M10 Applied Algebra

Organiser: Joonas Pääkkönen, *Aalto University*

1. Applications of Lie Groups to Wireless Communications and Shape Recognition

David Karpuk, *Aalto University*

A Lie group is, roughly, a smooth geometric object on which one can multiply points. For example, the group of real invertible n x n matrices is a Lie group. The structure inherent in such objects necessarily places them at the intersection of algebra, analysis, and topology. In this talk we will broadly introduce some basic notions associated with Lie groups, with the goal of demonstrating some real-world applications to wireless communications and shape recognition. These two applications roughly correspond to performing steepest descent and principal component analysis on Lie groups, respectively.

2. An Algebraic Approach to Rank-Constrained Beamforming

Matthew Morency, *Aalto University*

This works presents a new approach to solving the rank constrained beamforming problem. Instead of relaxing the problem to a feasible set of the positive semidefinite matrices, we restrict the problem to a space of polynomials whose dimension is equal to the desired rank. The solution to the resulting optimization is then required to be full rank, allowing a simple matrix decomposition to recover the beamforming matrix exactly. Simulation results show an exact agreement of the solution with the proposed algebraic structure, as well as significant performance benefits in terms of sidelobe suppression compared with previous methods.

3. Symmetry in Algorithmic and Quantitative Real Algebraic Geometry

Cordian Riener, *Aalto University*

This talk will present some results on aspects of symmetries in quantitative real algebraic geometry. More concretly, the talk will first present some classical connections of Real Algebraic Geometry and Complexity theory, which link the topological complexity of a semi-algebraic set (measured by the Betti numbers) to the algorithmic complexity of certain algorithmic questions. This connection motivates the study of bounds for Betti numbers of classes of semi-algebraic sets. In this context I aim to present recent results on bounds for the structure of (co)homology modules of symmetric semi-algebraic sets.

4. Applications of Matroid Theory to Coding Theory

Thomas Westerbäck, *Aalto University*

Matroid theory was introduced to capture and generalize certain fundamental properties of dependence common to vector spaces and graphs. The theory of matroids has since its introduction blossomed and is today a rich topic in algebraic combinatorics with connections to many areas of mathematics and modern science. Matroid-theoretic methods have recently started to play an important role in several areas of coding theory, such as network coding, distributed storage and index coding. In this talk we will present how tools from matroid theory can be connected to some areas in coding theory and how these tools can be used in order to get new results.