Summary

In this course we will define rigorous mathematical models for computing on large datasets, cover main algorithmic techniques that have been developed for sublinear (e.g. faster than linear time) data processing. We will also discuss limitations inherent to computing with constrained resources.

Content

The tentative list of topics is:

**Streaming:** given a large dataset as a stream, how can we approximate its basic properties using a very small memory footprint? Examples that we will cover include statistical problems such as estimating the number of distinct elements in a stream of data items, finding heavy hitters, frequency moments, as well as graphs problems such as approximating shortest path distances, maximum matchings etc.;

**Sketching:** what can we learn about the input from a few carefully designed measurements (i.e. a `sketch`) of the input, or just a few samples of the input? We will cover several results in sparse recovery and property testing that answer this question for a range of fundamental problems;

**Sublinear runtime:** which problems admit solutions that run faster than it takes to read the entire input? We will cover sublinear time algorithms for graph processing problems, nearest neighbor search and sparse recovery (including Sparse FFT);

**Communication:** how can we design algorithms for modern distributed computation models (e.g. MapReduce) that have low communication requirements? We will discuss graph sketching, a recently developed approach for designing low communication algorithms for processing dynamically changing graphs, as well as other techniques.

Keywords

streaming, sketching, sparse recovery, sublinear algorithms

Learning Prerequisites

**Required courses**

Bachelor courses on algorithms, complexity theory, and discrete mathematics

**Important concepts to start the course**

*Discrete probability; mathematical maturity*

Learning Outcomes

By the end of the course, the student must be able to:

- Design efficient algorithms for variations of problems discussed in class
• Analyze space/time/communication complexity of randomized algorithms
• Prove space/time/communication lower bounds for variations of problems discussed in class
• Choose an appropriate algorithmic tool for big data problem at hand

Teaching methods
Ex cathedra, homeworks, final

Assessment methods
Continuous control

Supervision
Office hours  Yes
Assistants  Yes
Forum  Yes