Automated production of Braille textbooks

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Workshop Summary

Overview

The workshop aimed to extend the availability of mathematics textbooks in braille to blind students and professionals. The overall goal of the project is to produce mathematical text accurately, inexpensively, and in a timely manner by developing a user-friendly software workflow using open-source software to automatically translate mathematical text to braille ready for embossing. The participants included authors of mathematics textbooks, educators, software developers, accessibility specialists, and members of the blind community. The workshop was conducted at the headquarters of the National Federation of the Blind in Baltimore, MD.

Activities during the workshop can be organized into three main groups: work on specific technical challenges and demonstrations of established and emerging technologies; exploration of directions for development of tactile graphics; and exploration of ideas for making the braille transcription tools more widely available to mathematical community.

Specific technical challenges and demonstrations

Mathematical braille text has two parts, each covered by a separate set of rules: literary text and mathematics expressions. There are sets of periodically updated rules describing how to transcribe literary text, how to transcribe mathematical formulas, and how to handle the interface between literary and mathematics parts of the text.

Work done prior to the workshop provided a set of tools to produce braille output from a PreTeXt source file. PreTeXt is a mark-up vocabulary that allows to write mathematics documents and compile the same source document into a variety of formats: html, PDF, EPUB, and braille. Remaining technical challenges for producing braille output were examined during the workshop and solutions for developers were identified. Among the challenges, for example, is the ability to do "smart" line breaks for mathematical formulas that are too long for the remaining space in the line.

Conversion of mathematical formulas into braille from PreTeXt focuses currently on producing Nemeth, a mathematical braille format that is commonly used in the United States. We discussed how this could be extended in order to provide translations for other formats, in particular UEB, a standard used in many other English speaking countries, but also reviewed developments in certain European countries, where LaTeX notation, the basis of math in PreTeXt, is used as the basis for 8-dot Braille formats taught to children starting in grade school. In this context we discussed https://journals.sagepub.com/doi/abs/10.1177/0145482X221089 most recent comparative research into different mathematical braille notations used in the world.

In braille, there is a standard table format for simple tables, and there are several special table formats that are used for large or complex tables. After selecting several large tables that would not fit into a standard table format, the participants reviewed the automated braille output provided by PreTeXt. We found that PreTeXt is currently using a what is called a linear table format as the default format for complex tables. PreTeXt was able to correctly transcribe the table contents into a linear table format, with a few minor problems that will be addressed by the developers.

There was a consensus that other specialized braille table formats should be supported within PreTeXt. A linear table format will be preferable for some content, but there are other table formats that may be easier to interpret and could be applied to less-complex tables. The recommendation was to use these less-complex table formats whenever possible.

Brief demonstrations during the workshop informed the participants about recent developments, such as IVEO software for audio-tactile graphics, sonification software for mathematical graphs, and plans for editor software that will allow to easily create and edit PreTeXt source files.

Directions for development of tactile graphics

Graphic content (e.g. diagrams, illustrations, etc.) is the most difficult content to transcribe into braille. Converting a print graphic into a tactile graphic is a complex process that requires careful consideration of the meaning of the graphic, how to best convey that meaning tactilely, and how to arrange content on the page so that it can be effectively interpreted tactilely. PreTeXt is currently able to automatically produce usable tactile graphics from diagrams written in TikZ. A group of participants has selected a collection of "challenge graphics" diagrams and examined their tactile versions. The group found that the use of variable dot heights, white space around braille labels, and control over line styles and thickness all improved the readability of the graphics. The group identified several specific issues and made recommendations to the developers.

The participants acknowledged that tactile graphics may not always be the most effective solution to convey information contained on the diagram. For example, not all users can access tactile content as effectively as others. This could be due to limited experience with tactile graphics, limited braille skills, or physical limitations. Sonification, audio-tactile diagrams (i.e. tactile graphics with touch-activated audio labels), or accessible digital diagrams are all potential alternatives of providing information for complex graphics.

Pre-written image descriptions are also an important means of conveying graphic information. In its *Guidelines and Standards for Tactile Graphics* (2010), BANA recommends image description as the first alternative to providing a tactile graphic. Image descriptions can be very effective, and this approach is one that is very familiar to blind learners. Ideally, image descriptions would be provided by the author(s) of a text. Because authors understand best the purpose of a given image, they are best positioned to provide a meaningful, succinct description that conveys the meaning of that image to the reader. The challenge, then, is how to best instruct authors on creating effective image descriptions. The workshop participants reviewed multiple resources detailing best-practices for describing complex images. After reviewing the available resources, workshop attendees felt that there were insufficient examples and guidance for describing the complex images that they regularly encounter or produce in their day-to-day work.

A group of participants took initial steps toward developing a mark-up language for diagrams. The idea is to design a set of mark-up elements that will produce graphical elements, such as a set of axes, or geometric figures, or graphs of functions in a form. These graphics elements will be rendered visually for formats like html or PDF; they would also have a built-in "alt-text" description and would provide the necessary information to the program that transcribes the diagrams into tactile form.

As initial practical experiments, we worked on a set of graphs of single-variable functions from the Active Calculus textbook to programmatically generate not only the final SVG graphic, but also an internal hierarchical structure and accompanying descriptive annotations. This allowed us to use the Diagcess library to make the resulting SVG diagrams interactive and accessible via screen reading and sonification of the depicted curves. For ongoing and further development we created a https://github.com/davidaustinm/ptx2svgdedicated github repository.

Ideas for advocacy

Due to difficulties in accessing education materials, few blind students choose to pursue undergraduate studies in STEM fields. Those who do, often face overworked accessibility support specialists at their universities (who may or may not be familiar with mathematics rules for braille) and professors who do not know how to make course materials (including handouts or custom homework assignments) available to the students in tactile form.

The participants of the workshop agreed to formalize the activities in a Raised Mathematics Project, an open-source project aiming to produce braille versions of college-level mathematics texts automatically from the source files. The participants formulated an initial outreach plan to help inform the wider mathematics community.