Topics in Theory of Computation (22-838, Fall 2019)

Discrete Geometric Optimization

Instructor: Amir Daneshgar
daneshgar@sharif.ir

Level: Graduate

Course description: The main objective of this course is to consider the theory and also computational aspects of clustering (i.e. concentration of measure) as well as optimal transportation as two fundamental geometric problems in discrete metric measure spaces (i.e. mm-spaces). In this regard, the course starts with basics of standard calculus on mm-spaces containing important aspects as spectral geometry of such spaces along with fundamental geometric concepts as isoperimetry, doubling property and basic PDE equations related to defusion and measure-concentration on mm-spaces.

The second part of the course is dedicated to isoperimetry and optimal transportation problems as two fundamental geometric problems in which we first go through the details of formulating these as two optimization problems and next we will discuss various computational issues as the computational complexity of these problems as well as different approaches to approximate them.

The third part of the course is dedicated to the applications of methods of statistical mechanics to analyze hard optimization problems. The main objective in this part is to show that the computational hardness of these problems are due to the phase-transition phenomenon appearing in these cases.

Evaluation: The final grade is based on a regular final exam, a take-home exam, and a 1-hour lecture based on an article assigned to the student.

References: The course is not based solely on the following references, but they may give you a general idea about the contents of this course.

References

[1] Alexander Hartmann and Martin Weigt. *Phase Transitions in Combinatorial Optimization Problems - Basics, Algorithms and Statistical Mechanics.* Wiley-VCH, 2005.

[2] Ramin Javadi. *Isoperimetric Problems on Graphs.* PhD thesis, Sharif University of Technology, 2011.

[3] Olaf Post. *Spectral Analysis on Graph-like Spaces.* Lecture Notes in Mathematics. Springer Berlin Heidelberg, 2012.

[4] Justin Solomon. *Transportation techniques for geometric data processing.* PhD thesis, Stanford University, 2015.

[5] Lenka Zdeborová. *Statistical physics of hard optimization problems.* PhD thesis, University Paris XI and Charles University, 2008.