Course Announcement - UC Berkeley - Spring 2014

Math 275: Introduction to Non-Linear Algebra

Instructor: Bernd Sturmfels

Office hours: Mondays 8-9, Wednesdays 10:30-11:30, or by appointment

Time and Place: Mondays, Wednesdays and Fridays, 9:00-10:00am, 81 Evans Hall

Prerequisites: Strong foundation in undergraduate algebra (Math 110, 113, 143). Experience with mathematical software.
Familiarity with graduate level mathematics in topics such as numerical linear algebra, optimization, or algebraic geometry.

Description: Many models in the sciences and engineering can be described by non-linear polynomial equations.
This course offers an introduction to both theoretical and computational methods for working with such models. It is aimed at graduate students from across the mathematical sciences (Mathematics, EECS, Statistics, Physics, etc).

Consultants: Qingchun Ren and Jose Rodriguez will help with the course.
One of them will be available for your questions on Fridays between 11am and 1pm.

Course Work: Seven homework sets and one term paper

Homework: There will be seven weekly assignments, posted below. Please turn in hard copies during class on Mondays.
Homework 1 is due Monday, January 27.
Homework 2 is due Monday, February 3.
Homework 3 is due Monday, February 10.
Homework 4 is due Wednesday, February 19.
Homework 5 is due Monday, February 24.
Homework 6 is due Monday, March 3.
Homework 7 is due Monday, March 10.

Term Paper: Write a term paper on a relevant topic of your choice. Collaborations are encouraged, especially if you collaborate with another students whose background is different from yours.
Paper Deadlines: Proposal due March 12, First Draft due April 16, Final Version due May 7.
Term papers are posted below, next to the names of the students and their presentation dates.

Primary Text: Solving Systems of Polynomial Equations, American Mathematical Society, 2002.

Other Recommended Books:
Bates-Hauenstein-Sommese-Wampler: Numerically Solving Polynomial Systems with Bertini, SIAM, 2013.
Blekherman-Parrilo-Thomas: Semidefinite Optimization and Convex Algebraic Geometry, SIAM, 2013.
Cox-Little-O'Shea: Using Algebraic Geometry, Springer, 2005.
Landsberg: Tensors: Geometry and Applications, American Mathematical Society, 2012.
Sottile: Real Solutions to Equations from Geometry, American Mathematical Society, 2011.

Syllabus: Each week of the semester is about a different topic in non-linear algebra, according to the schedule below.
Auditors interested in a particular topic are welcome to attend just that week. Enrolled students will attend all weeks.

Jan 22-24: Gröbner Basics
Jan 27-31: Elimination
Feb 3-7: Decomposing Varieties
Feb 10-14: Sparse Polynomial Systems
Feb 19-21: Semidefinite Programming
Feb 24-28: Nonnegative Polynomials and Sums of Squares
Mar 3-7: Invariant Theory and Tensors
Mar 10-14: Representation Theory and Tensors
Mar 17-21: Tropical Algebra
Mar 31-April 2: Nash Equilibria

April 4: Shamil Shakirov: Nonlinear algebra in physics
April 7: Jose Rodriguez: Numerical algebraic geometry
April 9: Qingchun Ren: Phylogenetics
April 11: Bernd Sturmfels: Get real

April 14-18: No Lectures

April 21: Ralph Morrison: Commuting tropical matrices
Joe Kileel: The calibrated trifocal variety
April 23: Andrew Lampinen: Minimal embedding dimension bounds for receptive fields
Kaie Kubjas and Zvi Rosen: Completion of rank one probability matrices
April 25: Jacob Emmert-Aronson and Moor Xu: Quintic spectrahedra
Frank Ban: Permanent versus determinant
April 28: Marco Vivero Avila: Retrosynthetic analysis via weighted graphs
Elina Robeva: Orthogonal tensor decomposition
April 30: Weiqiao Han: Singularities and genus of the k-ellipse
Danny Hermes: Principal components analysis in non-Euclidean spaces
May 2: Eric Lee and Madhusudan Manjunath: Steady states in metabolism
Emmanuel Tsukerman: Dimension of Gram spectrahedra
May 5: Matt Xuan: Duality and optimization
Bo Lin: Almost toric hypersurfaces