

Contents

1	Introduction	1
1.1	Preamble	1
1.2	Outline	4
	References	5
2	Linear Time-Frequency Analysis	7
2.1	AM/FM Components and the Analytic Signal	8
2.2	Time-Frequency Representations (TFRs)	11
2.2.1	Windowed Fourier Transform (WFT)	12
2.2.2	Wavelet Transform (WT)	14
2.2.3	Difference Between the WFT and the WT	17
2.3	Time-, Frequency- and Time-Frequency Resolution	19
2.3.1	General Formulation	19
2.3.2	Classical Definitions and Their Flaws	22
2.3.3	Notion of the Window/Wavelet ϵ -Support	23
2.3.4	Reconsidered Definitions	25
2.4	Practical Issues	27
2.4.1	Signal Preprocessing	27
2.4.2	Frequency Discretization	30
2.4.3	Boundary Effects and Padding	32
2.4.4	TFR Frequency Range	38
2.5	Summary	39
	References	40
3	Extraction of Components from the TFR	43
3.1	Identification of the Components	43
3.1.1	Ridge Curve and Its Extraction	43
3.1.2	Main Procedure	46
3.2	Estimation of the Component's Parameters	48
3.2.1	Ridge Reconstruction	48
3.2.2	Direct Reconstruction	49

3.2.3	Difference Between the Two Estimates.	52
3.2.4	Adaptive Choice of the Reconstruction Method.	53
3.3	Summary	56
	References	57
4	Nonlinear Mode Decomposition (NMD)	59
4.1	Basic Idea and Ingredients	60
4.1.1	Extraction of the Fundamental Harmonic	61
4.1.2	Harmonics: Extracting the Candidates	61
4.1.3	Harmonics: Identifying the True Ones	61
4.1.4	Harmonics: Practical Issues.	64
4.1.5	Stopping Criterion	66
4.2	Improvements	69
4.2.1	Adaptive Representation of the Harmonics	69
4.2.2	Improved Reconstruction of Nonlinear Modes.	74
4.3	Parameters and Their Choice.	75
4.3.1	Resolution Parameter f_0	75
4.3.2	TFR Type: WFT or WT?	77
4.3.3	Reconstruction Method: Direct or Ridge?	79
4.3.4	Other Parameters	79
4.4	Summary	80
	References	81
5	Examples, Applications and Related Issues	83
5.1	Simulated Examples.	83
5.1.1	Example 1	83
5.1.2	Example 2	86
5.2	Real Applications	89
5.2.1	Decomposing Human Blood Flow Signals	89
5.2.2	Clinical Application: Cardiac Waveform Study	92
5.2.3	Removing Cardiac Artifacts from a Human EEG Signal.	95
5.2.4	Other Applications.	97
5.3	Physical Interpretation and System Classification	98
5.3.1	“Decomposability” of Different Systems.	99
5.3.2	Chronotaxic Systems and Their Identification	105
5.4	Limitations and Possible Issues	109
	References	110

6 Conclusion	113
6.1 Summary	113
6.2 Original Contributions	114
6.3 Future Perspectives	115
References	115
7 Appendix: Useful Information and Derivations	117
7.1 Errors of the Analytic Estimates	117
7.2 Window and Wavelet Functions and Their Properties	119
7.2.1 Window Functions	119
7.2.2 Wavelet Functions	122
7.3 Derivation of the Direct Reconstruction Formulas	124
7.4 Forecasting Model for Predictive Padding	126
7.5 Step-by-step WFT and WT Algorithms	129
7.5.1 WFT $G_s(\omega_k, t_n)$	130
7.5.2 WT $W_s(\omega_k, t_n)$	131
7.6 Fast $O(N)$ Algorithm for Path Optimization	132
References	135

Nonlinear Mode Decomposition

Theory and Applications

Iatsenko, D.

2015, XXIII, 135 p. 33 illus., 13 illus. in color., Hardcover

ISBN: 978-3-319-20015-6