Knight Foundation School of Computing and Information Sciences

Course Title: Optimization Methods for Computing:Theory & Applications **Date:** 09/03/2019

Course Number: COT 5443

Number of Credits: 3

Subject Area: Data Science	**Subject Area Coordinator:** **email:**
Catalog Description: Optimization for CS graduate students, including algorithms, applications to widely used methods including efficient computing, machine learning and data science, and real-world problems. Basic calculus and programming skills are needed.	
Textbook: 1) Borwein, Jonathan, and Adrian S. Lewis. ***Convex analysis and nonlinear optimization: theory and examples***. Springer Science & Business Media, 2010. 2) Boyd, Stephen, and Lieven Vandenberghe. *Convex optimization*. Cambridge university press, 2004.	
References: None	
Prerequisite Courses: ((MAC 2311 Calculus I or equivalent) and (MAS 3105 Linear Algebra or equivalent)) or instructor's permission	
Corequisite Courses: None	

Type: **Elective**

Prerequisite Topics:

- Calculus, Basic Programming (e.g., Python or MATLAB)

Course Outcomes:

Students who successfully complete this course will be able to:

1. Explain the general concepts of optimization theory, linear/nonlinear optimization, convex/nonconvex problems;
2. Formulate an optimization problem from scratch, and utilize the most efficient algorithm to solve the formulated problem;
3. Describe decomposition techniques, their step by step implementation, and advantages for large-sclae computational problems;
4. Identify computing and decision making problems, e.g., data analytics and machine learning, and the theoretical optimization problems behind each notion
5. Explain and discuss emerging real-world applications of optimization for learning and data science, e.g., energy demand forecasting, traffic flow optimization, and community analysis in social networks.

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COT 5443
Optimization Methods for Computing: Theory and Applications

<u>Outline:</u>

Topic	Number of Lecture Hours (Total: 37.5 hours = 15 weeks * 2 lectures/week * 1.25 hrs/lecture)	Outcome
Introduction to Optimization • What are the main roles of optimization in computing? • How to formulate an optimization based on a real-world computing problem? • What are the applications of optimization in learning and data sciences?	5	1,2
Preliminaries • Linear algebra and matrix calculus preliminaries • Eigen value decomposition, singular value decomposition, matrix inversion • Overview of related Python libraries/ MATLAB functions	2.5	1,2,4
Centralized algorithm for general optimization problems • How to formulate and solve unconstrained optimization • How to formulate and solve constrained optimization • Karush–Kuhn–Tucker (first order necessary) conditions • Example: Optimal energy management in data centers	3.75	1,2
Convexity • What is the definition of convex optimization? • How can we solve convex optimization problems? • Duality theorem	2.5	1,2,3
Decomposition techniques for nonlinear optimization • Lagrangian decomposition • Augmented Lagrangian decomposition • Optimality condition decomposition • Examples: Data fitting, optimal pricing in financial systems	10	1,3,4
Decomposition techniques for linear optimization • Dantzig-Wolfe decomposition • Benders decomposition for linear problems	6.25	1,3,4,5

• Examples: Resource allocation in manufacturing		
Optimization for decision making and computing • Understanding the role pf optimization theory in computer science tools and problems • How to leverage optimization algorithms for more efficient data analytics? • How can we formulate a learning problem as an optimization problem? How to use the skills from this course to solve the formulated problem? •	6.25	4,5
Real-world examples of optimization	1.25	4,5

Assessment Plan for the Course & how Data in the Course are used to assess Program Outcomes

Student and Instructor Course Outcome Surveys are administered at the conclusion of each offering, and are evaluated as described in the School's Assessment Plan: https://abet.cs.fiu.edu/csassessment/