

Assistive Technology for Visually Impaired and Blind People

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Marion A. Hersh and Michael A. Johnson (Eds.)

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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 visually 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 Hersh¹ and Michael Johnson²

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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 Hersh¹ and Michael Johnson²

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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 Hersh¹ and Michael Johnson²

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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 Hersh¹ and Michael Johnson²

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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

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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 Hersh¹ and Michael Johnson²

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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

1	Disability and Assistive Technology Systems	1
1.1	The Social Context of Disability	2
1.2	Assistive Technology Outcomes: Quality of Life	4
1.2.1	Some General Issues	5
1.2.2	Definition and Measurement of Quality of Life	6
1.2.3	Health Related Quality of Life Measurement	7
1.2.4	Assistive Technology Quality of Life Procedures	9
1.2.5	Summary and Conclusions	13
1.3	Modelling Assistive Technology Systems	14
1.3.1	Modelling Approaches: A Review	15
1.3.2	Modelling Human Activities	18
1.4	The Comprehensive Assistive Technology (CAT) Model	20
1.4.1	Justification of the Choice of Model	20
1.4.2	The Structure of the CAT Model	21
1.5	Using the Comprehensive Assistive Technology Model	36
1.5.1	Using the Activity Attribute of the CAT Model to Determine Gaps in Assistive Technology Provision	37
1.5.2	Conceptual Structure of Assistive Technology Systems	38
1.5.3	Investigating Assistive Technology Systems	38
1.5.4	Analysis of Assistive Technology Systems	40
1.5.5	Synthesis of Assistive Technology Systems	41
1.6	Chapter Summary	45
	References	48
2	Perception, the Eye and Assistive Technology Issues	51
2.1	Perception	52
2.1.1	Introduction	52
2.1.2	Common Laws and Properties of the Different Senses	53
2.1.3	Multisensory Perception	54
2.1.4	Multisensory Perception in the Superior Colliculus	57
2.1.5	Studies of Multisensory Perception	58
2.2	The Visual System	58
2.2.1	Introduction	58
2.2.2	The Lens	60

2.2.3	The Iris and Pupil	61
2.2.4	Intraocular Pressure	62
2.2.5	Extraocular Muscles	63
2.2.6	Eyelids and Tears	65
2.3	Visual Processing in the Retina, Lateral Geniculate Nucleus and the Brain	65
2.3.1	Nerve Cells	65
2.3.2	The Retina	67
2.3.3	The Optic Nerve, Optic Tract and Optic Radiation	69
2.3.4	The Lateral Geniculate Body or Nucleus	71
2.3.5	The Primary Visual or Striate Cortex	71
2.3.6	The Extrastriate Visual Cortex and the Superior Colliculus .	72
2.3.7	Visual Pathways	73
2.4	Vision in Action	74
2.4.1	Image Formation	74
2.4.2	Accommodation	76
2.4.3	Response to Light	76
2.4.4	Colour Vision	77
2.4.5	Binocular Vision and Stereopsis	82
2.5	Visual Impairment and Assistive Technology	82
2.5.1	Demographics of Visual Impairment	83
2.5.2	Illustrations of Some Types of Visual Impairment	84
2.5.3	Further Types of Visual Impairment	91
2.5.4	Colour Blindness	93
2.5.5	Corrective Lenses	94
2.6	Chapter Summary	98
	References	99
3	Sight Measurement	103
3.1	Introduction	103
3.2	Visual Acuity	104
3.2.1	Using the Chart	105
3.2.2	Variations in Measuring Visual Acuity	105
3.3	Field of Vision Tests	107
3.3.1	The Normal Visual Field	107
3.3.2	The Tangent Screen	108
3.3.3	Kinetic Perimetry	108
3.3.4	Static Perimetry	110
3.4	Pressure Measurement	111
3.5	Biometry	112
3.6	Ocular Examination	113
3.7	Optical Coherence Tomography	114
3.7.1	Echo Delay	116
3.7.2	Low Coherence Interferometry	116
3.7.3	An OCT Scanner	117
3.8	Ocular Electrophysiology	118

3.8.1	The Electrooculogram (EOG)	120
3.8.2	The Electroretinogram (ERG)	123
3.8.3	The Pattern Electroretinogram	126
3.8.4	The Visual Evoked Cortical Potential	127
3.8.5	Multifocal Electrophysiology	127
3.9	Chapter Summary	132
	Reference Sources (not cited in chapter)	133
4	Haptics as a Substitute for Vision	135
4.1	Introduction	135
4.1.1	Physiological Basis	136
4.1.2	Passive Touch, Active Touch and Haptics	137
4.1.3	Exploratory Procedures	137
4.2	Vision and Haptics Compared	138
4.3	The Capacity of Bare Fingers in Real Environments	139
4.3.1	Visually Impaired People's Use of Haptics Without any Technical Aid	140
4.3.2	Speech Perceived by Hard-of-hearing People Using Bare Hands	140
4.3.3	Natural Capacity of Touch and Evaluation of Technical Aids	141
4.4	Haptic Low-tech Aids	141
4.4.1	The Long Cane	141
4.4.2	The Guide Dog	142
4.4.3	Braille	143
4.4.4	Embossed Pictures	144
4.4.5	The Main Lesson from Low-tech Aids	145
4.5	Matrices of Point Stimuli	145
4.5.1	Aids for Orientation and Mobility	145
4.5.2	Aids for Reading Text	148
4.5.3	Aids for Reading Pictures	149
4.6	Computer-based Aids for Graphical Information	149
4.6.1	Aids for Graphical User Interfaces	150
4.6.2	Tactile Computer Mouse	150
4.7	Haptic Displays	151
4.7.1	Information Available <i>via</i> a Haptic Display	152
4.7.2	What Information Can Be Obtained with the Reduced Information?	153
4.7.3	Haptic Displays as Aids for the Visually Impaired	156
4.8	Chapter Summary	158
4.9	Concluding Remarks	159
	References	160

5	Mobility: An Overview	167
5.1	Introduction	168
5.2	The Travel Activity	169
5.2.1	Understanding Mobility	169
5.2.2	Assistive Technology Systems for the Travel Process	173
5.3	The Historical Development of Travel Aids for Visually Impaired and Blind People	177
5.4	Obstacle Avoidance AT: Guide Dogs and Robotic Guide Walkers ...	180
5.4.1	Guide Dogs	180
5.4.2	Robotic Guides and Walkers	181
5.5	Obstacle Avoidance AT: Canes	185
5.5.1	Long Canes	186
5.5.2	Technology Canes	187
5.6	Other Mobility Assistive Technology Approaches	191
5.6.1	Clear-path Indicators	192
5.6.2	Obstacle and Object Location Detectors	194
5.6.3	The vOICe System	197
5.7	Orientation Assistive Technology Systems	198
5.7.1	Global Positioning System Orientation Technology	200
5.7.2	Other Technology Options for Orientation Systems	200
5.8	Accessible Environments	201
5.9	Chapter Summary	205
	References	207
6	Mobility AT: The Batcane (UltraCane)	209
6.1	Mobility Background and Introduction	209
6.2	Principles of Ultrasonics	210
6.2.1	Ultrasonic Waves	210
6.2.2	Attenuation and Reflection Interactions	211
6.2.3	Transducer Geometry	212
6.3	Bats and Signal Processing	213
6.3.1	Principles of Bat Sonar	213
6.3.2	Echolocation Call Structures	215
6.3.3	Signal Processing Capabilities	216
6.3.4	Applicability of Bat Echolocation to Sonar System Design ..	217
6.4	Design and Construction Issues	218
6.4.1	Outline Requirement Specification	218
6.4.2	Ultrasonic Spatial Sensor Subsystem	219
6.4.3	Trial Prototype Spatial Sensor Arrangement	219
6.4.4	Tactile User Interface Subsystem	221
6.4.5	Cognitive Mapping	222
6.4.6	Embedded Processing Control Requirements	223
6.5	Concept Phase and Engineering Prototype Phase Trials	223
6.6	Case Study in Commercialisation	225
6.7	Chapter Summary	226
	References	229

7	Navigation AT: Context-aware Computing	231
7.1	Defining the Orientation/Navigation Problem	231
7.1.1	Orientation, Mobility and Navigation	232
7.1.2	Traditional Mobility Aids	233
7.1.3	Limitations of Traditional Aids	233
7.2	Cognitive Maps	234
7.2.1	Learning and Acquiring Spatial Information	235
7.2.2	Factors that Influence How Knowledge Is Acquired	236
7.2.3	The Structure and Form of Cognitive Maps	237
7.3	Overview of Existing Technologies	238
7.3.1	Technologies for Distant Navigation	238
7.3.2	User Interface Output Technologies	239
7.4	Principles of Mobile Context-aware Computing	240
7.4.1	Adding Context to User-computer Interaction	241
7.4.2	Acquiring Useful Contextual Information	242
7.4.3	Capabilities of Context-awareness	244
7.4.4	Application of Context-aware Principles	245
7.4.5	Technological Challenges and Unresolved Usability Issues	248
7.5	Test Procedures	249
7.5.1	Human Computer Interaction (HCI)	249
7.5.2	Cognitive Mapping	252
7.5.3	Overall Approach	253
7.6	Future Positioning Technologies	253
7.7	Chapter Summary	255
7.7.1	Conclusions	256
	References	258
8	Accessible Global Positioning System (GPS) and Related Orientation Technologies	261
8.1	Defining the Navigation Problem	261
8.1.1	What is the Importance of Location Information?	262
8.1.2	What Mobility Tools and Traditional Maps are Available for the Blind?	263
8.2	Principles of Global Positioning Systems	263
8.2.1	What is the Global Positioning System?	263
8.2.2	Accuracy of GPS: Some General Issues	265
8.2.3	Accuracy of GPS: Some Technical Issues	267
8.2.4	Frequency Spectrum of GPS, Present and Future	269
8.2.5	Other GPS Systems	270
8.3	Application of GPS Principles	272
8.4	Design Issues	273
8.5	Development Issues	278
8.5.1	Choosing an Appropriate Platform	278
8.5.2	Choosing the GPS Receiver	279
8.5.3	Creating a Packaged System	279
8.5.4	Integration vs Stand-alone	280

8.6	User Interface Design Issues	281
8.6.1	How to Present the Information	281
8.6.2	When to Present the Information	282
8.6.3	What Information to Present	282
8.7	Test Procedures and Results	283
8.8	Case Study in Commercialisation	283
8.8.1	Understanding the Value of the Technology	283
8.8.2	Limitations of the Technology	284
8.8.3	Ongoing Development	285
8.9	Chapter Summary	286
	References	287
9	Electronic Travel Aids: An Assessment	289
9.1	Introduction	290
9.2	Why Do an Assessment?	291
9.3	Methodologies for Assessments of Electronic Travel Aids	292
9.3.1	Eliciting User Requirements	292
9.3.2	Developing a User Requirements Specification and Heuristic Evaluation	294
9.3.3	Hands-on Assessments	295
9.3.4	Methodology Used for Assessments in this Chapter	295
9.4	Modern-day Electronic Travel Aids	299
9.4.1	The Distinction Between Mobility and Navigation Aids	300
9.4.2	The Distinction Between Primary and Secondary Aids	300
9.4.3	User Requirements: Mobility and Navigation Aids	300
9.4.4	Mobility Aids	304
9.4.5	Mobility Aids: Have They Solved the Mobility Challenge?	311
9.4.6	Navigation Aids	312
9.4.7	Navigation Aids: Have They Solved the Navigation Challenge?	314
9.5	Training	315
9.6	Chapter Summary and Conclusions	317
	References	320
10	Accessible Environments	323
10.1	Introduction	323
10.1.1	Legislative and Regulatory Framework	323
10.1.2	Accessible Environments: An Overview	325
10.1.3	Principles for the Design of Accessible Environments	326
10.1.4	Relationship Between Environmental Information and Navigation Systems and Global Positioning Systems (GPS) Orientation Systems	327
10.2	Physical Environments: The Streetscape	328
10.2.1	Pavements and Pathways	328
10.2.2	Road Crossings	330
10.2.3	Bollards and Street Furniture	331

10.3	Physical Environments: Buildings	333
10.3.1	General Exterior Issues	334
10.3.2	General Interior Issues	335
10.3.3	Lighting and Décor	338
10.3.4	Signs and Notices	343
10.3.5	Interior Building Services	345
10.4	Environmental Information and Navigation Technologies	348
10.4.1	Audio Information System: General Issues	348
10.4.2	Some Technologies for Environmental Information Systems	350
10.5	Accessible Public Transport	354
10.5.1	Accessible Public Transportation: Design Issues	355
10.5.2	Accessible Public Transportation: Technological Information and Way-finding Systems	356
10.6	Chapter Summary	358
	References	360
11	Accessible Bus System: A Bluetooth Application	363
11.1	Introduction	363
11.2	Bluetooth Fundamentals	364
11.2.1	Brief History of Bluetooth	364
11.2.2	Bluetooth Power Class	364
11.2.3	Protocol Stack	365
11.2.4	Bluetooth Profile	365
11.2.5	Piconet	366
11.2.6	Bluetooth and Competing Wireless Technologies	366
11.3	Design Issues	367
11.3.1	System Architecture	368
11.3.2	Hardware Requirements	369
11.3.3	Software Requirements	369
11.4	Developmental Issues	372
11.4.1	Bluetooth Server	373
11.4.2	Bluetooth Client (Mobile Device)	377
11.4.3	User Interface	379
11.5	Commercialisation Issues	381
11.6	Chapter Summary	382
	References	384
12	Accessible Information: An Overview	385
12.1	Introduction	386
12.2	Low Vision Aids	387
12.2.1	Basic Principles	387
12.3	Low Vision Assistive Technology Systems	391
12.3.1	Large Print	392
12.3.2	Closed Circuit Television Systems	393
12.3.3	Video Magnifiers	395
12.3.4	Telescopic Assistive Systems	396

12.4	Audio-transcription of Printed Information	401
12.4.1	Stand-alone Reading Systems	401
12.4.2	Read IT Project	403
12.5	Tactile Access to Information	407
12.5.1	Braille	407
12.5.2	Moon	408
12.5.3	Braille Devices	408
12.6	Accessible Computer Systems	410
12.6.1	Input Devices	414
12.6.2	Output Devices	417
12.6.3	Computer-based Reading Systems	421
12.6.4	Accessible Portable Computers	422
12.7	Accessible Internet	423
12.7.1	World Wide Web Guidelines	424
12.7.2	Guidelines for Web Authoring Tools	430
12.7.3	Accessible Adobe Portable Document Format (PDF) Documents	434
12.7.4	Bobby Approval	437
12.8	Telecommunications	438
12.8.1	Voice Dialling General Principles	438
12.8.2	Talking Caller ID	441
12.8.3	Mobile Telephones	442
12.9	Chapter Summary	444
	References	447
13	Screen Readers and Screen Magnifiers	449
13.1	Introduction	449
13.2	Overview of Chapter	450
13.3	Interacting with a Graphical User Interface	451
13.4	Screen Magnifiers	453
13.4.1	Overview	453
13.4.2	Magnification Modes	454
13.4.3	Other Interface Considerations	462
13.4.4	The Architecture and Implementation of Screen Magnifiers	466
13.5	Screen Readers	478
13.5.1	Overview	478
13.5.2	The Architecture and Implementation of a Screen Reader	480
13.5.3	Using a Braille Display	485
13.5.4	User Interface Issues	486
13.6	Hybrid Screen Reader Magnifiers	489
13.7	Self-magnifying Applications	489
13.8	Self-voicing Applications	489
13.9	Application Adaptors	491
13.10	Chapter Summary	491
	References	495

14	Speech, Text and Braille Conversion Technology	497
14.1	Introduction	497
14.1.1	Introducing Mode Conversion	497
14.1.2	Outline of the Chapter	499
14.2	Prerequisites for Speech and Text Conversion Technology	500
14.2.1	The Spectral Structure of Speech	500
14.2.2	The Hierarchical Structure of Spoken Language	505
14.2.3	Prosody	508
14.3	Speech-to-text Conversion	509
14.3.1	Principles of Pattern Recognition	509
14.3.2	Principles of Speech Recognition	515
14.3.3	Equipment and Applications	517
14.4	Text-to-speech Conversion	521
14.4.1	Principles of Speech Production	521
14.4.2	Principles of Acoustical Synthesis	522
14.4.3	Equipment and Applications	525
14.5	Braille Conversion	528
14.5.1	Introduction	528
14.5.2	Text-to-Braille Conversion	531
14.5.3	Braille-to-text Conversion	535
14.6	Commercial Equipment and Applications	537
14.6.1	Speech vs Braille	537
14.6.2	Speech Output in Devices for Daily Life	538
14.6.3	Portable Text-based Devices	540
14.6.4	Access to Computers	540
14.6.5	Reading Machines	542
14.6.6	Access to Telecommunication Devices	543
14.7	Discussion and the Future Outlook	543
14.7.1	End-user Studies	543
14.7.2	Discussion and Issues Arising	545
14.7.3	Future Developments	546
	References	551
15	Accessing Books and Documents	555
15.1	Introduction: The Challenge of Accessing the Printed Page	555
15.2	Basics of Optical Character Recognition Technology	557
15.2.1	Details of Optical Character Recognition Technology	558
15.2.2	Practical Issues with Optical Character Recognition Technology	561
15.3	Reading Systems	562
15.4	DAISY Technology	565
15.4.1	DAISY Full Audio Books	567
15.4.2	DAISY Full Text Books	568
15.4.3	DAISY and Other Formats	569
15.5	Players	571
15.6	Accessing Textbooks	574

15.7	Accessing Newspapers	575
15.8	Future Technology Developments	576
15.9	Chapter Summary and Conclusion	577
15.9.1	Chapter Summary	577
15.9.2	Conclusion	578
	References	579
16	Designing Accessible Music Software for Print Impaired People	581
16.1	Introduction	582
16.1.1	Print Impairments	582
16.1.2	Music Notation	583
16.2	Overview of Accessible Music	584
16.2.1	Formats	584
16.2.2	Technical Aspects	593
16.3	Some Recent Initiatives and Projects	594
16.3.1	Interactive Music Network	594
16.3.2	Play 2	595
16.3.3	Dancing Dots	596
16.3.4	Toccata	597
16.4	Problems to Be Overcome	597
16.4.1	A Content Processing Layer	598
16.4.2	Standardization of Accessible Music Technology	599
16.5	Unifying Accessible Design, Technology and Musical Content	600
16.5.1	Braille Music	600
16.5.2	Talking Music	607
16.6	Conclusions	609
16.6.1	Design for All or Accessibility from Scratch	610
16.6.2	Applying Design for All in Emerging Standards	610
16.6.3	Accessibility in Emerging Technology	611
	References	612
17	Assistive Technology for Daily Living	615
17.1	Introduction	616
17.2	Personal Care	617
17.2.1	Labelling Systems	617
17.2.2	Healthcare Monitoring	625
17.3	Time-keeping, Alarms and Alerting	628
17.3.1	Time-keeping	628
17.3.2	Alarms and Alerting	630
17.4	Food Preparation and Consumption	633
17.4.1	Talking Kitchen Scales	633
17.4.2	Talking Measuring Jug	634
17.4.3	Liquid Level Indicator	635
17.4.4	Talking Microwave Oven	635
17.4.5	Talking Kitchen and Remote Thermometers	635
17.4.6	Braille Salt and Pepper Set	636

17.5	Environmental Control and Use of Appliances	636
17.5.1	Light Probes	637
17.5.2	Colour Probes	639
17.5.3	Talking and Tactile Thermometers and Barometers	641
17.5.4	Using Appliances	642
17.6	Money, Finance and Shopping	643
17.6.1	Mechanical Money Indicators	644
17.6.2	Electronic Money Identifiers	645
17.6.3	Electronic Purse	645
17.6.4	Automatic Teller Machines (ATMs)	647
17.7	Communications and Access to Information: Other Technologies ..	648
17.7.1	Information Kiosks and Other Self-service Systems	648
17.7.2	Using Smart Cards	650
17.7.3	EZ Access®	652
17.8	Chapter Summary	653
	References	656
18	Assistive Technology for Education, Employment and Recreation	659
18.1	Introduction	659
18.2	Education: Learning and Teaching	661
18.2.1	Accessing Educational Processes and Approaches	662
18.2.2	Educational Technologies, Devices and Tools	667
18.3	Employment	670
18.3.1	Professional and Person-centred	671
18.3.2	Scientific and Technical	673
18.3.3	Administrative and Secretarial	674
18.3.4	Skilled and Non-skilled (Manual) Trades	676
18.3.5	Working Outside	680
18.4	Recreational Activities	680
18.4.1	Accessing the Visual, Audio and Performing Arts	681
18.4.2	Games, Puzzles, Toys and Collecting	686
18.4.3	Holidays and Visits: Museums, Galleries and Heritage Sites	687
18.4.4	Sports and Outdoor Activities	688
18.4.5	DIY, Art and Craft Activities	696
18.5	Chapter Summary	700
	References	703
	Biographical Sketches of the Contributors	709
	Index	717