Towards Universal Rendering in MathJax

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Introduction

- Accessibility to Mathematics is essential for inclusive education
- Particular on the web as mathematics is badly supported
- MathJax is already a visual rendering solution
- Make it universally accessible
- Instead of relying on browsers or screen readers we have created an AT solution in MathJax

- Based on some work done in ChromeVox at Google and later extended in Benetech's MathMLCloud project
- Now supported by AMS and Sloan Foundation

The State of Maths (Accessibility) on the Web

- MathML is officially part of the HTML5 standard
- MathML has very limited support from Browser vendors
- MathML spec is seriously outdated

- Maths is given as LaTeX or ASCIIMath instead of MathML

Web Accessibility:

- Out of the box:
  - ChromeVox in Chrome (MathML or LaTeX/ASCIIMath via MathJax)
  - VoiceOver in Safari has some support for MathML
- NVDA, Jaws via MathPlayer (if installed!) and/or MathJax

What is MathJax?

- MathJax is a JavaScript library for rendering Mathematics in all browsers
- Can take LaTeX, AsciiMath, and MathML as input
- Generates browser output, e.g. HTML/CSS, SVG
- MathJax is the de facto rendering solution of (nearly) all Mathematics on the web (35 million unique daily rendering requests via CDN)

Web Accessibility:

- Can't expect Maths solutions from general AT
- Turn MathJax from Visual to Universal Rendering solution
- Support users with wide variety of print impairments: Enable magnification, simplification, highlighting, aural rendering, etc.

Visual to Universal Problem

- Presentation MathML information is rather trivial
- MathJax provides a variety of renderers:
  - CommonHTML, SVG, HTML/CSS, native MathML, ...

Example: Rendering Quadratic Equation

$$ax^2 + bx + c = 0$$

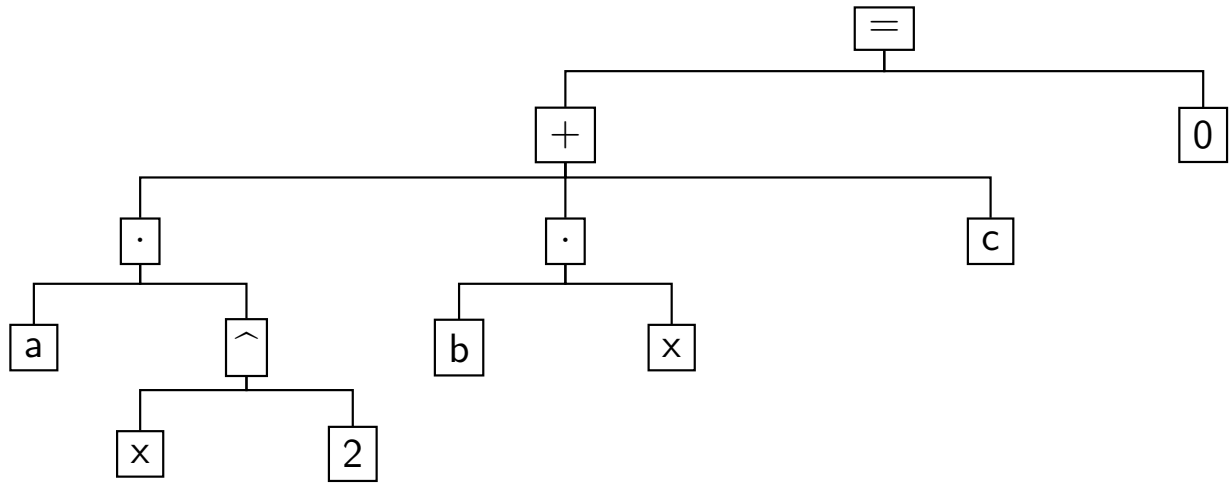
```
<math>
  <mi>a</mi>
  <msup>
    <mi>x</mi>
    <mn>2</mn>
  </msup>
  <mo>+</mo>
  <mi>b</mi>
  <mi>x</mi>
  <mo>+</mo>
  <mi>c</mi>
  <mo>=</mo>
  <mn>0</mn>
</math>
```

```
<span class="math" id="MathJax-Span-7" role="math" style="width
  <span style="display: inline-block; position: relative; width
    <span style="position: absolute; clip: rect(1.457em 1000em
      <span class="mrow" id="MathJax-Span-8">
        <span class="mi" id="MathJax-Span-9" style="font-family
        <span class="msubsup" id="MathJax-Span-10">
          <span style="display: inline-block; position: relativ
            <span style="position: absolute; clip: rect(3.397em
              <span class="mi" id="MathJax-Span-11" style="font
                <span style="display: inline-block; overflow: h
              </span>
              <span style="display: inline-block; width: 0px; h
            </span>
            <span style="position: absolute; top: -4.415em; lef
              <span class="mn" id="MathJax-Span-12" style="font
              <span style="display: inline-block; width: 0px; h
            </span>
          </span>
        </span>
...
</span>
```

Semantic Enrichment

- Impose "light" semantic interpretation on MathML expression
- Originally developed in ChromeVox for K-12 Mathematics
- Rewrite syntax tree into a term tree and "fold" into MathML.
- Propagate into DOM, expose via data attributes.

```
<math>
  <mi>a</mi>
  <msup>
    <mi>x</mi>
    <mn>2</mn>
  </msup>
  <mo>+</mo>
  <mi>b</mi>
  <mi>x</mi>
  <mo>+</mo>
  <mi>c</mi>
  <mo>=</mo>
  <mn>0</mn>
</math>
```



Assistive Technology Extension

- Responsive Equations and Abstraction
- Interactive Exploration
- Highlighting
- Speech Generation

Same UX regardless of MathJax renderer, platform, browser, AT.

Responsive Equations

- Responsive design enhances a core feature of HTML: reflow
- Re-arrange, optimise, and transform content (images, icons, tables)
- Mathematics combines the properties of text, tables, and graphics into a single problem

- Automatic reflow for simplifying layout, adapting to form factor of display and magnification
- Intelligent linebreaking by exploiting semantic enrichment
  - Don't break in the middle of an expression
- Chunking: Abstracting over large elements
  - collapsing mathematically meaningful sub-expressions

Aural Rendering/ Highlighting/ Interaction

- "Walkers" for interacting with mathematical expression
- Synchronised highlighting together with aural rendering
- Mathspeak speech strings are computed with Speech Rule Engine initially implemented in the context of ChromeVox and extended for MathMLCloud
- Speech output by updating ARIA live regions
- Chunking seems to be particular to reduce cognitive overload and also helpful for dyslexic students

Example: Quadratic formula

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

x equals StartFraction negative b plus-or-minus StartRoot b squared minus 4 a c EndRoot Over 2 a EndFraction

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StartFraction negative b plus-or-minus StartRoot b squared minus 4 a c EndRoot Over 2 a EndFraction

$x =$ ◀/▶

collapsed fraction

100%

$x =$ ◀/▶

x equals collapsed fraction

100%

Conclusion

- Runs with the majority of platform, browser, screen reader combinations. Full support matrix at `https://github.com/mathjax/MathJax-RespEq/wiki/Support-Matrix-a11y-tool`
- User feedback from experts and blind users at different levels
- Starting some pilot projects

- Current implementation is available as MathJax extension at `https://github.com/mathjax/MathJax-RespEq/`
- Available via our CDN soon `https://cdn.mathjax.org/`
- Should become permanent feature in 3.0 release

Web References

- Demo:
  - http://mathjax.github.io/MathJax-RespEq/examples/Struik.html
  - http://mathjax.github.io/MathJax-RespEq/Semantics-Lab/TeX.html
  - http://mathjax.github.io/MathJax-RespEq/Semantics-Lab/TeX-linebreaking.html
- Systems:
  - https://github.com/mathjax/MathJax/
  - https://github.com/mathjax/MathJax-RespEq/
  - https://github.com/zorkow/speech-rule-engine/
  - https://github.com/mathjax/MathJax-node/