

Contents

1	Introduction	1
2	Background and State-of-the-Art	11
2.1	Metaheuristics for Combinatorial Optimization	12
2.1.1	A Philosophical and Historical Perspective	12
2.1.2	The Optimization Problem	14
2.1.3	Combinatorial Optimization	15
2.1.4	On the Computational Complexity of Algorithms	18
2.1.5	On the <i>a priori</i> Equivalence of Search Algorithms	22
2.1.6	Exact Algorithms, Heuristics, and Metaheuristics	26
2.1.7	A Bird's-Eye View of Most Popular Metaheuristics	29
2.1.8	Current Practice in Tuning Metaheuristics	33
2.2	The Problem of Supervised Learning	39
2.2.1	A Philosophical and Historical Perspective	39
2.2.2	The Three Main Problems of Machine Learning	41
2.2.3	Supervised Learning	43
2.2.4	The Minimization of the Empirical Risk	47
2.2.5	The Theory of Generalization	48
2.2.6	Supervised Learning in Practice	54
2.2.7	Racing Methods for Model Selection	61
2.3	Discussion	67
3	Statement of the Tuning Problem	69
3.1	An Informal Example	69
3.2	The Formal Position of the Problem	74
3.3	Possible Variants and Extensions	75
3.3.1	Problem Subclasses and <i>a priori</i> Information	75
3.3.2	Generic Probabilistic Models	77
3.3.3	The Single-Instance Case	80

3.3.4	The Optimization of Generic Statistics	81
3.3.5	Time Versus Cost	81
3.4	Discussion	82
4	F-Race for Tuning Metaheuristics	85
4.1	How Many Instances, How Man Runs?	87
4.1.1	Formal Position of the Estimation Problem	87
4.1.2	First Order Analysis of the Estimator $\hat{\mu}_{\mathcal{S}_N}$	90
4.1.3	Second Order Analysis of the Estimator $\hat{\mu}_{\mathcal{S}_N}$	91
4.1.4	Yet Another Possible Estimator	96
4.1.5	Remarks	100
4.2	The <i>Brute-Force</i> Approach	101
4.3	The <i>Racing</i> Approach	103
4.4	The Peculiarities of <i>F-Race</i>	109
4.5	Discussion	114
5	Experiments and Applications	117
5.1	Empirical Analysis of <i>F-Race</i>	118
5.1.1	<i>Iterated Local Search</i> for QUADRATIC ASSIGNMENT	124
5.1.2	<i>Ant Colony Optimization</i> for TRAVELING SALESMAN	137
5.2	Some Applications of the <i>Racing</i> Approach	150
5.2.1	Tuning Metaheuristics for Timetabling	151
5.2.2	The <i>International Timetabling Competition</i>	154
5.2.3	<i>F-Race</i> for Feature Selection	159
5.2.4	Further Applications	165
5.3	Discussion	167
6	Some Considerations on the Experimental Methodology	171
6.1	Some Fundamental Methodological Issues	172
6.1.1	On Some Measures of Performance	172
6.1.2	On the Concept of Class of Instances	174
6.1.3	On the Empirical Comparison of Algorithms	175
6.1.4	On the <i>Over-Tuning</i> Phenomenon	177
6.2	Towards a Theory of Practice	183
6.2.1	The Real-Life Setting	186
6.2.2	The Proposed Methodology and Some Alternatives	188
6.3	Discussion	190
Appendix	191
6.A	Best Is Biased	191
7	Conclusions	197
References	203
Index	219