IE 8743: Nonlinear Programming

Hugh Medal

Syllabus

Course Information

Instructor

Hugh Medal
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Office Hours

My office hours are the following:

- Tuesday and Thursday: 10-11am; 2-4pm
- Friday: 9-10:30am

You are welcome to drop in. However, if you wish to reduce/eliminate waiting time, I would encourage you to schedule an appointment via https://hughmedal.youcanbook.me/.

Course materials

Required textbook "Linear and Nonlinear Programming," by David Luenberger and Yinyu Ye, 4th edition, Springer, 2016. ISBN 978-3-319-18841-6

Prerequisites

MA 3113 – Introduction to Linear Algebra; IE/MA 4733 – Linear Programming; students should also have a working of at least one programming language (python is a good choice)

Course Description

(3) Three hours lecture. Optimization of nonlinear functions; quadratic programming, gradient methods, integer programming; Lagrange multipliers and Kuhn-Tucker theory.

Course Website and Communication

I will use course website (found via mycourses.msstate.edu) to post assignments, grades, etc. Students will submit their homework to this website. Students should regularly check the course website for announcements, etc. Students are also responsible to check their msstate.edu email account.

Course Objectives

After completing this course students should be able to:

- Introduction, mathematics review, and basic theory
  - Introduction
    - formulate an NLP given a problem description
    - calculate the Hessian of a function
    - answer various questions about NLP notation
    - answer various linear algebra related questions related to NLP (e.g., find rank of a matrix)
  - Convexity theory
    - show whether or not a matrix is positive semidefinite
    - show whether or not a function/set is convex
    - graphically interpret the definitions of convex sets and functions
    - answer various T/F questions about convex functions
    - show whether a mathematical program is a convex program (include whether it is min or max)
    - find for which parameter values a function is convex
- Unconstrained NLPs
  - Optimality conditions
    - write the optimality conditions for a unconstrained nonlinear program
    - explain/prove why for a convex NLP a local minima is a global minima
    - find a minimum point of a function
    - prove that a point is a relative and/or global minimum point
  - Basic descent algorithms
    - write the pseudocode for a basic descent method
    - be able to solve a NLP problem (by hand and with code) using a line search method (Golden section, Fibonacci, Newton's, method of false positives)
  - Method of steepest descent
    - write the pseudocode for the steepest descent method
    - solve an NLP problem (by hand and in code) using Newton's method
    - solve an NLP problem (by hand and with code) using the C-G method
- Constrained NLPs
  - Optimality conditions
    - write the KKT conditions for a NLP problem)
  - Primal methods
    - solve an NLP problem using a primal method (by code and by hand)
    - explain various aspects of the gradient projection method
  - Penalty and barrier methods
    - solve an NLP problem using the penalty and barrier methods (by code and by hand)
  - Duality
    - write the dual of an NLP problem
    - recognize which NLP problems have a zero duality gap
    - solve an NLP problem using the Lagrangean dual method (by code and by hand)

Important Dates

- January 15, Last day to drop a course without a grade (5th class day) 5:00 p.m.
- January 18, Holiday
- January 19, Last day to register or add a course (6th class day)
- January 19, Last day to request undergraduate academic forgiveness via myState 5:00 p.m
- February 22, First progress grades reporting deadline
- March 14 – 18, Spring Break – No Classes Scheduled (Dates Subject to Change)
- March 24, Second progress grade reporting deadline
- March 25, Holiday
- April 13, Last day to withdraw from University (ten days of classes remaining); Progress grade reporting closes
- April 27, Classes end
- April 28, Reading Day (No mandatory class assignments, requirements, meetings)
- April 30 & May 6, Make-up days (if needed)
- **May 4, Final exam from 12-3pm**
- **May 8, Final project due at 11:59pm**
- May 9, Final Grades Due 12:00 noon

Course Assessments

Student learning will be assessed using the following methods: quizzes (about 5), problem sets (about 4), a final exam, and a final project.

Quizzes

All quizzes are closed book and closed notes. You are allowed to bring a formula sheet and a calculator only. No make-up quizzes will be given regardless of what the excuse is. There will be a quiz almost every week. I expect to give about five of these quizzes of which the best four will contribute to your average.

Problem Sets

Take-home assignments will be given about every other week. I expect to give about four assignments. Three of your best assignments will contribute to your average. Assignments can be done in groups of at most two. They should be typed and submitted online via the course website. Late assignments will not be accepted.

Final Exam

The same format and rules as for quizzes. The final will be given during the final exam period.

Final Project

Students will apply nonlinear programming to a problem of their interest. Students will review each other's work and provide constructive feedback. Students will submit a the following throughout the semester:

- project proposal
  - Background and motivation for your problem
  - Lit review (methodology that you plan to use, work on your problem from an NLP perspective
  - Problem description of the NLP problem you plan to solve
- proposal revision (if needed)
  - students can change their topic based on my feedback and peer feedback
- project plan
  - model formulation
  - show that your problem is a convex optimization problem
  - any reformulation tricks you might use
  - planned solution method
- final version of the project
  - validation of your solution method on a toy instance
  - run a few experiments to show how your solution method performs on larger instances of your problem

Grade Distribution

Problem sets	– 30 points (10 points each)	[30%]
Quizzes	– 20 points (5 points each)	[20%]
Final Exam	– 20 points	[20%]
Final project	– 30 points	[30%]

Grading Scale

The following scale represents the minimum percentages needed for you to be guaranteed each letter grade.

A	90.0%
B	80.0%
C	70.0%
D	60.0%

However, I also use gray areas to determine grades. The gray areas are as follows:

A	89.0-89.9%
B	78.0-80.9%
C	67.0-70.9%
D	55.0-60.9%

If you in a gray area, your grade may be bumped up based on the following criteria: Did you give attempt any of the challenge problems on the problem sets? Did your grade increase over the course of the semester?

Grading Policies

Late Problem Sets

If you cannot complete a problem set for a University-excused reason (see http://www.policies.msstate.edu/policypdfs/1209.pdf), you will be allowed to promptly submit it as soon as you are able. However, you must have your excuse validated by the Student Affairs office (http://www.saffairs.msstate.edu/).

Missing the Final Exam

If you cannot attend the final exam for a University-excused reason (see http://www.policies.msstate.edu/policypdfs/1209.pdf), you will be allowed to reschedule as soon as you are able. However, you must have your excuse validated by the Student Affairs office (http://www.saffairs.msstate.edu/).

Grade Appeals

Grades will be posted on the course web site and updated periodically. It is your responsibility to verify that your grades have been correctly entered. You have one week after an assignment or a test is returned to discuss changes in your grade. Note that grade changes may result in an increase or a decrease in your grade.

Guidelines

Academic Honesty

We will comply with the MSU Honor Code (http://www.honorcode.msstate.edu/pdf/honor-code.pdf), which requires me to report cases of academic dishonesty (page 8). Examples of academic dishonesty in this class include by are not limited to the following:

- Using unauthorized materials/resources on a quiz/test
- Communicating with people outside the class during a quiz or test
- Communicating or copying work on a quiz/test
- A conversation about an quiz/test between a student who has taken the exam and a student who has not yet taken it
- Copying homework from another student

Students Needing Extra Accommodation

If there are any issues that may affect your learning, please let me know. I would like to make accommodations in any way I can, in collaboration with Student Support Services (http://www.sss.msstate.edu/disabilities/). In addition, you may wish to consult with Student Support Services yourself to understand how you can receive help.

Title IX

MSU is committed to complying with Title IX, a federal law that prohibits discrimination, including violence and harassment, based on sex. This means that MSU's educational programs and activities must be free from sex discrimination, sexual harassment, and other forms of sexual misconduct. If you or someone you know has experienced sex discrimination, sexual violence and/or harassment by any member of the University community, you are encouraged to report the conduct to MSU's Director of Title IX/EEO Programs at 325-8124 or by e-mail to titleix@msstate.edu. Additional resources are available at http://www.msstate.edu/web/security/title9-12.pdf, or at http://students.msstate.edu/sexualmisconduct/<http://students.msstate.edu/sexualmisconduct/>.