CORE Seminar:

Nonnegative polynomials: from optimization to control and learning

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Friday, May 17, 2:30 PM in ECE 037

Abstract. The problem of recognizing nonnegativity of a multivariate polynomial has a celebrated history, tracing back to Hilbert's 17th problem. In recent years, there has been much renewed interest in the topic because of a multitude of applications in applied and computational mathematics and the observation that one can optimize over an interesting subset of nonnegative polynomials using "sum of squares optimization".

In this talk, we give a brief overview of some of our recent contributions to this area. In part (i), we propose more scalable alternatives to sum of squares optimization and show how they impact verification problems in control and robotics. Our algorithms do not rely on semidefinite programming, but instead use linear programming, or second-order cone programming, or are altogether free of optimization. In particular, we present the first Positivstellensatz that certifies infeasibility of a set of polynomial inequalities simply by multiplying certain fixed polynomials together and checking nonnegativity of the coefficients of the resulting product.

In part (ii), we study the problem of learning dynamical systems from very limited data but in presence of "side information", such as physical laws or contextual knowledge. This is motivated by safety-critical applications where an unknown dynamical system needs to be controlled after a very short learning phase where a few of its trajectories are observed. (Imagine, e.g., the task of autonomously landing a passenger airplane that has gone through sudden wing damage.) We show that sum of squares and semidefinite optimization are particularly suited for exploiting side information in order to assist the task of learning when data is limited. Joint work with A. Majumdar and G. Hall (part (i)) and with B. El Khadir (part (ii)).

Biography. Amir Ali Ahmadi (http://aaa.princeton.edu/) is a Professor at the Department of Operations Research and Financial Engineering at Princeton University and an Associated Faculty member of the Program in Applied and Computational Mathematics, the Department of Computer Science, the Department of Mechanical and Aerospace Engineering, and the Center for Statistics and Machine Learning. Amir Ali received his PhD in EECS from MIT and was a Goldstine Fellow at the IBM Watson Research Center prior to joining Princeton. His research interests are in optimization theory, computational aspects of dynamics and control, and algorithms and complexity. Amir Ali's distinctions include the Sloan Fellowship in Computer Science, a MURI award from the AFOSR, the NSF CAREER Award, the AFOSR Young Investigator Award, the DARPA Faculty Award, the Google Faculty Award, the Howard B. Wentz Junior Faculty Award as well as the Innovation Award of Princeton University, the Goldstine Fellowship of IBM Research, and the Oberwolfach Fellowship of the NSF. His undergraduate course at Princeton (ORF 363, ``Computing and Optimization'') has received the 2017 Excellence in Teaching of Operations Research Award of the Institute for Industrial and Systems Engineers and the 2017 Phi Beta Kappa.