NiCE Formula Editor

Jakob Leitner, Christian Rendl, Florian Perteneder, Adam Gokcezade, Thomas Seifried, Michael Haller
Media Interaction Lab
mi-lab@fh-hagenberg.at

Robert Zeleznik, Andrew Bragdon
Brown University, Department of Computer Science
{bcz, acb}@cs.brown.edu

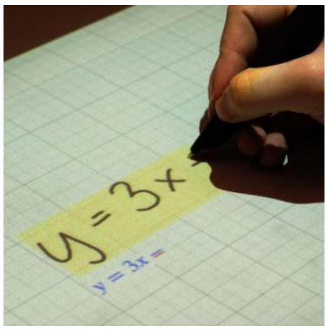

Figure 1: Writing mathematical expressions

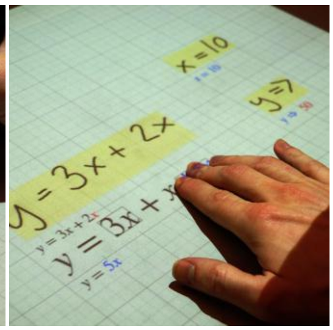

Figure 2: Manipulating digital interpretation of expressions

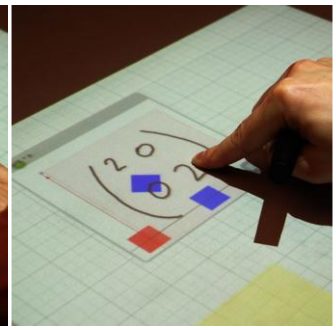

Figure 3: Dropping expressions on opened plug-ins

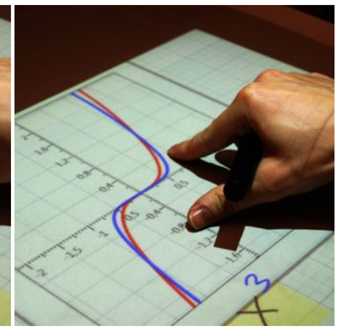

Figure 4: Interacting with plug-ins

1. Motivation

Interactive Whiteboards are becoming an increasingly important component of face-to-face meetings, particularly in educational settings. Still, non-interactive surfaces have remained the standard for mathematics-oriented discussions in part due to the lack of robust algorithms for recognizing handwritten mathematical expressions. Thus teachers, for example, are typically burdened with drawing visualizations by hand to reinforce abstract and complex mathematical problems. Our work expands upon the notion of mathematical sketching [1] by supporting both pen and touch interactions on an interactive whiteboard to write expressions, to perform algebraic transformations, and to drive sophisticated 2D and 3D illustrations. By incorporating lightweight touch-based interactions, students can “play” with formulas and explore mathematics from a fundamentally interactive perspective that we believe many will find to be engaging and enjoyable.

2. NiCE Formula Editor

In this talk, we present the NiCE Formula Editor, which recognizes handwritten formulas to provide *in situ* computation and visualization. Our editor uses a novel hardware setup, suitable for use as a desktop or whiteboard that disambiguates pen and multi-touch input. In our interface, the pen writes and performs gestures, while touch manipulates. Multiple users can sketch mathematical expressions (e.g. formulas, vectors, matrices, etc.) with digital pens on the interactive surface (see Figure 1). These expressions are analyzed and interpreted using the StarPad SDK’s [2] support for mathematics recognition. Pen and touch gestures can be used to manipulate the written expressions. In addition, expressions can be selected and moved by touch or pen input. For example, a scribbling gesture can be used to delete symbols and a loop gesture can be used to create a graph. Also, the digital interpretation of the written expression can be manipulated through touch interaction. For example a user can re-arrange terms in an equation or pinch equations to simplify them by combining the two touched terms together (see Figure 2).

Moreover, a written expression can be connected to visualization widgets simply by dragging the expression using a fingertip over an already visible widget and then dropping it by lifting the finger. A computer graphics teacher, for example, can drop various matrices onto the “2D Matrix Stack Viewer” widget to show how matrices transform a 2D object, as seen in Figure 3.

Due to the diversity of mathematical problems, our formula editor supports a plug-in architecture for incorporating customized widgets. This flexible plug-in API provides developers with pre-defined interaction modules and access to “equation-solving-functions” which are specially designed to support visualization.

3. Prototype

Our prototype implementation is fully functional and robustly supports simultaneous multi-pen and pressure-sensitive multi-touch input. A scratch resistant foil with printed Anoto [3] pattern on top of a 24” Interpolated Force Sensitive Resistor (IFSR) foil [4] is used for combined pen and touch input. Anoto DP-301 pens are used as wireless pen input devices.

Pressure-sensitive touch input provided by the IFSR foil is used to disambiguate between transforming graph windows as a whole and panning their graph contents. Touches with a high pressure lead to window-level transformations (*i.e.* move or scale a widget), while light pressure just affects the content (Figure 4).

REFERENCES

[1] LaViola, J. and Zeleznik, R. MathPad²: A system for the creation and exploration of mathematical sketches. In Proceedings of SIGGRAPH 2004, pp. 432-440

[2] http://pen.cs.brown.edu/starpad.html

[3] http://www.anoto.com

[4] Rosenberg, I. and Perlin, K. 2009. The UnMousePad: an interpolating multi-touch force-sensing input pad. In Proceedings of SIGGRAPH 2009.

SIGGRAPH 2010, Los Angeles, California, July 25 – 29, 2010.
ISBN 978-1-4503-0210-4/10/0007