

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 via 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

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	Use rInterface 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	461
13.4.4	The Architecture and Implementation of Screen Magnifiers	461
13.5	Screen Readers	471
13.5.1	Overview	471
13.5.2	The Architecture and Implementation of a Screen Reader	481
13.5.3	Using a Braille Display	481
13.5.4	User Interface Issues	481
13.6	Hybrid Screen Reader Magnifiers	481
13.7	Self-magnifying Applications	481
13.8	Self-voicing Applications	481
13.9	Application Adaptors	491
13.10	Chapter Summary	491
	References	491

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	Playes	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 Identifier	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