

Table of Contents

Introduction and Presentation	xv
Bassem JARBOUI, Patrick SIARRY and Jacques TEGHEM	
Chapter 1. An Estimation of Distribution Algorithm for Solving Flow Shop Scheduling Problems with Sequence-dependent Family Setup Times	1
Mansour EDDALY, Bassem JARBOUI, Radhouan BOUABDA, Patrick SIARRY and Abdelwaheb REBAÏ	
1.1. Introduction	1
1.2. Mathematical formulation	3
1.3. Estimation of distribution algorithms	5
1.3.1. Estimation of distribution algorithms proposed in the literature	6
1.4. The proposed estimation of distribution algorithm	8
1.4.1. Encoding scheme and initial population	8
1.4.2. Selection	9
1.4.3. Probability estimation	9
1.5. Iterated local search algorithm	10
1.6. Experimental results	11
1.7. Conclusion	15
1.8. Bibliography	15

Chapter 2. Genetic Algorithms for Solving Flexible Job Shop Scheduling Problems	19
Imed KACEM	
2.1. Introduction	19
2.2. Flexible job shop scheduling problems	19
2.3. Genetic algorithms for some related sub-problems	25
2.4. Genetic algorithms for the flexible job shop problem	31
2.4.1. Codings	31
2.4.2. Mutation operators	34
2.4.3. Crossover operators	38
2.5. Comparison of codings	42
2.6. Conclusion	43
2.7. Bibliography	43
Chapter 3. A Hybrid GRASP-Differential Evolution Algorithm for Solving Flow Shop Scheduling Problems with No-Wait Constraints	45
Hanen AKROUT, Bassem JARBOUI, Patrick SIARRY and Abdelwaheb REBAÏ	
3.1. Introduction	45
3.2. Overview of the literature	47
3.2.1. Single-solution metaheuristics	47
3.2.2. Population-based metaheuristics	49
3.2.3. Hybrid approaches	49
3.3. Description of the problem	50
3.4. GRASP	52
3.5. Differential evolution	53
3.6. Iterative local search	55
3.7. Overview of the NEW-GRASP-DE algorithm	55
3.7.1. Constructive phase	56
3.7.2. Improvement phase	57
3.8. Experimental results	57
3.8.1. Experimental results for the Reeves and Heller instances . .	58
3.8.2. Experimental results for the Taillard instances	60
3.9. Conclusion	62
3.10. Bibliography	64

Chapter 4. A Comparison of Local Search Metaheuristics for a Hierarchical Flow Shop Optimization Problem with Time Lags	69
Emna DHOUIB, Jacques TEGHEM, Daniel TUYTTENS and Taïcir LOUKIL	
4.1. Introduction	69
4.2. Description of the problem	70
4.2.1. Flowshop with time lags	70
4.2.2. A bicriteria hierarchical flow shop problem	71
4.3. The proposed metaheuristics	73
4.3.1. A simulated annealing metaheuristics	74
4.3.2. The GRASP metaheuristics	77
4.4. Tests	82
4.4.1. Generated instances	82
4.4.2. Comparison of the results	83
4.5. Conclusion	94
4.6. Bibliography	94
Chapter 5. Neutrality in Flow Shop Scheduling Problems: Landscape Structure and Local Search	97
Marie-Eléonore MARMION	
5.1. Introduction	97
5.2. Neutrality in a combinatorial optimization problem	98
5.2.1. Landscape in a combinatorial optimization problem	99
5.2.2. Neutrality and landscape	102
5.3. Study of neutrality in the flow shop problem	106
5.3.1. Neutral degree	106
5.3.2. Structure of the neutral landscape	108
5.4. Local search exploiting neutrality to solve the flow shop problem	112
5.4.1. Neutrality-based iterated local search	113
5.4.2. NILS on the flow shop problem	116
5.5. Conclusion	122
5.6. Bibliography	123

Chapter 6. Evolutionary Metaheuristic Based on Genetic Algorithm: Application to Hybrid Flow Shop Problem with Availability Constraints	127
Nadia CHAABEN, Racem MELLOULI and Faouzi MASMOUDI	
6.1. Introduction	127
6.2. Overview of the literature	128
6.3. Overview of the problem and notations used	131
6.4. Mathematical formulations	133
6.4.1. First formulation (MILP1)	133
6.4.2. Second formulation (MILP2)	135
6.4.3. Third formulation (MILP3)	137
6.5. A genetic algorithm: model and methodology	139
6.5.1. Coding used for our algorithm	139
6.5.2. Generating the initial population	140
6.5.3. Selection operator	142
6.5.4. Crossover operator	142
6.5.5. Mutation operator	144
6.5.6. Insertion operator	144
6.5.7. Evaluation function: fitness	144
6.5.8. Stop criterion	145
6.6. Verification and validation of the genetic algorithm	145
6.6.1. Description of benchmarks	145
6.6.2. Tests and results	146
6.7. Conclusion	148
6.8. Bibliography	148
Chapter 7. Models and Methods in Graph Coloration for Various Production Problems	153
Nicolas ZUFFEREY	
7.1. Introduction	153
7.2. Minimizing the makespan	155
7.2.1. Tabu algorithm	155
7.2.2. Hybrid genetic algorithm	157
7.2.3. Methods prior to GH	158
7.2.4. Extensions	159
7.3. Maximizing the number of completed tasks	160
7.3.1. Tabu algorithm	161
7.3.2. The ant colony algorithm	162
7.3.3. Extension of the problem	164

7.4. Precedence constraints	165
7.4.1. Tabu algorithm	168
7.4.2. Variable neighborhood search method	169
7.5. Incompatibility costs	171
7.5.1. Tabu algorithm	173
7.5.2. Adaptive memory method	175
7.5.3. Variations of the problem	177
7.6. Conclusion	178
7.7. Bibliography	179
Chapter 8. Mathematical Programming and Heuristics for Scheduling Problems with Early and Tardy Penalties	183
Mustapha RATLI, Rachid BENMANSOUR, Rita MACEDO, Saïd HANAFI, Christophe WILBAUT	
8.1. Introduction	183
8.2. Properties and particular cases	185
8.3. Mathematical models	188
8.3.1. Linear models with precedence variables	188
8.3.2. Linear models with position variables	192
8.3.3. Linear models with time-indexed variables	194
8.3.4. Network flow models	197
8.3.5. Quadratic models	197
8.3.6. A comparative study	199
8.4. Heuristics	203
8.4.1. Properties	207
8.4.2. Evaluation	209
8.5. Metaheuristics	211
8.6. Conclusion	217
8.7. Acknowledgments	218
8.8. Bibliography	218
Chapter 9. Metaheuristics for Biobjective Flow Shop Scheduling . . .	225
Matthieu BASSEUR and Arnaud LIEFOOGHE	
9.1. Introduction	225
9.2. Metaheuristics for multiobjective combinatorial optimization . .	226
9.2.1. Main concepts	227
9.2.2. Some methods	229

9.2.3. Performance analysis	232
9.2.4. Software and implementation	237
9.3. Multiobjective flow shop scheduling problems	238
9.3.1. Flow shop problems	239
9.3.2. Permutation flow shop with due dates	240
9.3.3. Different objective functions	241
9.3.4. Sets of data	241
9.3.5. Analysis of correlations between objectives functions	242
9.4. Application to the biobjective flow shop	243
9.4.1. Model	244
9.4.2. Solution methods	246
9.4.3. Experimental analysis	246
9.5. Conclusion	249
9.6. Bibliography	250

Chapter 10. Pareto Solution Strategies for the Industrial Car Sequencing Problem 253
Caroline GAGNÉ, Arnaud ZINFLOU and Marc GRAVEL

10.1. Introduction	253
10.2. Industrial car sequencing problem	255
10.3. Pareto strategies for solving the CSP	260
10.3.1. PMS ^{MO}	260
10.3.2. GISMOO	264
10.4. Numerical experiments	268
10.4.1. Test sets	269
10.4.2. Performance metrics	270
10.5. Results and discussion	271
10.6. Conclusion	279
10.7. Bibliography	280

Chapter 11. Multi-Objective Metaheuristics for the Joint Scheduling of Production and Maintenance 283
Ali BERRICHI and Farouk YALAOUI

11.1. Introduction	283
11.2. State of the art on the joint problem	285
11.3. Integrated modeling of the joint problem	287
11.4. Concepts of multi-objective optimization	291
11.5. The particle swarm optimization method	292

11.6. Implementation of MOPSO algorithms	294
11.6.1. Representation and construction of the solutions	294
11.6.2. Solution Evaluation	295
11.6.3. The proposed MOPSO algorithms	298
11.6.4. Updating the velocities and positions	299
11.6.5. Hybridization with local searches	300
11.7. Experimental results	302
11.7.1. Choice of test problems and configurations	302
11.7.2. Experiments and analysis of the results	303
11.8. Conclusion	310
11.9. Bibliography	311

**Chapter 12. Optimization via a Genetic Algorithm Parametrizing
the AHP Method for Multicriteria Workshop Scheduling** 315
Fouzia OUNNAR, Patrick PUJO and Afef DENGUIR

12.1. Introduction	315
12.2. Methods for solving multicriteria scheduling	316
12.2.1. Optimization methods	316
12.2.2. Multicriteria decision aid methods	318
12.2.3. Choice of the multicriteria decision aid method	319
12.3. Presentation of the AHP method	320
12.3.1. Phase 1: configuration	320
12.3.2. Phase 2: exploitation	321
12.4. Evaluation of metaheuristics for the configuration of AHP	322
12.4.1. Local search methods	323
12.4.2. Population-based methods	324
12.4.3. Advanced metaheuristics	326
12.5. Choice of metaheuristic	326
12.5.1. Justification of the choice of genetic algorithms	326
12.5.2. Genetic algorithms	328
12.6. AHP optimization by a genetic algorithm	330
12.6.1. Phase 0: configuration of the structure of the problem	331
12.6.2. Phase 1: preparation for automatic configuration	332
12.6.3. Phase 2: automatic configuration	334
12.6.4. Phase 3: preparation of the exploitation phase	335
12.7. Evaluation of G-AHP	336
12.7.1. Analysis of the behavior of G-AHP	336
12.7.2. Analysis of the results obtained by G-AHP	342

12.8. Conclusions	343
12.9. Bibliography	344

**Chapter 13. A Multicriteria Genetic Algorithm
for the Resource-constrained Task Scheduling Problem** 349
Olfa DRIDI, Saoussen KRICHEN and Adel GUITOUNI

13.1. Introduction	349
13.2. Description and formulation of the problem	350
13.3. Literature review	353
13.3.1. Exact methods	354
13.3.2. Approximate methods	355
13.4. A multicriteria genetic algorithm for the MMSAP	356
13.4.1. Encoding variables	357
13.4.2. Genetic operators	358
13.4.3. Parameter settings	359
13.4.4. The GA	360
13.5. Experimental study	361
13.5.1. Diversification of the approximation set based on the diversity indicators	364
13.6. Conclusion	369
13.7. Bibliography	369

**Chapter 14. Metaheuristics for the Solution of Vehicle Routing
Problems in a Dynamic Context** 373
Tienté HSU, Gilles GONÇALVES and Rémy DUPAS

14.1. Introduction	373
14.2. Dynamic vehicle route management	375
14.2.1. The vehicle routing problem with time windows	377
14.3. Platform for the solution of the DVRPTW	382
14.3.1. Encoding a chromosome	384
14.4. Treating uncertainties in the orders	386
14.5. Treatment of traffic information	392
14.6. Conclusion	397
14.7. Bibliography	398

Chapter 15. Combination of a Metaheuristic and a Simulation Model for the Scheduling of Resource-constrained Transport Activities	401
Virginie ANDRÉ, Nathalie GRANGEON and Sylvie NORRE	
15.1. Knowledge model	403
15.1.1. Fixed resources and mobile resources	403
15.1.2. Modelling the activities in steps	404
15.1.3. The problem to be solved	406
15.1.4. Illustrative example	407
15.2. Solution procedure	410
15.3. Proposed approach	413
15.3.1. Metaheuristics	414
15.3.2. Simulation model	421
15.4. Implementation and results	422
15.4.1. Impact on the work mode	423
15.4.2. Results of the set of modifications to the teaching hospital	425
15.4.3. Preliminary study of the choice of shifts	428
15.5. Conclusion	430
15.6. Bibliography	431
Chapter 16. Vehicle Routing Problems with Scheduling Constraints	433
Rahma LAHYANI, Frédéric SEMET and Benoît TROUILLET	
16.1. Introduction	433
16.2. Definition, complexity and classification	435
16.2.1. Definition and complexity	435
16.2.2. Classification	436
16.3. Time-constrained vehicle routing problems	438
16.3.1. Vehicle routing problems with time windows	438
16.3.2. Period vehicle routing problems	441
16.3.3. Vehicle routing problem with cross-docking	443
16.4. Vehicle routing problems with resource availability constraints	448
16.4.1. Multi-trip vehicle routing problem	448
16.4.2. Vehicle routing problem with crew scheduling	450
16.5. Conclusion	452
16.6. Bibliography	453

Chapter 17. Metaheuristics for Job Shop Scheduling with Transportation	465
Qiao ZHANG, Hervé MANIER, Marie-Ange MANIER	
17.1. General flexible job shop scheduling problems	466
17.2. State of the art on job shop scheduling with transportation resources	468
17.3. GTSB procedure	474
17.3.1. A hybrid metaheuristic algorithm for the GFJSSP	474
17.3.2. Tests and results	480
17.3.3. Conclusion for GTSB	489
17.4. Conclusion	491
17.5. Bibliography	491
List of Authors	495
Index	499