
Contents

PREFACE	ix
CHAPTER 1. INTRODUCTION AND MOTIVATIONS	1
1.1. Introduction: automatic control and optimization	1
1.2. Motivations to use metaheuristic algorithms	3
1.3. Organization of the book	5
CHAPTER 2. SYMBOLIC REGRESSION	7
2.1. Identification problematic and brief state of the art.	7
2.2. Problem statement and modeling	10
2.2.1. Problem statement	10
2.2.2. Problem modeling	10
2.3. Ant colony optimization	13
2.3.1. Ant colony social behavior	13
2.3.2. Ant colony optimization	14
2.3.3. Ant colony for the identification of nonlinear functions with unknown structure	16
2.4. Numerical results	18
2.4.1. Parameter settings	18
2.4.2. Experimental results	19
2.5. Discussion	22
2.5.1. Considering real variables	22
2.5.2. Local minima	22
2.5.3. Identification of nonlinear dynamical systems	23

2.6. A note on genetic algorithms for symbolic regression.	23
2.7. Conclusions	25
CHAPTER 3. PID DESIGN USING PARTICLE SWARM OPTIMIZATION	27
3.1. Introduction	27
3.2. Controller tuning: a hard optimization problem	29
3.2.1. Problem framework	29
3.2.2. Expressions of time domain specifications	30
3.2.3. Expressions of frequency domain specifications	32
3.2.4. Analysis of the optimization problem.	35
3.3. Particle swarm optimization implementation	35
3.4. PID tuning optimization.	37
3.4.1. Case study: magnetic levitation	37
3.4.2. Time response optimization	39
3.4.3. Time response optimization with penalization on the control input	41
3.4.4. Time response optimization with penalization on the control input and constraint on module margin	42
3.5. PID multiobjective optimization	43
3.6. Conclusions	48
CHAPTER 4. TUNING AND OPTIMIZATION OF H_∞ CONTROL LAWS	51
4.1. Introduction	51
4.2. H_∞ synthesis	54
4.2.1. Full-order H_∞ synthesis.	54
4.2.2. Tuning the filters as an optimization problem	57
4.2.3. Reduced-order H_∞ synthesis.	58
4.3. Application to the control of a pendulum in the cart.	60
4.3.1. Case study.	60
4.3.2. H_∞ synthesis schemes.	64
4.3.3. Optimization of the parameters of the filters	66
4.3.4. Reduced-order H_∞ synthesis: one DOF case.	70
4.3.5. Reduced-order H_∞ synthesis: three DOF case.	71
4.3.6. Conclusions	76

4.4. Static output feedback design	77
4.5. Industrial examples.	82
4.5.1. Mold level control in continuous casting.	83
4.5.2. Linear parameter varying control of a missile	83
4.5.3. Internal combustion engine air path control	86
4.5.4. Inertial line-of-sight stabilization	86
4.6. Conclusions	87
 CHAPTER 5. PREDICTIVE CONTROL OF HYBRID SYSTEMS	 89
5.1. Problematic.	89
5.2. Predictive control of power systems	92
5.2.1. Open-loop control and unit commitment.	92
5.2.2. Closed-loop control	94
5.3. Optimization procedure	96
5.3.1. Classical optimization methods for unit commitment.	96
5.3.2. General synopsis of the optimization procedure	97
5.3.3. Ant colony optimization for the unit commitment.	98
5.3.4. Computation of real variables.	100
5.3.5. Feasibility criterion	101
5.3.6. Knowledge-based genetic algorithm	102
5.4. Simulation results.	107
5.4.1. Real-time updating of produced powers	107
5.4.2. Case study	107
5.5. Conclusions and discussions	108
 CONCLUSION	 111
BIBLIOGRAPHY	115
INDEX	127