

Contents

Preface	7
List of symbols and acronyms	13
1. System identification for control	17
1.1. A background to optimal input design	17
1.2. Model predictive control	19
1.3. Iterative feedback tuning	21
1.4. Adaptive parameter estimation	22
2. Optimal inputs for (ODE) system identification	25
2.1. Single Weighted Cost Function Method	25
2.2. Input friendliness factor and system identification efficiency	29
2.3. Free final-time problem formulation	31
3. Optimal inputs for (FO) system identification	35
3.1. Fractional-order optimal control problem	35
3.2. Fractional-order operator approximation	38
3.3. Optimal input design problem reformulation	42
4. Model-based input design in system identification	45
4.1. Prediction error method	46
4.2. Input spectrum design problem	47
4.2.1. Partial correlation parametrization	47
4.2.2. Finite-dimensional parametrization	48
4.3. Application constraints	48
5. Least-costly input design for closed-loop system identification	53
5.1. Model parameter estimation	53
5.2. Uncertainty in the parameter estimates	55
5.3. Uncertainty of frequency function estimates	56
5.4. Spectrum representation	57
5.5. Quality constraints in ellipsoidal regions	58
5.6. Optimization problem formulation	59

6. Continuous system identification in the time domain.....	65
6.1. First-order linear system identification	65
6.2. Plant-friendly identification of a first-order system	70
6.3. Plant-friendly identification of a second-order nonlinear system	75
6.4. A single degree of freedom linear system identification.....	82
6.5. Free final time LTI system identification.....	90
6.6. Conclusions	98
7. Fractional-order optimal input design problem	101
7.1. Fractional-order inertial system optimal control	101
7.2. Experimental results for different system orders.....	104
7.3. Conclusions	109
8. Application-oriented input design for open-loop focused on MPC	111
8.1. Cascade tanks system overview.....	111
8.2. Cascade tanks model identification.....	114
8.3. Robust multi-tank system control	121
8.4. Conclusions	124
9. Application-oriented input design for closed-loop with fixed controller	127
9.1. The nonlinear cascaded double tank system application	127
9.2. Optimal input spectrum design-upper tank case study.....	129
9.3. Optimal input spectrum design – interacting tanks case study.....	132
9.4. Conclusions	134
Summary and suggestions for future work.....	135
References.....	141
List of Tables	151
List of Figures.....	153
Summary.....	157
Streszczenie	159