

E-LEARNING PLATFORM FOR INTERACTIVE ACCESS TO MULTIMEDIA MATERIALS IN DAISY FORMAT

Piotr Brzoza

Computer Science Department, Silesian University of Technology
Akademicka 16, 44-100 Gliwice, Poland
Email: piotrbr@polsl.pl. Tel: +48322371889. Fax: +48322372733

Abstract. The Paper presents multimedia system for accessible distant education which consists of multimedia browser accessible for visually impaired people and content distribution streaming server integrated with e-learning management system, which allow interactive online access to storage materials in DAISY 3 (ANSI/NISO Z39.86 2005 Specifications for the Digital Talking Book) format. The developed DaisyReader offers new functionality for interactive multimodal (visual and voice) presentation of structural information like: tables, lists and math formulas. DaisyReader supports new MathML Modular Extensions (2007) of Daisy standard.

Keywords: e-learning, accessibility, multimedia presentation, math

1. Introduction

Visually impaired people have limited access to traditional printed educational materials. Nowadays more and more publishers, schools and universities offer digital educational materials and e-learning services. Computers with assistive technologies give impaired people potential independent access to digital information. However accessibility of digital content strongly depends on information format, presentation and its structure.

Screen readers, screen magnifiers and multimedia browsers allow impaired users easy access to traditional text book's content. A lot of educational materials present multimedia content: text, pictures, audio, video, graphs, charts and other structural information like math formulas, especially technical and scientific materials. Accessibility of complex structural information for visually impaired people is limited and requires designing alternative interactive multimodal presentation (visual voice and tactile).

2. Daisy Standard

We present new multimedia eBook format (DAISY 3.0 ANSI/NISO Z39.86-2005) developed by Daisy Consortium www.daisy.org. Daisy books present book content in multimode form including text, audio and graphics. Readers can easily navigate in logical book structure by: chapters, headings, pages, paragraphs and sentences. Daisy books can be played using hardware or software players. Currently world wide there are about 130000 book titles in Daisy format.

3. E-learning Management System

We present developed interactive system for accessible distant education which main components are shown in Figure 1.

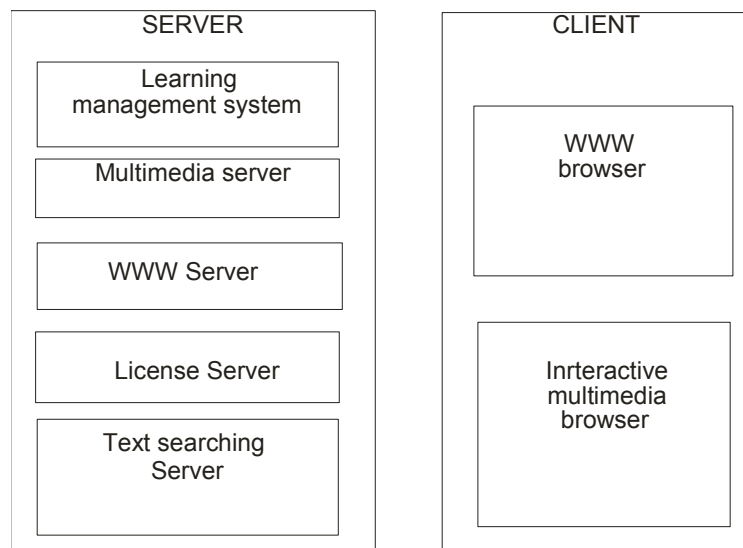


Figure 1 Multimedia system components

The goal of our research is accessible interactive multimodal (visual, voice and tactile) presentation of educational materials, especially scientific content which often consists of graphs, charts and other structural information like math formulas. Interface of e-learning management system has been designed with the special attention to requirements of blind and low vision students and allows direct access to educational materials by internet services (Spinczyk and Brzoza, 2005).

The accessibility of e-learning materials is one of the main problem in ICT system. In our approach we propose design course materials in DAISY standard.

4. Interactive Multimedia Daisy Books Browser

Currently available Daisy players allow to read multimedia Daisy books only from CD/DVD discs or local computer hard discs. Books recorded on CD/DVD's are collected personally or ordered by mail in the library. Some libraries offer digital books by Internet. This method requires full book contents download over the Internet before start reading it. Books in Daisy format range from several to hundreds of megabytes in size. Downloading large amounts of data makes this approach to books' distribution both difficult and time consuming. Access to information contained in multiple books is very difficult and multiple books information searching is practically impossible.

In our continuous research and development of the multimedia e-learning system we have designed and developed new multimedia Daisy books browser (Brzoza and Spinczyk, 2006). The new software Daisy reader allows playing Daisy books online over the Internet or in the standard way, from CD or from the local hard disk. Online Daisy books are played from a multimedia server and are available for reading after a few seconds from being found in the e-learning system. Books audio, text and graphics content are presented synchronously. Consecutive book pages are displayed. Sentences are highlighted with simultaneous audio playing. The book's index allows to access to selected chapter. The reader can also navigate through the logical book structure by: chapters, headings, pages, tables, paragraphs and sentences.

Similar as in printed books readers can add bookmarks with text, audio notes and exchange bookmarks list each other (Brzoza, 2003). Browser offers searching text function which allows playing narrator's speech and presenting highlighted text from place where it has been founded. We extend browser functionality, which allows reading aloud text DAISY book with synthetic voice.

5. Voice browsing of Maths Formulae in Daisy Books

Previous research focused on conversion from math formulas represented in TeX to math Braille notation. Daisy Consortium approved Specification for a Digital Talking Book Modular Extension for Mathematics in 23 February, 2007 (Daisy Consortium, 2007). This document describes additional tags and complete set of rules for embedding math formulas in Daisy books. Math expressions are represented in MathML markup language. Daisy modular extension for mathematics defines how Multimedia browsers should render math content visually and aurally, but lacks rules how to read it aloud. Math formulas can be expressed by presentation tags or content tags. Usage of content tags in Daisy book is recommended, because of unambiguity.

During our research we defined the rules of conversion from MathML content representation to voice representation in Polish language. We compared it to the previous work of Fitzpatrick and Karshmer (2004) which covered voice browsing of formulas in English language. Our proposed rules were consulted with math teachers and tested on many complex math formulas. We prepared dictionaries containing math vocabulary and additional terms, which help to describe formulas. We also developed algorithm, that creates internal structures of math expressions which is based on analysis of MathML content. These proposed structures, used for interactive voice browsing, are hierarchical representation of math formulas, sub formulas and operators. Below is example of tree structure obtained from analysis of math formula.

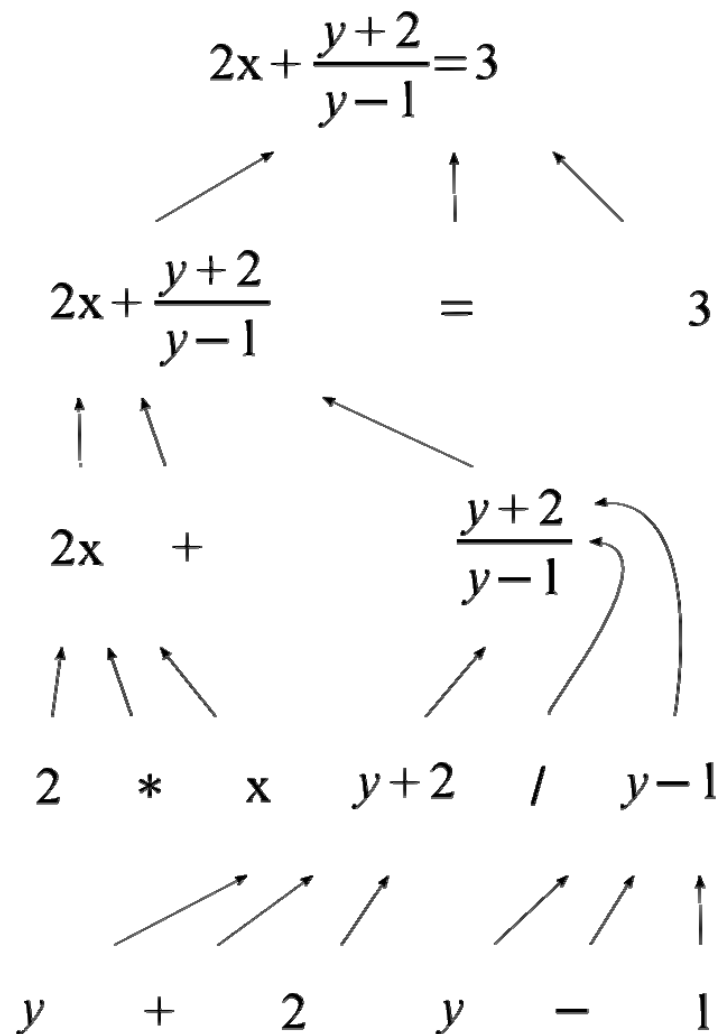


Figure 2 Tree showing how decomposition of mathematical expression is made

We designed algorithms for interactive voice browsing over math expressions. These algorithms, interacted by users, analyse internal tree structure, current tree level, types of arguments, operators,

expressions and produce information how it should be read aloud. Rules of voice reading can be adapted to people's level of math understanding and experience. Our DaisyReader offers functions for voice browsing formulas with full description, suitable for beginners and also shortened description proper for more experienced readers.

Daisy book containing basic and complex series of math expressions with comments was prepared in order to test implemented algorithms for interactive voice browsing. We proposed testing methodology for this experiment. Firstly, examples were grouped by used math operators, structure and complexity. Next, we prepared questionnaires for teachers, which helped collecting information about the way how math formulas were browsed, tester math experience and disability level. Moreover, some parts of tests were recorded for later additional analysis of questionnaires. There were two groups of test participants: pupils and university students, both blind or low vision. Each of the groups consisted of people who were beginning learning math and those who were more advanced in this discipline. Before test had been conducted, teachers demonstrated how to browse math with DaisyReader. During the test, participants examined series of basic and complex equations using interactive voice browsing commands of DaisyReader. Math formulas were presented in groups of the same category and in mixed ones in order to evaluate novice users understanding level. Math teachers together with testers gathered notes about problems with understanding math expressions and suggestions how to improve proposed reading functions.

We modified our approach to rules of voice reading math formulas on the basis of experiment results and extended proposed vocabulary for describing expressions. Moreover, we implemented audio signalisation of expression structure during examination of formulas. After the suggested changes tests were conducted for the second time. Both of the test results showed that complex formulas need to be examined more carefully and a few times to be understood correctly. Low-vision students in comparison to blind students tended to better recognise structure of complex formulas, because of accessing multimodal (simultaneous visual and voice) presentation of information. Results of tests showed us that visually impaired people using DaisyReader can understand most of presented math formulas. In future we plan to conduct more tests on larger scale together with schools and universities. We are currently working on adding Math Braille formulas presentation in order to raise up level of math understanding.

6. E-learning System Performance Evaluation

Our interactive multimedia Daisy books browser works together with multimedia Helix Universal server. Multimedia Helix server is integrated with the e-learning management system (Brzoza and Spinczyk, 2006). Using the web browser, users can search and browse catalogue of e-learning courses. The web browser automatically starts the interactive multimedia Daisy book browser with the selected file. Next Daisy books browser establishes a connection with the streaming Helix Universal server. Text and graphics files and meta data describing book structure are accessed from WWW server. Multimedia book content in DAISY format is divided into parts and stored in many files: text xml, audio mp3 and graphics files. This is essential to continuous online book presentation over the Internet.

Additional browser mechanisms preload book fragments and allow to present book contents without interruptions. Files are accessed in parallel with audio multimedia stream. Loaded xml files (containing book text) are buffered in Daisy browser memory which allows for smooth navigation. The user can search for information in the document before the document is loaded. The text search server implements this function. After the search request is processed and information about found text is passed back to browser. This information allows Daisy browser to playback book contents from any fragment that meets the search criteria.

Selected multimedia streaming server (Helix Universal Server) works in a multiprocessor environment and allows for simultaneous data transmission and multi user service. During our work we tested the system's scalability with a dual processor Pentium server running Linux operating system. Scalability tests were conducted using special developed client and test coordination server applications with client applications up to 100. The purpose of those tests was to evaluate quality of transmitted audio streams and book content data. Client applications collected statistics of received and lost packets. They also offered recording from audio streams, which were evaluated by groups of people. Tests

were conducted in Fast Ethernet computer network with multimedia streaming server connected to Gigabit Ethernet switch port. We tested concurrent access to various Daisy books over that network. The results we received have shown that implemented learning system can support several dozen users at the same time with satisfactory quality of book reading.

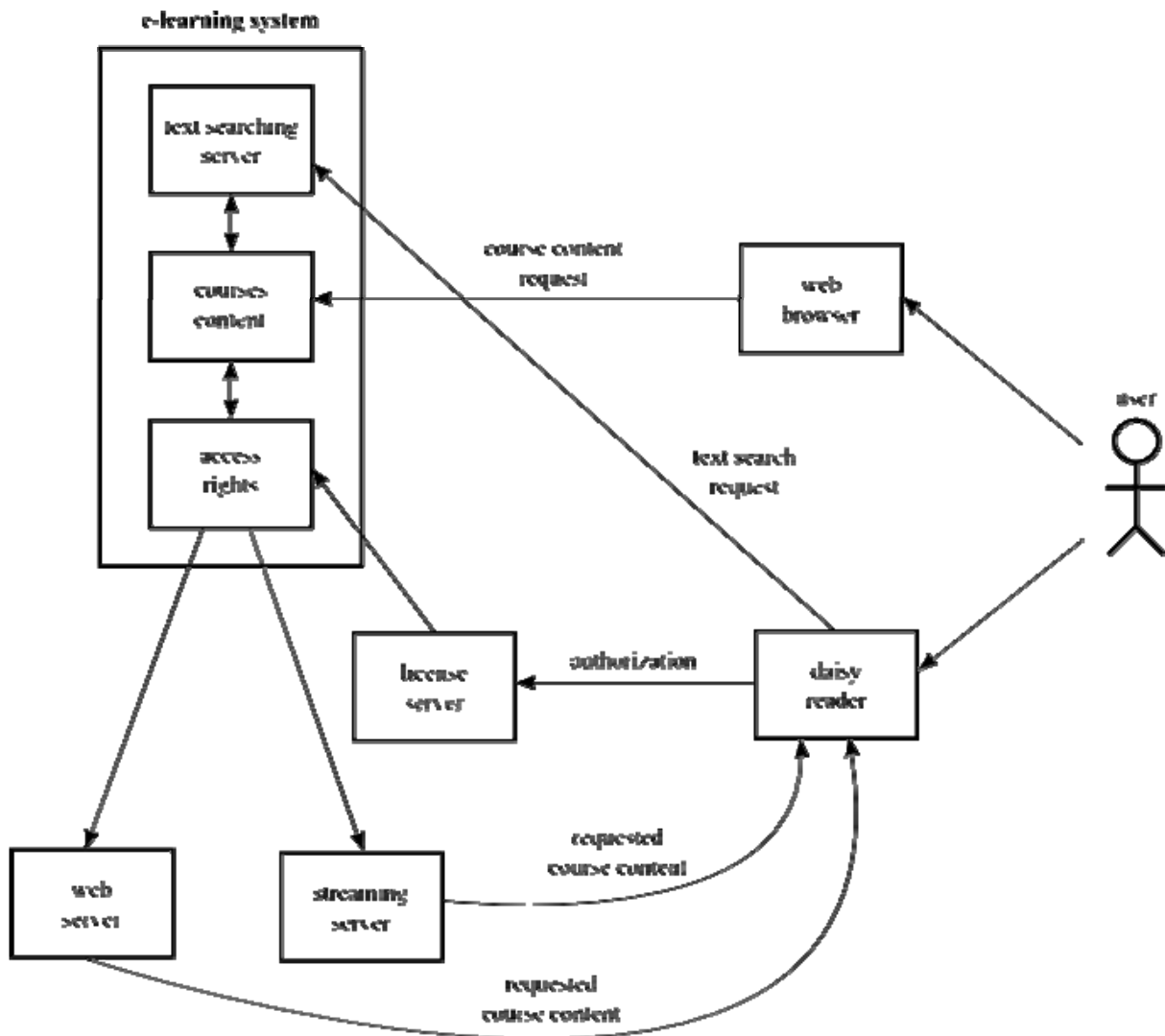


Figure 3 E-learning system components interaction diagram

7. Conclusions

Our research is the result of national project Multimedia Presentation of structural information accessible for all and European FP6 IST project: European Accessible Information Network – www.euain.org. In our research interactive voice and visual presentation of math formulas have been developed based on collaboration with math teachers, impaired pupils and students.

During our study we propose several voice reading methods for basic and advanced maths formulae and examples. Alternative presentation of different math formulas needs to develop new rules of conversion from MathML to voice representation. Reading of math formulas is different from language to language. We focus on Polish and English languages. Our tests of DaisyReader in schools shown that this application can be successful aid in learning math. Developed e-learning platform will be used in education of impaired people in Poland.

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