Contents

1 Introduction 1
1.1 Necessity of Statistical Modeling for Complex, Large Systems 1
1.2 Model of Ship Motion and Main Engine 2
1.3 Experimental Ships and Outline of Topics Discussed in Remaining Chapters 3
References 6

2 Time Series Analysis Through AR Modeling 7
2.1 Univariate Time Series Analysis Through AR Modeling 7
2.1.1 AR Model and Its Identification 7
2.1.2 Time Series Analysis Using the Univariate AR Model 10
2.2 Analysis of Ship Motion Through Univariate AR Modeling 12
2.2.1 Features of Roll and Pitch 13
2.2.2 Roll Stability 15
2.2.3 Increasing Horizon Prediction of Roll and Pitch 16
2.3 Multivariate AR Modeling of Controlled Systems 16
2.3.1 Multivariate AR Model 16
2.3.2 Identification of Multivariate AR Model 18
2.3.3 ARX Model for a Control System 20
2.4 Power Contribution Analysis of a Feedback System 21
2.4.1 Power Contribution of a Feedback System 21
2.4.2 Analysis of Ship Feedback Motion 23
2.5 State-Space Model and Kalman Filter 27
2.5.1 State-Space Model 27
2.5.2 State Estimation and Kalman Filter 30
2.5.3 Likelihood Computation and Parameter Estimation for a Time Series Model 31

2.6 Piecewise Stationary Modeling . . . 33
2.6.1 Locally Stationary AR Model . . . 33
2.6.2 On-Line Identification of the Locally Stationary AR Model . . . 35
2.7 Model-Based Monitoring System . . . 36
2.7.1 Motivation . . . 36
2.7.2 Ship-Born Model-Based Monitoring System (SBMMS) . . . 37
2.8 RBF-ARX Modeling for a Nonlinear System . . . 40
2.8.1 Introduction: Use of the RBF-ARX Model for Nonstationary Nonlinear Systems . . . 41
2.8.2 RBF-ARX Modeling . . . 43
2.8.3 Identification of the RBF-ARX Model . . . 46
2.8.4 Illustrative Examples . . . 51
References . . . 54

3 Design of a Model-Based Autopilot System for Course Keeping Motion . . . 57
3.1 Statistical Optimal Controller Based on the ARX Model . . . 57
3.1.1 Statistical Optimal Control Problem . . . 57
3.1.2 Optimal Control Law . . . 59
3.2 AR Model-Based Autopilot System . . . 62
3.2.1 Autopilot System for Ships . . . 62
3.2.2 Design of the ARX Model-Based Autopilot System . . . 63
3.3 Rudder-Roll Control System . . . 71
3.4 Application to the Marine Main Engine Governor System . . . 74
3.4.1 Marine Main Engine Governor . . . 74
3.4.2 Dynamic Characteristics of the Main Engine Governor System . . . 75
3.4.3 Design of the ARX Model-Based Governor . . . 76
3.4.4 Design of the AR Governor Considering Pitch Motion . . . 77
References . . . 80

4 Advanced Autopilot Systems . . . 83
4.1 Noise-Adaptive Autopilot System . . . 83
4.1.1 Construction of a Noise-Adaptive Control System . . . 83
4.1.2 Actual Sea Test of the Noise-Adaptive Autopilot System . . . 85
4.2 RBF-ARX Model-Based Predictive Control . . . 87
4.2.1 MIMO RBF-ARX Model and Its State-Space Form . . . 87
4.2.2 MIMO RBF-ARX Model-Based Nonlinear MPC . . . 90

4.3 GPS Signal-Based Computation of a Ship's Tracking Error and Course Deviation 94
4.4 Tracking Control Approach to Marine Vehicles 99
4.4.1 RBF-ARX Model-Based Ship Motion Modeling for Tracking Control 100
4.4.2 Predictive Controller Design for Path Tracking of a Ship 103
4.4.3 Simulation Study and Real-Time Experiment 104
References 114

Index 117

http://www.springer.com/978-4-431-55302-1

Time Series Modeling for Analysis and Control
Advanced Autopilot and Monitoring Systems
Ohtsu, K.; Peng, H.; Kitagawa, G.
2015, IX, 119 p. 77 illus., 14 illus. in color., Softcover
ISBN: 978-4-431-55302-1