

# MathML in Polynomial Toolbox for Matlab

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## Abstract

This short note reports on a useful application of MathML to web presentation and export/import of polynomial matrices from/to the *Polynomial Toolbox for Matlab<sup>TM</sup>*. Two Matlab functions are described that can be used both for high quality visualization of polynomial matrices on web and for data exchange between Polynomial Toolbox and other software packages that compute with polynomial matrices and support MathML format like Mathematica 4.1 and Maple 7.

## 1 Basic definitions

*Polynomial Toolbox for Matlab<sup>TM</sup>* is a commercial Matlab-based package for systems, signals and control analysis and design based on advanced polynomial methods. Being developed by leading specialists in the field, the toolbox offers by far the most complete set of reliable algorithms for computation with polynomials and polynomial matrices. All the algorithms are numerical in nature and as such they are several orders of magnitude faster than their symbolic counterparts found in some computer algebra systems.

The toolbox relies on the object oriented programming features of Matlab. It defines a new Matlab class POL for storing all the information necessary for full specification of a polynomial matrix with constant coefficients.

Consider a polynomial matrix

$$A(s) = \begin{bmatrix} 1 & 1+s \\ 1-s^2 & 2s \end{bmatrix}$$

Entering a polynomial matrix in Matlab prompt is very convenient as the Polynomial Toolbox follows the general Matlab syntax

```
>> A=[1 1+s; 1-s^2 2*s];
```

*MathML* is a new markup language for encoding the structure of mathematical expressions so that they can be displayed, manipulated and shared over the World Wide Web. MathML expression can be evaluated in a computer algebra system, rendered in a web browser, edited in a word processor, and printed on your laser printer. MathML 2.0, a W3C Recommendation was released on 21 Feb 2001. It is product of the W3C Math working group [7].

## 2 Conversion from POL format to MathML

The first of the two presented Matlab functions converts the specification of the polynomial matrix in the POL format to the MathML format. The function is named POL2MML and the syntax is very simple. Get the MathML code corresponding to the POL representation of the matrix  $A(s)$  using the function POL2MML:

```
>> pol2mml(A)
```

In Matlab command window we immediately see the required code

```
<math xmlns='http://www.w3.org/1998/Math/MathML'>
<mrow>
<semantics>
<mrow>
<mi>A</mi>
<mo>&ApplyFunction;</mo>
<mfenced><mi>s</mi></mfenced>
<mo>=</mo>
<mo>[</mo>
<mrow>
<mtable>
<mtr>
<mtd>
<mrow>
<mn>1.00</mn>
</mrow>
</mtd>
.
.
.
</mrow>
</mtd>
</mtr>
</mtable>
<mrow>
```

```

<mo>]</mo>
</mrow>
<annotation-xml encoding="MathML-Content">
<reln>
<eq/>
<apply>
  <fn><ci>A</ci></fn>
  <ci>s</ci>
</apply>
<matrix>
<matrixrow>
  <cn type="real">1.000000000000000</cn>
  <apply>
    <plus/>
    <ci>s</ci>
    .
    .
    .
    <ci>s</ci>
  </apply>
</matrixrow>
</matrix>
</reln>
</annotation-xml>
</semantics>
</mrow>
</math>

```

The dots in the code listing are just space-savers and were inserted manually. This listing reveals several features of POL2MML:

- Presentation, content and mixed markup are supported. Default method is mixed markup.
- Mixed markup is implemented via XML annotation mechanism.
- Optional insertion of Java applet tags specifying "webeq.Main" for the code parameter. Intended for WebEQ Math Viewer display method [5].
- The format of coefficients in the presentation markup is inherited from the display format of POL object in Matlab or can be specified explicitly.
- The format of coefficients in the content markup is 15-digit scaled fixed point (*long* format in Matlab) to assure as low loss of precision due to truncation as possible.
- Optionally copies the output in the clipboard (on Windows systems only).
- Optionally saves the MathML code to a specified file.
- Possible insertion of XML namespaces (m:) for displaying with MathPlayer engine [6].

### 3 Conversion from MathML to POL format

The developers of both numerical and symbolic algorithms for polynomial matrices as well as practising en-

gineers need to compare the results across the computational platforms. MathML appears to be a good format for this purpose. Indeed, packages like Mathematica and Maple in their latest versions support MathML language. Matlab function MML2POL was developed that takes MathML code either from a specified file or directly from the clipboard (on Windows systems) and creates a corresponding POL object. Detailed error report is produced if inconsistencies in code are encountered.

## 4 Experience with MathML features in Mathematica 4.1 and Maple 7

In this section some discrepancies and bugs in MathML features in Mathematica 4.1 and Maple 7 are pointed out that prevent from full utilization of MathML language to mathematical data exchange. Our experience proves that the MathML technology is not well settled yet. But this will surely improve. Nonetheless, our function was fine-tuned to recognise some of these Mathematica- and Maple-specific bugs and to get around them. The rest has been reported as bugs to the producers.

### 4.1 MathML in Mathematica 4.1

1. Lack of Content Markup or Mixed Markup option for export from Mathematica. Only Presentation Markup is supported.
2. The command `MathMLForm[s^2+3*s+5]` gives

```

<math>
<mrow>
  <msup>
    <mi>s</mi>
    <mn>2</mn>
  </msup>
  <mo>+</mo>
  <mrow>
    <mn>3</mn>
    <mo>&it;</mo>
    <mstyle>
      <mspace width='0.3em' height='0.3ex' />
    </mstyle>
    <mo>&it;</mo>
    <mi>s</mi>
  </mrow>
  <mo>+</mo>
  <mn>5</mn>
</mrow>
</math>

```

Note that in the middle of the code listing, double usage of `<mo>&it;</mo>` tag is exhibited. It appears that Wolfram developers use this tag just to include white space, while the original purpose can be best seen from its full name - `&InvisibleTimes;`. For presentational purpose it makes no problems but as Mathematica has no Content Markup option, some other packages might have hard time trying to understand the content.

3. The command `MathMLForm[s^2 + 5.4*s]` gives

```
<math>
<mrow>
  <msup>
    <mi>s</mi>
    <mn>2</mn>
  </msup>
  <mo>+</mo>
  <mrow>
    <mn>5.4</mn>
    <mo>&it;</mo>
    <mstyle>
      <mspace width='0.3em' height='0.3ex' />
    </mstyle>
    <mo>&it;</mo>
    <mi>s</mi>
  </mrow>
</mrow>
</math>
```

Note that apostrophe is erroneously inserted into `<mn>5.4'</mn>`.

#### 4.2 MathML in Maple 7

The command `ExportPresentation(5e9)` gives `<mn>.5e9</mn>`, which is wrong because `0.5e9` is not the same as `5e9`.

### 5 GUI for display of a polynomial matrix during a Matlab session

Current version of Matlab (version 6.1) does not enable visualization of user's data using Matlab interactive *workspace browser*. A tiny GUI was developed that serves the purpose of displaying polynomial matrices during a Matlab session. This GUI is based on containment of a commercial (about \$20) *IBM techexplorer Hypermedia Browser* ActiveX control in a Matlab figure container. Nice technical display of a polynomial matrix might be helpful when scrutinizing the result of some operation for a particular numerical property.

#### Conclusions

A few applications of MathML that might be useful for scientists and engineers computing with polynomials and polynomial matrices were described in this report. First, a Matlab function `POL2MML` for export from the Polynomial Toolbox for Matlab to MathML is reviewed. The produced MathML code can then be imported to some other package like Mathematica or Maple or used directly for high quality reusable display on web. Second, a Matlab function `MML2POL` for import of a MathML code into the Polynomial Toolbox is advertised. It has been pointed out however, that as the MathML standard is not quite settled in practice, there are several 'clones' of MathML around which a good parser must

be able to deal with. The presented tool has been tested and fine-tuned for MathML code produced by Mathematica<sup>TM</sup> and Maple<sup>TM</sup> software packages. Third, a tiny GUI called POLVIEW was presented that might be appreciated by the users of the Polynomial Toolbox. This GUI serves the purpose of displaying a polynomial matrix during a Matlab session and modification of its display format, including fonts, displaying precision, color. Currently (version 6.1) Matlab does not allow for incorporating user's data types into its interactive workspace browser and therefore POLVIEW might fill the gap temporarily. This GUI assumes that the *IBM techexplorer Hypermedia Browser* professional version is installed on the computer.

The three functions are available for free at [1].

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