Syllabus

AE 8803: Optimal Transport Theory and Applications

Graduate course, Spring 2020

Instructor

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Office hours: Tuesday 9:30am-10:30am (otherwise by appointment)

Schedule

8:00am - 9:15am Tuesday
8:00am - 9:15am Thursday
Guggenheim 244

Credits

3.0

Course descriptions

Optimal transport is a powerful mathematical framework to study probability distributions. It has found a range of applications in image/signal processing, system controls, physics, finance, economics and machine learning. In this course, we will systematically go over optimal transport theory. We will cover classical topics in optimal transport such as Kantorovich duality, Wasserstein distance, gradient flow, displacement interpolation etc. We will also study more recent developments such as entropic regularization, connections to stochastic control, Wasserstein generative adversarial networks and statistical optimal transport. Algorithms and applications of optimal transport will be discussed in details. The students are expected to build a solid background in optimal transport by the end of the semester. The course is project based. The students will have the opportunities to conduct research in this timely topic and possibly publish at top venues such as NeurIPS.

Textbooks

1. *Topics in Optimal Transportations* by Cédric Villani
2. *Optimal Transport for Applied Mathematicians* by Filippo Santambrogio
3. *Partial Differential Equations and Monge-Kantorovich Mass Transfer* (survey) by Lawrence C. Evans
4. *Gradient Flows in Metric Spaces and in the Space of Probability Measures* by Luigi Ambrosio, Nicola Gigli, and Giuseppe Savaré
5. *Optimal Transport, old and new* by Cédric Villani
6. *Computational Optimal Transport* by Gabriel Peyré and Marco Cuturi
7. *Mass Transportation Problems* Vol I & II by Svetlozar Rachev and Ludger Rüschendorf
8. *Optimal Transport Methods in Economics* by Alfred Galichon

Prerequisites

Advanced Calculus, Real Analysis, Convex optimization, Riemannian Geometry

Website

All relevant information on the class will be disseminated electronically at Canvas.

Attendance and Class Behavior

Class attendance is mandatory. Each student will be responsible for obtaining notes and homework assignments for the days she/he will miss. No cell-phones, no eating, no reading newspapers, magazines, etc or other material which are not related to the class are allowed.

Grading scheme

- There will be two to three sets of homework.
- There will be no final exam.
- There will be a course project. The students are grouped together (2-4 members per group) to carry out a research project that is related to optimal transport. Each group needs to submit a research proposal (less than 3 pages) by Feb 20th, submit a project report and deliver a presentation at the end of the semester. The last three lectures will be devoted to project presentations.
- The overall distribution of grades is as follows:

Homework	30%
Course project	70%

- Final letter grade will be assigned following the table below

Precentage	Grade
90 - 100	A
80 - 89	B
65 - 79	C
50 - 64	D
< 50	F

Scholastic Dishonesty

Cheating, whether it is on your problem sets or exams, is absolutely unacceptable. Please refer to the Student Conduct Code at: `http://www.policylibrary.gatech.edu/student-life/academic-misconduct`

Health and Well-Being

Georgia Tech and the School of Aerospace Engineering understand that many students experience stress through a variety of academic, financial and personal experiences. We value you and want to make you aware of resources available to you should you need them. Your well-being and mental health are important, and we are here for you.

Center for Assessment, Referral and Education (CARE) https://care.gatech.edu/
Campus Police (any emergency): 404-894-2500 http://www.police.gatech.edu/
Counseling Center: 404-894-2575 https://counseling.gatech.edu/
Dean of Students Office: 404- 894-6367 https://studentlife.gatech.edu/
Georgia Crisis and Access Line: 800-715-4225
National Suicide Prevention Lifeline: 800-273-TALK (8255) https://suicidepreventionlifeline.org/
Crisis Text Line: Text HOME to 741741
VOICE: Victims Survivor Support: (404) 385-4464 (or 4451)
http://healthinitiatives.gatech.edu/well-being/voice
Stamps Health Services https://health.gatech.edu/contact

Outlines

1 Introduction and math background - (2 lectures)

2 Optimal transport theory - (10 lectures)

- Kantorovich duality
- Optimal transport map
- Dynamic formulation
- Geometry of Wasserstein space
- Gradient flow and functional inequalities
- Schrödinger bridge problems

3 Optimal transport algorithms - (4 lectures)

- Entropic regularization and Sinkhorn algorithm
- Benamou-Brenier algorithm
- Wasserstein-1 algorithm
- Large scale algorithms
- other algorithms

4 Optimal transport applications - (5 lectures)

- Machine learning
- Image processing
- Systems and control
- Finance and economics
- other applications

5 Extensions of optimal transport theory - (3 lectures)

- Multi-marginal optimal transport
- Optimal transport on graphs
- Wasserstein-Gromov distance
- other extensions

6 Statistical optimal transport - (2 lectures)