*** USE AS A TEXTBOOK!!! ***

"Evolutionary Algorithms for Solving Multi-Objective Problems"

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Kluwer Academic Publishers

Educational Goals of Course(s):

i. Explore and evaluate Multi-Objective Evolutionary algorithm (MOEA) space, Multi-Objective Problem (MOP) space, and parameter space along with MOEA performance comparisons
ii. Motivate the student to investigate new areas of MOEA design, implementation, and performance metrics
iii. Developed an ability to utilize and improve MOEA performance across a wide variety of application problem domains.

"This innovative book provides a comprehensive set of discussion questions that provide insight to the modeling of MOPs, MOEAs and their solutions, and other associated evaluation techniques. The extensive set of chapter research ideas allows for student investigation and faculty direction in furthering MOEA development"

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Educational Objectives -- Introductory MOEA Elements:

1. Familiarity with MOPs and generic solution approaches
2. Understanding and ability to use symbolic MOP formulations
3. Understanding of MOP characteristics
4. Understanding of MOEA approaches to solving MOPs
5. Ability to employ specific MOEAs in solving MOPs
6. Understanding of general MOEA structure and ability to identify specific classes
7. Understanding and ability to use MOEA testing metrics in solving MOPs
8. Ability to design MOEA test experiments and perform statistical analyses
9. Ability to employ MOEAs in solving specific application domain design problems

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"Evolutionary Algorithms for Solving Multi-Objective Problems (cont'd)"

Course Outline -- Introductory MOEA Elements: "Chapters 1,2,3,4,6"

1. Brief overview of MOP history and general MOP solution Techniques (Chapter 1)
2. Formulation of MOPs and their associated solution space (Section 1.8)
3. Study of MOP domain characteristics (Appendix A)
4. Study basic MOEA algorithmic structures and parameters (Chapter 2)
    a. a-priori and posteriori MOEA solution approaches
    b. Contemporary MOEAs - MOEA, NSGA-II, PAES, SPGA, MOMGA-II
    c. Operators - crossover, mutation, selection, sharing/niching/crowding
    d. Parameters - operator probabilities, population size, convergence tests, …
    e. Chromosome encodings – binary, real-valued, integer-valued
5. Study MOEA test function suite generation and selection (Chapter 3)
    a. Consider MOP1 to MOP5 (Section 3.3.1) for unconstrained MOPs
    b. Consider MOP-C1 to MOP-C4 (Section 3.3.2) for constrained MOPs
    c. Consider MOP-G1 to MOP-G6 (Section 3.3.3) for generated MOPS
    d. Consider combinatorial/real-world MOP test vehicles (Sections 3.4-3.5)
6. Design experiments for MOEA evaluation with selected MOPs (Section 4.3)
7. Study, analysis, and use of MOEA metrics (Section 4.4.1)
    a. Start with E, G, ME, ONVGR, RP for known Pareto Front
    b. Start with S, ONVG, P, GNVG, NVA for unknown Pareto Front
8. Examine statistical analysis techniques of experimental results (Section 4.4.2, 4.5)
    a. Begin with mean/average, standard deviation, min, max, etc.
9. Study selected MOP applications and associated mathematical model (Chapter 6)

Initial Homework Considerations -- Introductory Elements: "or part there of"

A. Chapter 1 (pages 55-57): #1, #3, #10; "Generate known analytical MOP solutions"
B. Chapter 2 (pages 97-99): #2, #3, #5, #8; "Analyze a time/space complexity of a MOEA"
C. Chapter 3 (page 140): #1, #2, #4, #5, #7; "Study numerical accuracy for solving a MOP"
D. Chapter 4: (page 176-178): #1, #2, #5, #6, #7, #12, #13; "List good metric criteria:
E. Chapter 6 (page 291-292): #2, #3, #4, #6; "Analyze selected MOEA application results"

"Consider research suggestions at end of each Chapter for individual student study"

Laboratory (Introductory Elements):

1. Chapter 1: Problems 7, 8 and 9
2. Chapter 2: Problem 7
3. Download several MOEA software packages (see Section 2.5.8 and Table 4.1) per instructors' selection, develop script files for local computational environment, and execute for simple MOP
4. Download or develop MOP software (Section 4.3) integrate into MOEA code
5. Execute selected MOPs and evaluated results using Excel or Matlab for example. Using statistical analysis techniques and test over selected various metrics (Section 4.4)

6. Submit report on MOEA results over selected MOPs. As appropriate, compare to results in current literature.
7. Selected an application MOP domain (Chapter 6) along with MOEA software. Test and analyze. As appropriate compare to results in current literature.

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Educational Objectives -- Advanced MOEA Elements:

1. Develop more extensive insight to current MOEA architectures
2. Develop an appreciation of MOEA theoretical and design issues
3. Develop an extensive understanding of MOEA testing metrics
4. Understand performance advantages for parallelizing certain MOEA structures
5. Ability to compare MOEA results to those of other stochastic search routines
6. "Could be a seminar type course"

Course Outline -- Advanced MOEA Elements: "Chapters 5,7,8,9"

1. MOEA theories regarding convergence to Pareto front (Section 5.2)
2. Measuring MOEA performance with the variety of metrics.
3. MOEA design and implementation issues associated with performance: (Section 5.3 and Chapter 2)
    a. fitness, ranking, niching/crowding/fitness sharing (Section 5.3.1-5.3.3)
    b. operator restriction - mating, constrains … (Section 5.3.4)
    c. stability and robustness of results (Section 5.3.5)
    d. MOEA complexity issues (Section 5.3.6 & 5.3.7)
4. Parallelization techniques for MOEA design and implementation (Chapter 7)
5. Multi-Criteria Decision Making as related to MOEA utilization (Chapter 8)
6. MOEA comparison to other stochastic search algorithms & local search (Chapter 9)

Suggested Homework -- Advanced Elements: "or part there of"

A. Problems not listed above in Chapters 1, 2, 3, 4 and 6.
B. Chapter 5 (page 205): #1-4; "Read & report on current MOEA theory literature"
C. Chapter 7 (page 319-320): #1-9; "Time & space analysis of a parallelized MOEA"
D. Chapter 8 (page 346- 347): #1-7
E. Chapter 9 (page 386-388); #1-8

Laboratory -- Advanced MOEA Elements:

1. Extensive study of at least one MOP application domain with at least 3 contemporary MOEAs employed. Include a thorough study of the problem domain(s). Results should be analyzed from quantitative and qualitative viewpoints with extensive statistical techniques that are appropriate.
2. Compare results of above experiment to use of integrated local search techniques.
3. Report should reflect an EC conference quality paper that would be submitted
4. Extra credit – development and/or use of parallelized MOEA.

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Comments:

1. A single course (quarter, semester, individual study) could incorporate all of the elements with emphasis depending upon instructor's educational objectives.
2. Prerequisites -- Introductory Elements: Basic background in genetic algorithms, algebra, statistical techniques, and at least one application domain.
3. Suggested MOEA packages for labs include those in Section 2.5.8 and in Table 4.1.
4. Selection of application domains in Chapter 6 depends upon instructor's expertise, and student's domains of interest/research as well as contemporary literature.
5. Emphasis of course is left to the instructor as to specific MOEAs, MOPs, metrics, and analysis techniques employed. However, a variety of current MOEAs should be studied with a spectrum of MOP application characteristics.
6. Students should be made aware of the general sources of MOEA and MOP literature including the CEC, GECCO, EMO conferences, the IEEE Transactions on EC and the MIT EC journal. Discussion of current MOEA papers is suggested.
7. Lab reports could be of an informal character or more formal in the sense of conforming for example to an IEE, IEEE, or ACM conference or journal two-column format.

"Online support for the book and associated course material can be found at www.lania.mx/~ccoello/EMOO. If you have suggestions for improving and extending the use of this book as a text please sent email to this website or those of the book authors: Carlos Coello (ccoello@cs.cinvestav.mx), David Van Veldhuizen (david.vanveldhuizen@wpafb.af.mil), and Gary Lamont (gary.lamont@afit.edu)."

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