Metaheuristic Optimization for the Design of Automatic Control Laws

Description: The classic approach in Automatic Control relies on the use of simplified models of the systems and reformulations of the specifications. In this framework, the control law can be computed using deterministic algorithms. However, this approach fails when the system is too complex for its model to be sufficiently simplified, when the designer has many constraints to take into account, or when the goal is not only to design a control but also to optimize it. This book presents a new trend in Automatic Control with the use of metaheuristic algorithms. These kinds of algorithm can optimize any criterion and constraint, and therefore do not need such simplifications and reformulations.

The first chapter outlines the author’s main motivations for the approach which he proposes, and presents the advantages which it offers. In Chapter 2, he deals with the problem of system identification. The third and fourth chapters are the core of the book where the design and optimization of control law, using the metaheuristic method (particle swarm optimization), is given. The proposed approach is presented along with real-life experiments, proving the efficiency of the methodology. Finally, in Chapter 5, the author proposes solving the problem of predictive control of hybrid systems.

Contents

1. Introduction and Motivations.
2. Symbolic Regression.
3. PID Design Using Particle Swarm Optimization.
5. Predictive Control of Hybrid Systems.

About the Authors

Guillaume Sandou is Professor in the Automatic Department of Supélec, in Gif Sur Yvette, France. He has had 12 books, 8 journal papers and 1 patent published, and has written papers for 32 international conferences. His main research interests include modeling, optimization and control of industrial systems; optimization and metaheuristics for Automatic Control; and constrained control.

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. $H_\infty$ synthesis schemes 64
4.3.3. Optimization of the parameters of the filters 66
4.3.4. Reduced-order $H_\infty$ synthesis: one DOF case 70
4.3.5. Reduced-order $H_\infty$ 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
Ordering:  
Order Online - [http://www.researchandmarkets.com/reports/2586701/](http://www.researchandmarkets.com/reports/2586701/)

Order by Fax - using the form below

Order by Post - print the order form below and send to

Research and Markets,  
Guinness Centre,  
Taylors Lane,  
Dublin 8,  
Ireland.
Fax Order Form
To place an order via fax simply print this form, fill in the information below and fax the completed form to 646-607-1907 (from USA) or +353-1-481-1716 (from Rest of World). If you have any questions please visit http://www.researchandmarkets.com/contact/

Order Information
Please verify that the product information is correct.

Product Name: Metaheuristic Optimization for the Design of Automatic Control Laws
Web Address: http://www.researchandmarkets.com/reports/2586701/
Office Code: SCDKNUR5

Product Format
Please select the product format and quantity you require:

Quantity
Hard Copy (Hard Back): USD 106 + USD 29 Shipping/Handling

* Shipping/Handling is only charged once per order.

Contact Information
Please enter all the information below in BLOCK CAPITALS

Title: Mr ☐ Mrs ☐ Dr ☐ Miss ☐ Ms ☐ Prof ☐
First Name: ___________________________ Last Name: ___________________________
Email Address: * ___________________________
Job Title: ___________________________
Organisation: ___________________________
Address: ___________________________
City: ___________________________
Postal / Zip Code: ___________________________
Country: ___________________________
Phone Number: ___________________________
Fax Number: ___________________________

* Please refrain from using free email accounts when ordering (e.g. Yahoo, Hotmail, AOL)
Payment Information
Please indicate the payment method you would like to use by selecting the appropriate box.

☐ Pay by credit card: You will receive an email with a link to a secure webpage to enter your credit card details.

☐ Pay by check: Please post the check, accompanied by this form, to:

Research and Markets,
Guinness Center,
Taylors Lane,
Dublin 8,
Ireland.

☐ Pay by wire transfer: Please transfer funds to:

<table>
<thead>
<tr>
<th>Account number</th>
<th>833 130 83</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sort code</td>
<td>98-53-30</td>
</tr>
<tr>
<td>Swift code</td>
<td>ULSBIE2D</td>
</tr>
<tr>
<td>IBAN number</td>
<td>IE78ULSB98533083313083</td>
</tr>
<tr>
<td>Bank Address</td>
<td>Ulster Bank, 27-35 Main Street, Blackrock, Co. Dublin, Ireland.</td>
</tr>
</tbody>
</table>

If you have a Marketing Code please enter it below:

Marketing Code: ____________________________

Please note that by ordering from Research and Markets you are agreeing to our Terms and Conditions at http://www.researchandmarkets.com/info/terms.asp

Please fax this form to:
(646) 607-1907 or (646) 964-6609 - From USA
+353-1-481-1716 or +353-1-653-1571 - From Rest of World