Winter 2006

2006 (Winter)

University of Dayton. Department of Mathematics

Mathematics Colloquium Schedule: Winter 2006

Department of Mathematics

Contraction Mapping Principle and Resolvent Properties of Volterra Equations
Dr. Muhammad Islam
Abstract: Contraction mapping principle is employed to obtain three important properties of the resolvent kernel of a linear Volterra integrodifferential equations. These properties have been extensively studied by many researchers during the last 40 years using various methods including Lyapunov's method and the methods of mathematical transforms. In this talk the contraction mapping will be applied to obtain these properties under a very simple and easily verifiable condition. Possible extensions of these results to more general equations including nonlinear perturbed equations as well as integral equations will be discussed.

Kauffman NK Model - A Stochastic Combinatorial Optimization Model for Complex Systems
Hemanshu Kaul
Abstract: Many scenarios in theoretical biology, physics, and management science can be modeled as discrete complex systems with several interacting components that can be in various states. The aim is to maximize a performance measure involving contributions from each component. This measure may depend on both the state of each component and on interactions between components. In 1987, Kauffman and Levin introduced a combinatorial optimization model for such systems, called the Kauffman NK model, where N is the number of components of the system and K measures the interaction between the components. This was proposed to model the evolution of genomes in theoretical biology but has since been applied in other areas as listed above.

Previous research on the NK model has emphasized simulations and analysis of local optima. Here we focus on rigorous results for global optima. We describe a computational setup using a stochastic network model, which leads to applicable strategies for computing bounds on global optima. Recent papers used tools from analysis and probability to obtain bounds on the expected value of the global optima for fixed K and large N. We present bounds when K grows with N, using ideas and tools from graph theory, probabilistic combinatorics and order statistics. These general ideas are then applied to the analysis of the cases when underlying distributions are uniform and normal distributions.

Hemanshu Kaul was born and raised in India. He has a B.Sc.(Honors) in mathematics from St.Stephen's College, Delhi and a M.Sc. mathematics from Indian Institute of Technology, Bombay. Currently, he is a graduate student at the Department of Mathematics, University of Illinois at Urbana-Champaign. He works in the fields of Discrete Mathematics and Operations Research, especially graph theory, discrete optimization, and their applications, with his two advisors from Mathematics and Industrial Engineering, and other collaborators.

Recognizing Bipartite Tolerance Graphs
Dr. Arthur Busch
Abstract: Interval graphs were first introduced in the late 1950s as a way to model the (then unknown) structure of DNA and have also been useful in analyzing certain scheduling problems. Since their introduction, many generalizations of interval graphs have been suggested, and the study of interval graphs and their generalizations has led to results in a variety of fields including biology, computer science, and mathematics. We will discuss the relationships between interval graphs, probe interval graphs, tolerance graphs and interval bigraphs and digraphs, as well as the algorithms for determining if

a graph G belongs to one or more of these classes. We will then focus on the class of tolerance graphs, and building on a characterization of bipartite tolerance graphs, we will outline a linear-time algorithm to recognize and certify when a bipartite graph is a tolerance graph. An extension of this work gives a related algorithm for the class of bipartite probe interval graphs.

Pseudocodewords and Iterative Decoding of LDPC Codes

Christine Kelley

Abstract: Error-correcting codes are used in everyday practical applications such as digital-storage media, wireline and wireless networks, and satellite and deep-space communication systems. Among the many types of codes, those which have underlying graph representations, the so-called "codes on graphs", have gained widespread importance over the last decade. Low-density parity-check (LDPC) codes are a class of codes that can be described on sparse graphs. The popularity of LDPC codes is due to their simple decoding. The complexity of a graph-based iterative decoder that operates on a graph representation of a block length n LDPC code is only $O(n)$. However, these iterative decoders are sub-optimal in the sense that they use only the local graph structure of the code for decoding. Discrepancies between iterative and optimal decoding of LDPC codes have recently been attributed to the presence of pseudocodewords. In this talk, we will begin with a brief background on LDPC codes and iterative decoding. We will then look at the effect of pseudocodewords on decoding performance and obtain some lower bounds on the minimum pseudocodeword weight for LDPC codes using the underlying LDPC constraint graph properties, including graph expansion.

Braids and Loop Braids

Dr. Alissa Crans

Abstract: It is well known to physicists that in 3d spacetime, the process of exchanging identical particles is described by a representation of the braid group, B_n. In fact, we get an action of B_n on the configuration space for n identical particles. It turns out that a similar result holds for exchanging particles in 4d spacetime. In this situation, we obtain a theory governed not by the braid group, but by a larger group: the ‘loop braid group.’ This group has a set of generators that describe two circles trading places without passing through each other, just as if they were point particles, but also a set of generators that switch two loops by passing one through the other. The first set generates a copy of the symmetric group, while the second generates a copy of the braid group. We will carefully describe this loop braid group, give its presentation, and show it is isomorphic to the more familiar ‘braid permutation group.’

Bio: Alissa Crans earned her PhD in 2004 at the University of California, Riverside in Lie 2-Algebras. She is currently a VIGRE Ross Assistant Professor at The Ohio State University. Dr. Crans investigates properties of structures with fascinating names like loops and braids and quandles. As an undergraduate, Dr. Crans studied at the University of Redlands, and was chosen to participate in Carleton College's Summer Mathematics Program in 1997 and in the REU at the College of William and Mary in 1998. Now Dr. Crans regularly participates in programs designed for undergraduate research and/or enhancement in mathematics. She has been a presenter at Carleton College's Summer Mathematics Program, the Nebraska Conference for Undergraduate Women, the EDGE program, and our Undergraduate Mathematics Day. She is a judge for the undergraduate poster session at the Joint Mathematics Meetings. Her honors include being chosen as a 2004-05 Project NExT Fellow, receiving a grant from the MAA for an undergraduate conference later this month in California, and receiving an AWM travel grant to attend a conference in Australia last year.

Asymptotic Stability for Second Order Dynamic Equations on Time Scales
Dr. Gro Hovhannisyan
Abstract: Exponential decay and stability of solutions of dynamic equations on time scales was investigated in papers of R. Aulbach, S. Hilger, C. Potzsche, S. Siegmund, F. Wirth, A. Peterson, C. C. Tisdell, A. Peterson, Y. Raffoul by using Lyapunov method. We use different approach of Levinson based on asymptotic solutions. To examine asymptotic stability of second order dynamic equation on a time scale we establish stability estimates using calculus on time scales, integral representations of solutions via asymptotic solutions, and error estimates.

A FFT and Moment Match Based VUL Rider Pricing
Ran Huang
Abstract: Variable Universal Life (VUL) is a popular product in insurance industry that combines investment with insurance. Rider is an embedded option that offers minimum guaranteed amount at the maturity. In this talk, we first present the mathematical model of the underlying asset price. The model is different from the commonly used Geometrical Brownian Motion (GBM) model. We then propose a FFT algorithm using moment match technique. We conduct numerical simulations and compare the results with the Monte Carlo simulations and finite difference solutions of the PDE satisfied by the price function. By comparing the simulation results of the three numerical methods, we are able to show the feasibility and advantages of the FFT and moment match based method.

An Advanced Financial Analysis Toolkit for Excel
David Martin
Abstract: Excel is a commonly used tool in the financial industry today. The goal was to use John C. Hull's "Options, Futures and Other Derivatives" and Salih N. Neftci's "An Introduction to the Mathematics of Financial Derivatives" to develop an advanced financial analysis toolkit for excel. The package includes the Black-Scholes analytic solution for Option Pricing, binomial tree option pricing models, trinomial tree option pricing models, and their associated Greeks. The package was tested against DerivaGem Software (included in John C. Hull's "Options, Futures and Other Derivatives") and the Financial Derivates Toolkit for MATLAB® for speed and accuracy.

Implied and Realized Volatility for Soybean Option
Masako Yatsuki
Abstract: Volatility measures how much the prices are likely to change and is an important tool for pricing option and making investment decisions. Two methods that have been used to predict the volatility of stock and commodity prices are time series analysis and implied volatility. Time series methods employ the GARCH model to account for changes in volatility over time. Only the basic price data for predictions of future price and volatility are employed. Implied volatility is obtained using the Black Option Pricing Formula which employs information from option prices and requires iterative numerical algorithms. These two methods are illustrated and compared using soybean and its option prices.

A Review of Energy Harvesting Potential
Matthew Kocoloski
Abstract: The issue of peak oil production has recently come to the forefront of discussions in economic,

engineering, and environmental circles. Many experts predict that peak oil production will occur within the next 20 years, if not before. Following peak oil production, the production of oil will begin to decline, and oil will no longer be able to serve as the primary source for society's energy requirements. Thus, if the world wishes to continue to develop socially and industrially following peak oil production, alternative energy sources will have to be developed.

Energy harvesting technologies represent a very promising alternative energy source, one that could help solve the energy related problems that society will soon face. Energy harvesting technologies refer to those technologies that convert energy from the surrounding environment into a useable form of energy, usually in the form of electricity, and include solar photovoltaic, thermoelectric, thermionic, and piezoelectric devices. Under the direction of Dr. Kevin Hallinan, I have been compiling a review of the potential held by these technologies. The project first quantifies the available energy for each of these technologies and identifies theoretical limitations to their conversion efficiency, often derived from basic first- and second-law thermodynamic analysis. Second, the project summarizes the current state of the art for each of these technologies and, in some cases, projects the future performance for these technologies. The current state of the art performance and future projections are then compared to the theoretical limitations, giving an idea of how well these technologies perform based on second-law efficiency. Finally, various technologies are compared with each other based on efficiency, specific power, and power density to determine which technologies would be best suited for a particular application.