

Contents

1	Overview of Heuristic Optimization	1
1.1	What is Optimization?	1
1.1.1	Searching vs. Optimization	2
1.1.2	Constraints	3
1.1.3	Finding through a little Searching	3
1.1.4	Accuracy	4
1.1.5	Certainty	4
1.2	Exact vs. Heuristic Methods	5
1.2.1	Exact Methods	5
1.2.2	Heuristic Methods	6
1.2.3	Multi-Objective Optimization	7
1.3	Practical Issues	9
1.4	Example Theoretical Problems	11
2	Statistical Analysis in Solution Space	13
2.1	Basic Vocabulary of Statistical Mechanics	14
2.2	Postulates of the Theory	18
2.3	Entropy	20
2.4	Temperature	23
2.5	Ergodicity	25
3	Project Management	29
3.1	Waterfall Model vs. Agile Model	30
3.2	Design of Experiments	34
3.3	Prioritizing Goals	35
4	Pre-processing: Cleaning up Data	37
4.1	Dirty Data	37
4.2	Discretization	38
4.2.1	Time-Series from Instrumentation	38
4.2.2	Data not Ordered in Time	39

4.3	Outlier Detection	40
4.3.1	Unrealistic Data	41
4.3.2	Unlikely Data	41
4.3.3	Irregular and Abnormal Data	41
4.3.4	Missing Data	42
4.4	Data reduction / Feature Selection	43
4.4.1	Similar Data	43
4.4.2	Irrelevant Data	43
4.4.3	Redundant Data	44
4.4.4	Distinguishing Features	44
4.5	Smoothing and De-noising	47
4.5.1	Noise	47
4.5.2	Singular Spectrum Analysis	48
4.6	Representation and Sampling	50
4.7	Interpolation	51
4.8	Case Study: Self-Benchmarking in Maintenance of a Chemical Plant	53
4.8.1	Benchmarking	53
4.8.2	Self-Benchmarking	54
4.8.3	Results and Conclusions	56
4.9	Case Study: Financial Data Analysis for Contract Planning	58
4.10	Case Study: Measuring Human Influence	62
4.11	Case Study: Early Warning System for Importance of Production Alarms	63
5	Data Mining: Knowledge from Data	67
5.1	Concepts of Statistics and Measurement	67
5.1.1	Population, Sample and Estimation	67
5.1.2	Measurement Error and Uncertainty	68
5.1.3	Influence of the Observer	70
5.1.4	Meaning of Probability and Statistics	71
5.2	Statistical Testing	73
5.2.1	Testing Concepts	73
5.2.2	Specific Tests	75
5.2.2.1	Do two datasets have the same mean?	75
5.2.2.2	Do two datasets have the same variance?	76
5.2.2.3	Are two datasets differently distributed?	76
5.2.2.4	Are there outliers and, if so, where?	77
5.2.2.5	How well does this model fit the data?	78
5.3	Other Statistical Measures	79
5.3.1	Regression	79
5.3.2	ANOVA	81
5.3.3	Correlation and Autocorrelation	84
5.3.4	Clustering	85
5.3.5	Entropy	89
5.3.6	Fourier Transformation	91

5.4	Case Study: Optical Digit Recognition	92
5.5	Case Study: Turbine Diagnosis in a Power Plant	96
5.6	Case Study: Determining the Cause of a Known Fault	102
5.7	Markov Chains and the Central Limit Theorem	105
5.8	Bayesian Statistical Inference and the Noisy Channel	107
5.8.1	Introduction to Bayesian Inference	107
5.8.2	Determining the Prior Distribution	108
5.8.3	Determining the Sampling Distribution	110
5.8.4	Noisy Channels	110
5.8.4.1	Building a Noisy Channel	111
5.8.4.2	Controlling a Noisy Channel	112
5.9	Non-Linear Multi-Dimensional Regression	113
5.9.1	Linear Least Squares Regression	113
5.9.2	Basis Functions	114
5.9.3	Nonlinearity	115
5.10	Case Study: Customer Segmentation	117
6	Modeling: Neural Networks	121
6.1	What is Modeling?	121
6.1.1	Data Preparation	124
6.1.2	How much data is enough?	125
6.2	Neural Networks	126
6.3	Basic Concepts of Neural Network Modeling	129
6.4	Feed-Forward Networks	131
6.5	Recurrent Networks	132
6.6	Case Study: Scrap Detection in Injection Molding Manufacturing ..	135
6.7	Case Study: Prediction of Turbine Failure	140
6.8	Case Study: Failures of Wind Power Plants	143
6.9	Case Study: Catalytic Reactors in Chemistry and Petrochemistry ..	148
6.10	Case Study: Predicting Vibration Crises in Nuclear Power Plants ..	152
6.11	Case Study: Identifying and Predicting the Failure of Valves	155
6.12	Case Study: Predicting the Dynamometer Card of a Rod Pump	157
7	Optimization: Simulated Annealing	165
7.1	Genetic Algorithms	166
7.2	Elementary Simulated Annealing	167
7.3	Theoretical Results	169
7.4	Cooling Schedule and Parameters	172
7.4.1	Initial Temperature	173
7.4.2	Stopping Criterion (Definition of Freezing)	174
7.4.3	Markov Chain Length (Definition of Equilibrium)	175
7.4.4	Decrement Formula for Temperature (Cooling Speed)	177
7.4.5	Selection Criterion	178
7.4.6	Parameter Choice	178
7.5	Perturbations for Continuous and Combinatorial Problems	181

7.6	Case Study: Human Brains use Simulated Annealing to Think	183
7.7	Determining an Optimal Path from <i>A</i> to <i>B</i>	186
7.8	Case Study: Optimization of the Müller-Rochow Synthesis of Silanes	189
7.9	Case Study: Increase of Oil Production Yield in Shallow-Water Offshore Oil Wells	194
7.10	Case Study: Increase of coal burning efficiency in CHP power plant	197
7.11	Case Study: Reducing the Internal Power Demand of a Power Plant	199
8	The human aspect in sustainable change and innovation	201
8.1	Introduction	201
8.1.1	Defining the items: idea, innovation, and change	202
8.1.2	Resistance to change	204
8.2	Interface Management	207
8.2.1	The Deliberate Organization	207
8.2.2	The Healthy Organization	209
8.3	Innovation Management	213
8.4	Handling the Human Aspect	216
8.4.1	Communication	217
8.4.2	KPIs for team engagement	219
8.4.3	Project Preparation and Set Up	221
8.4.4	Risk Management	223
8.4.5	Roles and responsibilities	226
8.4.6	Career development and sustainable change	228
8.4.7	Sustainability in Training and Learning	231
8.4.8	The Economic Factor in Sustainable Innovation	232
8.5	Summary	234
	References	237
	Index	243