MathBlackBoard as User Interface of Computer Algebra Systems

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Abstract: MathBlackBoard is a Java program based on the blackboard applet. We can use the blackboard applet with GUI operations. The blackboard applet has a simple kernel as computational engine.

In this paper, we describe improvements of MathBlackBoard. MathBlackBoard is reconstructed as a set of objects. We have improved GUI operations of MathBlackBoard. And, we have added new functions which use some computer algebra systems as computational engine.

1. Introduction

We introduce a Java applet named blackboard applet which was written in 1997 by MATSUSHIMA Jun-ya ([1]). The blackboard applet has a simple kernel and GUI windows. It is a simple all-in-one system which has a computational engine and front end. One characteristic of that is GUI operations by which users can manipulate mathematical expressions.

The goal of it was to create an "ease to use" computer algebra system. MATSUSHIMA argued that difficult matters about the educational use of computer algebra systems are "difficulties of input by using CUI" and "dependence to OS." The blackboard applet was produced to try to overcome these issues.

Using GUI efficiently is the solution that he has presented. "GUI buttons for mathematical operation" and "drag & drop with the meaning of mathematical operation" were mentioned as keys of the solution of the first issue. And "use of Java applet on web browser" is effective for the second issue.

We improved the blackboard applet after his master thesis ([2]). The applet is able to run as not only Java applet but also Java application. And it was reconstructed as a set of objects. We renamed it as MathBlackBoard ([3]). MathBlackBoard has new functions which can connect to some computer algebra systems as computational engine. And its GUI operations have been improved.

This paper is organized as follows: We present basic operations of MathBlackBoard in section 2. Those operations are inherited from the blackboard applet. In section 3, we describe the improvement of GUI operations on MathBlackBoard. New functions to connect computer algebra systems are shown in section 4. And section 5 gives a conclusion.

2. Basic Operations

2.1. GUI Windows

MathBlackBoard has three different types of GUI window. Blackboard window is main window that has editing space (Fig.1). Mathematical expressions are shown in this window. Users can input and edit expressions on Blackboard window.

Second window is Keyboard window which is used to type expressions (Fig.2). And MathBlackBoard has GraphScreen window on which functions are plotted.
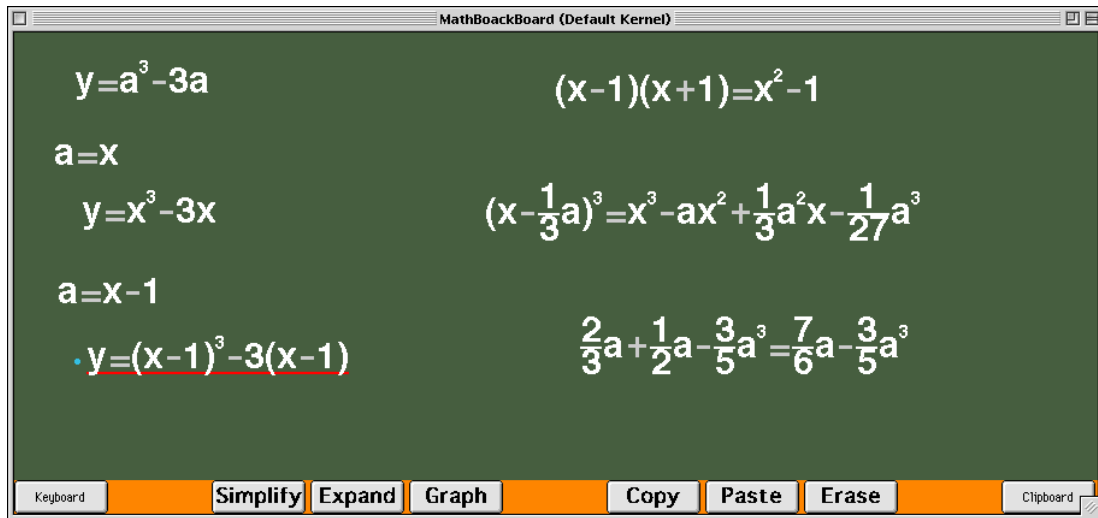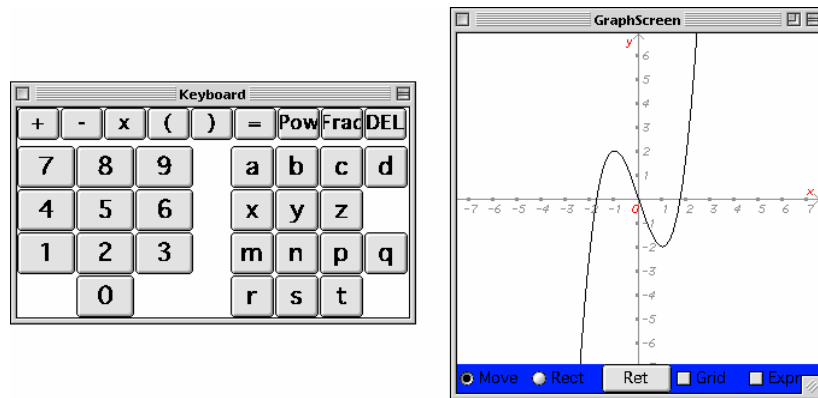
Figure 1 Blackboard Window

Figure 2 Keyboard Window and GraphScreen Window

2. 2. How to Input

MathBlackBoard provides GUI buttons located on Keyboard window. When user input mathematical expressions on Blackboard window, these buttons are used. Only pointing device, for example mouse, is needed for input of expressions.

For example, if the " y " button, the " $=$ " button, and the " x " button are clicked in order, " $y = x$ " will be typed on Blackboard window.

2.3. Flexibility of Position

The excellence of MathBlackBoard is flexibility of position of mathematical expressions displayed. When user input, the input position is flexible.

All expressions on Blackboard window have information of coordinates of themselves. Their coordinates are selected from all of pixels on the editing area of Blackboard window. The point clicked is starting point of an expression. The expression will be typed from that clicked point. And expressions can be moved to any position of the edit area.

As for the others, the input position is not flexible. For example, word processor displays words on straight lines. For the input of words, the position is not flexible.

2.4. GUI Buttons

The function buttons are placed at the bottom of Blackboard window (Fig.1). These GUI buttons are provided to execute functions instead of typing commands. If a function button is clicked after choosing an expression, the function of the button will be performed with the selected expression. For example, if the "Expand" button is clicked after choosing an expression "$(x+y)^2$", "$=$" and the result "$x^2 + 2xy + y^2$" will be put after the expression. Therefore "$(x+y)^2 = x^2 + 2xy + y^2$" will be displayed instead of "$(x+y)^2$."

2.5. Drag & Drop

MathBlackBoard provides another way to manipulate mathematical expressions. That is drag & drop by which not only edit operations but also mathematical operations are performed.

Edit operations are as follows: (1) Move expression to another point, (2) Connect grabbed expression to the other expression, (3) Copy selected expression to clipboard, and (4) Paste an expression from clipboard.

These operations are decided by where the dragged expression was dropped. If the expression is dropped on nothing but a point of editing area, it will be moved to the point. If dropped place is another expression, dragged expression will be connected to the target expression. And if starting point or dropped point of drag & drop is in visualized clipboard, paste or copy will be performed (described in section 3).

Mathematical operations are as follows: (5) Substitute, (6) Draw graph, and (7) Perform functions assigned to GUI buttons.

Operations are decided by dropped place. If the expression is dropped on another expression and "substitution" is selected on the dialog window, substitution will be performed. If the point dropped is in GraphScreen window, the expression will be plotted as a function. Or if dropped place is on one of function buttons, the function of the button will be performed with dragged expression.

2.6. Examples

Operations for the expressions of the right side of Figure 1 are as follows:

Input: $(x-1)(x+1)$
Operation: Click "Expand" button

Input: $(x - \frac{1}{3}a)^3$
Operation: Click "Expand" button

Input: $\frac{2}{3}a + \frac{1}{2}a - \frac{3}{5}a^3$
Operation: Click "Simplify" button

By using the keyboard window, the operation is written with "Input:". By using the GUI, the operation is written with "Operation:".

For the graph creation on the GraphScreen window of Figure 2, we do it as follows:

Input: $y = x^3 - 3x$
Operation: Click "Graph" button

Figure 3 shows that an expression "$a = x - 1$" is substituted for "$y = a^3 - 3a$" by using drag & drop.
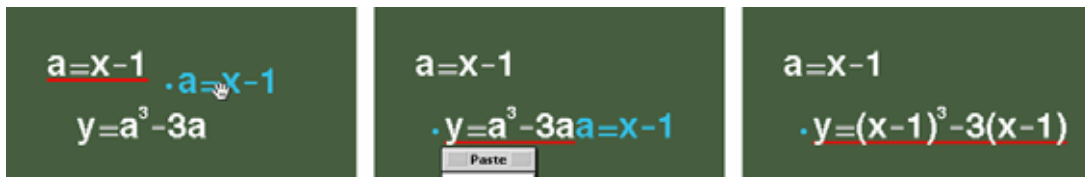
Figure 3 Substitution by using Drag & Drop

The Operations of that are as follows:

Input: $a = x - 1$

Input: $y = a^3 - 3a$

Operation: Drag "$a = x - 1$" and drop it on "$y = a^3 - 3a$"

Operation: Select "Substitution" in the dialog window displayed

If the selection of 2nd "operation:" is not "Substitution" and we chose "Left Side", "Right Side" or "Both Sides", then the selected part will be connected to the expression "$y = a^3 - 3a$." For Example, if we chose the "Right Side" in the example of figure 3, "$x - 1$" will be connected behind "$y = a^3 - 3a$."

If "Graph" operation is performed to two expressions, the expressions will overlap as shown in Figure 4. In Figure 4, grid lines and expressions are displayed by checking checkboxes.
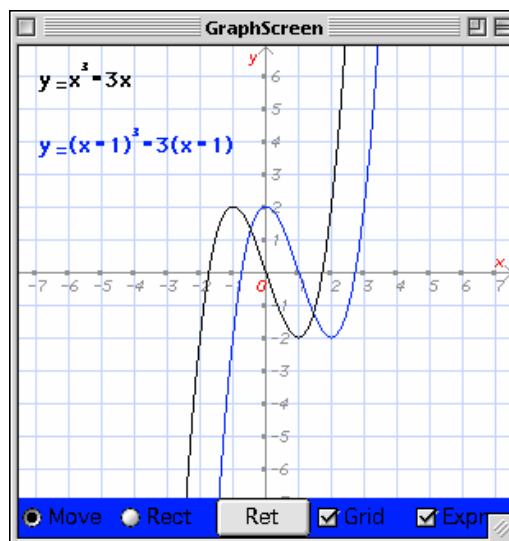
Figure 4 GraphScreen Window with Two Expressions

3. Improved Operations

The blackboard applet has drag & drop operation. And drag & drop of MathBlackBoard has been improved. Improved operations can be picked from subsection 5 of section 2 as follows: (1) Move expression to another point, (3) Copy selected expression to clipboard, (4) Paste an expression from clipboard, (6) Draw graph, and (7) Perform functions assigned to GUI buttons.

Drag & drop of the blackboard applet is same as copy & paste. In the blackboard applet, if dragged expression is dropped on edit area, a dialog window will be displayed. And "Right Side", "Left Side", or "Both Sides" must be chosen to move the expression to the point.

MathBlackBoard has new object that is visualized clipboard (Fig.5). If dragged expression is dropped on the visualized clipboard, the expression will be copied to clipboard. And if the expression is dragged from the visualized clipboard and it is dropped on edit area, the expression from clipboard will be pasted to the point of edit area.

GUI objects, such as GraphScreen window and function buttons of MathBlackBoard, can handle drag & drop operation. If an expression is dropped on one of these objects, functions which depend on the object will be performed with the expression, as described above.
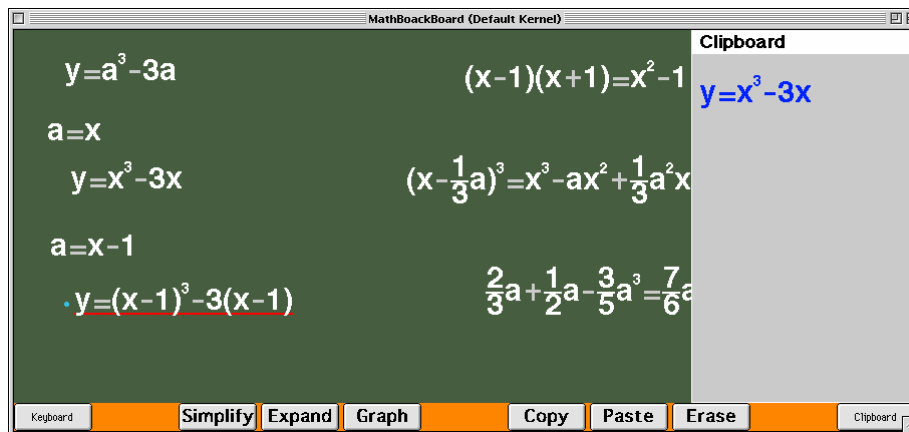

Figure 5   Visualized Clipboard

4. Using Computer Algebra Systems

In the process of improvement, MathBlackBoard has been reconstructed as a set of objects. These objects are mainly classified into 6 kinds (Fig.6). Each object is independent from the others. So, each object is able to be exchanged to another object that has same object interface as the original one. And then, we have constructed a kernel super class that provides object interface to kernel subclasses. One of subclasses is same as kernel part of the blackboard applet. In addition, MathBlackBoard can use three computer algebra systems, by using object interface of the kernel super class.

Mathematica ([4]) is called by using J/Link ([5]). J/Link is a set of Java classes that is an interface between Mathematica and Java. MathBlackBoard has a kernel subclass in which J/Link is wrapped. Thus, MathBlackBoard can use Mathematica kernel by using object interface of MathBlackBoard kernel class.

Through the server and client of OpenXM ([6]), MathBlackBoard uses Risa/Asir ([7]) as a computational engine. OpenXM provides an infrastructure for mathematical communication. There are many useful Java class files in the OpenXM source files. The path to these is "OpenXM/src/OpenMath/ORG." MathBlackBoard has a kernel subclass that wraps these OpenXM

classes. To use Risa/Asir, MathBlackBoard starts an OpenXM server and connect to that as OpenXM client.

Using HTTP protocol, webMathematica ([8]) is connected from MathBlackBoard. The MSP document for this work is to be put at webMathematica server. For example, the MSP document receives mathematical expressions by HTML form and displays the result of expanded expression. The kernel subclass for webMathematica extracts the information needed from the HTML document that was received. Therefore if another system's web interface, that has HTML form input and HTML document output, is designed properly, the system will be able to be exchanged to webMathematica.
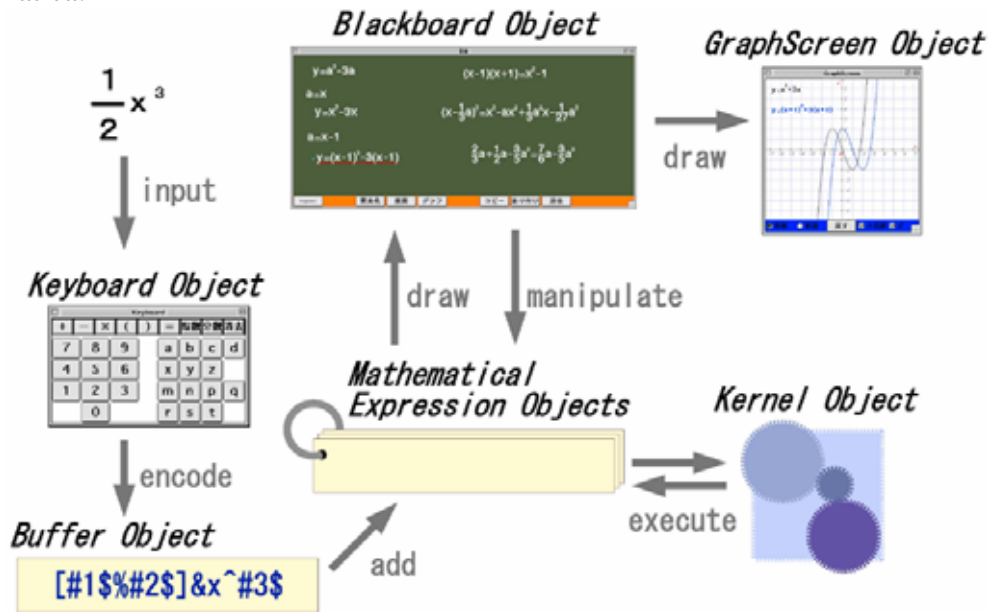

Figure 6   Objects of MathBlackBoard

5.   Conclusion

We have developed MathBlackBoard which has been improved from the blackboard applet. MathBlackBoard is a set of objects that are able to be exchanged. Kernel objects of MathBlackBoard have common object interface which is provided by the kernel super class. Therefore MathBlackBoard can use other computer algebra systems as computational engine, by using same object interface.

In the future, we are going to improve the user interface of MathBlackBoard. We will remove some GUI parts to make it simple. We show the following example for operation should be paid attention. For example, the dialog window which has a choice, such as "Substitution", "Right Side", "Left Side", or "Both Sides." We must find the other way to do these operations instead of dialog window.

As user interface of computer algebra systems, MathBlackBoard has to handle more functions of these systems. MathBlackBoard handles mathematical expressions in its own way. Development of the inside expressions for mathematical expression is needed.

Our far goal is to create a system like pens & notes. The system is like pens & notes, but is supported by information technology. In the system, computer algebra systems will be used as supplementary system. We have to categorize jobs on MathBlackBoard, by thinking about what are the jobs for human, and what are the jobs for computer. The system will be not a calculator. It will be just like an assistant system for mathematical thinking.

References

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[6] URL: OpenXM, http://www.openxm.org/

[7] URL: Risa/Asir (Kobe Distribution), http://www.math.kobe-u.ac.jp/Asir/asir.html

[8] URL: webMathematica, http://www.wolfram.com/products/webmathematica/index.html