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IE 507 Nonlinear Optimization Methods

Year and Semester: **2018-2019 Spring**
Credit Hour: **(3,0)3**
ECTS: **7.5**
Prerequisite(s): **Graduate standing**

Catalog Description
Review of convex sets and convex functions, local and global optima, basics of unconstrained optimization, Newton's method, steepest descent, quasi-Newton, and gradient methods for unconstrained problems, optimality conditions for constrained problems, Kuhn-Tucker conditions and Lagrangian duality, interior-point, penalty and barrier methods for constrained optimization.

Textbook

- S.G. Nash and A. Sofer, *Linear and Nonlinear Programming*, McGraw Hill 1996.

Reference Books

- M.S. Bazaraa, H.D. Sherali, and C.M. Shetty, *Nonlinear Programming* (2^{nd} ed.), Wiley, 1993.
- D.P. Bertsekas, *Nonlinear Programming*, Athena Scientific, 1995.
- J. Shapiro, *Mathematical Programming*, Wiley, 1979.
- R.L. Rardin, *Optimization in Operations Research*, Prentice-Hall, 1998.

Course Objective

The main objectives of this course are:

- To provide a vision of the theory of nonlinear optimization as well as understanding of algorithms.
- To enhance the ability of making mathematical proofs.
- To give an understanding of algorithmic complexity and convergence.
- To emphasize the application areas of nonlinear optimization.
- To teach the students implement nonlinear programming algorithms using basic software and computer programming.

Learning Outcomes

On successful completion of the course, all students will have developed:

- A vision of the theory of nonlinear optimization as well as understanding of algorithms
- Awareness of the theoretic fundamentals of nonlinear optimization
- Ability of making mathematical proofs
- Skills in implementing nonlinear optimization algorithms using basic software and computer programming

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On successful completion of the course, all students will have:

- Awareness of ethical issues

Course Outline

Week 1: Examples of nonlinear programming problems. Brief review of linear algebra. Linear equalities and inequalities, polyhedral sets. Linear objective functions.
Week 2: Convexity. Convex sets, cones, extreme points and extreme directions. Feasible directions for convex sets. Fundamental subspaces of linear algebra.
Week 3: Nonlinear equalities and inequalities. Separating hyperplanes and supporting hyperplanes. Convex functions. Convex optimization.
Week 4: Feasible point algorithms. Rates of convergence. Taylor series expansion of functions.
Week 5: Line search techniques. Unconstrained optimization problems. Necessary consitions of optimality. Sufficient conditions of optimality.
Week 6: Steepest descent algorithm. Newton's algorithm and its variants.
Week 7: Quasi-Newton methods.
Week 8: The conjugate gradient methods for linear feasibility and unconstrained optimization problems.
Week 9: Constrained optimization problems. Necessary conditions of optimality. Sufficient conditions of optimality.
Week 10: Feasible point methods for linear equality constraints. The reduced gradient and reduced Newton directions for constrained minimization problems.
Week 11: Feasible point methods for linear inequality constraints. Stepsize selection.
Week 12: An overview of penalty and barrier methods.
Week 13: Nonlinear programming approaches to linear feasibility/optimization problems. An overview of interior-point algorithms.
Week 14: The Affine Scaling Algorithm.

Computer Usage

Students should be able to use packages such as *MATLAB, LINGO,* and GAMS which will be required for homework assignments.

Grading Policy

HW Assignments	25%
Midterm Exam	30%
Final Exam	30%
Complementary Project	15%

Lecture Hours

Thursday 18:00—20:50 (SEDAM-1)

Lecturer

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