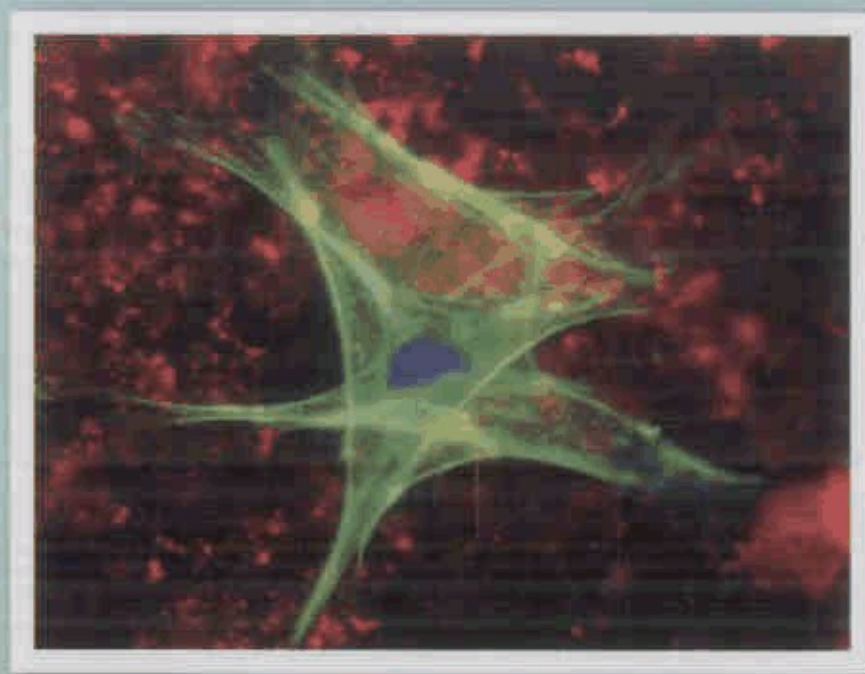


ACADEMIC PRESS SERIES IN BIOMEDICAL ENGINEERING



BIOMEDICAL INFORMATION TECHNOLOGY

Edited by

David Dagan Feng



Acknowledgments	xi
About the Editor	xiii
Contributors	xv
Introduction	xvii

Section I: Technological Fundamentals

Chapter 1 Medical Imaging <i>Dr. Xiaofeng Zhang, Prof. Nadine Smith, and Prof. Andrew Webb</i>	3
1.1 Introduction	3
1.2 Digital Radiography	4
1.3 Computed Tomography	6
1.4 Nuclear Medicine	7
1.5 Ultrasonic Imaging	11
1.6 Magnetic Resonance Imaging	15
1.7 Diffuse Optical Imaging	18
1.8 Biosignals	22
1.9 Appendix	24
1.10 Exercises	25
1.11 References and Bibliography	27
Chapter 2 Electronic Medical Records <i>Dr. Eugene Y. S. Lim, Prof. Michael Palhami, and Prof. David Dagan Feng</i>	29
2.1 Introduction	29
2.2 Medical Data and Patient Records	31
2.3 Terminology Standards—Vocabulary and a Clinical Coding System	34
2.4 Information Exchange Standards	38
2.5 Usability Issues in Electronic Medical Records	38
2.6 User Interface	40
2.7 Evaluation	42
2.8 Electronic Medical Records System—A Case Study: A Web-Based Electronic Record for Medical Imaging	42
2.9 Summary	45
2.10 Exercises	45
2.11 References and Bibliography	46
Chapter 3 Image Data Compression and Storage <i>Prof. Hong Ren Wu, Dr. Damian M. Lau, Dr. Tom Weidong Cai, and Prof. David Dagan Feng</i>	51
3.1 Introduction	51
3.2 Picture Compression	51
3.3 Compression in the DICOM Standard	69
3.4 Data Compression for Dynamic Functional Images	70
3.5 Summary	77
3.6 Exercises	78
3.7 References and Bibliography	78

Chapter 4	Content-Based Medical Image Retrieval	<i>Dr. Tom Weidong Cai, Dr. Jimman Kim, and Prof. David Dagan Feng</i>	83
4.1	Introduction		83
4.2	Content-Based Medical Image Retrieval by Physical Visual Features		88
4.3	Content-Based Medical Image Retrieval by Geometric Spatial Filters		94
4.4	Content-Based Medical Image Retrieval by Combination of Semantic and Visual Features		100
4.5	Content-Based Medical Image Retrieval by Physiologically Functional Features		107
4.6	Summary		107
4.7	Exercises		107
4.8	References and Bibliography		107
Chapter 5	Data Modeling and Simulation	<i>Dr. Alessandra Bertoldo and Prof. Claudio Cobelli</i>	115
5.1	Introduction		115
5.2	Compartment Models		115
5.3	Model Identification		118
5.4	Model Validation		127
5.5	Simulation		127
5.6	Case Study		128
5.7	Quantification of Medical Images		130
5.8	Exercises		135
5.9	References and Bibliography		135
Chapter 6	Techniques for Parametric Imaging	<i>Prof. David Dagan Feng, Dr. Lingfeng Wen, and Dr. Stefan Eberl</i>	137
6.1	Introduction		137
6.2	Parametric Image Estimation Methods		141
6.3	Noninvasive Methods		149
6.4	Clinical Applications of Parametric Images		152
6.5	Summary		158
6.6	Exercises		159
6.7	References and Bibliography		159
Chapter 7	Data Processing and Analysis	<i>Prof. Yue Wang, Prof. Chris Wyatt, Prof. Yu-Ping Wang, Prof. Matthew T. Freedman, and Prof. Murray Loew</i>	165
7.1	Introduction		165
7.2	Medical Image Enhancement		165
7.3	Medical Image Segmentation		170
7.4	Medical Image Feature Extraction		174
7.5	Medical Image Interpretation		177
7.6	Summary		182
7.7	Exercises		183
7.8	References and Bibliography		183
Chapter 8	Data Registration and Fusion	<i>Dr. Xiu Ying Wang, Dr. Stefan Eberl, Prof. Michael Fulham, Dr. Sea Sonu, and Prof. David Dagan Feng</i>	187
8.1	Introduction		187
8.2	Fundamentals of Biomedical Image Registration and Fusion		188
8.3	Feature-Based Medical Image Registration		193
8.4	Intensity-Based Registration		195

8.5	Hybrid Registration and Hierarchical Registration	198
8.6	Hardware Registration	200
8.7	Assessment of Registration Accuracy	201
8.8	Applications of Biomedical Image Registration and Fusion	203
8.9	Summary	205
8.10	Exercises	205
8.11	References and Bibliography	205
Chapter 9 Data Visualization and Display <i>Dr. Jinman Kim, Dr. Tom Weidong Cai, Prof. Michael Fulham, Dr. Stefan Eberl, and Prof. David Dagan Feng</i>		211
9.1	Introduction	211
9.2	Two-Dimensional Visualization Techniques	212
9.3	Three-Dimensional Visualization Techniques	213
9.4	Volume Navigation Interface	215
9.5	Volume Enhancement and Manipulation	216
9.6	Large Data Visualization and Optimization	218
9.7	Dual-Modality Positron Emission Tomography–Computed Tomography Visualization	219
9.8	Data Display Devices	222
9.9	Applications of Biomedical Visualization	223
9.10	Summary	224
9.11	Exercises	224
9.12	References and Bibliography	224
Chapter 10 Data Communication and Network Infrastructure <i>Prof. Doan B. Hoang and Dr. Andrew J. Simmonds</i>		229
10.1	Introduction	229
10.2	Transmission and Communication Technologies	230
10.3	The Internet and World Wide Web	233
10.4	Wireless and Mobile Technologies in M-Health	238
10.5	Sensor Networks for Health Monitoring	242
10.6	Applications of Wireless Technologies in Telemedicine	245
10.7	Summary	247
10.8	Exercises	247
10.9	References and Bibliography	248
Chapter 11 Data Security and Protection for Medical Images <i>Dr. Eugene Y. S. Lim</i>		249
11.1	Introduction	249
11.2	Overview of Cryptographic System	251
11.3	Digital Watermarking	252
11.4	Medical Image Watermarking	252
11.5	Region-Based Reversible Watermarking for Secure Positron Emission Tomography Image Management	254
11.6	Summary	255
11.7	Exercises	255
11.8	References and Bibliography	255
Chapter 12 Biologic Computing <i>Prof. Eric P. Hoffman, Erica Reeves, Dr. Javad Nazarian, Dr. Yezrib Houthout, Dr. Zuyi Wang, and Josephine Chen</i>		259
12.1	Introduction	259
12.2	Overview of Genomic Methods	259
12.3	Overview of Proteomic Methods	261
12.4	Bioinformatics and Information Infrastructure	266

12.5	Data Mining and Large Scale Biologic Databases	270
12.6	Biologic Event-Driven, Time-Driven and Hybrid Simulation Techniques	271
12.7	Summary	274
12.8	Exercises	276
12.9	References and Bibliography	275

Section II: Integrated Applications

Chapter 13	PACS and Medical Imaging Informatics for Filmless Hospitals <i>Prof. Brent J. Liu and Prof. H. K. Huang</i>	279
13.1	Introduction	279
13.2	PACS Infrastructure	280
13.3	PACS Components and Workflow	286
13.4	PACS Controller and Image Archive	291
13.5	Large-Scale PACS Implementation	295
13.6	PACS Clinical Experiences	299
13.7	Summary	304
13.8	Exercises	305
13.9	References and Bibliography	305
Chapter 14	KMeX: A Knowledge-Based Digital Library for Retrieving Scenario-Specific Medical Text Documents <i>Prof. Wesley W. Chu, Dr. Zhenyu Liu, Dr. Wenlei Mao, and Dr. Qinghua Zou</i>	307
14.1	Introduction	307
14.2	Extracting Key Concepts From Documents	308
14.3	Transforming Similar Queries into Query Templates	313
14.4	Topic-Oriented Directory	313
14.5	Phrase-Based Vector Space Model for Automatic Document Retrieval	317
14.6	Knowledge-Based Scenario-Specific Query Expansion	325
14.7	The KMeX System Architecture for Retrieving Scenario-Specific Free-Text Documents	338
14.8	Summary	338
14.9	Exercises	339
14.10	References and Bibliography	340
Chapter 15	Integrated Multimedia Patient Record Systems <i>Dr. Ruth E. Dayhoff, Mr. Peter M. Kuzniak, and Mr. Kevin Meldrum</i>	343
15.1	Introduction	343
15.2	Multimedia Patient Record	344
15.3	Components of the Multimedia Patient Record System Architecture	346
15.4	Electronic Medical Chart Components	348
15.5	Objects Comprising the Multimedia Patient Record	352
15.6	Capturing Multimedia Data with a Clinical Workstation	352
15.7	DICOM Image Acquisition	352
15.8	Remote Data and Image Viewing Across the Health Care Network	354
15.9	Impact on Patient Care	356
15.10	Summary	356
15.11	References and Bibliography	357
Chapter 16	Computer-Aided Diagnosis <i>Prof. Maryellen L. Giger and Dr. Kenji Suzuki</i>	359
16.1	Introduction	359
16.2	Computer Aided Diagnosis	359
16.3	Computer-Aided Diagnosis for Cancer Screening	362

16.4	Computer-Aided Diagnosis for Differential Diagnosis	366
16.5	Intelligent Computer-Aided Diagnosis Workstations: Indices of Similarity and Human/Computer Interfaces	367
16.6	Summary	370
16.7	Exercises	370
16.8	References and Bibliography	370
Chapter 17	Clinical Decision Support Systems <i>Dr. Peter Veller, Dr. Abdul Roudsari, and Prof. Ugart Carson</i>	375
17.1	Introduction	375
17.2	Overview of Clinical Decision Support Systems	376
17.3	Human Diagnostic Reasoning	377
17.4	A Structure for Characterizing Clinical Decision Support Systems	379
17.5	Decision Support Tools	384
17.6	Decision Support Systems in the Hospital and Other Health Care Settings	385
17.7	Health Care Education Applications	386
17.8	Verification, Validation, and Evaluation	387
17.9	Summary	389
17.10	Exercises	390
17.11	References and Bibliography	390
Chapter 18	Medical Robotics and Computer-Integrated Interventional Medicine <i>Prof. Russell H. Taylor and Prof. Peter Kazanzides</i>	393
18.1	Introduction	393
18.2	Technology and Techniques	394
18.3	Surgical CAD/CAM	403
18.4	Surgical Assistance	406
18.5	Summary	410
18.6	Exercises	410
18.7	References and Bibliography	411
Chapter 19	Functional Techniques for Brain Magnetic Resonance Imaging <i>Dr. Siyong Chen, Dr. Kai Ming Au Yeung, and Dr. Gladys Goh Lo</i>	417
19.1	Introduction	417
19.2	Diffusion-Weighted Magnetic Resonance Imaging in Brain	418
19.3	Magnetic Resonance Perfusion Imaging in Brain	421
19.4	Functional Magnetic Resonance Imaging Using BOLD Techniques	424
19.5	Clinical Magnetic Resonance Spectroscopy in Brain	425
19.6	Summary	428
19.7	Exercises	428
19.8	References and Bibliography	428
Chapter 20	Molecular Imaging in Cancer <i>Prof. Kristine Glunde, Dr. Catherine A. Foss, and Prof. Laver M. Bhatnagar</i>	431
20.1	Introduction	431
20.2	Imaging of Gene Expression	432
20.3	Receptor Imaging	439
20.4	Enzyme-Activated Probes	443
20.5	Metabolic Imaging	445
20.6	Imaging of Permeability, Perfusion, and Blood Flow	447
20.7	Imaging of the Tumor Microenvironment	448
20.8	Multimodality Imaging	449
20.9	Summary	452
20.10	Exercises	452
20.11	References and Bibliography	453

Chapter 21	Molecular Imaging in Biology and Pharmacology	<i>Prof. Sung Cheng Huang,</i> <i>Prof. Anna M. Wu, and Prof. Jorge R. Barrio</i>	457
21.1	Introduction and Background		457
21.2	Considerations for Quantitative Molecular Imaging		460
21.3	Design/Development of Molecular Imaging Probes		463
21.4	Molecular Imaging of Beta-Amyloid and Neurofibrillary Tangles		466
21.5	Molecular Imaging Using Antibody Probes		468
21.6	Some Other Molecular Imaging Applications		470
21.7	Summary and Future Perspectives		471
21.8	Exercises		475
21.9	References and Bibliography		475
Chapter 22	From Telemedicine to Ubiquitous M-Health: The Evolution of E-Health Systems	<i>Dr. Dejan Rašković, Dr. Aleksandar Milenković, Prof. Piet C. De Groen, and Dr. Emil Jovanov</i>	479
22.1	Introduction		479
22.2	Overview of M-Health Systems		480
22.3	M-Health Based on Wireless Body Area Networks		484
22.4	Wireless Intelligent Sensors for M Health		487
22.5	Wireless Mobile Devices for M-Health		491
22.6	Next-Generation M-Health Systems		492
22.7	Summary		494
22.8	Exercises		494
22.9	References and Bibliography		495
Chapter 23	Multimedia for Future Health—Smart Medical Home	<i>Dr. Jinnuan Kim, Dr. Zhiyang Wang,</i> <i>Dr. Tom Weidong Cai, and Prof. David Dagan Feng</i>	497
23.1	Introduction		497
23.2	Multimedia for Human-Computer Interaction		499
23.3	Multimedia Content Management		500
23.4	Multimedia Delivery		501
23.5	Smart Medical Home		503
23.6	Telemedicine in the Smart Medical Home		505
23.7	Sensory Devices and Health Monitoring		505
23.8	Speech Recognition and Conversational Systems		506
23.9	Multimedia Technologies for Patient Education and Care		506
23.10	Multimedia Operating Theater and Virtual Reality		507
23.11	Summary		508
23.12	Exercises		508
23.13	References and Bibliography		508
Index			513