Optimization for Analytics
IDS 435
Spring 2022

INSTRUCTOR

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TEACHING ASSISTANT

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TA office hours link: Zoom

CLASS HOURS

Tuesday & Thursday from 3:30 pm – 4:45 pm
Classes will be live on Zoom until further notice.
Class link: Zoom

TEXT BOOK

Main reference:

[KW] M. J. Kochenderfer, and T. A. Wheeler. Algorithms for optimization. MIT Press, 2019.

- Link: https://algorithmsbook.com/optimization

Additional references:

[BV] S. Boyd, and L. Vandenberghe. Barto, Convex Optimization. Cambridge University Press, 2004

- Link: https://web.stanford.edu/~boyd/cvxbook/bv_cvxbook.pdf

[SB] R. S. Sutton, A. G. Barto, Reinforcement Learning: An Introduction, Bradford Books, 2nd edition, 2020

- Link: http://www.incompleteideas.net/book/RLbook2020.pdf

COURSE TECHNOLOGY

We will use Blackboard as the repository for course material. You are encouraged to use the discussion boards on Blackboard to post questions regarding the class material and assignments (of course, without sharing answers). `

We will use Zoom for online classes and all TA and instructor office hours (see first page for Zoom links).

PRE-REQUISITE

IDS 371 or the equivalent; and knowledge of programming at the level of IDS 201 or equivalent.

What does this mean and why is it needed?

Understanding optimization models and solutions algorithms in IDS 435 relies on familiarity with mathematics that is covered in the first year of undergraduate studies. The IDS 371 pre-requisite ensures students have been exposed to topics such as probability distributions and regression, and have worked with mathematical notation. This exposure will help you understand what we learn in IDS 435. We also suggest that you review Appendix C of the main textbook reference [KW].

Similarly, implementation of optimization methods will require using a programming language. The programming prerequisite is to ensure that students have working knowledge in a programming language. Exposure to Python would be ideal but experience with another programming language should suffice. This will facilitate students focusing on the implementation of optimization algorithms as opposed to the basics of programming. Introducing students to basic programming is beyond the scope of the class. We have however prepared and shared a Python refresher on Blackboard to help. Programming templates will also be provided throughout the course.

In short, these prerequisites are present to maximize your learning. If you do not satisfy them, I recommend you fulfill them before taking IDS 435.

HEALTH AND WELLNESS

It is important to acknowledge that we are operating in unprecedented times. Take care of yourself and try to maintain a healthy lifestyle, despite the disruptions. All of us benefit from support during times of struggle.

You are not alone. There are several resources at UIC to help. Please see this link. I am also available to talk. Being a part of a university community goes beyond our important mission to learn – we look out for each other.

COURSE DESCRIPTION

The importance of data and analytics has grown rapidly in recent years across business, engineering, and the sciences. Examples range from social networks, e-commerce platforms, screening in healthcare diagnostics, trading in finance, targeted marketing, and political campaigns, to name a few. In 2021, according to IDC, global spending on big data and business analytics was projected to be $ 215 Billion.

Optimization is a core enabler of analytics. It is used in machine learning to find accurate and robust predictive models as well as in decision making to find smart decisions in complex business and engineering applications. This course will focus on introducing you to important classes of optimization problems, solution algorithms, and their deployment using Python.

The first half of the class will cover optimization algorithms relevant to machine learning, with a particular emphasis on continuous (convex & non-convex) optimization formulations and first-order solution methods. We will also discuss the role of constraints and the associated solution challenges. Students will be exposed to applications arising in regression, support vector machines, and neural networks, which are commonly used by machine learning scientists.

The second half of the class will shift towards optimization for decision making, also referred to as prescriptive analytics. Many of the optimization formulations and methods we learn for training machine learning models will be applicable here but we will also learn additional methods that have revolutionized (perhaps silently) decision making in practice. These include linear and mixed integer programming, and dynamic programming. We will also learn multi-armed bandits and reinforcement learning, which are projected to have significant impact in business.. We will apply what we learn to applications in finance, healthcare, transportation, and energy.

Instructional format will rely on discussions and the instructor will follow a Socratic approach. For this format to be successful, it is critical that you are prepared for class by reviewing prior materials. Slides will be posted on Blackboard before lectures. Additional material may be posted as recorded videos if needed to supplement in class learning, in lieu of recitations.

GRADING

The class has both undergraduate and graduate sections for three and four credits, respectively. Therefore, the grading components for each section have been created to reflect this difference. Please see below.

The grade breakdown grade for the undergraduate section is

1.	Participation	10
2.	Assignments	60
3.	Midterm	15
4.	Final	15
	Total	**100**

The grade breakdown for graduate students is

1.	Participation	10
2.	Assignments	60
3.	Midterm	15
4.	Final	15
5.	Project	20
	Total	**120**

Participation

Class discussions will follow a very open format – anyone who wants to contribute constructively can and should. Below are ways in which participation will be assessed.

Attendance: You are expected to attend all classes on time. If a student needs to be absent for an extended period (e.g. for health reasons), contact the instructor as early as possible.

Discussions: All students are expected to be prepared to contribute to classroom discussions. There will be activities and questions towards which you will be expected to provide thoughtful answers.

Assignments

There will be **five** assignments. Students are expected to submit answers via Blackboard **by the assignment due date.** You have the **option** to collaborate with another student of your choosing for assignments and submit one set of answers. You must state the name of the collaborator in your report if you have one. In addition, if your answers rely on external material (i.e., material not provided in class) you must cite relevant sources. Late submissions will result in a 25% point deduction each day. Submissions will not be accepted 2 days after the due date and time and the assignment will receive zero points. **Credit will not be given for answers that do not explain the steps used to reach them.**

Heads up: If you collaborate with a partner on assignments, then peer evaluations will be used to curve your grade. In other words, your individual score will be downgraded if you do not contribute equally. If you collaborate but do not state your partner's name, submissions that are similar will receive zero points and constitute a violation of the CBA honor code.

Midterm and Final

All students must take the midterm and final at their respective pre-scheduled date.

Project (graduate students only)

Graduate students can work in a team of two or alone. Each team will choose a project from four candidate projects. Each team will be expected to work on a different project.

ACADEMIC INTEGRITY

As a member of the UIC College of Business Administration community, the highest standard of academic behavior is expected of you. It is your responsibility to be aware of the standards and adhere to them. The honor code of the UIC CBA can be found here: http://www.uic.edu/ucat/07%20BA%20109-124.pdf. Safe assign software will be used to check the originality of all submitted assignments and case write-ups.

COURSE OVERVIEW

i. The course overview below gives you a plan for the course. There will very likely be changes to this plan as the semester progresses. I will communicate these changes to you and update the course overview.

ii. The "MATERIAL" column indicates the main reference material for the lecture. I will often supplement the slides with my own experience/material as well.

iii. The "DUE" column indicates the due dates for assignments (denoted by A followed by a number).

iv. You are expected to come prepared for class discussions by reviewing the relevant reading material.

v. KW and SB abbreviated the main and additional textbook references. Please see the first page of the syllabus.

Week	Month	Date	Topic	Material	Due
OPTIMIZATION FOR MACHINE LEARNING					
Unconstrained Optimization					
1	Jan	11 13	Intro to Course & Optimization Landscape	Syllabus; Ch 1 KW	
2	Jan	18 20	Optimization Formulations and Applications	Ch 2.1-2.3 BV; Ch 3.1-3.2 BV; Instructor Resources	
3	Jan	25 27	Derivatives and Gradients	Ch 2 KW	
4	Feb	1 3	Local Descent	Ch 4 KW	A1
5	Feb	8 10	First Order Methods	Ch 5 KW	
Constrained Optimization					
6	Feb	15 17	Constraints and Applications	Ch 10 KW	A2
7	Feb	22 24	Duality and Lagrangian Methods	Ch 10 KW + Instructor Resources	
8	Mar	1 3	Linear Programming	Ch 11 KW	

9	Mar	8	Midterm		
OPTIMIZATION FOR DECISION MAKING					
Decision-making Applications					
9	Mar	10	Linear Optimization Applications: Airlines and Energy	Instructor Resources	
10	Mar	15 17	Convex Optimization Applications: Finance	Instructor Resources	A3
11	Mar	21- 25	Spring Break. No Classes.		
Discrete Optimization					
12	Mar	29 31	Applications and Dynamic Programming	Ch 19 KW	
13	Apr	5 7	Mixed Integer Programming & Commercial Solver	Ch 19 KW	A4
Dynamic Optimization					
14	Apr	12 14	Multi-armed Bandits	Ch 2 SB	
15	Apr	19 21	Markov Decision Processes	Ch 3 SB	
16	Apr	26 28	Approximate Methods	Ch 4 SB	A5
17	May	2-6	Final Examinations. No Classes.		