USF - Department of Industrial and Management Systems Engineering
EIN 6935 Nonlinear Optimization and Game Theory
Spring 2016

1 Course Contact

- Class Meetings: T R 12:30–1:45 AM, EDU 254
- Course Website: https://usflearn.instructure.com/courses/1089742 (CANVAS via MyUSF)
- Instructor: Dr. Changhyun Kwon
  - E-mail: chkwon@usf.edu
  - Office Location: ENC 2506
  - Office hours: M W 1:00–2:00 PM, or by appointment

2 Course Description

This course will be an intensive study of nonlinear optimization and Game Theory. The first part will focus on theory and algorithms of nonlinear optimization. Topics include convex analysis, optimality conditions, Lagrangian duality, and numerical methods for unconstrained and constrained optimization problems.

The second part will apply theory and algorithms of nonlinear optimization to equilibrium problems that arise in management science, transportation science, regional science, and economics. Theory and algorithms of variational inequalities and complementarity problems are used to analyze and compute equilibria in connection with nonlinear optimization. Topics include Nash equilibrium and leader-follower games.

3 Prerequisites

- Knowledge of (or willingness to learn) a computer programming language such as `MATLAB`, `C/C++`, `Java`, `Python`, and `Julia`. This course will particularly emphasize the Julia Language.
- Knowledge of linear algebra, calculus, and basic mathematical concepts such as sets, functions, vectors, matrices, derivative, gradient, etc.

4 Topics Covered

- Basic Concepts and Modeling
- Convex Sets
- Convex Functions and Generalizations
- Karush-Kuhn-Tucker Conditions
- Lagrangian Duality
- Unconstrained Optimization
- Penalty and Barrier Functions
- Methods of Feasible Directions
- Basics of Mathematical Games

- Nash Equilibrium
- Variational Inequalities
- Complementarity Problems
- Leader-Follower Games
- Computational Methods for Equilibrium Problems

5 Textbook

Required

- Bazaraa, Sherali and Shetty, *Nonlinear Programming: Theory and Algorithms*, Wiley-Interscience, 3rd Edition, 2006. (The 2nd edition is also fine.)

6 References on Nonlinear Optimization

Optional Readings on Nonlinear Optimization

- Bertsekas, *Nonlinear Programming*, Athena Scientific, 1999
- Nocedal and Wright, *Numerical Optimization*, Springer, 2006

Other References on Nonlinear Optimization

- Luenberger and Ye, *Linear and Nonlinear Programing*, Springer, 2010
- Mangasarian, *Nonlinear Programming*, SIAM, 1987
- Ruszczynski, *Nonlinear Optimization*, Princeton University Press, 2006
- Peressini, Sullivan and Uhl, Jr., *The Mathematics of Nonlinear Programming*, Springer, 1993
- Boyd and Vandenberghe, *Convex Optimization*, Cambridge University Press, 2004
- Bertsekas, Nedic and Ozdaglar, *Convex Analysis and Optimization*, Athena Scientific, 2003
- Borwein and Lewis, *Convex Analysis and Nonlinear Optimization: Theory and Examples*, Springer, 2000.

7 References on Computational Game Theory

Key References on Computational Game Theory

- Harker, P. T., and Pang, J. S. (1990). Finite-dimensional variational inequality and nonlinear complementarity problems: a survey of theory, algorithms and applications. *Mathematical programming*, 48(1-3), 161-220.
- Facchinei, F. and Pang, J.-S. (2003), *Finite-Dimensional Variational Inequalities and Complementarity Problems I and II*, Springer

Other References on Computational Game Theory

Books

- Konnov, I. (2007), *Equilibrium Models and Variational Inequalities*, Elsevier Science

- Intriligator, M. D. (1987). *Mathematical optimization and economic theory* (Vol. 39). Society for Industrial and Applied Mathematics.
- Nagurney, A. (1999), *Network Economics: A Variational Inequality Approach*, Springer
- Nagurney, A. and Zhang, D. (1995), *Projected Dynamical Systems and Variational Inequalities with Applications*, Springer
- Friesz, T. (2010), *Dynamic Optimization and Differential Games*, Springer
- Gabriel, S. A., Conejo, A. J., Fuller, J. D., Hobbs, B. F., and Ruiz, C. (2012). Complementarity modeling in energy markets. Springer.
- Daniele, P. (2006), *Dynamic Networks And Evolutionary Variational Inequalities*, Edward Elgar Pub

Articles

- Harker, P. T. (1991). Generalized Nash games and quasi-variational inequalities. *European Journal of Operational Research*, 54(1), 81-94.
- Facchinei, F., Fischer, A., and Piccialli, V. (2007). On generalized Nash games and variational inequalities. *Operations Research Letters*, 35(2), 159-164.
- Pang, J. S., and Fukushima, M. (2005). Quasi-variational inequalities, generalized Nash equilibria, and multi-leader-follower games. *Computational Management Science*, 2(1), 21-56.
- Fukushima, M. (1992). Equivalent differentiable optimization problems and descent methods for asymmetric variational inequality problems. *Mathematical programming*, 53(1-3), 99-110.
- Florian, M., and Hearn, D. (1995). Network equilibrium models and algorithms. In: M.O. Ball, T.L. Magnanti, C.L. Monma and G.L. Nemhauser, Editor(s), *Handbooks in Operations Research and Management Science*, Elsevier, 1995, Volume 8, Chapter 6, Pages 485-550.
- Hearn, D., and Ramana, M. (1998). Solving congestion toll pricing models. In P. Marcotte and S. Nguyen (Eds.), *Equilibrium and Advanced Transportation Modeling*, Boston/Dordrecht/London: Kluwer Academic Publishers, Chapter 6, 109-124.
- Braess, D., Nagurney, A., and Wakolbinger, T. (2005). On a paradox of traffic planning. *Transportation Science*, 39(4), 446-450.
- Roughgarden, T., and Tardos, É. (2002). How bad is selfish routing? *Journal of the ACM*, 49(2), 236-259.

8 Topics Covered

- Basic Concepts and Modeling
- Convex Sets
- Convex Functions and Generalizations
- Karush-Kuhn-Tucker Conditions
- Lagrangian Duality
- Unconstrained Optimization
- Penalty and Barrier Functions
- Methods of Feasible Directions
- Variational Inequalities
- Complementarity Problems
- Robust Optimization

9 Grading

- **25% Homework Assignments.** You must work on the homework problems independently. You are allowed to discuss with other fellow students, but you must present the idea independently, and state the names of the students with whom you discussed. The allowed discussion does NOT include reading other students' writings.
- **25% Exam I.** One front-and-back reference sheet will be allowed. Scheduled on February 9, Tuesday.
- **25% Exam II.** One front-and-back reference sheet will be allowed. Tentatively scheduled on March 10, Thursday.
- **25% Exam III.** One front-and-back reference sheet will be allowed. Tentatively scheduled on April 26, Tuesday.

10 Academic Honesty and Integrity

Academic integrity is the foundation of the University of South Florida Systems (USF System) commitment to the academic honesty and personal integrity of its university community. Academic integrity is grounded in certain fundamental values, which include honesty, respect and fairness. Broadly defined, academic honesty is the completion of all academic endeavors and claims of scholarly knowledge as representative of ones own efforts. Knowledge and maintenance of the academic standards of honesty and integrity as set forth by the university are the responsibility of the entire academic community, including the instructional faculty, staff and students. The final decision on an academic integrity violation and related academic sanction at any USF System member institution shall affect and be applied to the academic status of the student throughout the USF System, unless otherwise determined by the independently accredited institution

Resources:

- USF Regulation 3.027: http://regulationspolicies.usf.edu/regulations/pdfs/regulation-usf3.027.pdf
- Tutorial: http://usfweb2.usf.edu/ethics/splash.html

Sactions include:

- Reduction or no credit given
- A make-up assignment at a more difficult level
- Required attendance in a non-credit workshop or seminar on ethics
- Failing grade for the assignment
- Failing grade for the course, which may be an F or FF on the internal transcript
- Suspension from the university for one semester
- Permanent academic dismissal from the University with the designation of "Dismissed for Academic Dishonesty" to be placed permanently on a students external transcript
- More serious violations of academic integrity may be referred to the Office of Students Rights and Responsibilities as a student conduct violation

One simple rule: If you fail to meet the USF policy and the instructor's policy for academic honesty and integrity, you will at least receive 'F', and it is possible that you are suspended or expelled from the university.

11 Examples of Academic Dishonesty

Academic dishonesty includes, but is not limited to, the following:

- *Previously submitted work.* Submitting academically required material that has been previously submitted—in whole or in substantial part—in another course, without prior and expressed consent of the instructor.
- *Plagiarism.* Copying or receiving material from any source and submitting that material as ones own, without acknowledging and citing the particular debts to the source (quotations, paraphrases, basic ideas), or in any other manner representing the work of another as ones own.
- *Cheating.* Soliciting and/or receiving information from, or providing information to, another student or any other unauthorized source (including electronic sources such as cellular phones and PDAs), with the intent to deceive while completing an examination or individual assignment.
- *Falsification of academic materials.* Fabricating laboratory materials, notes, reports, or any forms of computer data; forging an instructors name or initials; resubmitting an examination or assignment for reevaluation which has been altered without the instructors authorization; or submitting a report, paper, materials, computer data, or examination (or any considerable part thereof) prepared by any person other than the student responsible for the assignment.
- *Misrepresentation of documents.* Forgery, alteration, or misuse of any University or Official document, record, or instrument of identification.
- *Confidential academic materials.* Procurement, distribution or acceptance of examinations or laboratory results without prior and expressed consent of the instructor.
- *Selling academic assignments.* No person shall sell or offer for sale to any person enrolled at the University at Buffalo any academic assignment, or any inappropriate assistance in the preparation, research, or writing of any assignment, which the seller knows, or has reason to believe, is intended for submission in fulfillment of any course or academic program requirement.
- *Purchasing academic assignments.* No person shall purchase an academic assignment intended for submission in fulfillment of any course or academic program requirement.

12 Students with Disabilities Services

If you have a disability and may require some type of instructional and/or examination accommodation, please inform me early in the semester so that we can coordinate the accommodations you may need. If you have not already done so, please contact the Students with Disabilities Services office. The website is at: http://www.usf.edu/student-affairs/student-disabilities-services/