Aalto University School of Business
30E00100 Applied Optimization and Methodologies
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Objectives of the Course

The aim is to get acquainted with different types of nonlinear optimization problems and requisite optimization methodologies including optimality conditions, some well-known nonlinear programming methods. A major emphasis will be given in introducing evolutionary optimization methodologies and their scope in solving practical optimization problems. Issues such as constrained handling, multi-objective optimization and decision-making, customization procedures, hybrid methodologies, uncertainty-based optimization, multi-level optimization, and large-scale optimization will be covered. A number of cases studies from industries will be discussed.

Students will learn the importance of optimization in practice, a number of popular and efficient single and multi-criterion optimization methods to solve them, and a number of systematic approaches to go beyond optimization and discover useful insights related to practical problems. Students will also be acquainted with a number of popular optimization codes. The course should enhance problem solving capability of students.

Teaching Procedure

Morning sessions will be devoted to classroom teaching using power point slides, a copy of which will be provided to the students. The afternoon sessions will be devoted to problem solving by the supervision of the instructor. Some of the afternoon sessions will involve the use of computer codes under Matlab environment. Essential instruction will be provided to non-Matlab users.

Recommended Text

- **Deb, K.** (2001). *Multi-objective optimization using evolutionary algorithms.* Chichester, London: Wiley. Available from Amazon or directly from publisher's website.
- Number of papers and other materials will be posted on the course website.

Exams, Homework and Grading Policies

Here is a tentative assignments and exams.

- **Quiz: 20%**, Date to be announced, during tutorial session in the afternoon
- **Final Exam: 35%** (Covering all course material), Date to be announced

- **Homework: 20%** 3-4 Homework assignments will be given.
- **Term Project: 25%** Every student must do a term project applying the optimization methods learned in the class to a problem of their interest. A one to two-page typewritten project proposal will be due in the middle of the course. Students will have approximately one month after the course is over to turn in the project report by email to the instructor.

Course Syllabus

- Introduction to optimization and its importance in practice
- Classical single-criterion optimization
  - Important optimality conditions
  - Some popularly-used optimization methods
  - Use of Matlab optimization methods
- Evolutionary single-criterion optimization
  - Working principles and differences with classical methods
  - Some popularly-used evolutionary and other nature-inspired methods
  - Analysis of operators and important results
  - Use of public-domain GA codes
- Multi-criterion optimization
  - Basics and optimality conditions
  - Classical scalarization methods: Weighted-sum, epsilon-constraint, normal constraint, Tchebyshev method, etc.
  - Critical look at classical methods
- Evolutionary multi-criterion optimization (EMO)
  - Principles and a brief history of its development
  - Non-elitist EMO: VEGA, NSGA, NPGA, MOGA, etc.
  - Elitist EMO: NSGA-II, SPEA2, PESA etc.
  - Constraint handling in EMO
  - Advantages of EMO through practical examples
  - Representation of optimal solutions
  - Performance metrics: convergence metrics, diversity metrics, hypervolume, etc.
- Use of public-domain NSGA-II code
- Multi-criterion decision making (MCDM)
  - Principles

  - Popular methods: Achievement scalarizing methods, reference point based method, reference direction method, 'light beam' search, AHP, and others

- Advanced topics in EMO

  - Scalable test problem development: ZDT, DTLZ, WFG, etc.
  - Different domination and diversity preserving principles: Cone domination, nadir point estimation, partial front identification, niching, omni-optimizer, etc.
  - Handling many objectives: MOEA/D, NSGA-III, Borg-GA, etc.
  - Handling redundant objectives
  - Handling uncertainties: Robust EMO, Reliability-based EMO
  - Multi-objectivization concept and its applications
  - *Innovization:* Innovation through optimization
  - Parallel/Distributed EMO
  - Dynamic EMO
  - Bilevel EMO
  - Computational aspects: Metamodeling based EMO, performance metrics
  - Other nature-inspired multi-criterion optimization methods

- EMO-MCDM methods

  - A priori methods
  - A posteriori methods
  - Interactive methods

- Wrap-up