

An On-line MathML Editing Tool for Web Applications

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Abstract

MathEdit [23] is a browser-based tool implemented in JavaScript that provides a convenient and intuitive graphical user interface for creating and editing mathematical expressions as well as a well-defined API for interoperating with its containing Web page. MathEdit can produce MathML Content and Presentation Markup as well as infix expressions for Web applications. The results returned can be displayed in a Web page or used in further computations. Here, we describe the methods of expression editing, visual navigation, and the MathEdit API. We also present the actual use of MathEdit in such interactive Web applications as curve plotting and Math-capable BBS.

1. Introduction

The ability for users to interactively create and manipulate mathematical expressions is very important for systems such as Science Communication Environment, Computer Algebra Systems, and Web-based Mathematics Education [8, 14, 15, 25, 26]. MathEdit is a browser-based mathematical expression editor developed jointly by Lanzhou university/China and Kent University/USA [2, 23, 27]. Running in a Web browser, MathEdit allows users to create and edit mathematical expressions with a convenient and intuitive graphical user interface and programs to access it with a well-defined API. With MathEdit, users can easily enter mathematical expressions online as answers to questions in mathematics lesson pages [5, 22] for example. Web page authors can also embed MathEdit in their interactive Web page to create mathematical expressions. Figure 1 shows the main MathEdit user interface (boxes with black lettering are part of the illustration). The extent of the templates menu is easily customizable to support different levels and areas of mathematics. MathEdit is implemented in

standard JavaScript [17] and DOM [3]. MathEdit runs within any standard Web browser that supports JavaScript and DOM. Figure 2 shows the end-user view of the MathEdit architecture. User actions, mouse clicks and keyboard input, are treated as commands. Commands invoke JavaScript functions in the command processing module. The main command processing modules include expression editing and visual sub-expression navigation. Each edit operation basically adjusts the DOM tree of MathML content markup [2, 9, 20] kept internally for the mathematical expression being constructed or edited.

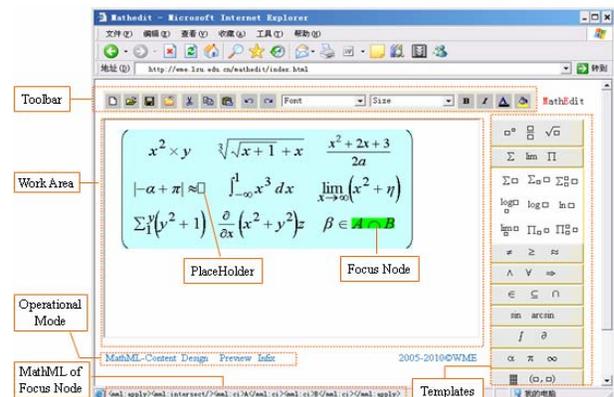


Figure 1. MathEdit Authoring Environment

MathEdit can serialize the content tree to MathML Content, Presentation, and Mixed Encodings as well as to an infix string. For reading an existing expression, we use the Mozilla XML Dom parser under the Mozilla family browsers [10, 11] and the MSXML parser under Microsoft IE to conveniently process the MathML input. The *Mathematical Expression Toolbar* is customizable and extensible via adding and deleting templates. New special characters, such as ∞ , Greek Characters, etc, can also be introduced by the user through a combination of keyboard and mouse operations.

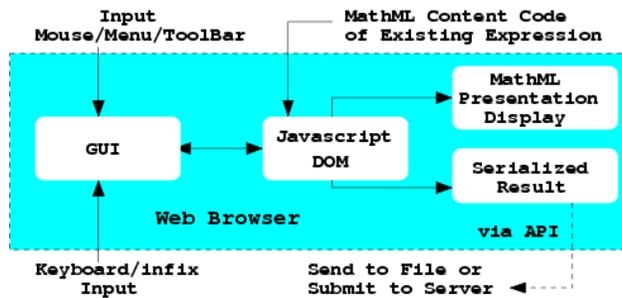


Figure 2. MathEdit Architecture

We begin by describing the editing and user interaction parts of MathEdit. Then we'll show how this tool can be used, through its API, to add mathematical formula capabilities in other Web applications.

2. Expression Editing

It is essential to provide convenient and intuitive operations to insert and remove the desired structures, including sub-expressions, operators and characters. MathEdit supports several forms of user input, infix, MathML and template. Infix is convenient for users who are familiar with the notation. For others, the common approach is to use graphical templates [1, 4, 7, 16, 19, 21] that can be selected to enter particular kinds of mathematical expressions such as fractions, square roots, powers, and so on.

2.1 Templates

Graphical icons represent mathematical special characters and expression patterns. Each item on the *template panel* expands to reveal a group of related templates (Figure 3). Combining infix input and template selection (via the mouse or keyboard shortcut) makes it easy and flexible for users to create expressions. After inserting a template, the internal DOM tree and the display are updated with required expressions indicated by *placeholders*. The user can select each placeholder to enter the desired expression.

2.2 Entering Expressions

Expression editing is done by selecting an insertion point or a sub-expression to replace and then entering an expression. The command processor module adjusts the target node on the MathML content tree through DOM.

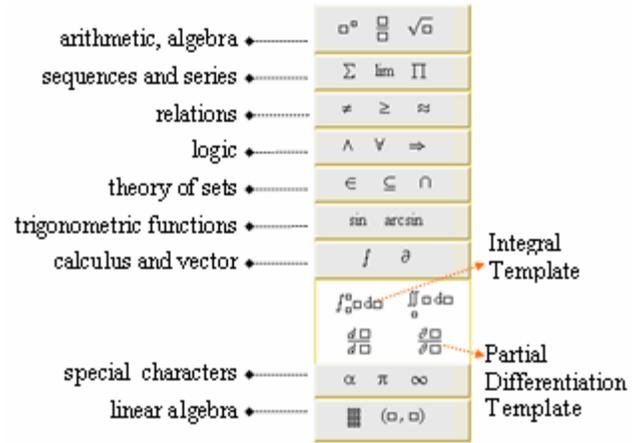


Figure 3. Template Panel

Token input is the most basic operation. Three kinds of input tokens, digit (0 through 9 and the decimal point), letter (alphabetical character, mathematical symbols and Greek characters) and sub-expression (including operator), can be entered by keyboard or mouse. The command processor analyzes the input token incrementally as it is received and displays it immediately. Table 1 shows how the treatment of a new token (row headings) is dependent on the previous token (column headings).

MathEdit makes it easy to correct typing errors. The Backspace key deletes the last character typed that is still in the input buffer. The Backspace key has no effect if the input buffer is empty. The Delete key erases the current expression and replaces it with a placeholder if necessary to maintain the integrity of the MathML content code.

Table 1. Inputting Operation Methods in MathEdit

New Token Previous Token	Letter	Number	Templates or Operator
Letter	Append the new letter. E.g. $a \leftrightarrow b \Rightarrow ab$	Append the new number. E.g. $a \leftrightarrow 2 \Rightarrow a2$	Add new sub-expression and the focus node will be the part of sub-expression. E.g. $\pi \leftrightarrow \frac{\square}{\square} \Rightarrow \frac{\pi}{\square}$

Number	The number multiplies the letter. E.g. $3 \mapsto b \Rightarrow 3b$	Append the new number. E.g. $3 \mapsto 2 \Rightarrow 32$	Add new sub-expression and the focus node will be the part of sub-expression. E.g. $3 \mapsto \sqrt[3]{\square} \Rightarrow \sqrt[3]{3}$
Sub-expression	Replace the sub-expression with new letter. E.g. $\lim_{x \rightarrow \infty} (x^2 + 1) \mapsto y \Rightarrow \lim_{x \rightarrow \infty} y$	Replace the sub-expression with new number. E.g. $\frac{d}{dx} y \mapsto 3 \Rightarrow \frac{d}{dx} 3$	Add new sub-expression and the focus sub-expression will be the part of new sub-expression. E.g. $(\beta \in A \mapsto (\square \cup \square)) \Rightarrow (\beta \in A \cup \square)$
Placeholder	Replace the placeholder with the letter. E.g. $\square \mapsto \theta \Rightarrow \theta$	Replace the placeholder with the number. E.g. $\square \mapsto 5 \Rightarrow 5$	Replace the placeholder with the template. E.g. $\square \mapsto \sum \square \Rightarrow \sum \square$

2.3 Editing Modes

MathEdit supports four operational modes: *Visual Edit mode*, *MathML mode*, *Infix mode*, and *Preview mode*. Generally, the *Visual Edit mode* is for users to create and edit mathematical expressions interactively. In *MathML mode*, a user can view, enter, and edit MathML source code directly. Copy and paste of MathML code is supported. In *Infix mode* a user can enter expressions in infix notation or extract the infix representation of the expression being edited. In *Preview mode*, the expression is displayed in its final form and no editing is allowed. Previewing is usually the last step before a user is done creating or editing an expression.

In *Visual Edit mode*, the MathML Content code of the currently selected expression is always displayed in the MathEdit status bar. It shows, at a glance, the nesting of the MathML structure at the cursor location, and gives users an easy way to select sub-expressions containing the cursor. The current sub-expression can be edited in a pop-up window and the edited code replaces the old code when the pop-up window is closed. Alternatively, a user can choose to edit the infix string for that sub-expression instead.

3. Visual Navigation

Editing operations, such as insert, edit, delete, covert, and replace, are relative to the *current node* (a node on the MathML Content tree) and the *cursor position* (blinking vertical line). The current node expression (the current expression) is highlighted visually and visual navigation refers to moving the current expression and the cursor to different positions in the expression being edited. Convenient visual navigation is important and a user has multiple ways to visually navigate the displayed expression: *basic navigation*, *traversal navigation*, and *cursor navigation*.

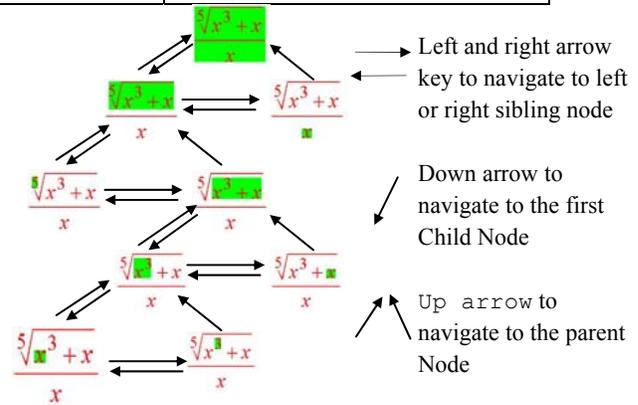


Figure 4. Basic Navigation

3.1 Basic Navigation and Traversal Navigation

The four arrow keys are used for Basic Navigation. They move the current sub-expression up to the parent node, down to the first child, or left/right to sibling nodes (Figure 4).

Because Basic Navigation is based on the hidden internal tree structure, it can be non-intuitive to the average user. MathEdit also supports a systematic traversal of the entire expression so the user has a way of reaching any node on the tree. By pressing the PageDown key, the current node is moved in a traversal sequence defined by DFS (depth-first search). The PageUp key, on the other hand, provides the inverse-orient traversal. Figure 5 shows the flow chart for the algorithm used for PageUp key navigation.

To make navigation more intuitive, MathEdit also allows the user to use the mouse to move the current node.

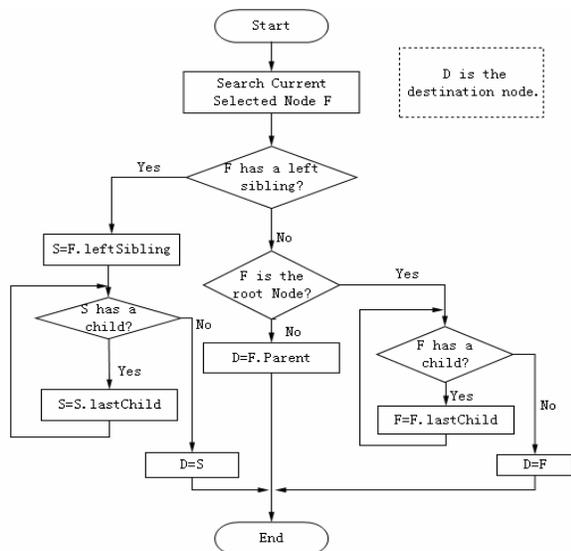


Figure 5. Traversal Navigation

3.2 Cursor Movement

In MathEdit the location of the cursor is indicated by a blinking vertical line. The cursor indicates the current insertion point and may be positioned either to the left or right of the current expression. The cursor can be moved with the mouse or the arrow keys. In general, the editor will move the cursor to the next valid insertion location in the direction of the arrow key or nearest to a mouse click. To implement this feature, MathEdit must negotiate the MathML Content Expression Tree. Moving the cursor to the right on the screen can involve non-trivial traversals on the DOM tree. The following DOM code shows the cursor display technique:

```

var domfrag=
designDoc.createDocumentFragment();
var tag=
designDoc.createElementNS(mmlns, "mi");
tag.setAttribute("id", "cursor");
tag.setAttribute("mathcolor", "#0f0");
var
tnode=designDoc.createTextNode("|");
tag.appendChild(tnode);
domfrag.appendChild(tag);

```

To make the cursor display work, an artificial `<mathphantom>` element is sometimes inserted to the DOM tree which will either be replaced by a new sub-expression entered by the user or removed when the cursor is moved elsewhere.

4. MathEdit API and Applying MathEdit in Interactive Web.

The MathEdit API, supported by a set of JavaScript functions, allows applications to create an editor instance, sets any initial expression in it, configure its template palette and other GUI features, and set/retrieve the MathML code it contains.

4.1 Two Methods of Applying MathEdit

Table 2 lists most API functions of MathEdit API Library. There are two methods of applying MathEdit into interactive Web: pop-up window and in-page frame.

In pop-up window, user can activate MathEdit by `newMath()` or `editMathByID()`. A pop-up window with MathEdit will open and user can edit their desired math expressions by MathEdit. When user clicks Return button, the object math code (MathML or Infix) will transfer to the main program.

In in-page frame, the MathEdit can be embedded in interactive Web to edit math expression. User can customize the templates and toolbars through MathEdit API function `showTemplate(templateID)` and `showToolbar(toolID)`.

4.2 Plotting User-Entered Equations

To demonstrate the use of the MathEdit API, let's look at a sample WME page (Figure 6) for graphing an equation entered by the user. The form has two entries. The user first clicks on an icon to pop up the MathEdit tool in order to create a desired formula interactively. When done, the user clicks the return folder icon on the menu bar to close the MathEdit window. The resulting MathML is retrieved via the MathEdit API and displayed in the step-1 entry via DOM operations.

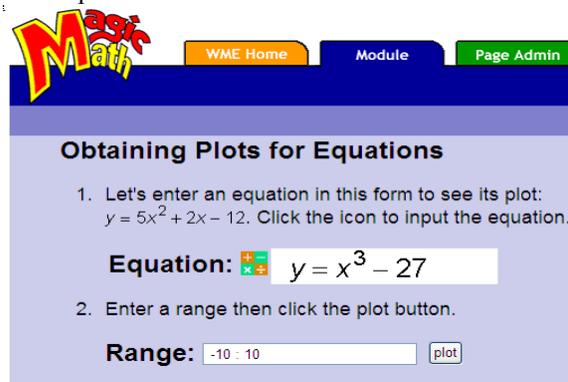


Figure 6: A Sample WME Page of Applying MathEdit

Table 2. The MathEdit API Library

Method	Description
newMath(id, parentId)	Create a new MathML expression.
setIframe(iframeID,matheditURL)	Set an Iframe with an ID attribute to Embed MathEdit in your Web.
editMathById(id)	Edit an existing Math Expression by ID.
showTemplate(templateID)	Display the mathematical template by template ID.
showToolbar(toolID)	Display the tool button by ID.
setEditorSize(width,height)	Set the size of editor area.
loadContentMath(filename)	Load Content MathML from a file
loadPresentationMath(filename)	Load Presentation MathML from a file
loadInfixMath(filename)	Load Infix math expression from a file
editContentMath(String)	Load Content MathML from a string
editPresentationMath(String)	Load Presentation MathML from a string
editInfixMath(String)	Load Infix math expression from a string
getContentMathML ()	Return Content MathML to host procedure
getPresentationMathML()	Return Presentation MathML to host procedure
getInfixMath ()	Return infix Math expression to host procedure

After filling in the plotting range, a click on the `plot` button triggers JavaScript code, in the enclosing Web page, which obtains the string representation of the formula created via the MathEdit API. The formula string then becomes part of a POST request to a curve plotting program which displays the result (Figure 7).

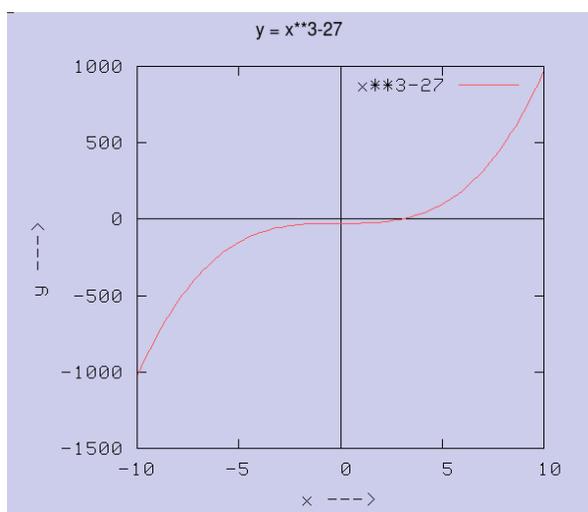


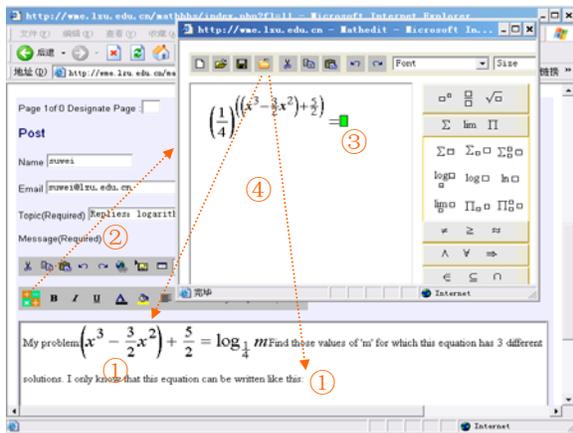
Figure 7. Plotting User-Entered Equations

4.3 Math-enabled BBS

Bulletin board systems (BBS) are on-Web forums for posting discussion topics, questions, responses, and comments. A useful tool for WME [13] is MathBoard, a math-enabled BBS for mathematics educators and students that can support online discussions. For a mathematical bulletin board (MathBoard), support for

mathematics expressions and diagramming must be provided. MathBoard implements online mathematical expressions editing powered by MathEdit and online mathematical graphic and geometry editing powered by GeoSVG [24].

Figure 8 shows the MathBoard GUI and the main steps to post a new or update an existing mathematical expression. To post a new formula, a user simply clicks the MathEdit icon to popup the tool. The expression created is then inserted at the cursor position. If the user selects an existing expression (highlighting it with the mouse) before clicking the icon, then the MathEdit popup window will display that expression for editing. The editing result will then replace the target expression. Mathematical expressions have IDs unique in their page to make DOM operations on them easy. Table 3 shows the essential JavaScript code for MathBoard to use MathEdit.



- ① Set insert focus or select existed expression
- ② Call MathEdit
- ③ Edit expression
- ④ Return MathML to insert point or replace existed expression

Figure 8. Using MathEdit in MathBoard

Table 3. The Essential Code in MathBoard To Apply MathEdit

```

if (editor.document.selection)
{
    var sele=editor.document.selection;
    var sel =sele.createRange();
}
if (sele.type=="Control")
{
    for (i = 0; i <sel.length; i++)
    {
        mathtID=sel(i).id;
    }
    mathedit.editMathById(mathtID);
}
else
{
    var mathtID="math"+(mathID++);
    mathedit.newMath(mathtID, "cursor");
}

```

5. Future Work

Work on MathEdit is continuing. MathEdit now has an IE version that works with the MathPlayer plugin and a Mozilla version that works with native MathML support in Firefox, Netscape Navigator, and Mozilla. There are some differences between the two versions, even at the user level. We are looking to integrate the two versions into a cross-browser tool. We also want to put MathEdit to more extensive use in different scientific, technical and educational systems, to collect

feedback, and to make improvements. User feedback will be important to fine tune the GUI and to refine the MathEdit API. Support for additional mathematical encoding formats such as OpenMath [18], MP [12], and LaTeX [6] may also be provided.

6. Acknowledgments

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