Sublinear Algorithms

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Brief course description

In the analysis of algorithms, the notion of *efficiency* is almost always assumed to mean *polynomial* time, where the gold standard of achievement is *linear* time. However, when the input is very large, even linear time may be prohibitive. This course will focus on the design and analysis of algorithms that are restricted to run in *sublinear* time, and thus can view only a very small portion of the input data. Such algorithms are, by nature, randomized approximation algorithms. As we shall see, despite the limitation to run in sublinear time (or even time that is *independent* of the input size), such algorithms exist for a wide range of areas, including algebra, graph theory, geometry, string and set operations, optimization and probability theory. The course will introduce many of the various techniques that have been applied to analyzing such algorithms.

The subjects that will be covered are contained in the following list

- Introduction: Sublinear algorithms in general and property testing algorithms in particular.
- Different Models for testing graph properties:
  - Dense graphs: Bipartitness, ρ-Clique, first order graph properties and using the regularity lemma. A lower bound for triangle-freeness.
  - Bounded-degree and sparse graphs: Connectivity, Diameter.
  - Directed graphs: Acyclicity.
- Algebraic properties and locally testable codes: Linearity and Low-Degree Polynomials.
- Properties of functions: Monotonicity, and basic properties of Boolean functions.
- Clustering.
- Approximating the weight of a Minimum-weight Spanning Tree.
- Approximating the distance to properties.
- Average degree approximation, higher moments, and counts of small subgraphs.
- Testing properties of Distributions.
- Streaming algorithms.
- Sampling almost uniformly in sublinear time.

Written Material

The course is based on several papers that have been published over the last couple of decades. I will upload lectures notes, if available, and post links to papers when helpful. There is also a textbook on Property Testing: Introduction to Property Testing:
`https://www.wisdom.weizmann.ac.il/õded/pt-intro.html`.

Course Requirements

Homework assignments will be given about once every two-three weeks. They will constitute 10% of the final grade. Cooperation is allowed but each student must write his/her own solution.

There will be short weekly quizzes posted on the course website to help you keep yourself in the picture. They will constitute 5% of the final grade.

There will be a final project that will involve reading, summarizing, and presenting research papers on sublinear algorithms. Before/after each presentation, there will be a short oral quiz concerning material studied in the course.