We present improved and simplified IO-efficient algorithms for map overlay and point location in planar subdivisions (also called planar maps). These are two important problems in computational geometry with application in Geographic Information Systems (GIS). We analyze the IO-complexity of our algorithms on the popular external-memory IO-model. We show that the IO-complexity scales well with both the parameters of the memory hierarchy and the geometric complexity of the input. Our algorithms and data structures improve on the previous best known bounds for general subdivisions both in the number of IOs and storage space; they are significantly simpler and easier to implement.

Specifically, we show how to pre-process a so-called low-density subdivision with \( n \) edges in \( O(\text{sort}) \) IOs into a compressed linear quadtree such that one can:

1. compute the overlay of two such preprocessed subdivisions in \( O(\text{scan}) \) IOs, where \( n \) is the total number of edges in the two subdivisions, and
2. answer a single point location query in \( O(\log_B n) \) IOs and \( k \) batched point location queries in \( O(\text{scan} + \text{sort}(k)) \) IOs.

For the special case where the subdivision is a fat triangulation, we show how to obtain the same bounds with an ordinary (uncompressed) quadtree, and we show how to make the structure fully dynamic using \( O(\log_B n) \) IOs per update.

This is joint work with Mark de Berg, Herman Haverkort, and Laura Toma. It will appear at ISAAC in December 2007.
We consider the problem of maximizing a submodular function \( f(S) \), where the only additional assumption on \( f(S) \) is non-negativity. This generalizes several NP-hard problems, including Max Cut, Max Directed Cut and Max Cut in hypergraphs.

We present several constant-factor approximation algorithms for this problem: 1/4-approximation achieved by a random set, 1/3-approximation by local search and 2/5-approximation by randomized local search. In the special case of symmetric submodular functions, we get a 1/2-approximation. In contrast to Max Cut problems, we prove that this is optimal, in the sense that a better approximation would require exponentially many queries to \( f(S) \).

Joint work with Uriel Feige and Vahab Mirrokni.

Thursday, September 20, 2007
Ke Chen: Noisy Binary Search and Its Applications, by Richard M. Karp and Robert Kleinberg

We study a noisy version of the classic binary search problem of inserting an element into its proper place within an ordered sequence by comparing it with elements of the sequence. In the noisy version we can not compare elements directly. Instead we are given a coin corresponding to each element of the sequence, such that as one goes through the ordered sequence the probability of observing heads when tossing the corresponding coin increases. We design online algorithms which adaptively choose a sequence of experiments, each consisting of tossing a single coin, with the goal of identifying the highest-numbered coin in the ordered sequence whose heads probability is less than some specified target value. Possible applications of such algorithms include investment planning, sponsored search advertising, admission control in queueing networks, college admissions, and admitting new members into an organization ranked by ability, such as a tennis ladder.

Thursday, September 13, 2007
Sariel Har-Peled: Shortest Open Approximation to a Convex Curve

Let \( C \) be a closed convex curve in the plane, which has radius of curvature at least \( 2\delta \) everywhere. We give a complete categorization of the shortest open curve \( \gamma \), such that any point on \( C \), has a point on \( \gamma \), in distance at most \( \delta \) from it.

This is a joint work with
Hee-Kap Ahn, Otfried Cheong and Mira Lee

Thursday, September 6, 2007:
Chandra Chekuri: Algorithmic Challenges in Optical Network Design

Optical dense wavelength division multiplexing (DWDM) technology enables very high capacity backbone networks but at the cost of extremely expensive equipment. These high costs and reliability requirements make it critical to optimize the network design process. However, the associated design problems involve many difficult algorithmic challenges. In this talk we provide a high level overview of the design desiderata and then focus on two clean optimization problems: buy-at-bulk network design (with protection) and wavelength provisioning with continuity. The former concerns choosing disjoint routes for each demand so as to take advantage of the economies of scale in deploying optical components. The latter concerns assigning wavelengths so that traffic demands sharing a common fiber are carried on distinct wavelengths. We discuss the complexity of the first problem and present a survey of approximation algorithms.

This talk is the same as the first half of a 90min tutorial that was presented at a DIMACS workshop in August jointly with Lisa Zhang of Bell Labs. You can find the full set of slides from that presentation at the URL below. http://dimacs.rutgers.edu/Workshops/NextGenerationNetworks/slides/ChekuriZhang.pdf

Thursday, August 30, 2007:
Jeff Erickson: Finding Small Holes: A Brief Foray Into Computational Topology

Numerous applications call for the detection of small topological features in various spaces; examples include simplification of surfaces reconstructed from point clouds, efficient algorithms for graphs embedded on surfaces, coverage analysis for ad-hoc/sensor networks, and topological analysis of high-dimensional data. This talk is a survey algorithms for one of the simplest problems of this type: finding the shortest cycle in a given topological space that cannot be continuously contracted to a point. Spaces of interest include polygons with holes, combinatorial surfaces, piecewise-linear 2-manifolds, Rips-Vietoris complexes, and general simplicial complexes. Almost no optimal algorithms are known, even in settings where the problem has a straightforward polynomial-time solution; consequently, the talk will include several open problems. No prior knowledge of topology will be assumed.

Links to Theory Seminars from Previous Semesters

Spring 2007 Theory Seminar
Fall 2006 Theory Seminar