The GF Mathematics Library

Jordi Saludes
UPC
Sistemes Avançats de Control

jordi.saludes@upc.edu

Sebastian Xambó
Universitat Politècnica de Catalunya.
Barcelona, Spain
??

The *Mathematics Grammar Library* (mgl for short)

1 Introduction

Using the *Grammatical Framework[10]*.

?? Descriure la historia: Projecte webALT ??

The objective of the library is to allow natural language services for mathematical constructs at the level of high school and college freshmen linear algebra and calculus, that eventually could grow up to cover more sophisticated productions.

At the present stage, the visible goal is to provide rendering of simple mathematical exercises in multiple languages. A demo is available (see [5])

2 The library

The library is a collection of GF modules

GF types are called *categories*, they are used to declare signatures for the functions that generate the grammar. Ours are all possible combinations of **Variable** and **Value** with the mathematical categories: **Number**, **Set**, **Tensor** and **Function**. Thus the category `VarNum` denotes a numeric variable like x, whilst `ValSet` denotes an actual set like "the domain of the natural logarithm". The distinction between variables and values allows us to type-check productions like lambda abstractions that require a variable as the first argument. Obviously variables can be promoted to values when needed.

Other categories stand for propositions, geometric constructions and indices.

The library is organised matrix-like with an horizontal axis ranging over the targeted natural languages. At the moment these are: Bulgarian, Catalan, English, Finnish, French, German, Italian, Romanian, Spanish and Swedish.

The vertical axis is for complexity and contains from bottom to top, three layers:

1. The *Ground* layer;
2. The *OpenMath* layer;
3. The *Operations* layer.

The ground layer is very shallow and stands for literals, indices and variables. The intermediate layer is called *OpenMath* because is modelled after *OpenMath Content Dictionaries* which are sets of mathematical objects collected by the *OpenMath consortium[7]*.

Each *Content Dictionary* corresponds to a module in this layer.

The top layer (*Operations*) deals with simple mathematical exercises like compute, find, prove, give an example ....

An example from the *OpenMath* layer:

```
mkProp
  (lt_num
    (abs (plus (BaseValNum (Var2Num x) (Var2Num y))))
    (plus (BaseValNum (abs (Var2Num x)) (abs (Var2Num y)))))
```

gives in Spanish:

> El valor absoluto de la suma de x y de y es menor que la suma del valor absoluto de x y del valor absoluto de y

```
DoSelectFromN
  (Var2Num y)
  (domain (inverse tanh))
  (mkProp
    (gt_num
      (At cosh (Var2Num y))
      pi))
```

gives in English:

> Select y from the domain of the inverse of the hyperbolic tangent such that the hyperbolic cosine of y is greater than pi.

References

[1] O. Caprotti (2006): *WebALT! Deliver Mathematics Everywhere*. In: *Proceedings of SITE 2006*.

[2] O. Caprotti, W. Ng'ang'a & M. Seppälä (2005): *Multilingual technology for teaching mathematics*. In: *Proceedings of the International Conference on Engineering Education, Instructional Technology, Assessment, and E-learning (EIAE 05)*.

[3] O. Caprotti & M. Seppälä (2006): *Multilingual Delivery of Online Tests in Mathematics*. In: *Proceedings of Online Educa Berlin 2006*.

[4] L. Carlson, J. Saludes & A. Strotmann (2005): *State of the art in multilingual and multicultural creation of digital mathematical content*. Available at `http://webalt.math.helsinki.fi/content/e16/e301/e305/Deliverable1.2_eng.pdf`.

[5] Thomas Hallgen & Jordi Saludes (2010): *Math bar online*. Available at `http://www.grammaticalframework.org/demos/minibar/mathbar.html`.

[6] B Greer L Verschffel & E De Corte (2000): *Making sense of word problems*. Taylor & Francis.

[7] Paul Libbrecht (2010): *OpenMath*. Available at `http://www.openmath.org/`.

[8] S Xambó M. Seppälä & O Caprotti (2008): *Toward autonomous learners of mathematics*. In E.M. Rocha J.M. Borwein & J.F. Rodrigues, editors: *Communicating Mathematics in the Age of Digital Libraries*, A K Peters, pp. 239–252.

[9] W. Ng'ang'a (2006): *Multilingual content development for eLearning in Africa*. In: *eLearning Africa: 1st Pan-African Conference on ICT for Development, Education and Training*.

[10] Aarne Ranta (2010): *Grammatical Framework*. Available at `http://www.grammaticalframework.org/`.

[11] Aarne Ranta (2011): *Grammatical Framework: Programming with Multilingual Grammars*. CSLI Publications, Stanford.

[12] A. Strotmann, W. Ng'ang'a & O. Caprotti (2005): *Multilingual Access to Mathematical Exercise Problems*. In M. Dobreva & J. Engelen, editors: *Electronic Proceedings of the Internet Accessible Mathematical Computation Workshop. ISSAC 2005*, Chinese Academy of Sciences, Bejing, China.

[13] A. Strotmann & M. Seppälä (2005): *Web Advanced Learning Technologies for Multilingual Mathematics Teaching Support*. In M. Dobreva & J. Engelen, editors: *ELPUB2005. From Author to Reader: Challenges for the Digital Content Chain. Proceedings of the 9th ICCC International Conference on Electronic Publishing*, Peeters Publishing, Leuven-Heverlee (Belgium).

[14] Wikipedia: *Word problem*. Available at `http://en.wikipedia.org/wiki/Word_problem_(mathematics_education)`.

[15] S. Xambó, H. Bass, G. Bola nos, R. Seiler & M. Seppälä (2006): *E-Learning Mathematics*. In: *Proceedings of the ICM-2006 (Volume III)*, European Mathematical Society, pp. 1743–1768.