Assistive Technology for Visually Impaired and Blind People

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Assistive Technology for Visually Impaired and Blind People

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Preface

Until quite recently, the medical model of disability was dominant and assistive technology was viewed as an extension of rehabilitation engineering. But times and viewpoints change so that now social inclusiveness is the pervading ethos of disability legislation, regulations and guidelines. While the existence of new legislative frameworks does not always mean that effective implementation has occurred in the community, it is a beginning. Thus, it is the widespread acceptance of the social model of disability that is driving these changes and it is the tools of assistive technology that are the physical enablers of social inclusiveness.

While we have previously published on Assistive Technology for Hearing Impaired, Deaf and Deafblind People (Springer-Verlag London 2003, ISBN 978-1-85233-382-9), this companion volume strikes out in a new direction by using the social model of disability as a framework. In Chapter 1, we present a comprehensive assistive technology (CAT) model that is designed to provide a generic and holistic description of all aspects of assistive technology whether social, human performance, or the engineering technology used. The idea is that the model can be used to provide the systematic vocabulary and interpretation needed to describe any branch of assistive technology applications. The book itself is structured around the activities module of the CAT model and there are several overview or survey chapters that make recourse to various aspects of the CAT model. Of course the volume concentrates on assistive technology for visually impaired and blind people and the various contributing authors have written about their specific assistive technological contributions to this field.

The objective of systematically reporting on assistive technology for visiually impaired people and also trying to imbue the survey chapters with a descriptive paradigm based on the social model of disability was an ambitious one. We could not have accomplished such a task without the cooperation, enthusiasm and, above all, the patience of our collaborating authors. We should like to thank them all for their help in seeing this publishing project come to fruition. We have been very fortunate to meet some of our collaborators at the Workshops and Conferences on Assistive Technologies for Vision and Hearing Impairment that we organise with invaluable European Union support. In many cases this has given us the opportunity to discuss and debate the engineering issues described in this book.

Patience, too, is a virtue our Springer Engineering editorial staff: Oliver Jackson and Anthony Doyle have in abundance. We should like to acknowledge their enthusiasm and support through the long gestation of this publishing project. Our copy editor, John Kirby, is also to be thanked for producing an elegantly presented volume. Thanks are also due for administrative and graphical support given by Vi Romanes and Peter McKenna of the Department of Electronics and Electrical Engineering at the University of Glasgow during the years of preparation for this volume.

We hope this book with its new modelling perspectives and its systematic coverage of assistive technology will inspire many new projects, new courses, and new ways to secure social inclusiveness for the visually impaired and blind community.

Marion A. Hersh and Michael A. Johnson
Glasgow, Scotland, U.K.

Who should read this book?

This book is designed to inform a wide range of current and future professionals about the assistive technology used by visually impaired and blind people to achieve independence and social inclusiveness in the home and the wider community. Basic engineering principles are explained and the ways these are used to develop and drive assistive technology applications for visually impaired and blind people described. The volume has some chapters that refer to a generic comprehensive assistive technology model to capture the essentials of the applied system and this model should find applications in other assistive technology areas.

The book is suitable for electrical engineering, mechanical engineering and scientific professionals. It is also considered highly appropriate for undergraduate courses in the discipline of assistive technology. Thus, we hope this book will be well placed to meet this need as a course textbook or to supplement existing course material. The authors have been encouraged to see many engineering undergraduates enjoy this type of material and it is hoped that this enjoyment will fire the ingenuity of new generations of engineering students to find new and innovative ways to develop assistive technology for visually impaired and blind people.

An Overview of the Book

The book has a map, for the first four chapters are devoted to fundamentals: disability and assistive technology models, eye physiology and sight, sight measurement principles and technology and finally, haptics. Subsequently groups of chapters explore the topics of mobility, communications and access to information, daily living, education and employment, and recreational activities. These chapter groupings follow the structure of the *Activities* module of the comprehensive assistive technology model as presented in Chapter 1 of the book.

The book is designed so that each chapter is self-contained and can be read on its own, although the overview chapters (Chapters 5, 10, 12, 17 and 18) assume some familiarity with the CAT model material in Chapter 1. Each chapter is motivated by specific learning objectives and contains introductory material or descriptions of the basic principles underlying the technology or applications area. The chapters close with a chapter summary, questions and suggestions for more investigative projects. Full citation details for references to journals, books, and conference papers are given along with information about useful related websites.

A brief description of the contents of each chapter along with full details of the chapter authors can be found next. For the interested reader, biographical sketches of all the contributing authors can be found at the end of the book. These are given in alphabetical order of the author family names. The concept of the book and the overall editorial direction was solely the responsibility of Marion Hersh and Michael Johnson. However, as is usual for a contributed book, the chapter authors are responsible for the opinions and factual accuracy expressed in their particular contributions.

Chapters on Fundamentals

1 Disability and Assistive Technology Systems

Marion Hersh[1] and Michael Johnson[2]

[1]University of Glasgow, [2]University of Strathclyde, Glasgow, U.K.

The social model of disability is discussed highlighting the recent pre-eminence achieved over the medical model of disability. The concept of "quality of life" indices is explored and its relevance to assessing assistive technology applications is described. A survey of the main assistive technology quality of life procedures is presented and the value of the individual procedures considered.

The later sections of the chapter investigate whether assistive technology can be described in a single holistic and generic model, the idea being that the model will provide a uniform and consistent framework for analysing existing applications and for creating or synthesizing new assistive technology systems. The new comprehensive assistive technology (CAT) model is presented and its use demonstrated in these sections.

2 Perception, the Eye and Assistive Technology Issues

Marion Hersh

University of Glasgow, Glasgow, U.K.

Many assistive technology systems for the visually impaired are supported by contributions from the senses of touch, hearing and smell. This chapter opens with a description of the nature of multisensory perception as this forms an important context for the design and use of assistive technology systems.

The chapter then concentrates on the sense of vision. Basic eye physiology is presented along with descriptions of some of the capabilities of the human eye for binocular vision, colour vision and motion tracking.

A brief review of the demographics of vision impairment is given and this is followed by descriptions of the effects of typical vision impairments. A set of photographic images illustrates the conditions described. The basics of simple spectacle provision close the chapter.

3 Sight Measurement

David Keating and Stuart Parks

Gartnavel Hospital, Glasgow, U.K.

Measurement science for the sense of sight has exploited advanced computer technology to emerge as an exciting technical and medical discipline. The chapter presents a full survey of sight measurement methods describing procedures, engineering principles, technological construction and diagnostic motivation. The chapter opens with the classical measurement tests for visual acuity, field of vision, and intraocular pressure, followed by the techniques used in biometry and ocular examinations.

The more advanced technological fields of optical coherence tomography and ocular electrophysiology are described in the last two sections of the chapter. These techniques have developed in sophistication over the last twenty years or so. Advances in computer visualisation software, laser technology, data collection, signal processing algorithms and human-sensor interface systems have all been used to provide complex and accurate measurements and visualisations of the eye physiology and functions for clinical diagnosis. The chapter presents a state-of-the-art review of these sight measurement advances.

4 Haptics as a Substitute for Vision

Gunnar Jansson

Department of Psychology, Uppsala University, Sweden

Historically the sense of touch has been used extensively to generate information for the visually impaired person. This chapter surveys the underlying principles of haptics and the perceptual capabilities of touch achievable with the human hand. After a presentation of these haptic fundamentals, the chapter proceeds to investigate how haptics can be used and enhanced through training or with the aid of specialist tools. A central section of the chapter concentrates on *low-tech* haptic applications; some, like the long cane and the guide dog, are for mobility whilst others, like Braille and embossed pictures, are for information from text, as well as embossed graphics. Subsequent sections in the chapter examine the more technologically advanced applications of haptic science. Of particular importance are the technologies for haptic computer interfaces and for haptic

displays. A project to provide haptic access to museum pieces for visually impaired people is one outcome of this advanced work.

Chapters on Mobility and Navigation

5 Mobility: An Overview

Marion Hersh[1] and Michael Johnson[2]

[1]University of Glasgow, [2]University of Strathclyde, Glasgow, U.K.

Visually impaired people usually require assistive technology to aid mobility and retain independent travel within the community environment. This overview chapter opens with a discussion of the travel activity and investigates how people negotiate a desired route or journey. Assistive technology for visually impaired person's travel has had a long history and this is briefly reviewed. One finding is that there have been quite a few attempts to harness the available contemporary technological advances in mobility assistive devices. The subsequent development of the chapter pursues three main topics: obstacle avoidance, navigation and orientation and the design of accessible environments. The presentation reveals that most effort has been devoted to obstacle avoidance assistive technology and that more recently global positioning system and mobile telephone technology has begun to impact the development of viable navigation and orientation assistive technology. The final section of the chapter reviews progress towards the accessible environment that is just beginning to appear in many cityscapes.

6 Mobility AT: The Batcane (UltraCane)

Brian Hoyle and Dean Waters

University of Leeds, Leeds, U.K.

The use of the long cane by visually impaired people as an obstacle detector is long standing. More recently the basic cane design has been equipped with laser or ultrasound transmitters and sensors and an interpretive human interface to improve its effectiveness, the objective being to allow safe travel by a visually impaired person. This chapter reports an important case study of the steps involved in developing an advanced technology obstacle avoidance cane that used bat echolocation signal processing techniques and ultrasonic technology. The final cane design is now marketed worldwide as the UltraCane™.

The chapter reviews the basic technological principles for ultrasonic waves and the advanced signal processing methods used. There is an extended discussion of all the design and construction issues followed by a description of the final engineering and prototype test phase. The chapter closes with an examination of the issues involved in bringing the prototype to eventual commercialisation.

7 Navigation AT: Context-aware Computing

Nicholas Bradley and Mark Dunlop

University of Strathclyde, Glasgow, U.K.

Achieving independence whilst attempting a journey involving long distance navigation still remains a significant challenge for the visually impaired community. In this chapter the contribution that might be made by context-aware computing is explored. The first half of the chapter investigates different aspects of the long distance navigation problem and presents a survey of existing assistive technology, along with an introduction to cognitive maps and navigation learning strategies.

It is in the second half of the chapter that the principles and potential application areas for context-aware computing are introduced. The topics examined include how contextual information, for example, about location and personal preferences, can be embedded into user-computer interactions and how these facilities and capabilities could be used to assist the visually impaired traveller on a long distance journey. The chapter closes with sections on specific prototype applications and some results from the authors' own research tests.

8 Accessible Global Positioning System (GPS) and Related Orientation Technologies

Michael May and Charles LaPierre

Sendero Group, United States of America

One of the better-developed technologies for pinpointing a person's location is the global positioning system (GPS). This US positioning technology has been widely exploited in many consumer applications and over future years alternative systems will become available for use (notably the European Galileo system). The success of a system for use by the visually impaired will depend on the accessibility of the interface design and the value of the information imparted to the user. This case study chapter looks at all the issues from the simple principles of GPS technology through to interface design, development and testing and finally the commercialisation aspects of marketing the end product accessible GPS device and system. The chapter is based on the authors' joint and direct experience of developing and then marketing an accessible GPS product for visually impaired people.

9 Electronic Travel Aids: An Assessment

Elizabeth M. Ball

Ergonomics and Safety Research Institute, Loughborough University, Loughborough, U.K.

Many assistive technology mobility products are expensive and visually impaired people are a community group with considerable variability in their range of sight

abilities. Thus, it is very useful to learn about the relative successes and limitations of many of the currently available mobility products; this chapter provides such an assessment.

The chapter opens with an analysis of the various types of methods that can be used to set-up an end-user assessment exercise. Part of this concerns the framework of user requirements of the products to be assessed and another part is concerned with selecting the way of collecting the raw data of end-users responses and experiences.

The second part of the chapter presents the author's findings for an end-user assessment of six obstacle avoidance mobility aids and two accessible navigation aids. The chapter closes with a discussion on the importance of training to achieve the best return from the use of advanced technology to assist in mobility and navigation.

10 Accessible Environments

Marion Hersh[1] and Michael Johnson[2]

[1]University of Glasgow, [2]University of Strathclyde, Glasgow, U.K.

One consequence of the social model of disability is the need for the community environment to be physically accessible to all members of society. This accessibility applies to both the outside environment of, for example, parks, shopping malls and bus stations and to the interior environments of, for example, schools, hospitals, health centres, sports centres, shops, banks, town halls and entertainment complexes. This chapter provides an overview of the types of features that make the community environments accessible for visually impaired people.

The opening section of the chapter looks at the legislative and regulatory frameworks and the general design principles for accessible environments. This is followed by two sections covering the streetscape and buildings respectively. More challenging applications involve embedding detailed information technology modules into the environment and these are covered in the last two sections of the chapter. This is where exemplary applications of accessible public transport and way-finding systems are described.

11 Accessible Bus System: A Bluetooth Application

Tai Fook Lim Jerry, Han Leong Goh and Kok Kiong Tan

National University of Singapore, Republic of Singapore

The flexibility and freedom offered by new wireless technologies are often discussed in the media and on the Internet. But having this potential translated into working assistive technology systems is not so common. In this chapter, an application of Bluetooth technology for a bus alerting and information system suitable for use by visually impaired people is described. The chapter reports case study material across all the activities found in a typical prototype development project.

The chapter opens with a detailed consideration of the elements of Bluetooth technology and has a short comparison section with other competing wireless technologies. Having selected Bluetooth as the enabling technology, the chapter then reports on the design requirements for the bus alerting system. The system development is presented in detail along with careful consideration of the user interface needed for visually impaired people using mobile telephone technology. A discussion of future plans and commercialisation issues closes the chapter.

12 Accessible Information: An Overview

Marion Hersh[1] and Michael Johnson[2]

[1]University of Glasgow, [2]University of Strathclyde, Glasgow, U.K.

In our modern society, increasingly complex media and technology are being used to transmit information. However, to participate and enjoy the benefits of the information revolution requires a continual familiarity with the new developments, so it is important that this area remains accessible to the visually impaired community.

This chapter opens with a review of the principles and technologies of low vision aids that are used to access print. Sections on audio transcription and Braille as access routes to print information then follow. It is the recent developments in speech processing and speech synthesis technology that are drivers in the wider use of audio as an information interface for the visually impaired. Major sections of the chapter describe the accessible computer and the accessible Internet. Both are extremely important in the processing and provision of information and there are many interface options to make these systems accessible to the visually impaired. Finally, since mobile telephony is increasingly accruing computer and Internet capabilities, the chapter closes by reviewing accessible communications technology.

13 Screen Readers and Screen Magnifiers

Gareth Evans and Paul Blenkhorn

University of Manchester, Manchester, U.K.

Two extremely important assistive technologies for the accessible computer are screen magnifiers and screen readers. Together these two tools create the accessibility for computer output needed by a wide range of visually impaired computer users.

The chapter has two major sections, one for screen magnifiers and one for screen readers. Within these extended sections are topics like historical perspectives on the technology developments, the architectures and implementation of the technologies and other sections on particular or special features of these two assistive technology systems.

The chapter is completed by sections on hybrid screen reader-magnifiers, self-magnifying applications and self-voicing applications.

14 Speech, Text and Braille Conversion Technology

Rüdiger Hoffmann

Dresden University of Technology, Dresden, Germany

This chapter is devoted to the fascinating triangle of conversion technologies that arise between text, speech and Braille. These are enabling technologies that allow speech to be converted into text as might happen in the creation of a letter, that allows text to be converted into speech as might happen in the reading of a book for enjoyment and then, the additional steps taking text into Braille for the Braille user. The everyday application of these technologies in making information and computers accessible to the visually impaired is an important assistive technology area.

The chapter opens with a presentation on the fundamentals of speech and text conversion technologies. The spectral analysis of speech is an important theoretical and practical component of this introductory material. Then, this is followed by sections that examine the three technologies; speech-to-text, text-to-speech and Braille conversion in detail. These sections describe the technological principles used and the equipment and applications that follow. The section on Braille conversion has additional material on more specialised Braille applications like Braille refreshable displays, reading machines and access to telecommunication devices.

15 Accessing Books and Documents

James Fruchterman

Benetech, Palo Alto, California, USA

Reading is an essential daily living task, and is crucial for school and work. Whether it is sorting the bills, reading a textbook or the daily newspaper, access to reading is critically important to people with disabilities that prevent easy reading of the printed page. Assistive technology has been created to address these needs and bridge the accessibility challenge to print. One of the first challenges is acquiring the text from the printed page. This need is met through optical character recognition that turns an image of the printed page into an accessible digital text file. In this chapter, the fundamentals of OCR technology and reading machines are described. The new international standard for digital talking books, the DAISY standard, is explored. The critically important move to direct digital access to textbooks and newspapers is projected and a discussion of future technological development closes the chapter.

16 Designing Accessible Music Software for Print Impaired People

David Crombie and Roger Lenoir

DEDICON (formerly FNB Nederland), Amsterdam, The Netherlands

Making music is a pastime enjoyed by many and making printed music accessible to the visually impaired community is a particularly challenging and technically interesting problem. Music notation is a form of symbolic information with its own systematic rules; since it is essentially a visual medium the challenge is to make this system accessible to the visually impaired and blind music player. There are three basic formats: Braille music, talking music (that might use the DAISY standard) and large print music, and the chapter covers all three formats.

The chapter opens with a brief introduction to music notation that defines many key terms and structures for later use. This is followed by a survey of the three music formats designed to support accessibility. Some international project activities are described along with attempts to prescribe an international standard for the field. A key section in the chapter carefully details the steps in the production of Braille music and also gives further information about Talking Music. Since these accessibility topics are still developing, closing sections of the chapter review the likely future developments for the field.

17 Assistive Technology for Daily Living

Marion Hersh[1] and Michael Johnson[2]

[1]University of Glasgow, [2]University of Strathclyde, Glasgow, U.K.

The first of the contextual activity areas in the comprehensive assistive technology model is that of Daily Living, and this is the subject of this chapter. Thus, the chapter describes assistive technology solutions designed to remove barriers to enable visually impaired and blind people enjoy independent living in their own home. These assistive technology solutions range from some very simple low technology devices to very sophisticated and specialised high technology solutions giving the chapter a large number of subsections and coverage of a wide variety of engineering methods.

Within this diversity of assistive technology applications, there are some techniques that span several of the activities found in the daily living category. Labelling is one generic assistive technology described in the chapter and this has a range of applications in personal care, food preparation and using appliances. Similar generic technologies are those for light and colour detection and identification and these too are described in this chapter. Along with these general solution technologies, the chapter presents groups of devices for the areas of personal care, time-keeping, alarms and alerting, food preparation, using appliances and money amongst others.

Summary conclusions, projects to pursue and reference citations close the chapter.

18 Assistive Technology for Education, Employment and Recreation

Marion Hersh[1] and Michael Johnson[2]

[1]University of Glasgow, [2]University of Strathclyde, Glasgow, U.K.

Education and employment, and recreational activities complete the trio of contextual activities of the comprehensive assistive technology model, and this final chapter of the book reports on the assistive technology available in these two areas.

Education and employment is divided into six subsections covering learning and teaching, and then five employment activity areas. The generic assistive technology to support mobility, access to information and communication that are essential to access education and employment have been described earlier in the book and in this chapter access to the higher level activities are discussed. For example, this part of the chapter covers access to mathematics in education, and the use of specialised tools in the skilled and non-skilled trades. There is also a discussion of the general levels of access attained by visually impaired and blind people to education and employment in the introductory section of the chapter.

Recreational activities are essential to personal wellbeing and this is the third contextual activities category in the CAT model. This category also divides into six sub-activity areas, and a wide variety of assistive technology solutions is described. These range from an infrared cinema audio description system, through to accessible football and tactile tape measures to facilitate craft activities.

Summary conclusions, projects for further investigation and reference and resource citations close the chapter.

Contents