Additional Exercises for Chapter 2 of the book: Coello Coello, Carlos A.; Van Veldhuizen, David A. & Lamont, Gary B. "Evolutionary Algorithms for Solving Multi-Objective Problems", Kluwer Academic Publishers, New York, ISBN 0-3064-6762-3, May 2002.

Exercises

1. Chen et al. [4] proposed the incorporation of fitness inheritance [16] to improve the efficiency of a multi-objective evolutionary algorithm (MOEA). Analyze this proposal and criticize it. Compare and contrast elitism with respect to fitness inheritance. Relate fitness inheritance to the global criterion method discussed in Chapter 1 (Section 7.1.1). Discuss possible ways to extend Chen et al.'s proposal.

2. Koch and Zell [10] proposed the multi-objective clustering selection evolutionary algorithm. Analyze this proposal and discuss the possible advantages and disadvantages of introducing clustering techniques in an MOEA. Compare this approach to Molyneaux et al.'s proposal [14]. Discuss computational complexity and parameter fine-tuning of both approaches.

3. Costa and Oliveira [5] proposed an evolution strategy for multiobjective optimization. Analyze this proposal and compare it to other related proposals (see for example [11, 1, 9]).

4. Socha & Kisiel-Dorohinicki [17] proposed an evolutionary multi-agent system for multiobjective optimization. Compare and constrast this proposal to Menczer et al.'s approach [13]. Do you see any particular advantages and disadvantages of applying multi-agent systems to multiobjective optimization. Discuss.

5. Valenzuela [18] proposed a simple evolutionary algorithm for multi-objective optimization. The author of this approach argues that her approach does not require Pareto ranking but only a clever replacement strategy. Analyze this proposal and criticize it. Do you foresee any possible limitations/disadvantages of this algorithm? Compare it to Chakraborti et al.'s [3] algorithm.

6. Mostaghim et al. [15] discuss three types of quadtrees used to store nondominated vectors and analyze their use in evolutionary multiobjective optimization. Compare this work with the proposal of Everson et al. [7]. Indicate the main

motivation to use efficient data structures to store nondominated vectors in the context of evolutionary multiobjective optimization.

7. Current researchers have placed little emphasis in developing approaches in which the number of fitness function evaluations is minimized. This cost reduction is vital in real-world applications. Analyze the strategy proposed by Farina [8] which is based on generalized response surfaces. Compare this strategy to the approach proposed by Duarte et al. [6].

8. Lu and Yen [12] proposed the Rank-Density based Genetic Algorithm (RDGA). Analyze the ranking strategy adopted by this algorithm as well as the diversity mechanism proposed. Relate the selection and replacement strategies adopted in the RDGA to the cellular genetic algorithm [20]. Do you see any possible limitations of this algorithm if we consider that it always tries to minimize rank and density values of the population (regardless of the number of objective functions of the problem)? Compare this approach to the non-generational genetic algorithm for multiobjective optimization [19, 2].

References

[1] To Thanh Binh and Urlich Korn. An evolution strategy for the multiobjective optimization. In *The Second International Conference on Genetic Algorithms (Mendel 96)*, pages 23–28, Brno, Czech Republic, 1996.

[2] Carlos C.H. Borges and Helio J.C. Barbosa. A Non-generational Genetic Algorithm for Multiobjective Optimization. In *2000 Congress on Evolutionary Computation*, volume 1, pages 172–179, San Diego, California, July 2000. IEEE Service Center.

[3] N. Chakraborti, R. Kumar, and D. Jain. A study of the continuous casting mold using a pareto-converging genetic algorithm. *Applied Mathematical Modelling*, 25:287–297, 2001.

[4] Jian-Jung Chen, David E. Goldberg, Shinn-Ying Ho, and Kumara Sastry. Fitness Inheritance in Multi-Objective Optimization. In W.B. Langdon, E. Cantú-Paz, K. Mathias, R. Roy, D. Davis, R. Poli, K. Balakrishnan, V. Honavar, G. Rudolph, J. Wegener, L. Bull, M.A. Potter, A.C. Schultz, J.F. Miller, E. Burke, and N. Jonoska, editors, *Proceedings of the Genetic and Evolutionary Computation Conference (GECCO'2002)*, pages 319–326, San Francisco, California, July 2002. Morgan Kaufmann Publishers.

[5] Lino Costa and Pedro Oliveira. An Evolution Strategy for Multiobjective Optimization. In *Congress on Evolutionary Computation (CEC'2002)*, volume 1, pages 97–102, Piscataway, New Jersey, May 2002. IEEE Service Center.

[6] N.M. Duarte, A. E. Ruano, C.M. Fonseca, and P.J. Fleming. Accelerating Multi-Objective Control System Design Using a Neuro-Genetic Approach. In *2000*

Congress on Evolutionary Computation, volume 1, pages 392–397, Piscataway, New Jersey, July 2000. IEEE Service Center.

[7] Richard M. Everson, Jonathan E. Fieldsend, and Sameer Singh. Full Elite Sets for Multi-Objective Optimisation. In I.C. Parmee, editor, *Proceedings of the Fifth International Conference on Adaptive Computing Design and Manufacture (ACDM 2002)*, volume 5, pages 343–354, University of Exeter, Devon, UK, April 2002. Springer-Verlag.

[8] M. Farina. A Neural Network Based Generalized Response Surface Multiobjective Evolutionary Algorithm. In *Congress on Evolutionary Computation (CEC'2002)*, volume 1, pages 956–961, Piscataway, New Jersey, May 2002. IEEE Service Center.

[9] Joshua D. Knowles and David W. Corne. Approximating the Nondominated Front Using the Pareto Archived Evolution Strategy. *Evolutionary Computation*, 8(2):149–172, 2000.

[10] Thomas E. Koch and Andreas Zell. MOCS: Multi-Objective Clustering Selection Evolutionary Algorithm. In W.B. Langdon, E. Cantú-Paz, K. Mathias, R. Roy, D. Davis, R. Poli, K. Balakrishnan, V. Honavar, G. Rudolph, J. Wegener, L. Bull, M.A. Potter, A.C. Schultz, J.F. Miller, E. Burke, and N. Jonoska, editors, *Proceedings of the Genetic and Evolutionary Computation Conference (GECCO'2002)*, pages 423–430, San Francisco, California, July 2002. Morgan Kaufmann Publishers.

[11] Frank Kursawe. Evolution strategies for vector optimization. In *Preliminary Procedings of the Tenth International Conference on Multiple Criteria Decision Making*, pages 187–193, Taipei, China, July 1992. National Chiao Tung University.

[12] Haiming Lu and Gary G. Yen. Rank-Density Based Multiobjective Genetic Algorithm. In *Congress on Evolutionary Computation (CEC'2002)*, volume 1, pages 944–949, Piscataway, New Jersey, May 2002. IEEE Service Center.

[13] Filippo Menczer, Melania Degeratu, and W. Nick Street. Efficient and Scalable Pareto Optimization by Evolutionary Local Selection Algorithms. *Evolutionary Computation*, 8(2):223–247, Summer 2000.

[14] A.K. Molyneaux, G.B. Leyland, and D.Favrat. A New, Clustering Evolutionary Multi-Objective Optimisation Technique. In *Proceedings of the Third International Symposium on Adaptive Systems—Evolutionary Computation and Probabilistic Graphical Models*, pages 41–47, Havana, Cuba, March 19–23 2001. Institute of Cybernetics, Mathematics and Physics.

[15] Sanaz Mostaghim, Jürgen Teich, and Ambrish Tyagi. Comparison of Data Structures for Storing Pareto-sets in MOEAs. In *Congress on Evolutionary Computation (CEC'2002)*, volume 1, pages 843–848, Piscataway, New Jersey, May 2002. IEEE Service Center.

[16] R. Smith, B. Dike, and S. Stegmann. Fitness inheritance in genetic algorithms. In *Proceedings of the ACM Symposium on Applied Computing*, pages 345–350, New York, 1995. ACM.

[17] Krzysztof Socha and Marek Kisiel-Dorohinicki. Agent-based Evolutionary Multiobjective Optimisation. In *Congress on Evolutionary Computation (CEC'2002)*, volume 1, pages 109–114, Piscataway, New Jersey, May 2002. IEEE Service Center.

[18] Christine L. Valenzuela. A Simple Evolutionary Algorithm for Multi-Objective Optimization (SEAMO). In *Congress on Evolutionary Computation (CEC'2002)*, volume 1, pages 717–722, Piscataway, New Jersey, May 2002. IEEE Service Center.

[19] Manuel Valenzuela Rendón and Eduardo Uresti Charre. A Non-Generational Genetic Algorithm for Multiobjective Optimization. In Thomas Bäck, editor, *Proceedings of the Seventh International Conference on Genetic Algorithms*, pages 658–665, San Mateo, California, July 1997. Michigan State University, Morgan Kaufmann Publishers.

[20] Darrell Whitley. Cellular Genetic Algorithms. In Stephanie Forrest, editor, *Proceedings of the Fifth International Conference on Genetic Algorithms*, page 658, San Mateo, California, 1993. University of Illinois at Urbana-Champaign, Morgan Kaufmann Publishers.