Multilingual mathematical e-document processing

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Outline

1. Arabic writing
   - Features

2. Arabic mathematical expressions
   - Mathematical language
   - Practices
   - Arabic mathematical notation
   - Internationalization & Localization

3. Arabic mathematical document composition
   - Problems
   - Normalization
   - Mathematical font
   - Symbols encoding
   - Typesetting system

4. Arabic mathematical expressions on the web
   - MathML I18n

5. Summary
- Arabic alphabet

  - the direction of writing spreads out from right to left
  - the shape of a letter depends on its position in the word
    - 4 forms: isolated, final, median, initial
  - the cursivity of the writing joins characters
  - Arabic letters represent only consonants or long vowels.
    - Optional diacritical marks for short vowels can be used to annotate text or spell it out in full when desired
  - some letters differ only by the presence, the number and the position of dots
  - some letters differ only by some parts of glyphs
Arabic alphabet

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  - input order  rendering order
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• the letters can be superposed through ligatures as characters
• the letters can be stretched in a curvilinear way through the kashida, which is a curved elongation of character
• some letters and words can also be superposed as non characters
• several calligraphic styles can be in use.
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Most electronic science, technical, engineering and medical documents contain mathematical expressions. Since the renaissance, the mathematical language knew a deep and constant evolution inside the western natural languages where mathematical knowledge was produced. Typesetting improvements followed, always in the same languages.

That was not the same for the Arabic language. Throughout this period where mathematical development was going with lingual evolution, Arabic mathematical language kept out of the mathematical turning out. Countries who have developed mathematics got a mathematical language rooted in their natural language. Arabic mathematical language stood as it was centuries ago until that modern mathematics came. Then, mathematics was to be taught in foreign languages.

Later, in some countries, the teaching of mathematics has been partially or totally arabizised.
There are many mathematical notations according to the regions:

- **Latin mathematical presentation** as in English or French: Symbols are then imported from one of these European languages writing, according to the dominant cultural influence. Symbolic writing is then running in the opposite direction of the natural language (text and expression are intermixed bidirectionally).

- **Arabic mathematical presentation**: Specific symbols are used and the writing follows the direction of the natural language handwriting which is from right to left. Arabic presentation uses symbols coming from the Arabic alphabet. Other symbols can be vertically reflected Latin symbols. The so-called Arabic or Arabic-Indic digits represent numbers.
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\int_{1}^{x} x^i \, dx & \text{if } x \in S \\
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- **Bi-directionality of writing**: in handwriting, whenever a line begins with an Arabic sentence followed by a Latin mathematical expression, it is necessary to know the length of this expression a-priori. Otherwise, the symbolic formulation writing will overpass the sentence or at contrary it will stand far from.

- **Reading symbols**: if the pronunciation of a foreign abbreviation is done in conformity with the foreign language, then the corresponding Arabic word will never be in use. If the abbreviation is done in Arabic, then there won’t be any relationship between what is written and what is said.

- **Origins of symbols**: the relationship between symbol’s shape and symbolized concept’s name vanishes completely when the western symbol is used into the Arabic writing. Cohabitation of two punctuation systems...
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expressions spread from right to left

\[
\frac{1 + \frac{\sqrt{2}}{2}}{(1 + \frac{\sqrt{2}}{2})^2} = \sum_{\varepsilon} \text{جاز} (\varepsilon) = \sinh(x) = \sum_{i=0}^{n} \frac{x^{2i+1}}{(2i + 1)!}
\]

- alphabetic symbols used are with or without dots
- the alphabetic order uses in mathematics differs from text one
- no cursivity is applied between adjacent alphabetic symbols
- several styles are used to extend the amount of symbols
- there are two numeral systems
- Arabic abbreviations in use are composed through connected letters with cursivity but without diacritic signs; with or without dots


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  \text{ب} \quad \text{ب} \quad \text{ب} \quad \text{ب} \\
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superscript and subscript are on the left

\[ b^2 \quad b_2 \]

- some symbols are mirrored
- some literal symbols are used
- there are two punctuation systems

These differences are an additional source of difficulties for mathematical documents composition tools in Arabic. Moreover, the use of a mathematical symbol can be localized. There can exist different local options to denote symbols. Both the previous symbols and \( \sum \) can denote the operator sum.
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with variable-sized symbol

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In a multilingual environment, allowing mathematical objects in Arabic to:

**Pedagogical goals**
- be composed in a perfect precision with high quality
- be adapted according to the area
- be moderated according to the schooling level
- be personalized to handicaps
- be translated between notations
- be computed and interacting for learning

**Technical goals**
- separate content from several presentations
- offer several formats allowing exchange between software
- be published on the web
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Intend to encode mathematical expressions human legible and hand writable with preserving all information.
Image based method

**Quality:** poor typographical quality

**Size:** big size files for storing or downloading

**Reuse:** mathematical expressions can’t be reedited

**Structuring:** mathematical information is not available for searching, indexing, ...

**Portability:** mathematical expressions can’t be processed by a computer algebra system nor a translation system

**Needs**
- Normalization
- Mathematical font
- Symbols encoding
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Needs

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Sources of the standards:

- handbooks
- conventions such as the Amman’s convention
- standards of the AMS and the ISO
- practices of \TeX{} and MathML
Creating a mathematical font is a complex artistic and technical task.

**RamzArab**

Design and development of the OpenType font RamzArab that tries to meet, as far as possible, the requirements of:

- **Homogeneity**: designing symbols with the same feather for homogeneous shapes, sizes, boldness, ... 
- **Completeness**: regrouping most of the usual specific Arabic symbols in use 
- **Originality**: observing the most of practical calligraphic rules
Conception of **CurExt** system designing some dynamic symbols. The parentheses and Kashida symbols are representative of the possible cases of horizontal and vertical curvilinear extensibility. So, that can be easily generalized to other variable-sized symbols. A lengthening of the straight line is not in conformity with the Arabic calligraphy rules.
The Unicode Standard provides a quite complete set of standard mathematical characters. There are a good deal of symbols found in Arabic mathematical handbooks that are not yet part of the Unicode Standard and can’t be obtained through a simple mirroring nor through a simple implementation process. Some of such special characters, designed in RamzArab, are proposed for inclusion into the Unicode Standard and now are on discussion. Until their adoption by Unicode, the symbols used in these tools will be located in the Private Use Area E000–F8FF in the Basic Multilingual Plane.
RydArab

Development of RydArab system as a TeX package. It preserves all the distinguished qualities:

- a full numerical composition
- a high typographical quality
- offering several options to adapt it to areas and levels
- same commands structure in order to automatize translation
- generating documents in several formats (DVI, PS, PDF)
- producing documents in format HTML with image based mathematical expressions
- towards transformation from/to OpenMath ⊗ MathML

\[
\text{\texttt{\textbackslash arabmath}}\ \{\text{\root{3b} \ of} \ \{2+\{\text{\frac{b*9}{c}}\}\}\}\\
\frac{9^\omega}{\omega} + 2\sqrt[3]{1}
\]
Semantically, an Arabic mathematical expression has the same functionality as its Latin equivalent: same content MathML tree skeleton but with different content for token elements.
Only rendering aspects need to be taken into account: same presentation MathML tree skeleton with different content for token elements is insufficient.
MathML extension

After examining all notational conventions, in current use with Arabic, the following step is to clarify the specification of MathML, proposing extensions where needed, so that MathML has the broadest coverage possible proposals:

- **Direction**: the overall mathematical directionality should be determined by a `dir` attribute on the outermost `math` element; which takes one of the values `ltr` or `rtl`. The text content of each token element should be treated as a separate directional segment and the bidirectional algorithm should be applied to each independently.

- **Additional Mathvariants**: isolated, initial, tailed, looped, stretched and double-struck.

- **Mirroring**: codepoints for Arabic mathematical symbols are not available yet, but appropriately marked for mirroring.

- **Arabic specific notation**: additional allowed value `madruwb` for the notation attribute `menclose` of factorial symbol.
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MathML CtoAP

Content MathML is generally language-neutral. In contrary, presentation MathML necessarily targets a specific language and notational conventions.
After carrying out mathematical operations on content code, the usual situation is that the result is rendered.
CtoAP is an XSLT stylesheet that converts a Content MathML to Arabic Presentation MathML.
There may be several notations for one concept in the Arabic mathematical notation to choose:
Dadzilla is a MathML browser for Arabic mathematical presentation. It is an adapted version of Mozilla. Already existing MathML elements can be used for both Latin and Arabic mathematical presentations after specifying the environment by the single attribute `dir="rtl"` in `<math>` element.

To correctly display MathML documents in Arabic presentation, some fonts must be installed: Mirrored **BaKoMa Computer Modern** fonts & Adapted Arabic mathematical symbols font **RamzArab**.

The mathematical expression editor **mathmled** is integrated after its adaptation for Arabic mathematical presentation.

In the future version of **Dadzilla**, some improvements should be made. In particular, using stretched Arabic alphabetical symbols, offering some localization choices and improving the interface.
Conclusion

The ambitious project for the development of communication and publication tools for Arabic scientific and technical e-documents in multilingual environment presents many challenges. Our goal was to identify the difficulties and limitations that can obstruct the use of existing tools for composing mathematics in Arabic presentation.

Arabic mathematical e-documents can be composed, structured and published on the web using these developed tools. Thus, such documents benefit from all the advantages of using available norms. We hope that the previous proposals can help in finding suitable recommendations for multilingual mathematics in appropriate standards (Unicode, MathML, OpenMath, . . . ).
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لكل نمط مما ينوي أربع إجابات واحدة فقط صحيحة أُطلق إلى دفتر أجابته رمجمه ك: (1) 

\[
\cfrac{1}{5} \left( \frac{\sqrt{5-4s}}{5} + 1 \right)
\]

(2) إذا كانت ص = ق (س)، وكانت د (س) = 3 دس + (د س)² عندما تكون ص من 2 إلى 2+دس فإن معدل التغير في الدالة عندما ص = 2 هو

\[
5 \left( \begin{array}{c}
\cfrac{1}{5} \\
\cfrac{1}{5} \\
\cfrac{1}{5} \\
\cfrac{1}{5}
\end{array} \right)
\]

(3) من بين الدوال التالية، الدالة المفصلة عند ص = -4 هي:

\[
\left\{ 
\begin{array}{c}
\text{ب (س)} = \sqrt{4s + 4} \\
\text{ب (س)} = \sqrt{4s - 4}
\end{array} \right.
\]

(4) Azzeddine LAZREK 24/25

Dadzilla

Multilingual mathematical e-document processing
Outline
Arabic writing
Arabic mathematical expressions
Arabic mathematical document composition
Arabic mathematical expressions on the web

Summary

\[ \text{Dadzilla} \]

\[
<math xmlns="http://www.w3.org/1998/Math/MathML"
    dir="rtl">
  <mrow>
    <msup>
      <mi>\omega</mi>
      <mn>2</mn>
    </msup>
  </mrow>
</math>
\]