THE FIELDS INSTITUTE

AVNER MAGEN MEMORIAL LECTURE

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Lower bounds on the size of semidefinite programming relaxations

MAY 29, 2015 AT 11AM • BAHEN CENTER, ROOM BA1170

We introduce a method for proving lower bounds on the size of semidefinite programming relaxations for combinatorial problems. In particular, we show that the cut, TSP, and stable set polytopes on n-vertex graphs are not the affine image of the feasible region of any spectrahedron of dimension less than 2^{n^c} for some constant c > 0. A spectrahedron is the feasible region of an SDP: The intersection of the positive semidefinite cone and an affine subspace. This yields the first super-polynomial lower bound on the semidefinite extension complexity of any explicit family of polytopes. Our results follow from a general technique for proving lower bounds on the positive semidefinite rank of a nonnegative matrix. To this end, we establish a close connection between arbitrary SDPs and those arising from the sum-of-squares hierarchy. This can be alternately stated in the language of proof complexity and sum-of-squares representations of nonnegative real polynomials. For approximating maximum constraint satisfaction problems, we prove that SDPs of polynomial size are equivalent in power to those arising from degree-O(1) sum-of-squares relaxations. This implies, for instance, that no polynomial-size family of SDP relaxations for MAX-3SAT can achieve better than a 7/8 approximation.

This is joint work with Prasad Raghavendra and David Steurer.

Professor Lee (University of Washington) studies algorithms and complexity through the lens of analysis and geometry.

ABOUT AVNER MAGEN

Avner Magen was tragically killed in a climbing accident in Alaska on May 29th, 2010. Avner was a beloved and devoted father, husband and son; a terrifically warm, funny, and energetic person; a brilliant and creative researcher; and a wonderful friend and colleague.

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