

Contents

1	Speech Signal Modeling	1
1.1	Nature of Speech Signal	1
1.2	Linear Model of Speech Signal	4
2	Overview of Standard Methods	9
2.1	Autocorrelation Method	11
2.2	Covariant Method	12
2.3	Forward and Backward Prediction	15
2.4	Lattice Filter	17
2.5	Method of Minimization of Forward Prediction Error	19
2.6	Method of Minimization of Backward Prediction Error	19
2.7	Method of Geometric Mean	20
2.8	Method of Minimum	21
2.9	General Method	21
2.10	Method of Harmonic Mean	21
2.11	Lattice-Covariant LP Method	22
2.12	Basic Properties of Partial Correlation Coefficient	25
2.13	Equivalence of Discrete Model and Linear Prediction Model	25
2.14	Speech Synthesis Based on Linear Prediction Model	26
3	Fundamentals of Robust Parameter Estimation	29
3.1	Principles of Robust Parameter Estimation	29
3.2	Robust Estimation of Signal Amplitude	35
3.3	Fundamentals of Minimax Robust Estimation of Signal Amplitude	40
3.4	Recursive Minimax Robust Algorithms for Signal Amplitude Estimation	44
3.5	Statistical Models of Perturbations and Examples of Minimax Robust Estimator	51
3.6	Practical Aspects of Implementation of Robust Estimators	61

3.7	Robust Estimation of Parameters of Autoregressive Dynamic Signal Models.	65
3.8	Non-recursive Minimax Robust Estimation Algorithms	69
3.9	Recursive Minimax Robust Estimation Algorithm	75
3.10	Fundamentals of Robust Identification of Speech Signal Model	80
	Appendix 1—Analysis of Asymptotic Properties of Non-recursive Minimax Robust Estimation of Signal Amplitude.	84
	Appendix 2—Analysis of Asymptotic Properties of Recursive Minimax Robust Estimation of Signal Amplitude.	88
4	Robust Non-recursive AR Analysis of Speech Signal	95
4.1	Robust Estimations of Parameters of Linear Regression Model.	96
4.2	Non-recursive Robust Estimation Procedure: RBLP Method	99
4.2.1	Newton Algorithm	100
4.2.2	Dutter Algorithm.	101
4.2.3	Weighted Least Squares Algorithm.	104
4.3	Comparison of Robust and Non-robust Estimation Algorithms	105
4.3.1	Analysis of the Estimation Error Variance	106
4.3.2	Analysis of Estimation Shift	110
4.4	Characteristics of <i>M</i> -Robust Estimation Procedure	111
4.4.1	Model Validity	112
4.4.2	Stability.	112
4.4.3	Computational Complexity	112
4.5	Experimental Analysis	113
4.5.1	Test Signals Obtained by Filtering Train of Dirac Pulses	113
4.5.2	Test Signals Obtained by Filtering of Glottal Excitation	116
4.5.3	Natural Speech Signal.	119
4.6	Discussion and Conclusion.	123
5	Robust Recursive AR Analysis of Speech Signal.	125
5.1	Linear Regression Model for Recursive Parameter Estimation . . .	126
5.2	Application of <i>M</i> -Estimation Robust Procedure: RRLS Method	127
5.3	Robust Recursive Least-Squares Algorithm	129
5.4	Adaptive Robust Recursive Estimation Algorithm	132
5.5	Determination of Variable Forgetting Factor.	133
5.5.1	Approach Based on Discrimination Function	133
5.5.2	Approach Based on Generalized Prediction Error	135

5.6	Experimental Analysis on Test Sinusoids	136
5.6.1	Testing with Fixed Forgetting Factor	137
5.6.2	Testing with Variable Forgetting Factor	137
5.6.3	Testing with Contaminated Additive Gaussian Noise	143
5.7	Experimental Analysis of Speech Signals	145
5.7.1	Test Signals Obtained by Filtering a Train of Dirac Pulses	146
5.7.2	Test Signals Obtained by Filtering Glottal Excitation	147
5.7.3	Natural Speech Signal	149
5.8	Discussion and Conclusion	153
6	Robust Estimation Based on Pattern Recognition	155
6.1	Unsupervised Learning	156
6.1.1	General Clustering Algorithms	157
6.1.2	Frame-Based Methods	158
6.1.3	Quadratic Classifier with Sliding Training Set	161
6.2	Recursive Procedure Based on Pattern Recognition	163
6.3	Application of Bhattacharyya Distance	170
6.3.1	Bhattacharyya Distance	172
6.4	Experimental Analysis	174
6.4.1	Direct Evaluation	174
6.4.2	Indirect Evaluation	177
6.5	Conclusion	183
7	Applications of Robust Estimators in Speech Signal Processing	185
7.1	Segmentation of Speech Signal	186
7.1.1	Basics of Modified Generalized Maximum Likelihood Algorithm	187
7.1.2	Robust Discriminant Function	190
7.1.3	Tests with Real Speech Signal	191
7.1.4	Appendix 4: Robust MGLR Algorithm (RMGLR)	191
7.2	Separation of Formant Trajectories	195
7.2.1	Experimental Analysis	197
7.3	CELP Coder of Speech Signal	200
7.3.1	LSP Parameters	201
7.3.2	Distance Measure	203
7.3.3	Linear Prediction Methods with Sample Selection	206
7.3.4	Experimental Analysis	207
	References	213
	Index	221

Robust Digital Processing of Speech Signals

Kovacevic, B.; Milosavljevic, M.M.; Veinović, M.; Marković, M.

2017, XII, 224 p. 54 illus., Hardcover

ISBN: 978-3-319-53611-8