

# Text Signals and Accessibility of Educational Documents

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*Abstract:* - This paper presents our recent efforts towards advanced document accessibility by supporting not only the accessibility of the text content of a document, but also the accessibility of the text signals, i.e. the writing devices that emphasizes aspects of a text's content or structure. After the introduction of an appropriate document's architecture, we present the main principles and technological topics of document accessibility, including accessibility of Mathematics and graphics. Then, the emerging technological approach of Document-to-Audio (DtA) we have developed is presented. DtA is based on the principles of Design for All. DtA essentially constitutes the next generation of Text-to-Speech systems and is capable to provide much better accessibility to documents. Finally, we introduce the emotional-based mapping methodology for rendering typographic signals to the auditory modality.

*Key-Words:* - Document Accessibility, Document-to-Audio, Presentation Elements, Text Signal, Text-to-Speech, Design-for-all

## 1 Introduction

Electronic documents play an important role in computer aided learning. With the term educational documents we refer to any kind of documents, in any digital format, that are used in computer-aided learning, such as text books, presentations, text documents, articles from journals or periodicals, webpages, reports and e-mails.

Document accessibility enables an electronic document, either in the form of a common file format (such as .pdf .doc, .ppt) or a Web document, to be used effectively, efficiently and satisfactory by more users in more situations or context of use. It concerns all the aspects of document functionality that includes browsing, searching, navigation and reading [1]. Basic accessibility of documents is provided by the Text-to-Speech systems [2].

Accessibility of documents is very important not only for the print-disabled readers, i.e. those with vision impairment (blindness, low vision, color blindness, dyschromatopsia, etc.), a learning disability (including dyslexia) or a motor disability (such as loss of dexterity that prevents the physical handling of a document), but also for those with an occasional or situational "disability". A typical example is a user who wants to access a document while driving a car, i.e. his/her eyes and hands are busy.

In this paper, we present our recent efforts towards advanced document accessibility by

supporting not only the accessibility of the text content of a document, but also the accessibility of the text signals, i.e. the writing devices that emphasizes aspects of a text's content or structure. After the introduction of an appropriate document's architecture, we present the main principles and technological topics of document accessibility, including accessibility of Mathematics and graphics. Then, the emerging technological approach of Document-to-Audio (DtA) we have developed is presented. DtA is based on the principles of Design for All. DtA essentially constitutes the next generation of Text-to-Speech systems and they are capable to provide much better accessibility to documents.

## 2 Document Architecture

According to the communication theorist Marshall McLuhan [3], a document is the "medium" in which a "message" (information) is communicated. The content of the printed or electronic documents includes mainly the text and the images (i.e. figures, drawings, graphs, pictures, charts, diagrams, schematic illustrations, maps, photos, etc.). Furthermore, it may include mathematical or in general scientific symbols and formulas. The term text document refers to the textual content only of a document.

Besides its content, a printed or electronic document contains a number of presentation elements or attributes that apply on its text content: a) design glyphs or typographic elements (i.e. visual

representation of letters and characters in a specific font and style) and b) arrangement of the content on the page and the document as a whole. For example, the title of a chapter can be recognized by placing it at the top of the page and in larger font size than the body of the text. Also, text color, but also the bold font style, can be used to indicate emphasis in a specific part of a text document.

According to Fig. 1, the elements of a text document can be classified in three layers [4]:

- Logical layer: it associates content with structural elements such as headings, titles/subtitles, chapters, paragraphs, tables, lists, footnotes, and appendices.
- Layout layer: it associates content with architectural elements relating to the arrangement on pages and areas within pages, such as margins, columns, alignment and orientation (portrait or landscape).
- Typography layer: it includes font (type, size, color, background color, etc.) and font style such as bold, italics, underline. In contrast to the rich text, the term plain text indicates text of in any unique font type and size, but without font style.

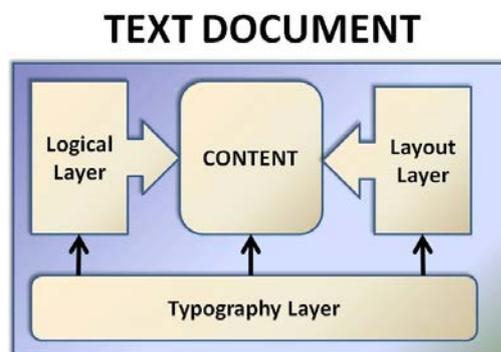


Figure 1: Text document architecture.

The above three layers are complementary and not independent. Typography can be applied to both the logical and the layout layers of a document. Moreover, typography can be applied to the main body of the text directly. For example, a word in bold can be used either for the introduction of a new term or to indicate a person's name. Also, a heading can be arranged in the center of a line (layout layer).

The organization of a document can be classified into two main aspects: the logical and the physical. The logical layer of the document architecture defined above corresponds to its logical organization with the same elements (e.g. headings, titles/ subtitles, chapters, paragraphs, tables, lists, footnotes, and appendices). At the page level, the

physical organization of a document is described by its layout layer in connection with the physical realization of a number of logical layout elements (e.g. headings, titles/ subtitles, paragraphs, tables, lists, footnotes). The organization of a printed or electronic multipage document as a whole corresponds with the physical implementation of a part of its logical layer elements (e.g. chapters, appendices, indexed, references). The organization of a document is domain specific (e.g. text book, scientific paper, technical report, newspaper, magazine).

The term text signal has been proposed [5] as the writing device that emphasizes aspects of a text's content or structure carrying semantic information over and above the content. It attempts to pre-announce or emphasize content and/or reveal content relationship [6]. Headings or titles in text documents are considered as signals [7].

### 3 Document Accessibility

The accessibility of documents can be analyzed in the following four dimensions: technological, legal, economic and social/ethical.

The Convention on the Rights of Persons with Disabilities [8] of the United Nations, adopted on 13 Dec. 2006 by the General Assembly and effective from 3 May 2008, and specifically Article 9, is the main international legal instrument for document accessibility. Up to the end of 2012, 126 countries ratified and adopted CRPD on a national legislation level. The Americans with Disabilities Act [9] enacted by the U.S. Congress in 1990 as well as the Federal procurement of electronic and information technology [10] cover the issue of document accessibility. i2010 [11], the European Union's respective policy framework for the information society and media 2005-2009, along with the Digital Agenda for Europe [12], incorporate the Commission's strategy involving with document accessibility.

The economic aspects of document accessibility include on one hand the development cost of accessible documents and on the other the return from their production and distribution (e.g. increase the range of possible customers and/or decrease the production of alternative formats). By applying the universal design principle, the extra cost one has to spend for a document to become accessible can be sufficiently small. Universal access embraces theoretical, methodological, and empirical research of both a technological and non-technological nature that addresses accessibility, usability, and, ultimately, acceptability of information society technologies by anyone, anywhere, at any time, and

through any media and device [45]. In the framework of universal access [13], we define universal design or design-for-all as the general framework catering for conscious and systematic efforts to proactively apply principles, methods, and tools to develop documents that are accessible and usable by more people, including the youngest, the elderly and people with different types of disabilities, in more situations or context of use, thus avoiding the need for a posteriori adaptations, or specialized design.

Social/ethical issues of document accessibility promote equal opportunities, without exclusion and are part of the Corporate Social Responsibility of an institution, either public or private.

The basic technological requirements for a document to be accessible are:

- Content must be perceivable: information must be presentable to users in ways (such as other modalities) they can perceive, i.e. content cannot be unobservable to all of their senses.
- The reading platform/agent (hardware and/or software) must be operable concerning user interface components as well as navigation, browsing and searching, i.e. the interface cannot require interaction that a user cannot perform.
- Content must be understandable: information and the operation of user interface must be understandable, i.e. the content or operation cannot be beyond the understanding of the users.
- Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies, i.e. as technologies and user agents evolve, the content should remain accessible.

Accessible documents are related to alternate media or alternative formats, including: e-document (accessible files in MS-Word, PDF, Open Office, LaTeX), large print, braille, tactile graphics, audio files, DAISY and accessible Web content. Most online e-documents, audio books or e-book readers or are not accessible. Any electronic document (such as a file in MS-Word, PDF or Open Office) is not accessible per se. A number of guidelines have been introduced for developing accessible electronic documents [14]. Microsoft provides detailed guidelines to create accessible documents, spreadsheets, and presentations with Microsoft Office [15] and has included accessibility checker functionality. Adobe provides a series of accessibility guides to assist authors to create PDF files that are accessible to people with disabilities [16]. Moreover, MS Word and PowerPoint plug-ins

exist that help to create accessible PDF documents [17].

Accessibility essentially ensures compatibility between the content of a document and the technology/agent of the reader. Within the scope of this chapter, a user agent is any software that retrieves, renders and facilitates end user interaction with the content of a document. An electronic document can be read by mainstream platforms, such as personal computers (either desktops or laptops), as well as by mobile devices (smart-phones and tablets). Assistive Technology (AT) includes products, devices, equipment or software applications that are used to maintain, increase or improve the functional capabilities of individuals with disabilities. AT is designed to enable independence for disabled and older people. The Human Activity Assistive Technology (HAAT) model introduced by Cook & Hussey [18] describes the overall goal of an AT system. There is a variety of AT for document accessibility, ranging from low-tech devices (e.g. portable magnifiers) to advanced Automated Reading Devices [19]. There are clear benefits of using AT [20] for the activities and the participation of persons with disabilities according to the International Classification of Functioning, Disability and Health [21]. Typical AT to access documents include:

- Screen readers [19],
- Screen Magnifiers [22],
- CCTV (Closed Circuit TeleVision) systems [23, 24],
- Alternative input devices (e.g. switches, joysticks, eye gazing) [25, 26],
- Braille displays [27],
- Automated Reading Devices (ARD) [19],
- DAISY readers [28]: software applications or portable hardware devices for playing e-books that follow the ANSI/NISO Z39.86-2005 specifications for the Digital Talking Book.

The design-for-all principle has been adopted by the main computer operating systems (MS-Windows, Linux, Mac OS, Android) and office applications (MS-Office, OpenOffice, Adobe PDF).

The Web Accessibility Initiative [31] of the World Wide Web Consortium [32] promotes the implementation of accessibility improvements in Web technologies through the development of a set of three WAI guidelines as Recommendations: Web Content Accessibility Guidelines (WCAG), User Agent Accessibility Guidelines (UAAG), and Authoring Tool Accessibility Guidelines (ATAG). These guidelines describe features needed to achieve different levels of accessibility, and include

reference checklists and implementation techniques. It is essential that several different components of Web development and interaction work together in order for the Web to be accessible to people with disabilities. These components include [31]:

- content - the information in a Web page or Web application, including:
- natural information such as text, images, and sounds
- code or markup that defines structure, presentation, etc.
- Web browsers, media players, and other "user agents"
- Assistive Technology, in some cases - screen readers, alternative keyboards, switches, scanning software, etc.
- users' knowledge, experiences, and in some cases, adaptive strategies using the Web
- developers - designers, coders, authors, etc., including developers with disabilities and users who contribute content
- authoring tools - software that creates Web sites
- evaluation tools - Web accessibility evaluation tools, HTML validators, CSS validators, etc.

Web developers usually use authoring tools and evaluation tools to create Web content. People ("users") use Web browsers, media players, Assistive Technologies, or other "user agents" to get and interact with the content.

The WAI Technical Activity develops techniques to improve tools for evaluation and repair of Web sites. Web Accessibility Guidelines introduced by the Web Accessibility Initiative [31] of the World Wide Web Consortium [32] play a very significant role in the domain of web content accessibility. These guidelines concern all the Web content developers (page authors and site designers) as well as the developers of authoring tools. Following these guidelines the Web documents become a device / software independent. Web Content Accessibility Guidelines (WCAG) 2.0 are now also an ISO/IEC International Standard, ISO/IEC 40500:2012. In the context of WAI [32], an AT:

- relies on services (such as retrieving Web resources and parsing markup) provided by one or more other "host" user agents. AT communicate data and messages with host user agents by using and monitoring APIs.
- provides services beyond those offered by the host user agents to meet the requirements of users with disabilities. Additional services

include alternative renderings (e.g. as synthesized speech or magnified content), alternative input methods (e.g. voice), additional navigation or orientation mechanisms, and content transformations (e.g. to make tables more accessible).

The Digital Accessible Information System consortium [33] proposed standards (officially known as ANSI/NISO Z39.86 and ANSI/NISO Z39.98-2012) [34]. These standards define the format and the content of the electronic file set that comprises a digital talking book (DTB) and establishes a limited set of requirements for DTB playback devices. A DTB is a collection of navigable digital files arranged to present information to the target population via alternative media, namely, human or synthetic speech, refreshable braille, or visual display, e.g., large print.

In the case of scientific documents, accessibility deals also with mathematical or in general scientific symbols and formulas, as well as scientific graphics [35].

MathML [36] is a W3C Recommendation defining an XML vocabulary for marking up mathematical expressions. It contains two sub-languages: presentation MathML (for describing the layout of a mathematical expression) and content MathML (for marking up some aspects of the meaning, or at least the mathematical structure, of expressions). Many software packages, including browsers, editors (e.g. MS-Word2010), and publishing software (including DAISY), have adopted MathML. MathPlayer [37] is a freeware software that enhances Internet Explorer to display mathematical notation in large size or to transform any mathematical formula into spoken form using TtS.

Scalar Vector Graphics [38] is a language for describing two-dimensional graphics and graphical applications in XML. SVGs offer a number of features to make graphics on the Web more accessible, to a wider group of users. The users who benefit include; those with low vision, color blind or blind users, and users of AT. A number of SVG features can also increase usability of content for many users without disabilities, such as users of mobile phones, tablets or other non-traditional Web access devices. SVG images are scalable, i.e. they can be zoomed and resized by the reader as needed. Scaling can help users with low vision and users of some AT (e.g., tactile graphic devices, which typically have low resolution).

Tactile graphics are simplified graphical images that use raised lines and textures to convey

information. They can be produced either with tactile graphic software applications that send simple images to a Braille embosser or with dedicated devices on a microcapsule paper that is heated (“toasted”) to produce raised images.

#### 4 Document To Audio

The primary goal of utilizing text signals or presentation elements in text documents is to distinguish parts of the text and to create a well-formed presentation of the content in order, for instance, to augment the reading performance or attract the reader. Authors use typography and layout in a specific way, e.g. there are “strict” typographic rules for the documents to be published in a scientific journal. But in newspapers and books the page designer (or the page manager), and not the author, has the primary responsibility for applying the typography and layout layers. Traditional factors that play a leading role in documents formation and presentation include readability (the gauge that measures how easily words, phrases, and blocks of text can be read) and legibility (the measure of easiness to distinguish one letter from another in a particular typeface). More recent factors include visual aesthetics and accessibility. Design attributes such as character shapes and proportions, stroke weight and axis, affect legibility. Legibility is about perception. Readability refers to comprehension and visual comfort in reading long text passages [39]. People who design types, i.e. type designers, have a direct influence on legibility and people who set type, i.e. typographers, are determinant in text readability [40].

It seems that there is a plethora of semantics in applying the typographic layer. For example, in contrast to the tags introduced by the W3C for the bold and italics font styles, we have identified [41] eight different “labels” that the readers seem to use most frequently in order to semantically characterize text in “bold” and “italics”.

All the above attributes play an important role in reading a text by a person with low vision, even in the case he/she uses an appropriate AT such as a screen magnifier or a CCTV magnification system. On the other hand, blind users can access a text document with audio, mainly through a Text-to-Speech system. Most of the current Text-to-Speech systems do not take into account the semantics and the cognitive aspects of the presentation elements or text signals. There is an effort towards Document-to-Audio (DtA) synthesis [4], which essentially constitutes the next generation of the Text-to-Speech systems. DtA supports the extraction of the semantics of document metadata of the presentation

elements [41] and the efficient acoustic representation of both text formatting and typography, as well data tables [42]. This is accomplished in DtA through the modeling of the parameters of the synthesized speech signal by: (a) combining alternative text insertion in the document text stream, (b) altering the prosody, (c) switching between voices, and/or (d) inserting non-speech audio (like earcons) in the waveform stream, according to the class of metadata provided in the document.

Recently, an automated reader’s emotional state extraction process derived from the typographic elements has been proposed [43], as well as an appropriate modeling of reader’s emotional state response on document’s typographic elements [44] towards their acoustic rendition using expressive speech synthesis. Nowadays, there is not a systematic and formal methodology, based on sound research founding, on how the typographic elements should be used while creating a rich text document.

Previous approaches for rendering typographic signals to auditory modality can be characterized as direct mapping methodologies. Most of them are based on the relation similarity, i.e. each typographic attribute is directly mapped into a respective acoustic cue. The principle of relational similarity explores two physical quantities with magnitudes that humans perceive by different senses in an analogous way. For example, the font size of a text and the volume of the speech signal when the text is vocalized comprise relational similarity in the case we perceive the change of their magnitudes in a proportional way.

Present work introduces the emotional-based mapping methodology for rendering typographic signals to auditory modality. First, we measure and model the way emotional states are induced to the reader by the typographic signals. Then, following a number of psychoacoustic experiments, we determine analogous prosodic cues that produce the same emotional states to the listener when he/she hears the acoustic rendition of the document by a TtS system. Our ultimate goal is to incorporate automatic typography-to-speech mapping in DtA by emotional analogy between the visual (typographic signals) and the acoustic (speech prosody) modalities. In this framework we introduce the notion “typographic profile” of an emotion, in a similar way to the “prosodic profile”. The way typographic attributes are used by a specific author or page designer constitute the typographic profile of the document. The profile defines the space within each emotion is located (and vice-versa).

Figure 2 presents the prosodic and typographic profile respectively.

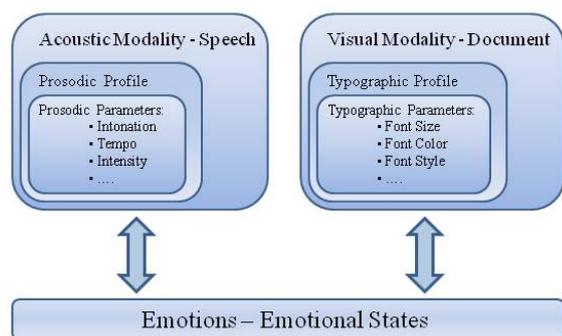


Figure 2: The prosodic and typographic profiles.

## 5 Conclusions

We have presented our recent efforts towards advanced document accessibility by supporting not only the accessibility of the text content of a document, but also the accessibility of the text signals, i.e. the writing devices that emphasizes aspects of a text's content or structure. First, we introduced an appropriate document's architecture, and the main principles and technological topics of document accessibility, including accessibility of Mathematics and graphics. Then, the emerging technological approach of Document-to-Audio (DtA) we have developed was presented. DtA essentially constitutes the next generation of Text-to-Speech systems and is capable to provide much better accessibility to documents. Finally, we introduced the emotional-based mapping methodology for rendering typographic signals to the auditory modality.

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