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TOWARDS AN ACCESSIBLE SCIENCE: FACILITATING ACCESS TO SCIENTIFIC DIGITAL RESOURCES FOR VISUALLY IMPAIRED STUDENTS

D2.2 Accessible and usable scientific books

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e*Content*plus

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[1] OJ L 79, 24.3.2005, p. 1.

EXECUTIVE SUMMARY

This document is part of the work package 2.1 about the state of the art. It illustrates the state of the art about accessible and usable books at university. This work is intended to illustrate the issues and the opportunities about reading scientific books, which will be exploited to go towards guidelines and to select and collect best practices.

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1 INTRODUCTION

1.1 Scope of the document

This document covers the state-of-the-art about scientific books reading opportunities for visually impaired university students. Problems, reading strategies and emerging opportunities are introduced with respect to the mainstream assistive technology and cutting-edge assistive tools. At first are introduced peculiarities of scientific books which make them more difficult to be accessed and used by visually impaired students than literary books. Then the main alternative reading techniques are introduced and analysed as for scientific books. Subsequently, accessibility issues concerning digital formats for scientific and technical books publishing are illustrated. Then, a list of online scientific resources providers which produce scientific resources accessible and usable by visually impaired is reported and accessibility and usability problems introduced in the previous sections are further discussed by examples. A survey about accessible and usable scientific books at university follows. In order to actually understand the possibilities available for visually impaired to have scientific books adapted in accessible formats, a worldwide list of transcription and document adaptation services is annexed in Appendix 1.

1.2 Overview

One of the most relevant problems met by visually impaired students who attend scientific courses is the lack of scientific books, lecture notes, papers and technical reports, available in alternative formats, accessible through mainstream or specialized assistive tools. That often induces many learning difficulties. If the books are not available during the university courses, visually impaired students have problems in staying update with the lessons scheduled and they often loose many learning opportunities. Therefore, is of crucial importance to get a full overview of the formats which can be used by visually impaired to read scientific documents. Furthermore, a tentative list of online scientific resources and transcription and books adaptation services for visually impaired is reported in the document so as to provide state-of-the-art about the available services. In the end, through the preparation and distribution of a questionnaire about accessible and usable scientific books at university, the national peculiarities are come out and they can be analysed in the coming work packages.

2 METHODOLOGY

In order to collect state-of-the-art information about opportunities for visually impaired students to retrieve and read scientific resources (e.g. textbooks, scientific articles, conference proceedings, lecture notes, etc.) generally used in university courses, the following activities were undertaken:

- literature review about accessible reading resources. In particular, ACM digital library, IEEE collections and Springer publications were studied;
- selection of online services for accessible scientific and technical resources;
- definition of a list of worldwide services which adapt printed books into accessible formats. In particular, Braille, talking books, electronic books and large print books were taken into account. Most of the companies and institutions listed in the appendix were contacted in order to get information about the services provided;
- preparation of a questionnaire to collect information about how visually impaired students access books at university in the countries involved in the @Science network. The questionnaire was distributed to the @Science members who filled it according to their long term experience and to the experiences of the students contacted.

3 SCIENTIFIC BOOKS

As for the structure and the content types, scientific books are far more complex than literary ones. Literary books are usually made up of only one content type, text, which is structured according to chapters, sections, subsections, paragraphs, sentences and words. Instead, scientific books present peculiarities as for the content and the structure. Three content types can be pointed out: text, mathematical expressions and figures.

Text is usually structured in chapters, sections, subsections, paragraphs, words and it is often characterized by many attributes such as font, colour, typeface and style.

Mathematical expressions are generally presented in scientific books through the traditional two-dimensional mathematical notation. They can be found in the text (inline expressions) or in a separate area. They are usually numbered according to the section they belong to. Also mathematical expressions can be characterized by many attributes such as colour, font and style.

Figures are separated from text and mathematical expressions because they are generally positioned in different frames in the page. Figures are often commented through a caption. Enumeration according to the section is generally used for figures, too.

Many structural elements are used in scientific books. In particular are used simple or nested ordered or unordered lists and tables. Furthermore, specific parts especially interesting for the reader are numbered and highlighted. The most known are: definitions, theorems and lemmas. The overall page layout can be deeply different from page to page according to the structural elements to be presented and to the concept to be conveyed. In order to enable visually impaired students to read scientific books, the following techniques are the most widespread:

- large print books. The book is printed or photocopied on paper enlarging the size of the characters and the size of the figures. It is especially useful for partially sighted readers;
- Braille books. The book is embossed on paper according to the rules of the national Braille code;
- audio books. The book is speech recorded by a human reader or through a speech synthesizer. It can be recorded on audio tape or in a digital audio format;
- books in digital format. The book is adapted in a digital format accessible and usable through speech synthesizer and Braille display. Figures have to be embossed on paper or verbal descriptions should be provided because of the lack of a mainstream refreshable display able to reproduce tactile graphics. In order to be used through mainstream assistive technologies, scientific books should be represented through highly granular digital formats. If metadata about layout are separated from metadata about the structure and the content types are described through a semantics oriented markup language, software agents, which are in charge of alternative rendering, will be able to find the mutual relations among the structural elements making up the book and among the elements making up a certain content type (e.g. numerator and

denominator in a mathematical expression, two sentences in a text section, etc.). That allows for the generation of the proper Braille or speech output.

In order to generate large print books, Braille books and accessible digital books, the book has to be available in a digital format to be properly processed. To this purpose, two methods are used:

- publishers are required by visually impaired people or by services for visually impaired people to provide the files of the book for adaptation in alternative formats. If the publisher agrees to distribute the files, further problems may occur. Especially, the file format is not often the best one to be processed (e.g. source files are not provided, but print oriented file format are provided);
- the paper book is scanned and processed by an OCR software in order to generate a digital file format to be processed. That can be hardly done for scientific books, especially because of the problems in recognizing mathematical expressions. There is only one not prototype OCR program for mathematical expressions. It is InftyReader (further information can be found at: http://www.inftyproject.org). It is able to recognize printed mathematical expressions and generate LaTeX or MathML source code. InftyProject continues to go on, so Inftyreader is being updated. It is a very promising tool.

4 LARGE PRINT SCIENTIFIC BOOKS

Visually impaired people can be facilitated in reading scientific books by enlarging the size of the characters making up text and mathematical expressions and the size of the figures. Whether a large print book can be effectively read or not often depends on the level of sight impairment of the reader. Nevertheless, scientific books pose some difficulties in being adapted for partially sighted. For example, if a fraction was horizontally stretched, before overcoming the right or the left margin it should be split. It is necessary to split the whole fraction, not the numerator, then the fraction line and at last the denominator. So, it is necessary to put a sign at the end of line to inform the reader that the fraction is not over (e.g. a times sign) and then copy under the first part of the fraction the final part of the denominator, the final part of the fraction line and the final part of the denominator. If that was not accurately made, it would be generated a meaningless notation. More complex problems come out with enlarged figures. They concern the preservation on the page of mutual relations among the parts making up the figure (e.g. shapes, text labels, etc.). So, some editing operations have to be done by expert professionals in order to prepare a high quality large print scientific book. The list reported in appendix 1 also collects information about services for the production of large print scientific books.

5 BRAILLE SCIENTIFIC BOOKS

Scientific books can be embossed on paper by using a Braille embosser. In order to prepare a Braille scientific book, text and mathematical expressions have to be converted into Braille according to the rules of the chosen national Braille code. As illustrated in the deliverable 2.1 about assistive tools in scientific studies, there are programs which automate the conversion of text and mathematical expressions into national 6-dots Braille codes (e.g. DBT developed by Duxbury systems). In spite of that, this process is usually time-consuming, very expensive and it requires a skilled professional to achieve high quality results. Figures can be embossed in the book after adaptations or verbal descriptions are provided in the Braille edition. Full university textbooks are seldom embossed in Braille on paper because of the high number of Braille volumes which are produced. Moreover, since university scientific textbooks are not read sequentially, but the reading plan changes according to the topic to be found (e.g. at first it is read the result of a theorem, then some definitions introduced many pages in advance are studied and then the proof is read), the book fragmentation through many volumes makes the understanding rather difficult. Braille books can hardly be distributed across countries because of the national peculiarities of the Braille code, especially of the one for mathematics. In Appendix 1 were collected references to worldwide Braille transcription services, which have experience to adapt scientific books.

6 AUDIO SCIENTIFIC BOOKS

6.1 Introduction

One more method to adapt scientific books for visually impaired consists of speech recording the book on audio tapes or in audio digital format. Speech recording can be achieved either through human readers or through a speech synthesizer which automatically reads text available in digital format. Many scientific exercise books can be understood by sighted readers without any knowledge of the national language used to write them because they are mainly made up of mathematical formulae. Human speech reading binds whatever book to the reader's spoken language thus making difficult transnational distribution of the books produced. The use of speech synthesizers would make the production language independent. However, further problems occur. First of all, if it is not used a high quality speech synthesizer (no such synthesizer is available for all languages) the resulting audio books cannot be understood at all. Moreover, in order to be speech recorded by a synthesizer, the text has to be available in digital format and mathematical expressions have to be described through a markup language which can be interpreted by the speech synthesizer software. There aren't documented experiences of scientific books production through speech synthesizer. Figures are introduced in speech recorded books through verbal description or tactile representations are provided on paper together with the audio book. As mentioned in section 3, scientific books present a very complex structure: they are usually divided in chapters, sections, subsections, etc., they contain nested ordered and unordered lists or tables, which are made up rows and columns of cells, mathematical expressions themselves have a structure (round brackets, brackets, curly brackets, numerator and denominator, function name and function argument, etc.) and definitions, theorems and lemmas are usually mutually related. Therefore, it would be extremely useful for the listener of audio scientific books to have the possibility to navigate the structure of the book so as to better understand the topics by exploring according to a reading plan, not sequentially forward and backward. That depends both on the player and on the granularity of the file format. Traditional audio books do not allow for structure exploration. DAISY digital talking books, introduced in the following section, offer this feature. Appendix 1 reports a list of worldwide services which produce and distribute audio scientific books.

6.2 DAISY: digital talking books

Website: http://www.daisy.org

6.2.1 Introduction

In 1995, many organizations around the world producing analog talking books founded the Digital Audio-based Information SYstem (DAISY) Consortium with the goal of developing the standards for the next generation of information technology for the blind or print disabled. The DAISY Consortium’s technologists analysed the analog formats and e-text specifications, then began research and development of a format that would combine human narration with the power of

evolving electronic text implementations: the DAISY specification. In 1997, the National Library Service for the Blind and Physically Handicapped (NLS) in the USA invited the DAISY Consortium and North American organizations serving persons with print disabilities to join them in working through the National Information Standards Organization (NISO) to develop further standards for Digital Talking Books (DTBs). The DAISY Consortium worked with the NISO committee and developed a third-generation standard in conjunction with NLS and its partner agencies. DAISY is the common name used to classify the DTBs produced according to the rules described below. It is not the only way of producing accessible DTBs, but it is the only standardized one.

6.2.2 Digital Talking Books

A Digital Talking Book (DTB) [1] is a collection of electronic files arranged to present information to the target population via alternative media, namely, human or synthetic speech, refreshable Braille devices, or visual display, (e.g. large print). When these files are created and assembled into a DTB in accordance with this standard, they make possible a wide range of features, such as rapid, flexible navigation, bookmarking and highlighting; keyword searching, spelling of words on demand, and user control over the presentation of selected items; thus allowing the reader to access the information in DTBs easily and efficiently.

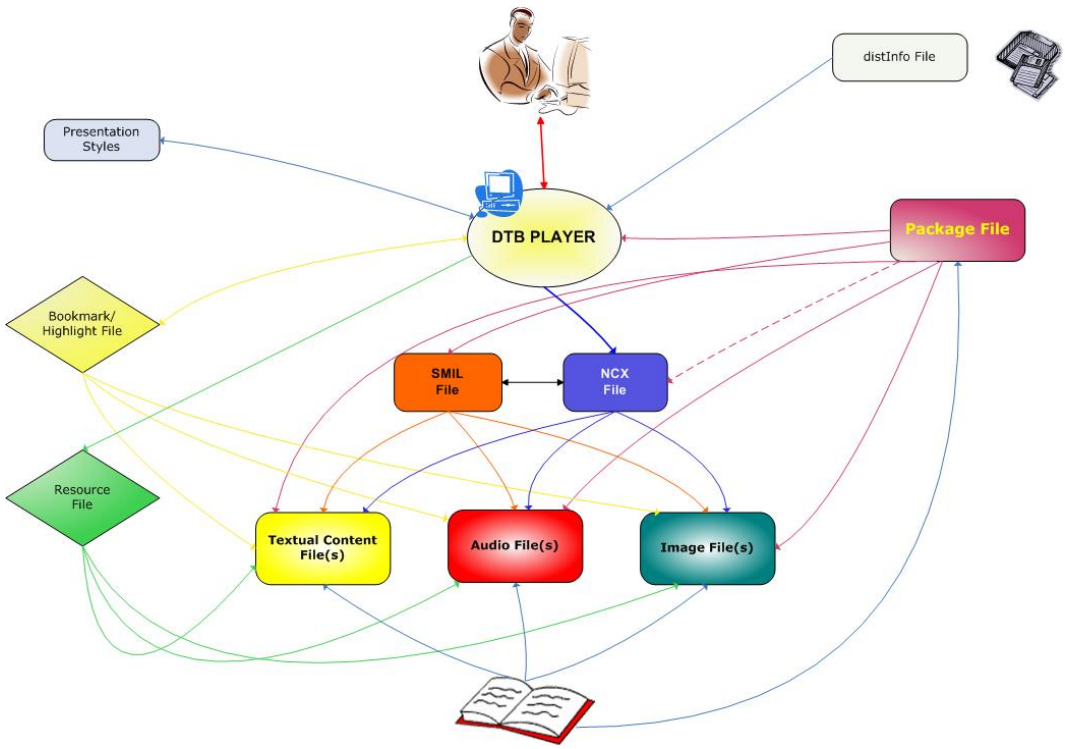

Fig. 1: Diagram of the different files that compose a DAISY Digital Talking Book. The arrows indicate the relationships between the various files and their interactions.

DTBs range from audio alone, through a combination of audio, text, and images, to text alone. DTB players will also be produced with a variety of capabilities. The simplest might be portable devices

with audio-only capabilities. More complex portable players could include text-to-speech capabilities as well as audio output for recorded human speech. The most comprehensive playback systems are expected to be PC-based, supporting visual and audio output, text-to-speech capability, and output to a Braille display.

6.2.3 Mathematical expressions in the digital talking book

The DAISY/NISO standard defines a comprehensive system for Digital Talking Books. A part of this standard is DTBook, an XML vocabulary that provides a core set of elements that are needed to produce most types of books. However, DTBook is not intended to be an exhaustive vocabulary for all types of books.

Many organizations have inquired about the correct approach to extend the DAISY/NISO standard so that it can address additional needs. Some extensions that have been mentioned are for mathematics, video support, testing, workbooks, music, dictionaries, chemistry, searching and more. In 2005 started the activity of the MathML-in-DAISY working group. The objective of this working group is to develop and submit a formal proposal (including all supporting documentation) for a MathML modular extension to ANSI/NISO Z39.86-2005 in accordance with the modular extension guidelines, a process for developing interoperable extensions within the constraints of the 2005 revision of the standard. At the moment, the DAISY/NISO Standard does not have a method for including mathematical expressions in a document other than via images with a verbal description. The standard does however, include an extension mechanism. [2] The DAISY MathML working group has been working on a solution for including mathematical expressions based on this extension mechanism. There are many problems associated with the use of images for mathematics for authors and for readers (both those with and without visual disabilities). These include:

- inability to magnify the image or change its colours;
- fixed text that can not be tailored to an individual's needs;
- no navigation and exploration of the mathematical structure;
- no synchronized highlighting of speech;
- inability to be translated to a braille math code.

MathML represents a possible solution to these problems. Because it is an XML application and has been designed to work with XHTML, using MathML in the DAISY/NISO Standard was the direction that the DAISY Math Working Group pursued. The first public draft of the MathML-in-DAISY Modular Extension is available on the DAISY website.

7 DIGITAL FORMATS FOR SCIENTIFIC RESOURCES: ACCESSIBILITY AND USABILITY

7.1 Introduction

Up to recently, scientific resources (e.g. books, technical reports, papers, etc.) have been produced in digital formats suitable to be displayed on the screen or to be printed on paper. Therefore, the markup languages for scientific documents have been oriented for years to produce files to be converted into page description languages for document printing or displaying (e.g. PostScript files). LaTeX is the document markup language and document preparation system most well-known by the scientific community and mostly used by scientific publishers. It is mainly oriented to generate high quality printing through a conversion into DVI files which can be used to produce PostScript or PDF files. So, LaTeX does not provide information about the semantics of the mathematical expressions and mathematical concepts (e.g. definitions, theorems, etc...) described in the document. Thanks to the evolution of interactive web services for the scientific community, to the widespreading of SGML and especially of XML derived markup languages, to the evolution of multimodal systems, to the growing need for processing the scientific document (e.g. in order to perform advanced editing operations, to make computations, automatic proves, etc.), not only to read them, markup languages for the production of scientific resources in digital format evolved. In particular, from the middle nineties on, the attention has been focused also on giving a highly granular structure to the final file of a scientific book, on taking into account different rendering modalities (e.g. through the application of different styles for screen rendering, through the transformation of mathematical expressions to be displayed in different output forms, through the availability of multiple reading styles such as reading from right to left, etc.), on integrating the scientific production with the web-based repositories and interactive services, on specifying the exact semantics of the mathematical notations and concepts so as to enable software agents to execute computations or automatic deductions. Therefore, at present, more than one markup language for scientific document is available. Even if LaTeX continues to be the most widespread and the most suitable for many publishing tasks, and it is likely to be used for long, also other markup languages are being developed and widespreading. The following sections will introduce some of the most known markup languages to produce scientific resources. At first LaTeX is introduced, then XHTML and MathML are outlined in order to understand how web published scientific books can be accessible by speech and Braille output, subsequently OpenMath format is sketched because of the potentiality to provide high quality speech and Braille access not only to a finite set of mathematical symbols and notations, but also to whatever accurately described mathematical notation and concepts. At the end, PostScript and PDF file formats are briefly illustrated, especially as far as speech and Braille access to embedded mathematical expressions is concerned.

7.2 LaTeX

7.2.1 Description

LaTeX [3] is the document markup language and document preparation system mostly well-known by the scientific community and the mainly used by scientific publishers because of the TeX typesetting program which can produce high quality printing. It is also used as intermediate format to achieve high quality printing of other markup languages for scientific documents (e.g. MathML). It makes available a lot of features to automate most aspects of typesetting and desktop publishing, including numbering (e.g. pages, chapters, sections, subsections, theorems, definitions, etc.) and cross-referencing, ordered and unordered lists, tables and figures, page layout and bibliographies. LaTeX provides a high-level language to access TeX, which is based on low-level formatting commands, through a collection of macros and a program to process LaTeX documents. In preparing a LaTeX document, the author specifies the logical structure using familiar concepts such as chapter, section, table, figure, etc., and lets the LaTeX system work about the presentation of these structures. It therefore encourages the separation of layout from content, while still allowing manual typesetting adjustments where needed. LaTeX can be arbitrarily extended by using the underlying macro language to develop custom formats. Such macros are often collected into packages, (e.g. for advanced mathematical notation). In order to generate the final book file to be distributed, LaTeX files are compiled into Device Independent format (DVI) and then into PostScript or PDF files.

7.2.2 Remarks

LaTeX source file is very often used by visually impaired students to read the university. Since it is a text file, it can be read on the Braille display or through the speech synthesizer. Anyway, the reading effectiveness and efficiency can be very low. Actually, source LaTeX was designed to write scientific resources and to read them after conversion into some final format (e.g. PostScript or PDF). So, LaTeX source file is sometimes too verbose to be easily understood by human readers. That happens especially when macros are extensively used throughout the document or whether the LaTeX source file is generated by some WYSIWYG working environment for technical writing. One attempt to provide human readable TeX was achieved by Mario Batusic at Linz University, who developed HrTeX, a LaTeX package which can be used to produce source documents readable by human readers, especially useful for blind readers. Figures introduced in LaTeX source files can be understood by visually impaired either through the caption which is often provided or by having them embossed on paper. There is no interactive mechanism to have figure displayed on a refreshable tactile device during the document reading process. Visually impaired students or university support services often ask scientific publishers to have LaTeX source files of university scientific textbooks. Publishers sometimes send the LaTeX source file and other times either do not own the source file because they own only the PostScript file or they do not distribute it because of copyright issues. In spite of the problems which can be met in reading or having LaTeX source files, at the moment LaTeX is the most used format among visually impaired students to read scientific resources.

7.3 XHTML embedding MathML

7.3.1 Description

XHTML (eXtensible Hypertext Markup Language) [4] is the most popular markup language used to publish documents on the web. MathML (Mathematical Markup Language) [5] is the markup language promoted by the W3C (website: http://www.w3.org/math) to put mathematical expressions on the web. It was developed and it is maintained by the W3C Math Working Group. MathML is an XML application for describing mathematical notation and capturing both its structure and content. The goal of MathML is to enable mathematics to be served, received, and processed on the World Wide Web, just as HTML has enabled this functionality for text. MathML can be used to encode both mathematical notation and mathematical content. About thirty of the MathML tags describe abstract notational structures, while another about one hundred and fifty provide a way of unambiguously specifying the meaning of an expression. MathML content and presentation tags interact to generate mixed markup which can be used for different rendering purposes. Even if MathML is a text format which can be potentially read by human readers, it was not designed to be read by human readers, but it was designed to be processed by software components (e.g. equation editors, conversion programs, and other specialized software tools to generate MathML such as converters from other mainstream formats). At the moment, MathML can be successfully displayed by Mozilla Firefox browser and through a plug-in (e.g. MathPlayer [6]) by Microsoft Internet Explorer browser.

7.3.2 Remarks

MathML introduced a promising opportunity for visually impaired readers who need to read web published scientific resources (e.g. lecture notes collected in a book published by the professor on the university course website). Up to six years ago, the only way to publish mathematical formulae on the web has been through images with or without alternative text. By using software agents (e.g. speech or Braille enabled MathML-aware browsers) which provide access to MathML expressions (e.g. MathPlayer, see deliverable 2.1) is now possible, even if still not so immediate, to access web pages embedding MathML. Further software development will make more and more easy the reading process, in particular as for the use of national Braille codes and local languages for speech rendering. [7]

7.4 OpenMath

Website: http://www.openmath.org

7.4.1 Description

OpenMath is an emerging format for representing mathematical objects with their semantics, allowing them to be exchanged between computer programs, stored in databases, or published on the web. OpenMath is now attracting interest from many areas of scientific computation and from many publishers of electronic scientific documents. There is a strong relationship between OpenMath and MathML recommendation from the Worldwide Web Consortium, and a large overlap between the two developer communities. Even if content MathML provides the meaning of some mathematical objects, MathMlL deals principally with the presentation of mathematical objects, while OpenMath is solely concerned with their semantic meaning or content. MathML also allows semantic information encoded in OpenMath to be embedded inside a MathML structure. Thus the two technologies may be seen as highly complementary.
Mathematical objects encoded in OpenMath can be displayed in a browser, exchanged between software systems, cut and pasted for use in different contexts, verified as being mathematically sound, used to make interactive documents thus highly extending the concept of reading scientific documents. The worldwide OpenMath activities are coordinated within the OpenMath Society, based in Helsinki, Finland. The Society brings together tool builders, software suppliers, publishers and authors.

7.4.2 Remarks

The possibility to have a formal definition of the mathematical notation and concepts used in a document is likely to extremely useful to improve Braille and speech output of mathematical expressions. When new mathematical notations are used in a document they need a description, which is usually oriented to the visual rendering. So, speech players or Braille translators cannot always provide the most suitable speech or Braille rendering of new mathematical notations. OpenMath explicitly declares the meaning of new mathematical objects, so a good speech or Braille rendering could always be achieved. At the moment, OpenMath is not supported by mainstream rendering tools and is not integrated in the publishing process, but it can be promising for the future evolution.

7.5 PostScript

7.5.1 Description

PostScript is a page description language and programming language used to produce high quality printing or display rendering of documents. It is often the final format for the LaTeX composition process. It does not embed information about the meaning of the elements to be printed, but it describes precisely how they have to be drawn on the page. PostScript is very often the file format which is distributed by the main scientific publishers.

7.5.2 Remarks

PostScript can be hardly accessed by state-of-the-art speech and Braille assistive tools. Even if there exist programs which try to apply reverse-engineering techniques to transform PostScript files

into source LaTeX, the result is usually not readable by human readers. So, visually impaired do not have access to scientific PostScript files.

7.6 PDF

7.6.1 Description

Portable Document Format (PDF) is an open file format introduced by Adobe Systems to represent two-dimensional documents in a device independent and display resolution independent fixed-layout document format. Each PDF file encapsulates a complete description of a document that includes the text, fonts, images and vector graphics that compose the document. PDF files are widely used to distribute scientific books in digital format by publishers. PDF files for scientific books are usually the result of the LaTeX composition process. Recent releases of the PDF file format also addressed accessibility issues. Current PDF file formats can include tags, text equivalents, captions and audio descriptions, and other accessibility features. Leading screen readers, including JAWS, Window-Eyes, and Hal, can read tagged PDF files; current versions of the Acrobat and Acrobat Reader programs can also read PDF files by speech output. Moreover, tagged PDF files can be reflowed and zoomed for partially sighted readers.

7.6.2 Remarks

Even if some accessibility issues have been recently addressed by PDF specification, many problems remain. First of all is rather difficult to add tags existing PDF files. If PDF files are generated from scanned documents, accessibility tags and reflowing are usually unavailable and must be created either by hand or using OCR techniques. Furthermore, mathematical expressions embedded in PDF files are either recognized as text which is vocally output or displayed on the Braille line without any meaning or they are skipped without any text replacement. The most advanced tool which aims to give access to mathematical expressions in PDF files is the ChattyInfty document reader. [8] [9]. ChattyInfty engine does not only recognize PDF documents as page images through the InftyReader OCR engine for mathematical expressions [10], but it also exploits the text information embedded in PDF files to verify its recognition results, thus improving the recognition performance. ChattyInfty system also provides a user interface customized for visually impaired people.

8 ONLINE SCIENTIFIC RESOURCES

8.1 Introduction

Many online resources (e.g. conference proceedings, journals, technical reports, tutorials, guides, etc.) are available for science and technology learning, but not all resources can be accessed and used by visually impaired students. Some resources cannot be accessed because the websites which allow for searching and retrieving the files do not respect web accessibility guidelines [wcag]. Other resources can be easily found and downloaded by visually impaired students, but they are documents which cannot be read through screen readers. Some of these documents can be read after conversion into other formats or through adaptations. This work can be done by university support services or by other specialized services. The following sections introduce some useful online reading resources which sometimes can be used as complementary resources during the university courses. Since university scientific books are often not accessible by visually impaired students and much time is needed to adapt them, visually impaired students often do not have every book at the beginning of each course. So they can rely on some of these online resources when they are attending the university course.

8.2 ACM, IEEE and Springer

Website: http://www.acm.org, http://ieeexplore.ieee.org, http://www.springer.com

8.2.1 Description

ACM (Association for Computing Machinery), is one of the most well-known educational and scientific computing societies. IEEE publishes high quality technical literature in the fields of electrical engineering, computer science, and electronics. Springer is a well-known publisher of scientific and technical literature, journals and conference proceedings. These publishers provide a digital library, where many reading resources can be found. In particular, guides, journals, transactions and conference proceedings are available for download by subscribed members. The files of articles can be downloaded in PDF format.

8.2.2 Remarks

Many university libraries have subscriptions to the ACM, IEEE or Springer digital services. So, visually impaired students can search for articles and download them according to their needs. The web interface is highly accessible for screen readers, too. PDF files downloaded do not provide access to mathematical formulae or to images. Anyway, they can be easily read both when no mathematical expressions are present and whether the images used are not indispensable for understanding the meaning. Text can be easily extracted from these PDF file, so, when necessary, adaptations can be done by university support services or by specialized services. Especially,

formulae can be embedded in the text file where needed, images can be embossed on paper and references are inserted in the text. Of course, this process can be expensive and time-consuming.

8.3 ArXiv: e-Print archive

Website: http://www.arxiv.org

8.3.1 Description

ArXiv is an e-print service in the fields of physics, mathematics, non-linear science, computer science, and quantitative biology. The contents of arXiv conform to Cornell University academic standards. ArXiv is owned, operated and funded by Cornell University, a private not-for-profit educational institution. ArXiv is also partially funded by the National Science Foundation. The Cornell University Library acknowledges the support of Sun Microsystems and U.S. Department of Energy's Office of Scientific and Technical Information (providers of the E-Print Alert Service, which automatically notifies users of the latest information posted on arXiv and other related databases). At the moment, ArXiv ensures open access to 426224 high quality e-prints. In order to get a glance at the amount of resources, all of the categories available on arXiv are reported: Accelerator Physics, Atmospheric and Oceanic Physics, Atomic Physics, Atomic and Molecular Clusters, Biological Physics, Chemical Physics, Classical Physics, Computational Physics, Data Analysis, Statistics and Probability, Fluid Dynamics, General Physics, Geophysics, History of Physics, Instrumentation and Detectors, Medical Physics, Optics, Physics Education, Physics and Society, Plasma Physics, Popular Physics, Space Physics, Quantum Physics, Algebraic Geometry, Algebraic Topology, Analysis of PDEs, Category Theory, Classical Analysis and ODEs, Combinatorics, Commutative Algebra, Complex Variables, Differential Geometry, Dynamical Systems, Functional Analysis, General Mathematics, General Topology, Geometric Topology, Group Theory, History and Overview, K-Theory and Homology, Logic, Mathematical Physics, Metric Geometry, Number Theory, Numerical Analysis, Operator Algebras, Optimization and Control, Probability, Quantum Algebra, Representation Theory, Rings and Algebras, Spectral Theory, Statistics, Symplectic Geometry, Adaptation and Self-Organizing Systems, Cellular Automata and Lattice Gases, Chaotic Dynamics, Exactly Solvable and Integrable Systems, Pattern Formation and Solitons, Computer Science, Architecture, Artificial Intelligence, Computation and Language, Computational Complexity, Computational Engineering, Finance, and Science, Computational Geometry,Computer Science and Game Theory, Computer Vision and Pattern Recognition, Computers and Society, Cryptography and Security, Data Structures and Algorithms, Databases, Digital Libraries, Discrete Mathematics, Distributed, Parallel, and Cluster Computing, General Literature, Graphics, Human-Computer Interaction, Information Retrieval, Inormation Theory, Learning, Logic in Computer Science, Mathematical Software, Multiagent Systems, Multimedia, Networking and Internet Architecture, Neural and Evolutionary Computing, Numerical Analysis, Operating Systems, Other, Performance, Programming Languages, Robotics, Software Engineering, Sound, Symbolic Computation, Biomolecules, Cell Behavior, Genomics, Molecular Networks, Neurons and Cognition, Populations and Evolution, Quantitative Methods, Subcellular Processes and Tissues and Organs.

Documents retrieved on ArXiv can be downloaded in multiple formats: PDF, PostScript using Bitmapped Fonts, PostScript using Type I Fonts, DVI and Source, namely LaTeX or HTML format. The default download format can be set by the user.

8.3.2 Remarks

ArXiv is an excellent resource of scientific papers. The categories available collect papers on advanced scientific topics, so tit is very good for students who are going to choose a thesis or for researchers. On arXiv papers are available also in source format (e.g. LaTeX). This is crucial for blind readers, even if it is not always enough to enable full readability of the document (e.g. if much layout markup is used or if the dissertation is based on a lot of images which are indispensable to understand the meaning).

8.4 O'Relly – Safari books online

Website: http://safari.oreilly.com

8.4.1 Description

Books about technical topics, manuals, tutorials, reference guides are stored in digital format and delivered through an online service.

Safari Features:

- immediate access to the newest books - New books are added in conjunction with, or in advance of, their print publication;
- Rough Cuts Online Access - Safari Library subscribers can view all Rough Cuts titles online. Rough Cuts provide information about the book before it is published in print;
- chapter downloads - Download five chapters per month;
- cut and paste code - Cut and paste code directly from Safari. That allows for time saving and for trying error free code examples;
- print fidelity or HTML viewing mode;
- accurate search. It is possible to search the complete text of thousands of books simultaneously.

Publishers on Safari: O'Reilly, Addison Wesley, Sams, Prentice Hall, Que, lynda.com, Inc., Cisco Press, Microsoft Press, Peachpit Press, New Riders Publishing, Course Technology, IBM Press, Macromedia, Adobe Press, SAS Publishing, Alpha Books, Financial Times, Prentice Hall, Muska & Lipman, MySQL Press, No Starch, Novell Press, Premier Press, Prima Publishing, Syngress, Wharton School Publishing.

8.4.2 Remarks

Visually impaired readers can find resources about technical issues which are sometimes very useful to learn or get updated about computer related issues (e.g. programming languages, work environments, etc.). In particular, HTML viewing mode provides highly accessible resources. Moreover, the search function is of special interest to find quickly specific topics through thousands of pages.

8.5 Manning

Website: http://www.manning.com

8.5.1 Description

Manning publisher distributes eBooks about technical issues. In particular: programming languages tutorials, new technologies, programming environments, and so on. Manning eBooks are distributed mainly in structured PDF format.

8.5.2 Remarks

Blind and partially sighted readers can get advantage of Manning books because the PDF files distributed are sufficiently accessible. Actually, mathematical expressions are not present in these books, so a well-structured PDF file can guarantee enough accessibility. Furthermore, Manning is starting to distribute e-books in open formats which will be evaluated by the @Science network in the coming months.

8.6 Blindprogramming

Website: www.blindprogramming.com

8.6.1 Description

This website collects tutorials, reference guides and set files about many programming languages and issues concerning programming for visually impaired.
These reading resources are all available in accessible formats and they can be downloaded from the website.

8.6.2 Remarks

The resources available from blindprogramming website are selected by expert blind or partially sighted programmers. They can be of great help when a blind student is learning programming languages or applications at university.

8.7 MathWorld

Website: www.mathworld.com

8.7.1 Description

It collects resources about many mathematical topics. Resources are divided into the following sections: Algebra, Applied Mathematics, Calculus and Analysis, Discrete Mathematics, Foundations of Mathematics, Geometry, History and Terminology, Number Theory, Probability and Statistics, Recreational Mathematics, Topology. This website is supported by Wolfram Research Inc. So, Mathematica notebooks about the topics illustrated are available for download. The topics can be browsed through categories or through a search function usable by mainstream screen readers. Mathematical expressions are embedded as images in the web pages. Anyway, They are usually provided with a text alternative. They are described through a text language (LaTeX-like or

Mathematica-like syntax) which can be read on the Braille display. For the sake of clarity, an example taken from the MathWorld website follows. It is an excerpt about quintic equation. Mathematical expressions are reported as they appear on the braille line.

Quintic equation

Unlike quadratic, cubic, and quartic polynomials, the general quintic cannot be solved algebraically in terms of a finite number of additions, subtractions, multiplications, divisions, and root extractions, as rigorously demonstrated by Abel (Abel's impossibility theorem) and Galois. However, certain classes of quintic equations can be solved in this manner. Irreducible quintic equations can be associated with a Galois group, which may be a symmetric group S_n, metacyclic group M_n, dihedral group D_n, alternating group A_n, or cyclic group C_n, as illustrated above. Solvability of a quintic is then predicated by its corresponding group being a solvable group. An example of a quintic equation with solvable cyclic group is

1024x^5-2816x^4+2816x^3-1232x^2+220x-11==0 (1)

which arises in the computation of

sin(pi/11).

In the case of a solvable quintic, the roots can be found using the formulas of Malfatti (1771), who was the first to "solve" the quintic using a resolvent of sixth degree (Pierpont 1895). The general quintic can be solved in terms of Jacobi theta functions, as was first done by Hermite in 1858. Kronecker subsequently obtained the same solution more simply, and Brioschi also derived the equation. To do so, reduce the general quintic

a_5x^5+a_4x^4+a_3x^3+a_2x^2+a_1x+a_0==0 (2)

into Bring quintic form

x^5-x+rho==0. (3)

Defining

k = tan[1/4sin^(-1)((16)/(25sqrt(5)rho^2))] (4)

s = {-sgn(I[rho]) for R[rho]==0; sgn(R[rho]) for R[rho]!=0 (5)

b= (s(k^2)^(1/8))/(2.5^(3/4)sqrt(k(1-k^2))), (6)

where k is the elliptic modulus, the roots of the original quintic are then given by

x_1 = (-1)^(3/4)b{[m(e^(-2pii/5)q^(1/5))] ^ (1/8)+

+i[m(e^(2pii/5)q^(1/5))]^(1/8)}{[m(e^(4pii/5)q^(1/5))]^(1/8)+

+[m(e^(4pii/5)q^(1/5))]^(1/8)}{[m(q^(1/5))]^(1/8)+

+q^(5/8)(q^5)^(-1/8)[m(q^5)]^(1/8)} (7)

.....

8.7.2 Remarks

This website is a very rich resource of mathematics related topics. It can be used at university by visually impaired students as a complementary reference in conjunction with mathematical courses notes or books. Some drawbacks are reported:

- the alternative text for formula images is not always available;
- because of the use of alternative text on images, when the web pages are exported as text to be read or processed offline in a word processor, some browsers (e.g. Internet Explorer) do not save alternative text provided with images, so formulae are missing in the resulting text file;
- screen reader speech output of mathematical expression is rather unsatisfactory because no uniform syntax is used on the website and no semantics oriented markup language is used. Whether MathML was used, speech-aware players such as MathPlayer by Design Science could be employed;
- formulae magnification meets problems related with image magnification in web pages. The use of MathML could contribute to improve scalability of mathematical expressions; transition to MathML is not an ongoing activity.

8.8 Wikipedia

Website: www.wikipedia.org

8.8.1 Description

Wikipedia, the popular online free encyclopaedia, collects knowledge about scientific concepts. Many updated definition and reports about technology related topics are available through these web resources. These resources are completely accessible, apart from images, which are anyway usually commented. As for technical definitions of concepts which involve necessarily mathematical expressions, wikipedia usually employs two techniques:

- mathematical expressions are embedded as images in the web page;

- images describing mathematical expressions are provided with alternative text describing the mathematical notation. This textual description usually employs LaTeX or LaTeX-like notation;
- when mathematical notation is not so complex, HTML tags (e.g. <sub> <sup>, etc.) are used.

For the sake of clarity, a definition extracted from wikipedia is reported below, exactly as it is read by a blind reader on the Braille display.

Absolute convergence

A series or integral is said to converge absolutely if the sum or integral of the absolute value of the summand or integrand is finite.

More precisely, a series

= \sum_{n=0}^\infty a_n

is said to converge absolutely if and only if

= \sum_{n=0}^\infty \left|a_n\right| < \infty.

If an is a complex number, this theorem can be imagined as follows: the sum of all ak is a vector addition path through the complex plane. If the length

of the path, that is the sum of all the lengths of the parts | ak | , is finite, the end point has to be a finite distance from the origin.

.....

8.8.2 Remarks

Wikipedia can be successfully used mainly for reference purposes. For example, when a blind student is taking a course about linear algebra, some definitions can be easily retrieved on wikipedia as complementary information to the course. Anyway, some problems may occur:

- taking definitions and concept descriptions from resources out of the learning context may be somewhat misleading, especially for unexperienced students in the early university courses;
- LaTeX or LaTeX-like notation is not always available as alternative text. Anyway, many wikipedia mathematical entries about basic university subjects have a LaTeX description together with the images. That was found by many readers (both blind and sighted students) who daily use wikipedia;

the use of HTML tags often poses problems. For example, in the excerpt reported above, the sentence "If an is a complex number" contains a notation, a subscript n, which was embedded in the page by using the HTML tag <sub>. It should have been input as LaTeX: a_n. Screen readers do not tell <sub> tag from <sup> tag. So, the notation "a subscript n" is rendered on the braille display the same as "a superscript n", namely "an". That may generate ambiguities.

8.9 Lettura agevolata

Website: http://www2.comune.venezia.it/letturagevolata/

8.9.1 Description

Lettura agevolata project is a national initiative supported by Venezia (Italy) municipal district. It aims at facilitating visually impaired people to access cultural and information resources as well as informing about alternative reading opportunities. All of the activities of this project are available as a web service. Two activities are especially interesting for students who are looking for alternative reading opportunities for science learning:

- alternative reading. Here tools and techniques to read by tactile and hearing perception or through magnification are introduced. In particular, information about a book on readability and a kit for partially sighted are available;
- unified catalogue. It is a catalogue which contains entries on accessible books available from many Italian associations, transcription centres, libraries and talking books producers. About 85000 entries are available. Mathematical and computer related books can be found especially in the section about talking books, electronic books and large print books.

8.9.2 Remarks

Lettura agevolata is a very good search engine for accessible books all over Italy. As soon as more accessible scientific textbooks are available, they are catalogued by Lettura agevolata project. Anyway, it cannot be considered as an exhaustive resource for the university student. Especially, foreign books (e.g. English books), which are highly used in many scientific courses (e.g. in computer science and information technology courses), cannot be found by this search tool.

9 A SURVEY ABOUT ACCESSIBLE SCIENTIFIC BOOKS AT UNIVERSITY

9.1 Introduction

In order to collect the latest information about how visually impaired students have access to scientific books at university, a questionnaire was prepared and distributed among the @Science network members. Each network member, according to the national peculiarities and especially to the very low number of visually impaired students attending university scientific courses, chose the sample of students to contact. Because of the different reading needs between partially sighted and blind students, the questionnaire was divided into two parts: one for blind students and one for partially sighted students.

9.2 The questionnaire: "Accessible and Usable Scientific Books"

9.2.1 Blind students

1. Do blind students use Braille scientific books on paper at university? If they use them, which institutions prepare these books?

AUSTRIA, LINZ UNIVERSITY, INSTITUTE INTEGRIERT STUDIEREN, LINZ	They seldom use Braille books at university, especially in scientific studies.
BELGIUM, KATHOLIEKE UNIVERSITEIT, LEUVEN	None were found.
FRANCE, UNIVERSITE PIERRE ET MARIE CURIE, PARIS	Books are partially adapted by transcription centres, according to needs.
ITALY, UNIVERSITÀ DEGLI STUDI DI MILANO, MILANO – UNIONE ITALIANA CIECHI, VERONA	Full Braille scientific books are not used for university courses. Excerpts from some books are sometimes produced in Braille. Braille transcription centres or Biblioteca Italiana per Ciechi are the main Braille books producers for schools and for universities.
NETHERLANDS	Cannot comment.
IRELAND	No, not usual; Dedicon should be able to provide books in Braille, in Word, or as DAISY; but production time is very long and books will often be too late. So students themselves, sometimes with assistance of the university, will scan (Infty) or ask publishers to give them the text in LaTeX, or scan the text and find someone to insert the mathematical expressions in LaTeX for them.
SLOVAKIA, COMENIUS UNIVERSITY, FACULTY OF MATHEMATICS, PHYSICS AND INFORMATICS, BRATISLAVA	No, they don't use braille scientific books. No one institution in the Slovak republic prepare scientific (texts of maths, computer science) books for university students. The support centre for VI students at Comenius University used to prepare braille books for secondary school/gymnasium students (mathematics, chemistry).

2. **Do blind students use audio books in digital formats to learn scientific subjects? If they use them: which formats do they use (e.g. MP3, DAISY, etc.)? Which institutions prepare these books?**

AUSTRIA, LINZ UNIVERSITY, INSTITUTE INTEGRIERT STUDIEREN, LINZ	Audio books are not often used. When they are used they are recorded by human readers. Speech synthesizers are not often used to produce audio books. Library of Speaking books in Wien produces audio books.
BELGIUM, KATHOLIEKE UNIVERSITEIT, LEUVEN	The blind student had used some audio books from the Netherlands, but they were not satisfying because the persons who read aloud the content did so in a parrot-like fashion. For example, tables were read row by row instead of explaining the underlying principles; this was not useful if the table contained many numbers. Graphics were sometimes only mentioned instead of described. However, this was seven years ago. He was also aware of the use of DAISY.
FRANCE, UNIVERSITE PIERRE ET MARIE CURIE, PARIS	No.
ITALY, UNIVERSITÀ DEGLI STUDI DI MILANO, MILANO – UNIONE ITALIANA CIECHI, VERONA	Audio books are often used at university. They are not produced in specific digital formats for visually impaired (e.g. DAISY) but in mainstream formats (e.g. MP3 files or recorded on audio CDs). They are usually recorded by human readers, who are usually students volunteers, university tutors for students with special needs or they work for talking books production centers (e.g. Centro Internazionale del Libro Parlato or Libro Parlato, Unione Italiana Ciechi).
IRELAND	Cannot comment.
NETHERLANDS	See 1.
SLOVAKIA, COMENIUS UNIVERSITY, FACULTY OF MATHEMATICS, PHYSICS AND INFORMATICS, BRATISLAVA	In Technical University Kosice blind students use the audio format, MP3. These are prepared by university - Access Center. At Comenius University Bratislava scientific books are not prepared into audio form. In this form have been used only humanitarian books prepared partially by Support Centre for VI (MP3). The Slovak library for the blind in Levoca started new with production DAISY formats.

3. **Do blind students use books in accessible digital formats? Which are the formats used?**

AUSTRIA, LINZ UNIVERSITY, INSTITUTE INTEGRIERT STUDIEREN, LINZ	Blind students at university use books mainly in DOC format and LaTeX format. They often rely on Internet resources where LaTeX descriptions are available (e.g. Wikipedia).
BELGIUM, KATHOLIEKE UNIVERSITEIT, LEUVEN	N/A
FRANCE, UNIVERSITE PIERRE ET MARIE CURIE, PARIS	Yes, generally they use Word, Power Point, LaTex or PDF.
ITALY, UNIVERSITÀ DEGLI STUDI DI MILANO, MILANO – UNIONE ITALIANA CIECHI, VERONA	At university, visually impaired mainly use books adapted to text formats personally developed for their needs. They also use LaTeX resources very much and available resources on the web (e.g. XHTML pages embedding formulae as images with text descriptions), which are generally incomplete and hardly accessible.
IRELAND	Cannot comment.
NETHERLANDS	See above, mainly LaTeX
SLOVAKIA, COMENIUS UNIVERSITY, FACULTY OF MATHEMATICS, PHYSICS AND INFORMATICS, BRATISLAVA	Yes, they use e-books. Scientific books are available mainly in text oriented and linearized description language AMS. Books are transformed by the Support centre. AMS system had been assumed and partly adapted from SZS Karlsruhe.

4. Are graphical representations specifically adapted in the books?

AUSTRIA, LINZ UNIVERSITY, INSTITUTE INTEGRIERT STUDIEREN, LINZ	They are sometimes adapted as tactile representations, but not often for university books. Verbal descriptions are provided when possible.
BELGIUM, KATHOLIEKE UNIVERSITEIT, LEUVEN	N/A
FRANCE, UNIVERSITE PIERRE ET MARIE CURIE, PARIS	No.
ITALY, UNIVERSITÀ DEGLI STUDI DI MILANO, MILANO – UNIONE ITALIANA CIECHI, VERONA	Graphical representations are seldom adapted in the books for university students. They are usually described through captions explaining the figure. University assistants for students with special needs or students volunteers sometimes adapt figures as raised lines images or through tactile embossers.
IRELAND	Cannot comment.
NETHERLANDS	See 1.
SLOVAKIA, COMENIUS UNIVERSITY, FACULTY OF MATHEMATICS, PHYSICS AND INFORMATICS, BRATISLAVA	Scientific braille books used to be not produced in braille paper format for university students. Text books for secondary students have been produced in paper braille format including specially adapted graphics (ZyFuse). At Comenius University tactile math graphics have been produced very seldom, because in most cases the formulae are more important than the pictures. Students have preferred text elaboration of graphics. In current cases tactile graphic can be produced (ZyFuse). Similar experience have been reported at Technical University in Kosice.

9.2.2 Partially Sighted Users

5. Do partially sighted students use audio books in digital formats to learn scientific subjects?

AUSTRIA, LINZ UNIVERSITY, INSTITUTE INTEGRIERT STUDIEREN, LINZ	They sometimes use them from the Library of speaking books in Wien.
BELGIUM, KATHOLIEKE UNIVERSITEIT, LEUVEN	The PhD student used it for one course (not science) in order to be able to listen to the content on the train. For this, he used the synthetic speech of OmniPage Pro (OCR software) recorded on an audio cassette.
FRANCE, UNIVERSITE PIERRE ET MARIE CURIE, PARIS	No. The most of them don't know these books.
ITALY, UNIVERSITÀ DEGLI STUDI DI MILANO, MILANO – UNIONE ITALIANA CIECHI, VERONA	Audio books are used very much at university by partially sighted students. They are not produced in specific digital formats for visually impaired (e.g. DAISY) but in mainstream formats (e.g. MP3 files or recorded on audio CDs). They are usually recorded by human readers, who are usually students volunteers, university tutors for students with special needs or they work for talking books production centers (e.g. Centro Internazionale del Libro Parlato or Libro Parlato, Unione Italiana Ciechi).
IRELAND	Some scientific books are scanned, proofread and emailed to students who are partially sighted and studying in the Science area.
NETHERLANDS	N/A
SLOVAKIA, COMENIUS UNIVERSITY, FACULTY OF MATHEMATICS, PHYSICS AND INFORMATICS, BRATISLAVA	No, partially sighted students mostly use magnifying device CCTV and magnifying software.

6. Do partially sighted students use large character books?

AUSTRIA, LINZ UNIVERSITY, INSTITUTE INTEGRIERT STUDIEREN, LINZ	Only if there is availability for them.
BELGIUM, KATHOLIEKE UNIVERSITEIT, LEUVEN	The PhD student uses electronic magnifiers instead of large print books.
FRANCE, UNIVERSITE PIERRE ET MARIE CURIE, PARIS	Photocopying enlargement.
ITALY, UNIVERSITÀ DEGLI STUDI DI MILANO, MILANO – UNIONE ITALIANA CIECHI, VERONA	They sometimes use parts of books produced in large print at university (e.g. by photocopies). They sometimes use large print books from Biblioteca Italiana per Ciechi.
IRELAND	N/A
NETHERLANDS	N/A
SLOVAKIA, COMENIUS UNIVERSITY, FACULTY OF MATHEMATICS, PHYSICS AND INFORMATICS, BRATISLAVA	Some partially sighted students use large character books, some of them prefer magnifying device CCTV.

7. **Are graphical representations specifically adapted in the books (e.g. through magnification)?**

AUSTRIA, LINZ UNIVERSITY, INSTITUTE INTEGRIERT STUDIEREN, LINZ	Only through large characters printing.
BELGIUM, KATHOLIEKE UNIVERSITEIT, LEUVEN	The PhD students has graphical representations photocopied (and enlarged) on A3-size sheets. This means that this adaptation is not in the book itself but derived from it.
FRANCE, UNIVERSITE PIERRE ET MARIE CURIE, PARIS	Photocopying enlargement.
ITALY, UNIVERSITÀ DEGLI STUDI DI MILANO, MILANO – UNIONE ITALIANA CIECHI, VERONA	No particular adaptation is done for graphical representations except from large printing.
IRELAND	Diagrams used in books are explained in textual format to assist understanding of the subject.
NETHERLANDS	N/A
SLOVAKIA, COMENIUS UNIVERSITY, FACULTY OF MATHEMATICS, PHYSICS AND INFORMATICS, BRATISLAVA	Quite seldom, only in case when books are copied to a large print.

9.3 Remarks

After comparing the questionnaires, the following remarks can be pointed out:

- blind students do not use Braille books at university, partly because institutions do not prepare them, partly because they prefer digital formats such as LaTeX;
- audio books are sometimes used by blind students. They sometimes use MP£ format and DAISY (only Netherlands). Only books recorded by human readers are used;
- blind students mainly use books in digital format, mainly as LaTeX source files or also as Microsoft Word or PDF files;
- graphical representations are very seldom adapted in university books. Verbal comments are provided where possible and where indispensable;
- audio books are sometimes used by partially sighted students;
- partially sighted students use sometimes large character books, when they are available. They prefer magnifying devices;
- graphical representations are often copied and enlarged for partially sighted students.

10 CONCLUSIONS

This document illustrated state-of-the-art assistive technologies, strategies and techniques which enable visually impaired students to access scientific literature. Nonetheless, as a consequence of the questionnaire prepared and distributed among @Science network members, some remarks can be pointed out:

- at university, visually impaired students mainly rely on books in digital formats. Partially sighted students read them through magnification tools, whereas blind students mainly exploit LaTeX source format;
- tactile drawings are very seldom used by blind students who read university books;
- emerging formats such as MathML or accessible PDF are not mentioned neither by partially sighted students nor by blind students. Further informational work will be planned about these technologies.

Since, in order to adapt scientific books in accessible digital formats it is indispensable to have the book in a digital format to be processed; collaboration with publishers would be of great help to increase reading opportunities.

APPENDIX 1: WORLDWIDE SERVICES FOR SCIENTIFIC BOOKS PRODUCTION IN ACCESSIBLE FORMATS

Australia

Andrew Daly; Royal Society for the Blind of South Australia
PO Box 1855; 230 Pirie Street
5001 Adelaide SA
Australia
+61 8-223-6222 voice
+61 8-223-7836 fax
Braille transcription

Australian Working Group, Mapping Science Institute
c/o Flexigraphics, Shepherd Street
2008 Chippendale NSW
Australia
+61-2-9319 1034 voice
Volunteer group producing graphics and maps

Lee Gray; Royal Institute for the Blind
P.O. Box 33
2118 Carlingford NSW
Australia
Braille production at a school for the blind (translation)

David Gribble; Association for the Blind of Western Australia
16 Sunbury Road
6100 Victoria Park WA
Australia
+61 9-311-8202 voice
+61 9-361-8696 fax
mailbox@abwa.asn.au
Braille transcription of educational books

Susan Liepa; Vision Australia Library
31-51 Commercial Road
3141 South Yarra Victoria
Australia
+61 3-9867 6022 voice
+61 3-9820 1335 fax
visaulib@vicnet.net.au
Braille transcription and large print production

Royal Institute for Deaf & Blind Children
361-365 North Rocks Road
2151 North Rocks NSW
Australia
+61 2-871-1233 voice
+61 2-9871-2196 fax
Braille transcription

Royal Victorian Institute for the Blind
557 St Kilda Road
Melbourne ACT
Australia
+61-3-529-3544 voice
+61-3-510-4735 fax
Braille transcription, electronic books.

Austria

Blindenerziehungsinstitut
Wittelsbachstrasse 5
A-1200 Vienna
Austria
+43 1-728 0483 voice
+43 1-728 35621 fax
Braille printing house

Bundes-Blindenerziehungstitut
Wittelsbachstrasse 5
A 1020 Wien
Austria
+43 222-728 0483 x 18 voice
+43 222-218 3561 fax
Braille printing house

Bangladesh

Assistance for Blind Children
167 Green Rd. Post Box 5082
1205 Dhaka
Bangladesh
+880 2-316079 voice
+880 2-819320 fax
Braille transcription

Belgium

Ligue Braille - Inst. Nationale pour le Bien des Aveugles
57 Rue d'Angleterre
B-1060 Brussels
Belgium
+32 2-533 3211 voice
+32 2-537 6426 fax
Braille production facility

Stievenart; Les Amis des Aveugles
Rue de la Barriere 37
7410 Ghlin
Belgium
+32 65-3511331 voice
Braille transcription department

Belize

BCVI Belize Council for the Visually Impaired
1 Gabourel Lane, PO Box 413
Belize City
Belize
Central America
+501 2-77776 voice
+501 2-32907 fax
Braille transcription, electronic books.

Brazil

Fundacao para o Livro do Cego no Brasil
Rua dr Diogo de Faria 558, Vila Clementino
04037 Sao Paulo SP
Brazil
+55 11-5490611 voice
Braille production

Bulgaria

Central Union of Blind
172 Naicho Zanov St
1309 Sofia
Bulgaria
+359 2-2191/211861 voice
+359 2-220018 fax
Braille transcription

Canada

Alberta Education/MRGN (Braille Production)
10053 111 Street, 1st floor Edwards Building
Edmonton Alb T5K 2H8
Canada
Braille transcription, tactile graphics production, Nemeth transcription

Charles Crane Memorial Library University of British Columbia
1874 East Mall
Vancouver BC V6T 1Z1
Canada
604-822-6111 voice
604-822-6113 fax
Braille and digital books translation

Christian Blind Mission International
P.O. Box 800
Stouffville ON L4A 7Z9
Canada
416-640-6464 voice
Braille transcription of educational books

Jacques Cote; Braille Jymico
110 51 Rue Est
Charlesbourg Quebec G1H 2J9
Canada
418-624-2105 voice
418-624-0994 fax
jcote@Braillejymico.ca
Production of literary Braille and Nemeth

CNIB, Alberta NWT Division
12010 Jasper Ave
Edmonton AB T5K 0P3
Canada
403-488-4871 voice
CNIB is the largest blindness organization in Canada

Stan Flamer; Library for the Blind Canadian National Institute for the Blind
1929 Bayview Ave
Toronto ON M4G 3E8
Canada
416-480-7674 voice
416-480-7700 fax
stan.flamers@cnib.ca

The CNIB Library is one of the largest producers of materials in accessible formats in the world; including Braille, audio, large print and tactile graphics.

Frontier Computing
250 Davisville Ave #205
Toronto Ontario M4S 1H2
Canada
888-480-0000 or 416-489-6690 voice
416-489-6693 fax
sales@frontiercomputing.on.ca
For pay, transcribe into Braille from print or from disk

I Can See Books
88 Captain Morgans Blvd
Nanaimo BC V9R 6R1
Canada
250-616-7414 voice
transcription@Braille-books.com
Transcription for pay, quick turn around, also recording on audio tape

Institut Nazareth et Louis-Braille
1111 St. Charels West
Longueuil PQ J4K 5G4
Canada
Braille production

Maria de Rege; Montreal Association for the Blind, Braille dept.
7000 Sherbrooke Street West
Montreal PQ H4B 1R3
Canada
514-489-3477 voice
514-489-3477 fax
Serves English speaking population of Quebec; literary, textbooks, math, uncontracted foreign languages. (translation)

Mark Joly; Access 20/20
29 Indian Road
Nepean Ont K2G 1N7
Canada
800-563-0668 voice
613-224-3480 fax
markj@access2020.com
For pay, very knowledgeable with electronic systems; Braille transcription and accessible digital formats production

Inez Kreamer;
Box 5, Site 4, RR2
Kingman AB T0B 2M0
Canada
780-62-3608 voice
780-62-2998 fax
inezk@telus.net
Individual transcriber, Braille literary textbooks and scientific textbooks, Nemeth code

Materials Resource Centre for the Visually Impaired
12360 142 ST NW
Edmonton AB T5L 4X9
Canada
403-427-4681 voice
403-427-6683 fax
imiller@edc.gov.ab.ca
For pay organization; serve students through 12th grade, preschool and university; Nemeth, foreign language, literary, textbook

Neeraj Kapoor;
12-6111 Tiffany Boulevard
Richmond BC V7C 4Y7
Canada
skapoor@prcvi.org
Certified in literary and Nemeth

PAL Reading Services
252 Bloor Street West, Suite 12-105
Toronto ON M5S 1V6
Canada
416-960-1177 voice
Braille transcription and audio books production

People Helping People
183 Catherine Avenue
Brantford Ont N3T 1Z1
Canada
For pay, Braille transcription, production of literary and scientific literature in digital formats, expertise in Nemeth code

Fred Poon; Provincial Resource Center for the Visually Impaired
106-1750 West 75th Ave
Vancouver BC V6P 6G2
Canada
604-266-3699 voice
604-261-0778 fax
fpoon@prcvi.org
Braille production, mixed text and graphics books production

Sheryl Ruckert; Manitoba Education
Canada
204 774-5421 voice
Sir Frederick Fraser School
5940 South Street
Halifax NS B3H 1S6
Canada
902-424-8500 voice
902-424-0543 fax

China

Beijing Braille Publishing House
109 Lu Gou Qiao
Beijing

China
Braille books, audio books

Hong Kong Society for the Blind
248 Cheong St
Kowloon Hong Kong
China
+852 2778-8332 voice
+852 2788-0040 fax
Braille books

Croatia

Hrvatski Savez Slijepih
Draskoviceva 80, POB 736
Sagreb 40001
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