Spring 2007 Theory Seminar

Thursdays 3-4 p.m., 3405 Siebel Center

Organized by Chandra Chekuri
Theory Seminar gnome: Nitish Korula

If you're a theory student, sign up for CS 591cc. Also, email Nitish to sign up for a talk.

Thursday, April 26th, 2007: (3 p.m., at 3405 Siebel Center)
Ke Chen will give a talk on Approximation algorithms for k-medians with m outliers

We consider approximation algorithms for the k-median with outliers problem. We are given a set of n data points in a metric space, and we want to remove m points (called outliers) from the data, such that the cost of the k-median clustering of the remaining points is minimized. We present an algorithm for computing a constant-factor approximation solution for this problem.

In the previous semester, part 1 of this result was presented; this talk covers part 2.

Thursday, April 19th, 2007: (3 p.m., at 3405 Siebel Center)
Erin Wolf Chambers will give a talk on Continuous Frechet Distance Between Two Curves in the Punctured Plane

The Frechet distance between two curves, the so-called dog-leash distance, is the minimum length of a leash required to connect a dog and its owner as they walk continuously along their respective curves from one endpoint to the other. We introduce a novel and important continuity requirement on the motion of the leash in the presence of obstacles. We define the continuous Frechet distance between two curves and give polynomial time algorithms to compute this distance between two polygonal curves in the plane minus point obstacles.

Thursday, April 12th, 2007: (3 p.m., at 3405 Siebel Center)
Tracy Grauman will give a talk on Distance-Preserving Approximations of Polygonal Paths

We are interested in finding an approximation Q to a given a polygonal path P in d-dimensional Euclidean space. In particular, we're looking for a t-distance-preserving approximation, which is to say that each straight-line edge (p_i, p_j) of Q approximates the distance between p_i and p_j measured along the original path P within a factor of a given real number t \geq 1.

Thursday, April 5th, 2007: (3 p.m., at 3405 Siebel Center)
Pratik Worah will give a talk on Counting Problems in the Plane

A few counting problems on the plane are presented. For example, given a set of points P on the plane they induce \binom(n, 3) triangles. Now, given a point p, we define f_p to be the number of triangles containing p. The aim is to put bounds on max(f_p), where the max is taken over p.

Thursday, March 29th, 2007: (3 p.m., at 3405 Siebel Center)
Nitish Korula will give a talk on A 2+\epsilon approximation for Undirected Orienteering

In the Orienteering problem, we are given a graph with edge lengths, and a fixed budget B; the goal is to find a walk in G that visits as many vertices as possible subject to the constraint that the total length of the walk is at most B. In the rooted version, we are also given a desired start vertex s; the goal is to find a walk of length at most B that begins at s and maximizes the number of vertices visited. Finally, in the point-to-point version of this problem, we are given both a desired start vertex s and an end vertex t.

Blum, Chawla, et al. gave the first constant-factor approximation algorithm for the rooted orienteering problem; their algorithm had an approximation ratio of 4. Bansal et al. observed that this approach could easily be extended to obtain a 3-approximation to the more general point-to-point version. We give an algorithm that, for any \epsilon > 0, obtains a 2+\epsilon - approximation to the point-to-point orienteering problem.

This is joint work with Chandra Chekuri and Martin Pal.

Thursday, March 15th, 2007: (3 p.m., at 3405 Siebel Center)
Mike Rosulek will give a talk on Anonymous Rerandomizable RCCA Encryptions
In this talk, we'll look at public-key encryption schemes in which encryption hides the content of the message and its recipient (in the strongest possible way), and yet anyone who sees an encryption can make a "copy" that cannot be linked to the original. Such schemes have applications in anonymous routing networks, as well as being of theoretical interest. I'll describe how to formally define the necessary security properties, and then describe our construction which achieves these properties. It is the first efficient encryption scheme to achieve these security properties, and the first which uses a standard cryptographic assumption. Finally, I'll describe the key ideas of our proofs of security.

This talk is the result of joint work with Manoj Prabhakaran.

Thursday, March 8th, 2007: (3 p.m., at 3405 Siebel Center)
Sariel Har-Peled will give a talk on **Embeddings of Moving Points in Euclidean Space**

Let \( S(t) \) be a set of moving points in \( \mathbb{R}^d \). We show that any set of \( n \) points with motion of bounded winding degree \( u \) in \( \mathbb{R}^d \) admits an embedding into \( \mathbb{R}^k \) with distortion \( 1+\epsilon \) where \( k=O(\epsilon^{-2} \log(n \ u / \epsilon) ) \) is independent of the dimension \( d \). This result can be viewed as a generalization of the classical Johnson-Lindenstrauss Lemma for static point sets. We also show that the above embedding preserves the radius of the smallest enclosing ball of the moving points within an approximation factor of \( 1+O(\epsilon^{1/3}) \) at every moment of the motion.

This is a joint work with Pankaj K. Agarwal and Hai Yu. The paper is available online.

Thursday, March 1st, 2007: (3 p.m., at 3405 Siebel Center)
Chandra Chekuri will give a talk on **Multi-route Flows and Cuts**

Multi-route flows were introduced a little over a decade ago by Kishimoto as a generalization of standard flows. The motivation was fault tolerance in routing. In standard routing between two nodes \( s \) and \( t \) in a graph \( G \) can be thought of as assigning non-negative numbers to each path between \( s \) and \( t \). In \( k \)-route flows, where \( k>1 \) is an integer, one assigns non-negative numbers to the collection of \( k \)-edge-disjoint paths between \( s \) and \( t \). One can compute the maximum \( k \)-route flows for single-source single sink and also multi-commodity versions using linear programming. For single-source single-sink nice characterizations are also known.

I will describe the background and the way \( k \)-route flows differ from 1-route flows (the standard flows). The main interest for me is the associated cut questions for which the \( k \)-route flows are dual. Here is a problem. Given \( s \) and \( t \) in a graph \( G \) with edge capacities/costs, remove the minimum cost set of edges such that \( s \) and \( t \) are disconnected. If \( k=1 \) this is the regular min-cut. However, if \( k>1 \) then we do not need to disconnect \( s \) and \( t \) but only reduce their connectivity to \( k-1 \). Max-flow min-cut properties do not hold for \( k>1 \). I will discuss open problems on computing cuts via \( k \)-route flows.

Thursday, Feb 22nd, 2007: (3 p.m., at 3405 Siebel Center)
Jeff Erickson will give a talk on **Two Open Shortest-path Problems**

Suppose we have a bunch of Euclidean triangles glued together into a topological sphere, such that every vertex has total angle less than \( 2\pi \). A classical theorem of Alexandrov states that this piecewise-linear sphere is isomorphic as a metric space to a unique convex polyhedron, but possibly with a (VERY) different facets structure? How quickly can we compute the shortest path between two points in this space?

I (Jeff) played in 7th grade. A race track is drawn on a piece of graph paper. Each player has a race car, represented as a point with integer coordinates \((x,y)\) and with an integer velocity vector \((a,b)\). Initially, every car starts on a common start line with velocity \((0,0)\). In each turn, each player changes his velocity by at most \( 1 \) in each coordinate and then moves his car by the new velocity (from \((x,y)\) to \((x+a,y+b)\)). If a car crosses the boundary of the race track, it is removed from the race. The first surviving car to cross the finish line wins. How quickly can we compute the shortest path (meaning the minimum number of steps) to the finish line, if the race track is specified by a list of line segments?

Both of these problems are in \( \text{PSPACE} \); nothing else is known about their complexity, except in special cases. In both cases, an explicit description of the shortest path can have length exponential in the number of input bits. However, there seems to be enough structure in the shortest paths to allow a COMPRESSED representation of polynomial size, so a polynomial-time algorithm is not completely out of the question. Or maybe the problems are \( \text{PSPACE-complete} \) after all.

Thursday, Feb 8th, 2007: (3 p.m., at 3405 Siebel Center)
Deepak Ramachandran will give a talk on **Solving Markov Decision Processes in Metric Spaces**

We present an approximation scheme for solving Markov Decision Processes (MDPs) in which the states are embedded in a metric space. Our algorithm has a time bound of \( \mathcal{O}(n^4 \log \log n / \epsilon) \), independent of the numerical size of the input and the discount factor. We will prove the result for deterministic MDPs and then discuss the extension to stochastic MDPs. Unlike most MDP algorithms, ours does not make local iterative updates, but uses a divide and conquer approach. It partitions the space into nested regions and considers only policies that transition between partitions through **portals**. A simple dynamic program suffices to obtain the optimal portal-respecting policy which is shown to be close to the true optimum. Our technique is very general and is likely to give insight into more difficult problems like Reinforcement Learning and Partially Observable MDPs.

Thursday, Feb 1st, 2007: (3 p.m., at 3405 Siebel Center)
Nitish Korula will give a talk on **The Prize-collecting Steiner-tree Problem**

[Note: The rest of the content is not included in the provided text.]
In the prize-collecting steiner tree problem, we are given a graph, a cost $c(e)$ on each edge $e$, and a penalty $p(v)$ for each vertex $v$. Our aim is to find a minimum-cost tree, where the cost of a tree is the sum of the costs of the edges in the tree, and the penalty of vertices not in the tree. This generalizes other well-known NP-complete problems such as the Steiner Tree problem. We present a 2-approximation algorithm for the prize-collecting Steiner-tree problem due to Goemans and Williamson.

**Thursday, Jan 25th, 2007:** (3 p.m., at 3405 Siebel Center)  
Prof. Sanjeev Khanna from the University of Pennsylvania will give a talk on **Disjoint Paths in Networks**.

A fundamental problem in combinatorial optimization is the edge-disjoint paths problem (EDP). We are given a network and a collection of source-destination pairs in the network. The goal is to maximize the number of pairs that can be connected by edge-disjoint paths (i.e. the paths can not share any edges). Even special cases of EDP correspond to non-trivial optimization problems and the problem becomes NP-hard in very restricted settings. A well-studied approach for designing approximation algorithms for EDP is to use the multicommodity flow relaxation. In this talk, we will describe some recent progress on understanding the integrality gap of the multicommodity flow relaxation as well as present some new hardness of approximation results for EDP and related problems in directed graphs.

### Links to Theory Seminars from Previous Semesters

- Fall 2006 Theory Seminar