

Contents

Contributors

1	Wavelets on irregular point sets	1
	<i>Ingrid Daubechies, Igor Guskov, Peter Schröder, and Wim Sweldens</i>	
1	Introduction	1
1.1	One-dimensional subdivision	2
1.2	Two-dimensional subdivision	5
1.3	Overview	6
2	The one-dimensional case	7
2.1	Multilevel grids	7
2.2	Subdivision schemes	7
2.3	Smoothness results	8
2.4	Wavelets	10
3	The two-dimensional case	11
3.1	Polygonal simplification	12
3.2	Functional setting: multivariate commutation formula	13
3.3	Constructing a subdivision scheme	13
3.4	Functions on surfaces	15
3.5	Burt–Adelson pyramid	16
4	Applications	17
5	Conclusion	17
6	Acknowledgements	18
7	References	18
2	Revealing a lognormal cascading process in turbulent velocity statistics with wavelet analysis	21
	<i>A. Arneodo, S. Manneville, J. F. Muzy, and S. G. Roux</i>	
1	Introduction	21
2	Experimental evidence for lognormal statistics in high-Reynolds-number turbulent flows	25
2.1	A method for determining the kernel G	25

5.1	Images collected in palaeopathology	79
5.2	Models for deformations	81
5.3	Gaining information from the wavelet model	82
6	Discussion	82
7	Acknowledgements	85
A	The discrete wavelet transform	85
8	References	86
5	Wavelets and the theory of non-parametric function estimation	89
<i>Iain M. Johnstone</i>		
1	Introduction	89
2	A simple model for sparsity	90
3	The ‘signal in Gaussian white-noise’ model	97
4	Optimality in the white-noise model	99
4.1	Linear estimators	100
4.2	Wavelet bases and thresholding	102
5	Concluding remarks	107
6	Acknowledgements	108
7	References	108
6	Ridgelets: a key to higher-dimensional intermittency?	111
<i>Emmanuel J. Candès and David L. Donoho</i>		
1	Introduction	111
1.1	Wavelets and point singularities	112
1.2	Singularities along lines	112
1.3	Ridgelet analysis	113
1.4	Ridgelets and ridge functions	114
2	The continuous ridgelet transform	115
2.1	Relation to Radon transform	116
2.2	An example	116
3	Discrete ridgelet transform: frames	117
4	Orthonormal ridgelets in dimension 2	119
5	Ridgelet synthesis of linear singularities	121
5.1	Using dual frames	121
5.2	Using orthonormal ridgelets	121
6	Ridgelet analysis of ridge functions	122
6.1	Using dual ridgelets	122
6.2	Using orthonormal ridgelets	122
7	Ridge spaces	123
8	Ridgelets and curves	126
9	Discussion	126
10	References	127

2.2	Experimental determination of the kernel G	27
3	Experimental evidence for a non-scale-invariant lognormal cascading process in high-Reynolds-number turbulent flows	32
3.1	Space-scale correlation functions from wavelet analysis	32
3.2	Analysis of random cascades using space-scale correlation functions	33
3.3	Analysis of velocity data using space-scale correlation functions	37
4	The multifractal description of intermittency revisited with wavelets	38
4.1	WTMM probability density functions	38
4.2	ζ_q scaling exponents	40
5	Conclusions and perspectives	44
6	Acknowledgements	46
7	References	46
3	Wavelets for the study of intermittency and its topology <i>F. Nicolleau and J. C. Vassilicos</i>	49
1	Introduction	49
2	Intermittency and eddy capacity	50
3	Validity of $F(r) \sim r^{D_E-1}$	52
4	Application to high resolution turbulent velocity signals	63
5	Conclusion	68
	Acknowledgements	69
A	D_E and D'_K	69
6	References	70
4	Wavelets in statistics: beyond the standard assumptions <i>Bernard W. Silverman</i>	71
1	Introduction	71
1.1	The standard assumptions	71
1.2	Prior information and modelling uncertainty	72
2	Correlated and non-stationary noise	73
2.1	Level-dependent thresholding	73
2.2	Adaptivity results	74
3	The non-decimated wavelet transform	74
3.1	The transform and the average basis reconstruction	74
3.2	Using the NDWT for curve estimation	75
3.3	A neurophysiological example	75
4	Dealing with irregular data	77
4.1	Coefficient-dependent thresholding	77
4.2	Finding the variances of the wavelet coefficients	78
4.3	Robust estimation	79
5	Deformable templates	79

7 Wavelets in time-series analysis	<i>Guy P. Nason and Rainer von Sachs</i>	129
1 Introduction		129
2 Estimation of ‘global’ scale behaviour		131
2.1 Long-memory processes, Allan and wavelet variance		132
2.2 Wavelet spectral analysis of $1/f$ processes		135
2.3 Synthesis of long-memory processes using wavelets		137
3 Wavelet processes: a particular time-scale model		137
3.1 Local stationarity		137
3.2 Locally stationary wavelet processes		139
4 Acknowledgements		143
A Discrete non-decimated wavelets		144
5 References		145
8 Wavelets, vision and the statistics of natural scenes	<i>D. J. Field</i>	147
1 Introduction		147
2 The mammalian visual system		148
2.1 Wavelet-like transforms		150
3 Image transforms and the statistics of natural scenes		151
4 The goal of visual coding		152
4.1 Principal components and the amplitude spectra of natural scenes		153
4.2 Discovering sparse structure		155
4.3 Sparse structure in natural scenes		157
5 Neural networks and independent coding		158
5.1 Nonlinear decorrelation		160
6 Overview		161
7 Acknowledgements		162
8 References		162
9 Image processing with complex wavelets	<i>Nick Kingsbury</i>	165
1 Introduction		165
2 The wavelet tree for multi-dimensional signals		166
3 Common wavelets with perfect reconstruction		168
4 Some problems with common wavelets		171
4.1 Shift dependence		171
4.2 Poor directional selectivity		172
5 Properties of complex wavelets		173
5.1 Extension to multiple dimensions		174
6 The dual-tree complex wavelet transform		175
7 Shift-invariant filter design		178

8	Applications of the complex wavelet transform	183
9	References	184
10	Application of wavelets to filtering of noisy data <i>Ue-Li Pen</i>	187
1	Introduction	187
2	Classical filters	188
2.1	Thresholding	188
2.2	Wiener filtering	189
3	Non-Gaussian filtering	189
3.1	Estimating prior Θ	191
3.2	Maximizing non-Gaussianity using wavelets	192
4	Examples	193
5	Discussion	197
6	Conclusions	197
	Acknowledgements	197
7	References	198
11	Approximation and compression of piecewise smooth functions <i>Paolo Prandoni and Martin Vetterli</i>	199
1	Introduction	199
2	The compression problem	201
3	RD upper bounds for a piecewise polynomial function	203
3.1	Polynomial approximation	204
3.2	Wavelet-based approximation	207
3.3	Commentary	208
4	RD optimal approximation	210
4.1	Joint segmentation and allocation	211
4.2	Efficient solution	213
4.3	Implementation and results	215
5	Conclusions	217
A	Local Legendre expansion	218
B	Estimate of the series truncation error	218
6	References	219
12	The contribution of wavelets to the analysis of economic and financial data <i>James B. Ramsey</i>	221
1	Introduction	221
2	A selective review of the literature	223
2.1	Non-stationarity and complex functions	223
2.2	Time-scale decompositions	226
2.3	Forecasting	229

2.4	Some miscellaneous papers	229
3	The research potential	231
3.1	Exploratory analysis: time-scale versus frequency	231
3.2	Density estimation and local inhomogeneity	232
3.3	Time-scale decomposition	232
3.4	Aspects for forecasting	233
4	Conclusion	234
5	References	234
13	Harmonic wavelets in vibrations and acoustics	237
<i>D. E. Newland</i>		
1	Introduction	237
2	Harmonic wavelet theory	238
3	Numerical algorithm	238
4	Phase interpretation	241
5	Bending wave transmission in a beam	241
6	Response of an acoustic waveguide	244
7	Underground train vibration	246
8	Geotechnical centrifuge testing	249
9	Experimental data	250
10	Power spectral densities	250
11	Cross-spectral densities	252
12	Simulated results	254
13	Acknowledgements	254
14	References	255
14	Image processing with complex wavelets	255
<i>J. G. Daubechies</i>		
14.1	Introduction	255
14.2	Complex wavelets and independent components	256
14.3	Complex wavelets and decompositions	256
14.4	Complex wavelets and denoising	257
14.5	Overviews	258
14.6	Acknowledgements	258
14.7	References	262
15	Image processing with complex wavelets	262
<i>J. G. Daubechies</i>		
15.1	Introduction	262
15.2	The basis for real-valued signals	263
15.3	Complex wavelets and filters	263
15.4	Some problems with complex wavelets	263
15.5	4.1. Shift dependence	264
15.6	4.2. Poor directional selectivity	272
15.7	Properties of complex wavelets and their wavelet filters	273
15.8	5.1. Wavelet-based image segmentation techniques	274
15.9	On dual-tree complex wavelet transforms: theory and applications	275
15.10	Shift-invariant filter design	275