-theory prefix (dots 48).

Union Prefix	for set theory and addition
Set difference	Prefix for set theory and subtraction
Proper subset	Prefix for set theory and less than
Improper subset	refix for set theory and less than or equal

Besides the set-theory prefix (for the Italian Braille dots 4 and 8), other three prefixes have been defined:
- negation (dots 3468), it inverts the meaning of the following symbol (for example: not equal, it is not an element of…);
- greek (dots 45), to represent the Greek letters; it is to be followed by the corresponding Latin letter, both capital or small letter;
- generic (dots 34568), used in various disciplines, in particular Geometry and Logic.

Notice that, even if they are represented by more characters, the symbols and the markers are always considered as a single element (they have to be entered, cancelled, moved, selected… as they were a single character). Moreover, the vocal synthesis will always read the name of the element, not the sequence of symbols (for example, it will pronounce “gamma” and not “Greek prefix g”, “union” and not “set-theory prefix addition”, “much greater than” and not “greater than, greater than”).

How to interact with the mathematical document on the screen



Even if LAMBDA is intended for blind people, its documents have to be used also by sighted individuals through the screen or the traditional ink printer. In a didactical environment, the teacher support is fundamental, since he has to follow up all the learning process and not only to test and evaluate the final work. For a blind student, the most typical feature in doing Mathematics is the linearity of the code, not the use of Braille or the other specific devices. To become a real help, the teacher has to understand all the consequences this kind of approach involves; for example, the need to use markers that usually are not necessary in the traditional notation, the risks tied to their use, the greater difficulties in operating with fractions (for example, to find the common denominator to sum algebraic fractions), the strategies to be used to manipulate the document using the keyboard, instead of a pen and a piece of paper. The pupil has to be helped in these tasks and that is the teacher's duty.
For this reason, the LAMBDA system shows the mathematical text on the screen as a linear code, exactly what appears on the Braille display, by using a textual graphic font. The symbols, that do not have a conventional representation, are displayed using specific characters, designed on purpose, showing as much clear as possible the meaning of the text.

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International price list

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