

# **Contents**

## **Chapter 1.**

### **An introduction to computational intelligence in medical diagnosis**

*H.-N. Teodorescu and L.C. Jain*

1	What is computational intelligence? .....	1
2	Why CI in medicine and especially in medical diagnosis? .....	3
3	CI in medical diagnosis .....	4
4	Data mining and knowledge discovery .....	6
5	Qualitative reasoning methods .....	6
6	Issues related to CI management in medicine .....	6
7	The prospects of CI in medicine.....	7
	Acknowledgments .....	9
	References .....	10

## **Chapter 2.**

### **Computational intelligence techniques in medical decision making: the data mining perspective**

*V. Maojo, J. Sanandres, H. Billhardt, and J. Crespo*

1	Background – artificial intelligence in medicine.....	13
2	Data mining .....	16
2.1	Knowledge discovery in databases .....	16
2.2	Methods .....	18
2.2.1	Statistics and pattern recognition .....	21
2.2.2	Machine learning.....	23
2.2.3	Artificial neural networks (ANNs) .....	27
2.3	Data mining tools.....	30
3	Applications in medicine .....	31
4	Limitations of data mining in medicine.....	34
5	Conclusions .....	36
	References .....	37

## **Chapter 3.**

### **Internet-based decision support for evidence-based medicine**

*J. Simpson, J.K.C. Kingston, and N. Molony*

1	Introduction .....	45
2	The protocol assistant – feasibility assessment .....	47

2.1	Feasibility: organizational issues .....	48
2.2	Feasibility: technical issues .....	50
2.3	Feasibility: project & personnel issues .....	52
3	Representing clinical protocols .....	54
3.1	Knowledge acquisition and modeling using PROforma.....	54
3.2	“Running” a clinical protocol using JESS .....	56
3.3	Representing and reasoning with clinical uncertainty .....	58
4	Design and implementation of the protocol assistant.....	60
4.1	System design .....	60
4.2	User interface design .....	63
4.3	Implementation .....	64
5	Evaluation and future work .....	65
	Acknowledgments .....	68
	References .....	68

## **Chapter 4.**

### **Integrating kernel methods into a knowledge-based approach to evidence-based medicine**

*K. Morik, T. Joachims, M. Imhoff, P. Brockhausen, and S. Rüping*

1	Introduction .....	71
2	Data acquisition and data set .....	76
2.1	Data acquisition .....	76
2.2	Data set .....	78
2.3	Statistical preprocessing .....	79
3	Data-driven acquisition of state-action rules .....	80
3.1	Support vector machine .....	80
3.2	Learning the directions of interventions .....	81
3.3	Learning when to intervene .....	82
3.4	SVM rules in evidence based medicine .....	84
3.5	More learning tasks.....	85
4	Medical knowledge base .....	87
4.1	Knowledge acquisition and representation .....	87
4.2	Validating action-effect rules .....	91
4.3	Integrating learned decision functions with the knowledge base .....	92
5	Using the knowledge base of effects to validate interventions ...	93
5.1	Validating learned decision rules.....	93
5.2	Validating proposed interventions .....	94
6	Comparison with related work .....	95

7	Conclusions .....	96
	Acknowledgements .....	97
	References .....	97

## Chapter 5.

### Case-based reasoning prognosis for temporal courses

*R. Schmidt and L. Gierl*

1	Introduction .....	101
2	Methods .....	102
2.1	Case-based reasoning.....	102
2.2	Prognostic model .....	104
2.2.1	State abstraction .....	105
2.2.2	Temporal abstraction.....	105
2.2.3	CBR retrieval .....	106
3	Applications.....	106
3.1	Kidney function courses .....	107
3.1.1	Objectives.....	107
3.1.2	Methods.....	108
3.1.3	Learning a tree of prototypes .....	115
3.1.4	Evaluation .....	118
3.2	Prognosis of the spread of diseases .....	120
3.2.1	Searching for similar courses .....	122
3.2.2	Adaptation.....	122
4	Generalization of our prognostic method .....	123
5	Summary.....	125
	References .....	125

## Chapter 6.

### Pattern recognition in intensive care online monitoring

*R. Fried, U. Gather, and M. Imhoff*

1	Introduction .....	129
2	Curve fitting.....	131
3	Median filtering .....	137
4	Statistical time series analysis .....	139
5	Intervention analysis.....	143
6	Statistical process control .....	149
7	Online pattern recognition based on statistical time series analysis .....	156
7.1	Dynamic linear models .....	156

7.2	ARMA modeling .....	158
7.3	Trend detection .....	160
8	Conclusion .....	163
	Acknowledgements .....	165
	References .....	165

## Chapter 7.

### Artificial neural network models for timely assessment of trauma complication risk

*R.P. Marble and J.C. Healy*

1	Artificial neural network models .....	173
1.1	Background .....	173
1.2	Neural networks and statistical analysis .....	176
1.3	Neural networks in medicine .....	178
2	A neural network model for predicting the incidence of coagulopathy in victims of blunt injury trauma .....	180
2.1	Model description .....	181
2.2	Results .....	182
2.3	Remarks .....	184
3	Prospects for refining and utilizing neural models in trauma care settings .....	186
3.1	Sensitivity analysis, pruning, and rule extraction .....	186
3.2	Trauma systems development .....	188
	References .....	189

## Chapter 8.

### Artificial neural networks in medical diagnosis

*Y. Fukuoka*

1	Introduction .....	197
2	Foundations of artificial neural networks .....	198
2.1	Artificial neuron .....	198
2.2	Network architectures .....	198
2.3	Learning algorithms .....	199
2.3.1	Back-propagation .....	200
2.3.2	Self-organizing map .....	203
3	Applications to biomedicine .....	205
3.1	Pattern classification with BP .....	206
3.1.1	Clinical data .....	207
3.1.2	Bioelectric signals .....	208

3.1.3 Image analysis .....	210
3.2 Pattern classification with SOM .....	211
3.3 Data compression with BP .....	213
3.4 System modeling with BP .....	214
3.5 More detailed reviews.....	216
3.5.1 Chronic stress evaluation using ANNs .....	216
3.5.2 Gene expression data analysis with SOM.....	219
4 Conclusion .....	221
References .....	222

## Chapter 9.

### The application of neural networks in the classification of the electrocardiogram

*C.D. Nugent, J.A. Lopez, N.D. Black, and J.A.C. Webb*

1 Introduction to the classification of the electrocardiogram .....	229
1.1 Diagnostic utilities of the ECG.....	230
1.2 Introduction to computerized classification.....	231
2 Fundamentals of the 12-lead ECG .....	233
2.1 The 12-lead ECG and associated nomenclature.....	234
3 Computerized classification of the 12-lead ECG .....	237
3.1 Classification .....	239
4 Neural networks in 12-lead ECG classification .....	241
4.1 The artificial neuron .....	241
4.2 The MLP and ECG classification .....	244
5 Summary .....	251
References .....	254

## Chapter 10.

### Neural network predictions of significant coronary artery stenosis in women

*B.A. Mobley, W.E. Moore, E. Schechter, J.E. Eichner,  
and P.A. McKee*

1 Introduction .....	262
1.1 Systems enabling the avoidance of unnecessary angiography .....	262
1.2 Women and angiography .....	263
1.3 Other clinical predictions by neural network.....	264
2 Methods .....	265
2.1 Development of the data set from the SCA&I database .....	265

2.2	Artificial neural network.....	270
2.3	Patient files .....	272
2.4	Logistic regression.....	274
2.5	ROC analysis .....	275
3	Results .....	276
3.1	Neural network training and cross validation.....	276
3.2	Network application to the cutoff determination file .....	276
3.3	Network application to the test file.....	278
3.4	Relative weights of the neural network .....	281
3.5	Logistic regression.....	282
4	Discussion.....	285
4.1	Patients and data .....	285
4.2	Patient files .....	286
4.3	Cutoff determination file .....	287
4.4	Predictive systems .....	287
4.5	Network weights .....	287
5	Conclusions .....	288
	Acknowledgments .....	288
	References .....	289

## **Chapter 11.**

### **A modular neural network system for the analysis of nuclei in histopathological sections**

*C.S. Pattichis, F. Schnorrenberg, C.N. Schizas, M.S. Pattichis,  
and K. Kyriacou*

1	Introduction .....	292
1.1	The need of quantitative analysis in diagnostic histopathology.....	292
1.2	A brief overview of the use of artificial neural network (ANN) systems in diagnostic histopathology .....	293
1.3	Quantitative analysis in immunocytochemistry.....	293
2	Material.....	294
3	Modular neural network system .....	295
3.1	Detection of nuclei: the receptive field-squashing function (RFS) module.....	295
3.1.1	Step 1: convert color image to optical density image .....	297
3.1.2	Step 2: compute the receptive field filter .....	297
3.1.3	Step 3: apply iteratively the receptive field and the squashing function .....	297

3.1.4 Step 4: threshold bimodal histogram .....	298
3.1.5 Step 5: revise the list of detected nuclei.....	298
3.2 Detection of nuclei: the feedforward neural network (FNN) module.....	299
3.2.1 Step 1: color image to optical density image conversion.	300
3.2.2 Step 2: histogram stretching and thresholding.....	300
3.2.3 Step 3: SV expansion and feedforward neural network identification of image blocks.....	301
3.2.4 Step 4: calculation of the exact nuclei locations .....	301
3.3 Combination of detection modules.....	301
3.4 Nuclei classification and diagnostic index calculation.....	302
3.4.1 Step 1: extract features for each nucleus.....	303
3.4.2 Step 2: classify each nucleus.....	304
3.4.3 Step 3: compute diagnostic index .....	304
3.5 System validation.....	304
4 Results .....	306
4.1 Detection example .....	306
4.2 ROC analysis .....	308
4.3 Classification and diagnostic index computation module .....	310
5 Discussion.....	312
6 Future work .....	314
References .....	315
Appendix A: Semi-quantitative diagnostic index.....	321

## Chapter 12.

### Septic shock diagnosis by neural networks and rule based systems

*R. Brause, F. Hamker, and J. Paetz*

1 Introduction .....	323
2 The data .....	325
2.1 The data context.....	326
2.2 Data problems and preprocessing.....	326
2.3 Selecting feature variables .....	328
2.4 Basic statistical analysis .....	329
3 The neural network approach to diagnosis.....	331
3.1 The network.....	331
3.1.1 The network architecture .....	332
3.1.2 Treatment of missing values .....	333
3.2 Training and diagnosis.....	334

3.2.1	The training and test performance .....	334
3.2.2	The problem of medical data partition.....	335
3.3	Selection and validation of a neural network.....	336
3.4	Results for septic shock diagnosis .....	338
4	The neuro-fuzzy approach to rule generation.....	339
4.1	The rule extraction network.....	340
4.2	Application to septic shock patient data .....	343
5	Conclusions and discussion.....	345
	Acknowledgments .....	348
	References .....	348
	Appendix A: The network adaptation and growing .....	352
	Adaptation of the layers.....	352
	Growing of the representation layer .....	353
	Appendix B: The main rule building algorithm .....	354
	Appendix C: The rule shrinking procedure .....	355

## Chapter 13.

### Monitoring depth of anesthesia

*J.W. Huang, X.-S. Zhang, and R.J. Roy*

1	Introduction .....	357
2	Computational intelligence (CI) for DOA.....	359
2.1	Fuzzy logic assessment.....	360
2.1.1	Fuzzy inference process .....	361
2.1.2	Why not fuzzy? .....	363
2.2	Artificial neural networks .....	363
2.3	Neuro-fuzzy modeling .....	366
3	ANN-based CI model for MLAEP .....	368
3.1	MLAEP-derived parameter extraction .....	369
3.1.1	Wavelet transformation.....	370
3.2	System design based on ANN for MLAEP .....	372
3.3	ANN system: experiment results .....	373
4	Neuro-fuzzy based CI model for EEG .....	375
4.1	EEG-derived parameter extraction .....	376
4.1.1	Complexity analysis .....	376
4.1.2	Regularity analysis .....	376
4.1.3	Spectral entropy analysis .....	377
4.2	ANFIS – “derived” fuzzy knowledge model.....	377
4.3	System design based on ANFIS for EEG .....	379
4.4	ANFIS system: experiment results .....	380

5	Discussions .....	382
5.1	ANN versus ANFIS .....	382
5.2	EEG versus MLAEP .....	383
5.3	Performance issues .....	384
	Acknowledgments .....	385
	References .....	386

## Chapter 14.

### Combining evolutionary and fuzzy techniques in medical diagnosis

*C.A. Peña-Reyes and M. Sipper*

1	Introduction .....	391
2	Background.....	392
2.1	Fuzzy modeling .....	392
2.2	Evolutionary computation .....	396
2.3	Evolutionary fuzzy modeling .....	400
3	Fuzzy systems for breast cancer diagnosis .....	403
3.1	The WBCD problem.....	403
3.2	Fuzzy-system setup.....	405
4	A fuzzy-genetic approach.....	407
4.1	The evolutionary setup .....	407
4.2	Results.....	408
5	A fuzzy coevolutionary approach: fuzzy CoCo .....	411
5.1	Cooperative coevolution.....	411
5.2	The coevolutionary algorithm.....	413
5.3	The evolutionary setup .....	416
5.4	Results.....	419
6	Concluding remarks.....	421
	References .....	422

## Chapter 15.

### Genetic algorithms for feature selection in computer-aided diagnosis

*B. Sahiner, H.P. Chan, and N. Petrick*

1	Introduction .....	427
2	Genetic algorithms.....	429
2.1	Encoding .....	430
2.2	Initial population.....	431
2.3	Fitness function.....	431

2.4	Genetic operators .....	431
2.5	Working parameters.....	431
3	Feature selection and GAs.....	432
4	Applications in CAD .....	434
4.1	Classification of malignant and benign microcalcifications.....	436
4.1.1	Feature extraction.....	437
4.1.2	Data set.....	437
4.1.3	Morphological feature space .....	438
4.1.4	Texture feature space .....	440
4.1.5	GA implementation.....	442
4.1.6	Classification.....	444
4.1.7	Results.....	445
4.1.8	Discussion .....	452
4.2	Classification of mass and normal breast tissue .....	453
4.2.1	Data set.....	453
4.2.2	Morphological features .....	455
4.2.3	Texture features.....	455
4.2.4	Classification.....	455
4.2.5	GA implementation.....	456
4.2.6	Results .....	457
4.2.7	Discussion .....	461
4.3	Classification of malignant and benign masses .....	463
4.3.1	Data set.....	464
4.3.2	Image transformation .....	464
4.3.3	Texture features.....	466
4.3.4	Classification.....	467
4.3.5	GA implementation.....	467
4.3.6	Results .....	469
4.3.7	Discussion .....	474
5	Conclusion .....	475
	References .....	476
	<b>Index .....</b>	<b>485</b>
	<b>List of contributors.....</b>	<b>489</b>