

Contents

- 1 Introduction to Compressed Sensing: Fundamentals and Guarantees** 1
 - 1.1 Signal Acquisition and Compressed Sensing 1
 - 1.2 Low-Dimensional Signal Models 4
 - 1.2.1 Concentrated and Localized Signals 4
 - 1.2.2 Sparse and Compressible Signals 6
 - 1.3 Sensing Operators 8
 - 1.4 Coherence 9
 - 1.5 Restricted Isometries 12
 - 1.5.1 Random Sensing Matrices 15
 - 1.6 Signal Reconstruction 23
 - References 27
- 2 How (Well) Compressed Sensing Works in Practice** 29
 - 2.1 Non-Worst-Case Assessment of CS Performance 29
 - 2.2 Beyond Basis Pursuit 34
 - 2.3 A Framework for Performance Evaluation 37
 - 2.4 Practical Performance 41
 - 2.5 Countering the Myth of Democracy and Paving the Way for Practical Optimization 44
 - References 55
- 3 From Universal to Adapted Acquisition: Rake That Signal!** 57
 - 3.1 Average Maximum Energy 57
 - 3.2 Rakeness-Localization Trade-Off 60
 - 3.3 Rakeness and the Dark Side of Off-Line Adaptation 71
 - 3.4 Rakeness and the Distribution of Measurements 76
 - 3.5 Rakeness Compared with Other Matrix Optimization Options 78
 - References 81

4 The Rakeness Problem with Implementation and Complexity Constraints	83
4.1 Complexity of CS	83
4.2 Rakeness and Zeroing	91
4.3 Solving TRLT and BRLT by Projected Gradient and Alternating Projections	95
4.4 Unstructured and Structured Zeroing	101
4.4.1 Puncturing	104
4.4.2 Input Throttling	105
4.4.3 Output Throttling	107
References	108
5 Generating Raking Matrices: A Fascinating Second-Order Problem	109
5.1 Signal Modeling and Definitions	109
5.2 Quantized Gaussian Sequences	110
5.3 Antipodal Sensing Sequences	113
5.3.1 Antipodal Generation in the Stationary Case	114
5.3.2 Antipodal Generation in the Non-Stationary Case	118
5.3.3 Feasibility Space for Antipodal Sequences Generation	126
5.4 Ternary and Binary Sensing Sequences	133
5.4.1 Ternary Sensing Sequences	134
5.4.2 Binary Sensing Sequences	136
References	137
6 Architectures for Compressed Sensing	139
6.1 Introduction and Definitions	139
6.2 The CS Signal Acquisition Chain	141
6.3 Architectures and Implementation Guidelines	147
6.3.1 Random Sampling	147
6.3.2 Random Demodulator	149
6.3.3 Random Modulator Pre-Integration	151
6.3.4 Hybrid RD-RMPI Architecture	152
6.4 The Saturation Problem	156
6.5 From Temporal Domain to Mixed Spatial–Temporal Domain	162
References	166
7 Analog-to-Information Conversion	169
7.1 Introduction and Notation	170
7.2 AIC for Radar Pulse Signals by Yoo et al., 2012	174
7.2.1 Hardware Architecture	174
7.2.2 Experimental Results	177
7.3 AIC for Wideband Multi-tone BPSK Signals by Chen et al., 2012	179
7.3.1 Hardware Architecture	181
7.3.2 Experimental Results	184

7.4	AIC for ECG Signals by Gangopadhyay et al., 2014	185
7.4.1	Hardware Architecture	186
7.4.2	Experimental Results	189
7.5	AIC for Intracranial EEG by Shoaran et al., 2014.....	190
7.5.1	Hardware Architecture	191
7.5.2	Experimental Results	194
7.6	AIC for Biomedical Signals by Pareschi et al., 2016.....	196
7.6.1	Hardware Architecture	197
7.6.2	Experimental Results	200
7.7	Prototype Comparison	204
	References	209
8	Low-Complexity Biosignal Compression Using	
	Compressed Sensing	211
8.1	Low-Complexity Biosignal Encoding by CS	211
8.1.1	Lossy Compression Schemes for Biosignals	213
8.1.2	Lossy Compression by CS	216
8.1.3	Performance Evaluation	220
8.2	Dual Mode ECG Monitor by Bortolotti et al., 2015.....	223
8.2.1	System Architecture and Mathematical Model.....	224
8.2.2	Hardware Implementation and Energy Performance.....	227
8.3	Zeroing for HW-Efficient CS in WSNs by Mangia et al., 2016	231
8.3.1	Energy Analysis of Transmission/Storage Phase.....	235
8.4	Design of Low-Complexity CS by Mangia et al., 2017	238
8.4.1	Low-Complexity Sensor Node for ECGs Acquisition	239
8.4.2	Comparison with Other Methods	242
8.5	Implantable Neural Recording System by Zhang et al., 2014	244
8.5.1	Signal Dependent CS	244
8.5.2	Hardware Implementation	250
	References	252
9	Security at the Analog-to-Information Interface Using	
	Compressed Sensing	255
9.1	A Security Perspective on CS	256
9.1.1	CS as a Cryptosystem	256
9.1.2	Preliminary Considerations	257
9.1.3	Fundamental Security Limits	258
9.2	Statistical Cryptanalysis	260
9.2.1	Asymptotic Secrecy	260
9.2.2	Non-Asymptotic Secrecy	262
9.3	Computational Cryptanalysis	267
9.3.1	Preliminary Considerations	268
9.3.2	Eavesdropper's Known-Plaintext Attack	269

9.3.3	Expected Number of Solutions to an Eavesdropper's Known-Plaintext Attack	271
9.3.4	Expected Distance of Solutions to an Eavesdropper's Known-Plaintext Attack	274
9.4	Multiclass Encryption by Compressed Sensing	277
9.4.1	Security and Matrix Uncertainty by Random Perturbations ..	278
9.4.2	Elements of Multiclass Encryption	284
9.4.3	Properties and Main Results.....	291
9.4.4	Application Examples	300
9.4.5	Resilience Against Known-Plaintext Attacks	305
9.4.6	Practical Attack Examples	311
	References	317

Adapted Compressed Sensing for Effective Hardware
Implementations

A Design Flow for Signal-Level Optimization of
Compressed Sensing Stages

Mangia, M.; Pareschi, F.; Cambareri, V.; Rovatti, R.;
Setti, G.

2018, XIV, 319 p. 180 illus., 142 illus. in color.,
Hardcover

ISBN: 978-3-319-61372-7