Preprocessing	. 1
Things Everyone Should Know	
Transformations	
Scaling	. 6
Status and Event Flags	
Centering and Detrending	
Centering	
Detrending	
Data Reduction and Orthogonalization	
Optimizing Factors Using Class Membership	
Filtering for Information Selection	
What Is a Filter?	
Why Filter a Time Series?	
Filter Parameters	
A Basic Filtering Example	
An Alternative Bandpass Filter	
Another Argument for Information Preservation	
Revealing Trends	
Subduing Seesanal Components	12
Subduing Seasonal Components	
The Problem of Harmonics	
Moving Averages and Alternatives	
A Seasonality Example.	
Summary of the Examples	50
Frequency-Domain Techniques I: Introduction	61
Introduction to the Frequency Domain	63
The Discrete Fourier Transform	66
Computing the Discrete Fourier Transform	69
The Power Spectrum	70
Frequency versus Period	72
Aliasing and the Nyquist Frequency	74
Data Windows	75
Code for Computing the Power Spectrum	80
Smoothing for Enhanced Visibility of Spectral Features	81
The Cumulative Power Spectrum	83
The Maximum Entropy Power Spectrum	90
Power Spectrum Examples and Summary	92
Summary of Power Spectrum Usage	99

What Is a Digital Filter? 102 Filtering in the Frequency Domain. 104 Padding to Avoid Wraparound Effects. 106 Endpoint Flattening to Reduce End Effects. 108 Shaping the Filter. 110 Bandpass Filters. 112 Lowpass and Highpass Filters. 114 An Alternative Bandpass Filter. 115 Implementation Details and Sample Code. 116 Summary of Basic Filters. 120 In-quadrature Filters. 121 In-quadrature Filters for Change Detection. 125 Quadrature-Mirror Filters. 129 Wavelet and QMF Features. 135 Feature Presence versus Feature State. 136 An Introductory Example. 138 Summary of Filter Outputs. 139 The Width Dilemma. 145 One More Implication of Time-Domain Extent. 148 A More Realistic Example. 150 Summary of this Example. 160 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 1	Frequency-Domain Techniques II: Filters and Features	101
Filtering in the Frequency Domain. 104 Padding to Avoid Wraparound Effects. 106 Endpoint Flattening to Reduce End Effects. 108 Shaping the Filter. 110 Bandpass Filters. 112 Lowpass and Highpass Filters. 114 An Alternative Bandpass Filter. 115 Implementation Details and Sample Code. 116 Summary of Basic Filters. 120 In-quadrature Filters. 121 In-quadrature Filters for Change Detection. 125 Quadrature-Mirror Filters. 129 Wavelet and QMF Features. 135 Feature Presence versus Feature State. 136 An Introductory Example. 138 Summary of Filter Outputs. 139 The Width Dilemma. 145 One More Implication of Time-Domain Extent. 148 A More Realistic Example. 150 Summary of this Example. 160 Wavelet Features. 160 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 175		
Padding to Avoid Wraparound Effects. 106 Endpoint Flattening to Reduce End Effects. 108 Shaping the Filter. 110 Bandpass Filters. 112 Lowpass and Highpass Filters. 114 An Alternative Bandpass Filter. 115 Implementation Details and Sample Code. 116 Summary of Basic Filters. 120 In-quadrature Filters. 121 In-quadrature Filters for Change Detection. 125 Quadrature-Mirror Filters. 129 Wavelet and QMF Features. 136 An Introductory Example. 138 Summary of Filter Outputs. 139 The Width Dilemma. 145 One More Implication of Time-Domain Extent. 148 A More Realistic Example. 150 Summary of this Example. 160 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175		
Endpoint Flattening to Reduce End Effects. 108 Shaping the Filter. 110 Bandpass Filters. 112 Lowpass and Highpass Filters. 114 An Alternative Bandpass Filter. 115 Implementation Details and Sample Code. 116 Summary of Basic Filters. 120 In-quadrature Filters. 121 In-quadrature Filters for Change Detection. 125 Quadrature-Mirror Filters. 129 Wavelet and QMF Features. 135 Feature Presence versus Feature State. 136 An Introductory Example. 138 Summary of Filter Outputs. 139 The Width Dilemma. 145 One More Implication of Time-Domain Extent. 148 A More Realistic Example. 150 Summary of this Example. 150 Summary of this Example. 160 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175		
Bandpass Filters. 112 Lowpass and Highpass Filters. 114 An Alternative Bandpass Filter. 115 Implementation Details and Sample Code. 116 Summary of Basic Filters. 120 In-quadrature Filters. 121 In-quadrature Filters for Change Detection. 125 Quadrature-Mirror Filters. 129 Wavelet and QMF Features. 135 Feature Presence versus Feature State. 136 An Introductory Example. 138 Summary of Filter Outputs. 139 The Width Dilemma. 145 One More Implication of Time-Domain Extent. 148 A More Realistic Example. 150 Summary of this Example. 150 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175		
Lowpass and Highpass Filters. 114 An Alternative Bandpass Filter. 115 Implementation Details and Sample Code. 116 Summary of Basic Filters. 120 In-quadrature Filters. 121 In-quadrature Filters for Change Detection. 125 Quadrature-Mirror Filters. 129 Wavelet and QMF Features. 135 Feature Presence versus Feature State. 136 An Introductory Example. 138 Summary of Filter Outputs. 139 The Width Dilemma. 145 One More Implication of Time-Domain Extent. 148 A More Realistic Example. 150 Summary of this Example. 160 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175	Shaping the Filter	110
An Alternative Bandpass Filter. 115 Implementation Details and Sample Code. 116 Summary of Basic Filters. 120 In-quadrature Filters. 121 In-quadrature Filters for Change Detection. 125 Quadrature-Mirror Filters. 129 Wavelet and QMF Features. 135 Feature Presence versus Feature State. 136 An Introductory Example. 138 Summary of Filter Outputs. 139 The Width Dilemma. 145 One More Implication of Time-Domain Extent. 148 A More Realistic Example. 150 Summary of this Example. 160 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175	Bandpass Filters	112
Implementation Details and Sample Code. 116 Summary of Basic Filters. 120 In-quadrature Filters. 121 In-quadrature Filters for Change Detection. 125 Quadrature-Mirror Filters. 129 Wavelet and QMF Features. 135 Feature Presence versus Feature State. 136 An Introductory Example. 138 Summary of Filter Outputs. 139 The Width Dilemma. 145 One More Implication of Time-Domain Extent. 148 A More Realistic Example. 150 Summary of this Example. 160 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175	Lowpass and Highpass Filters	114
Summary of Basic Filters 120 In-quadrature Filters 121 In-quadrature Filters for Change Detection 125 Quadrature-Mirror Filters 129 Wavelet and QMF Features 135 Feature Presence versus Feature State 136 An Introductory Example 138 Summary of Filter Outputs 139 The Width Dilemma 145 One More Implication of Time-Domain Extent 148 A More Realistic Example 150 Summary of this Example 160 Wavelet Features 166 Arranging Filters According to Width 167 What Is a Wavelet? 170 The Morlet Wavelet 172 Code for the Morlet Wavelet 175	An Alternative Bandpass Filter	115
In-quadrature Filters. 121 In-quadrature Filters for Change Detection. 125 Quadrature-Mirror Filters. 129 Wavelet and QMF Features. 135 Feature Presence versus Feature State. 136 An Introductory Example. 138 Summary of Filter Outputs. 139 The Width Dilemma. 145 One More Implication of Time-Domain Extent. 148 A More Realistic Example. 150 Summary of this Example. 160 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175	Implementation Details and Sample Code	116
In-quadrature Filters for Change Detection. 125 Quadrature-Mirror Filters. 129 Wavelet and QMF Features. 135 Feature Presence versus Feature State. 136 An Introductory Example. 138 Summary of Filter Outputs. 139 The Width Dilemma. 145 One More Implication of Time-Domain Extent. 148 A More Realistic Example. 150 Summary of this Example. 150 Summary of this Example. 160 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175	Summary of Basic Filters	120
Quadrature-Mirror Filters.129Wavelet and QMF Features.135Feature Presence versus Feature State.136An Introductory Example.138Summary of Filter Outputs.139The Width Dilemma.145One More Implication of Time-Domain Extent.148A More Realistic Example.150Summary of this Example.160Wavelet Features.166Arranging Filters According to Width.167What Is a Wavelet?170The Morlet Wavelet.172Code for the Morlet Wavelet.175	In-quadrature Filters	121
Wavelet and QMF Features. 135 Feature Presence versus Feature State. 136 An Introductory Example. 138 Summary of Filter Outputs. 139 The Width Dilemma. 145 One More Implication of Time-Domain Extent. 148 A More Realistic Example. 150 Summary of this Example. 160 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175	In-quadrature Filters for Change Detection	125
Feature Presence versus Feature State. 136 An Introductory Example. 138 Summary of Filter Outputs. 139 The Width Dilemma. 145 One More Implication of Time-Domain Extent. 148 A More Realistic Example. 150 Summary of this Example. 160 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175	Quadrature-Mirror Filters	129
Feature Presence versus Feature State. 136 An Introductory Example. 138 Summary of Filter Outputs. 139 The Width Dilemma. 145 One More Implication of Time-Domain Extent. 148 A More Realistic Example. 150 Summary of this Example. 160 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175		
Summary of Filter Outputs. 139 The Width Dilemma. 145 One More Implication of Time-Domain Extent. 148 A More Realistic Example. 150 Summary of this Example. 160 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175	Wavelet and QMF Features	135
Summary of Filter Outputs. 139 The Width Dilemma. 145 One More Implication of Time-Domain Extent. 148 A More Realistic Example. 150 Summary of this Example. 160 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175		
One More Implication of Time-Domain Extent. 148 A More Realistic Example. 150 Summary of this Example. 160 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175	Feature Presence versus Feature State	
A More Realistic Example. 150 Summary of this Example. 160 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175	Feature Presence versus Feature State	
A More Realistic Example. 150 Summary of this Example. 160 Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175	Feature Presence versus Feature State. An Introductory Example	
Wavelet Features. 166 Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175	Feature Presence versus Feature State. An Introductory Example Summary of Filter Outputs. The Width Dilemma	
Arranging Filters According to Width. 167 What Is a Wavelet? 170 The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175	Feature Presence versus Feature State. An Introductory Example Summary of Filter Outputs. The Width Dilemma One More Implication of Time-Domain Extent	
What Is a Wavelet?	Feature Presence versus Feature State. An Introductory Example Summary of Filter Outputs. The Width Dilemma. One More Implication of Time-Domain Extent. A More Realistic Example.	
The Morlet Wavelet. 172 Code for the Morlet Wavelet. 175	Feature Presence versus Feature State. An Introductory Example Summary of Filter Outputs. The Width Dilemma. One More Implication of Time-Domain Extent. A More Realistic Example. Summary of this Example.	
Code for the Morlet Wavelet	Feature Presence versus Feature State. An Introductory Example Summary of Filter Outputs. The Width Dilemma. One More Implication of Time-Domain Extent. A More Realistic Example. Summary of this Example. Wavelet Features.	
	Feature Presence versus Feature State. An Introductory Example Summary of Filter Outputs. The Width Dilemma. One More Implication of Time-Domain Extent. A More Realistic Example. Summary of this Example. Wavelet Features. Arranging Filters According to Width.	
Implementing Wavelets with NPREDICT177	Feature Presence versus Feature State. An Introductory Example Summary of Filter Outputs. The Width Dilemma. One More Implication of Time-Domain Extent. A More Realistic Example Summary of this Example. Wavelet Features. Arranging Filters According to Width. What Is a Wavelet?.	
	Feature Presence versus Feature State. An Introductory Example Summary of Filter Outputs. The Width Dilemma. One More Implication of Time-Domain Extent. A More Realistic Example. Summary of this Example. Wavelet Features. Arranging Filters According to Width. What Is a Wavelet? The Morlet Wavelet.	

Overview of the ARMA Paradigm. 182 Duality Between AR and MA Models. 184 ARMA Models. 185 Homogeneity, Periodicity, and Stationarity. 185 Computing the Parameters. 187 Univariate ARMA Prediction. 191 Predicting with Predicted Shocks. 193 Multivariate ARMA Models. 200 Computing the Error and Predicting. 203 Training the Multivariate ARMA Model. 211 Computing Initial AR Parameter Estimates. 211 Iterative Refinement of All Parameters. 215 The Complete Training Algorithm. 217 Designing and Testing ARMA Models. 223 Examining the Power Spectrum. 229 Multivariate Models. 232 Computing Lagged Correlations. 234 Autocorrelation. 234 Autocorrelation. 234 Partial Autocorrelation. 235 Partial Autocorrelation. 235 Partial Orosscorrelation. 235 Partial Orosscorrelation. 235 A Multivariate Example.	Box-Jenkins ARMA Models	181
Duality Between AR and MA Models. 184 ARMA Models. 185 Homogeneity, Periodicity, and Stationarity. 185 Computing the Parameters. 187 Univariate ARMA Prediction. 191 Predicting with Predicted Shocks. 193 Multivariate ARMA Models. 200 Computing the Error and Predicting. 203 Training the Multivariate ARMA Model. 211 Computing Initial AR Parameter Estimates. 215 The Complete Training Algorithm. 217 Designing and Testing ARMA Models. 223 Examining the Power Spectrum. 229 Multivariate Models. 234 Computing Lagged Correlations. 234 Autocorrelation. 234 Crosscorrelation. 235 Partial Autocorrelation. 235 Partial Crosscorrelation. 235 Spatial Grosscorrelation. 237 A Multivariate Example. 237 Differencing. 251 Stationarity. 253 Identifying Nonstationary Behavior. 254 Removing Nonstationarity. 259		
ARMA Models. 185 Homogeneity, Periodicity, and Stationarity. 185 Computing the Parameters. 187 Univariate ARMA Prediction. 191 Predicting with Predicted Shocks. 193 Multivariate ARMA Models. 200 Computing the Error and Predicting. 203 Training the Multivariate ARMA Model. 211 Computing Initial AR Parameter Estimates. 211 Iterative Refinement of All Parameters 215 The Complete Training Algorithm. 217 Designing and Testing ARMA Models. 223 Examining the Power Spectrum. 229 Multivariate Models. 232 Computing Lagged Correlations. 234 Autocorrelation. 234 Crosscorrelation. 235 Partial Autocorrelation. 235 Partial Crosscorrelation. 237 A Multivariate Example. 237 Differencing. 251 Stationarity. 253 Identifying Nonstationary Behavior. 254 Removing Nonstationarity. 259 ARIMA Models. 261	-	
Computing the Parameters. 187 Univariate ARMA Prediction. 191 Predicting with Predicted Shocks. 193 Multivariate ARMA Models. 200 Computing the Error and Predicting. 203 Training the Multivariate ARMA Model. 211 Computing Initial AR Parameter Estimates. 211 Iterative Refinement of All Parameters. 215 The Complete Training Algorithm. 217 Designing and Testing ARMA Models. 223 Examining the Power Spectrum. 229 Multivariate Models. 232 Computing Lagged Correlations. 234 Autocorrelation. 234 Crosscorrelation. 235 Partial Autocorrelation. 235 Partial Crosscorrelation. 235 Partial Crosscorrelation. 237 A Multivariate Example. 237 Differencing. 251 Stationarity. 253 Identifying Nonstationarity Behavior. 254 Removing Nonstationarity. 259 ARIMA Models. 261 Seasonal Differencing. 261 Spott		
Computing the Parameters. 187 Univariate ARMA Prediction. 191 Predicting with Predicted Shocks. 193 Multivariate ARMA Models. 200 Computing the Error and Predicting. 203 Training the Multivariate ARMA Model. 211 Computing Initial AR Parameter Estimates. 211 Iterative Refinement of All Parameters. 215 The Complete Training Algorithm. 217 Designing and Testing ARMA Models. 223 Examining the Power Spectrum. 229 Multivariate Models. 232 Computing Lagged Correlations. 234 Autocorrelation. 234 Crosscorrelation. 235 Partial Autocorrelation. 235 Partial Crosscorrelation. 235 Partial Crosscorrelation. 237 A Multivariate Example. 237 Differencing. 251 Stationarity. 253 Identifying Nonstationarity Behavior. 254 Removing Nonstationarity. 259 ARIMA Models. 261 Seasonal Differencing. 261 Spott	Homogeneity, Periodicity, and Stationarity	185
Univariate ARMA Prediction. 191 Predicting with Predicted Shocks. 193 Multivariate ARMA Models. 200 Computing the Error and Predicting. 203 Training the Multivariate ARMA Model. 211 Computing Initial AR Parameter Estimates. 211 Iterative Refinement of All Parameters. 215 The Complete Training Algorithm. 217 Designing and Testing ARMA Models. 223 Examining the Power Spectrum. 229 Multivariate Models. 232 Computing Lagged Correlations. 234 Autocorrelation. 234 Crosscorrelation. 235 Partial Autocorrelation. 235 Partial Crosscorrelation. 235 Partial Crosscorrelation. 237 A Multivariate Example. 237 Differencing. 251 Stationarity. 253 Removing Nonstationarity. 254 Removing Nonstationarity. 259 ARIMA Models. 261 Seasonal Differencing. 261 Spotting		
Multivariate ARMA Models. 200 Computing the Error and Predicting. 203 Training the Multivariate ARMA Model. 211 Computing Initial AR Parameter Estimates. 211 Iterative Refinement of All Parameters. 215 The Complete Training Algorithm. 217 Designing and Testing ARMA Models. 223 Examining the Power Spectrum. 229 Multivariate Models. 232 Computing Lagged Correlations. 234 Autocorrelation. 234 Crosscorrelation. 235 Partial Autocorrelation. 235 Partial Crosscorrelation. 235 Partial Crosscorrelation. 237 A Multivariate Example. 237 Differencing. 251 Stationarity. 253 Identifying Nonstationary Behavior. 254 Removing Nonstationarity. 259 ARIMA Models. 261 Seasonal Differencing. 261 Spotting the Need for Seasonal Differencing. 265 Computational Considerations. 268		
Multivariate ARMA Models. 200 Computing the Error and Predicting. 203 Training the Multivariate ARMA Model. 211 Computing Initial AR Parameter Estimates. 211 Iterative Refinement of All Parameters. 215 The Complete Training Algorithm. 217 Designing and Testing ARMA Models. 223 Examining the Power Spectrum. 229 Multivariate Models. 232 Computing Lagged Correlations. 234 Autocorrelation. 234 Crosscorrelation. 235 Partial Autocorrelation. 235 Partial Crosscorrelation. 235 Partial Crosscorrelation. 237 A Multivariate Example. 237 Differencing. 251 Stationarity. 253 Identifying Nonstationary Behavior. 254 Removing Nonstationarity. 259 ARIMA Models. 261 Seasonal Differencing. 261 Spotting the Need for Seasonal Differencing. 265 Computational Considerations. 268	Predicting with Predicted Shocks	193
Training the Multivariate ARMA Model. 211 Computing Initial AR Parameter Estimates. 211 Iterative Refinement of All Parameters. 215 The Complete Training Algorithm. 217 Designing and Testing ARMA Models. 223 Examining the Power Spectrum. 229 Multivariate Models. 232 Computing Lagged Correlations. 234 Autocorrelation. 234 Crosscorrelation. 235 Partial Autocorrelation. 235 Partial Crosscorrelation. 237 A Multivariate Example. 237 Differencing. 251 Stationarity. 253 Identifying Nonstationary Behavior. 254 Removing Nonstationarity. 259 ARIMA Models. 261 Seasonal Differencing. 261 Spotting the Need for Seasonal Differencing. 265 Computational Considerations. 268		
Training the Multivariate ARMA Model. 211 Computing Initial AR Parameter Estimates. 211 Iterative Refinement of All Parameters. 215 The Complete Training Algorithm. 217 Designing and Testing ARMA Models. 223 Examining the Power Spectrum. 229 Multivariate Models. 232 Computing Lagged Correlations. 234 Autocorrelation. 234 Crosscorrelation. 235 Partial Autocorrelation. 235 Partial Crosscorrelation. 237 A Multivariate Example. 237 Differencing. 251 Stationarity. 253 Identifying Nonstationary Behavior. 254 Removing Nonstationarity. 259 ARIMA Models. 261 Seasonal Differencing. 261 Spotting the Need for Seasonal Differencing. 265 Computational Considerations. 268	Computing the Error and Predicting	203
Iterative Refinement of All Parameters. 215 The Complete Training Algorithm. 217 Designing and Testing ARMA Models. 223 Examining the Power Spectrum. 229 Multivariate Models. 232 Computing Lagged Correlations. 234 Autocorrelation. 235 Partial Autocorrelation. 235 Partial Crosscorrelation. 237 A Multivariate Example. 237 Differencing. 251 Stationarity. 253 Identifying Nonstationary Behavior. 254 Removing Nonstationarity. 259 ARIMA Models. 261 Seasonal Differencing. 261 Spotting the Need for Seasonal Differencing. 265 Computational Considerations. 268		
The Complete Training Algorithm. 217 Designing and Testing ARMA Models. 223 Examining the Power Spectrum. 229 Multivariate Models. 232 Computing Lagged Correlations. 234 Autocorrelation. 235 Partial Autocorrelation. 235 Partial Crosscorrelation. 237 A Multivariate Example. 237 Differencing. 251 Stationarity. 253 Identifying Nonstationary Behavior. 254 Removing Nonstationarity. 259 ARIMA Models. 261 Seasonal Differencing. 261 Spotting the Need for Seasonal Differencing. 265 Computational Considerations. 268	Computing Initial AR Parameter Estimates	211
Designing and Testing ARMA Models. 223 Examining the Power Spectrum. 229 Multivariate Models. 232 Computing Lagged Correlations. 234 Autocorrelation. 234 Crosscorrelation. 235 Partial Autocorrelation. 237 A Multivariate Example. 237 Differencing. 251 Stationarity. 253 Identifying Nonstationary Behavior. 254 Removing Nonstationarity. 259 ARIMA Models. 261 Seasonal Differencing. 261 Spotting the Need for Seasonal Differencing. 265 Computational Considerations. 268	Iterative Refinement of All Parameters	215
Examining the Power Spectrum. 229 Multivariate Models. 232 Computing Lagged Correlations. 234 Autocorrelation. 235 Crosscorrelation. 235 Partial Autocorrelation. 237 A Multivariate Example. 237 Differencing. 251 Stationarity. 253 Identifying Nonstationary Behavior. 254 Removing Nonstationarity. 259 ARIMA Models. 261 Seasonal Differencing. 261 Spotting the Need for Seasonal Differencing. 265 Computational Considerations. 268	The Complete Training Algorithm	217
Multivariate Models 232 Computing Lagged Correlations 234 Autocorrelation 235 Crosscorrelation 235 Partial Autocorrelation 237 A Multivariate Example 237 A Multivariate Example 237 Differencing 251 Stationarity 253 Identifying Nonstationary Behavior 254 Removing Nonstationarity 259 ARIMA Models 261 Seasonal Differencing 261 Spotting the Need for Seasonal Differencing 265 Computational Considerations 268	Designing and Testing ARMA Models	223
Computing Lagged Correlations.234Autocorrelation.234Crosscorrelation.235Partial Autocorrelation.235Partial Crosscorrelation.237A Multivariate Example.237Differencing.251Stationarity.253Identifying Nonstationary Behavior.254Removing Nonstationarity.259ARIMA Models.261Seasonal Differencing.261Spotting the Need for Seasonal Differencing.265Computational Considerations.268	Examining the Power Spectrum	229
Autocorrelation. 234 Crosscorrelation. 235 Partial Autocorrelation. 235 Partial Crosscorrelation. 237 A Multivariate Example. 237 Differencing. 251 Stationarity. 253 Identifying Nonstationary Behavior. 254 Removing Nonstationarity. 259 ARIMA Models. 261 Seasonal Differencing. 261 Spotting the Need for Seasonal Differencing. 265 Computational Considerations. 268	Multivariate Models	232
Crosscorrelation.235Partial Autocorrelation.235Partial Crosscorrelation.237A Multivariate Example.237Differencing.251Stationarity.253Identifying Nonstationary Behavior.254Removing Nonstationarity.259ARIMA Models.261Seasonal Differencing.261Spotting the Need for Seasonal Differencing.265Computational Considerations.268	Computing Lagged Correlations	234
Partial Autocorrelation.235Partial Crosscorrelation.237A Multivariate Example.237Differencing.251Stationarity.253Identifying Nonstationary Behavior.254Removing Nonstationarity.259ARIMA Models.261Seasonal Differencing.261Spotting the Need for Seasonal Differencing.265Computational Considerations.268	Autocorrelation	234
Partial Crosscorrelation. 237 A Multivariate Example. 237 Differencing. 251 Stationarity. 253 Identifying Nonstationary Behavior. 254 Removing Nonstationarity. 259 ARIMA Models. 261 Seasonal Differencing. 261 Spotting the Need for Seasonal Differencing. 265 Computational Considerations. 268	Crosscorrelation	235
A Multivariate Example. 237 Differencing. 251 Stationarity. 253 Identifying Nonstationary Behavior. 254 Removing Nonstationarity. 259 ARIMA Models. 261 Seasonal Differencing. 261 Spotting the Need for Seasonal Differencing. 265 Computational Considerations. 268	Partial Autocorrelation	235
Differencing. 251 Stationarity. 253 Identifying Nonstationary Behavior. 254 Removing Nonstationarity. 259 ARIMA Models. 261 Seasonal Differencing. 261 Spotting the Need for Seasonal Differencing. 265 Computational Considerations. 268	Partial Crosscorrelation	237
Stationarity.253Identifying Nonstationary Behavior.254Removing Nonstationarity.259ARIMA Models.261Seasonal Differencing.261Spotting the Need for Seasonal Differencing.265Computational Considerations.268	A Multivariate Example	237
Stationarity.253Identifying Nonstationary Behavior.254Removing Nonstationarity.259ARIMA Models.261Seasonal Differencing.261Spotting the Need for Seasonal Differencing.265Computational Considerations.268	Differencing	251
Identifying Nonstationary Behavior.254Removing Nonstationarity.259ARIMA Models.261Seasonal Differencing.261Spotting the Need for Seasonal Differencing.265Computational Considerations.268		
Removing Nonstationarity		
ARIMA Models. 261 Seasonal Differencing. 261 Spotting the Need for Seasonal Differencing. 265 Computational Considerations. 268	, c	
Seasonal Differencing	•	
Spotting the Need for Seasonal Differencing		
Computational Considerations		
1		
	1	

Robust Confidence Intervals	273
Overview	274
Sampling the Prediction Errors	276
Collecting Errors for Neural Network Models	277
Collecting Errors for ARMA Models	284
Compensating for Differencing and Transformations	292
From Errors to Confidence Intervals	302
Confidence in the Confidence	306
Foundations	307
Bounding the Confidence Bounds	310
Code for Bounds on the Confidence Limits	318
Multiplicative Confidence Intervals	323
Confidence Intervals in Action	325
Numerical and Statistical Tools	333
Random Numbers.	
Uniform Random Numbers	
Gaussian (Normal) Random Numbers	
Multivariate Cauchy Deviates	
Other Random Number Generators	
Singular Value Decomposition.	
Deterministic Optimization	
Bounding a Univariate Minimum	
Refining a Univariate Minimum.	
Conjugate Gradient Minimization.	
Levenberg-Marquardt Minimization	
Powell's Algorithm	
Stochastic Optimization.	
Primitive Simulated Annealing	
Generic Traditional Simulated Annealing.	
Stochastic Smoothing	
Eigenvalues and Eigenvectors.	
Fourier Transforms.	
Data Reduction and Orthogonalization.	
Autoregression by Burg's Algorithm	
Neural Network Tools	267
Training and Test Sets.	
Generic Network Parameters.	
Generic Learning Parameters	
Generic Learning Parameters	
Multiple-Layer Feedforward Networks	
MLFN Training Considerations	
Probabilistic Neural Networks	
FIOUAUHISHU INCHAI INCHWOIKS	3/4

Using the NPREDICT Program	377
Using This Manual	378
General Commands	379
Exiting the Program	379
The Audit Log File	379
Progress Indicators for Slow Operations	380
Command Control Files	381
Working with Signals	381
Reading Signals from a Disk File	382
Saving a Signal to a Disk File	383
Generating a Signal	384
Modifying Signals	385
Copying and Subsetting a Signal	388
Displaying Signals	388
Displaying Correlations	390
Displaying Spectra	390
The Power Spectrum and its Relatives	390
Smoothing the Power Spectrum	392
The Maximum Entropy Spectrum	393
Data Reduction and Orthogonalization	393
An Example Ignoring Class Membership	400
An Example Using Class Membership	
Filters	
Lowpass, Highpass, and Bandpass Filters	403
Quadrature-Mirror Filters and Morlet Wavelets	
Padding	
Moving Average	
Autocorrelation and Related Operations	
Box-Jenkins ARMA/ARIMA Prediction	
Specifying the Model and Signals	
Training the Model	
Predicting with the Model	
Confidence Limits for ARMA Predictions	
Example of ARMA Prediction Confidence	
Predicting with Known Shocks	
Saving and Restoring ARMA models	
Neural Network Training and Test Sets	
Specifying Inputs and Outputs	
Class Names as Outputs	
Cumulating the Training or Test Set	
Clearing Information	
Examples	428

Neural Network Models	429
The Probabilistic Neural Network Family	429
Kernel Functions.	431
Multiple-Layer Feedforward Networks	432
General Training Considerations	433
Cross Validation Training	435
Specific PNN Training Parameters	436
PNN Progress Reports	437
Specific MLFN Training Parameters	438
MLFN Progress Reports	442
Testing a Trained Network	444
Saving a Trained Network	446
Neural Network Prediction	446
An Example of Neural Network Prediction	450
Confidence Intervals for Predictions	452
Example of Network Prediction Confidence	455
Alphabetical Glossary of Commands	456
Validation Suite	477
Appendix	479
Disclaimer	
CD-ROM Contents.	
Hardware and Software Requirements	482
Compiling and Linking the NPREDICT Programs	
The DOS Version	
The Windows NT Version	484
Data Files	485
Financial Data	485
Climate Data	
Sunspot Data	
Extra Data	488