Modern Mathematics Workshop 2018

SPEAKER TITLES/ABSTRACTS

Guest Speaker

Juan Meza

UC Merced

Bio: Dean Meza studies nonlinear optimization with an emphasis on methods for parallel computing. He has also worked on various scientific and engineering applications including scalable methods for nanoscience, power grid reliability, molecular conformation problems, optimal design of chemical vapor deposition furnaces, and semiconductor device modeling.

Title: NSF Highlights

Keynote Speaker

Javier Rojo, Korvis Professor of Statistics

Oregon State University

Bio: Javier received his Ph.D. in Statistics from the University of California at Berkeley under the direction of Erich L. Lehmann. He is currently the Korvis Professor of Statistics at Oregon State University. Prior to that, he was the Seneca C. and Mary B. Weeks endowed Chair of Statistics and Chair of the Department of Mathematics and Statistics at the University of Nevada at Reno. Prior to that he was Professor of Statistics at Rice University 2001-2013, and before that he was assistant, associate, and then full professor in the Department of Mathematical Sciences at the University of Texas, El Paso 1984-2001, where he was also the founding director of the BioStatistical Laboratory.

Javier is an elected Fellow of the following societies: American Statistical Association, The Institute of Mathematical Statistics, The Royal Statistical Society, The American Association for the Advancement of Science, and is an elected member of the International Statistical Institute. He also received the 2010 Don Owen award from the American Statistical Association, and recently

(Rojo - cont.)

received the 2018 Etta Z. Falconer award "*In recognition of your outstanding contributions to diversifying the landscape of the mathematical and statistical sciences through excellence, mentorship and leadership*". He served (1998-1999) as program director in the statistics and probability programs in NSF and has participated as a member and as chair of two subcommittees in the 2013 NSF-DMS Committee of Visitors. He again served in the NSF-DMS Committee of Visitors in 2016. He is a member of SAMSI's National Advisory Committee.

Title: Partial Orders of Distributions

Abstract: Partial orders of distributions permeate the theory of statistics and applications in Engineering, Economics, Finance, Extreme Value Theory, Genetics, etc. In this talk, we present two complementary approaches to defining and synthetizing several of these partial orders and some applications are presented. This talk is sponsored by Modern Math Workshop.

Mini Course Instructors

Ernest Fokoué

Rochester Institute of Technology

Bio: Fokoué was born and raised in Cameroon (Central Africa), and has been around mathematical sciences from his very early childhood. He studied Mathematics and Computer Science in Cameroon, and after his Bachelor of Science Degree in Mathematics and Computer Science and his Maitrise in Computer Science and Mathematics, he earned a Master of Science Degree in Neural Computation at Aston University in England and then a PhD in Statistics at Glasgow University in Scotland (UK). Fokoué is co-author of "Principles and Theory for Data Mining and Machine Learning", a statistics graduate textbook published by Springer-Verlag. He is also author of multiple peer-reviewed articles published in international journals and has been repeatedly invited as speaker and keynote speaker at various conferences. Fokoué has always greatly enjoyed the beauty and power that mathematics brings to problem solving and thrives on sharing his mathematical insights. Statistical Science in particular and specifically Statistical Machine Learning and Data Science are his passion, his profession and to some extent a substantial component of his vocation. Fokoué is the grateful father of his beloved daughter Ellie, and a faithful believer in the quintessential duality between scientific and authentic universal spiritual truths.

(Fokoué - cont.)

Title: Foundational Statistical Machine Learning Methods for Modern Data Science

Abstract: According to the standard Venn diagram depicting the building blocks of modern data science, algorithmics, mathematics and statistical machine learning combine to represent one of the three pillars of Data Science, along with application domain and computer science as the other two components. In this lecture, I will expose the audience to the foundational statistical machine learning methods for modern data science. The most frequently used methods of supervised learning, featuring both classification (pattern recognition) and regression are presented in greater details, with an emphasis on algorithmic clarity and statistical rigor.

Katie Newhall

University of North Carolina at Chapel Hill

Bio: Dr. Katherine Newhall is an assistant professor of mathematics at the University of North Carolina at Chapel Hill working on a diverse set of interdisciplinary applied math problems ranging from magnetic systems to granular media and active matter. She is tackling difficult problems in the field of stochastic dynamics to understand the large-scale and long-time behavior of physical and biological systems described by high-dimensional equations that evolve randomly in time. The mathematical problems she works on also help to explain experimentally observable phenomena, exposing the underlying mechanisms to intuitively explain the system's behavior.

Title: Stochastic Dynamics on Energy Landscapes

Abstract: Many intriguing dynamical properties of complex systems, such as metastability or resistance to applied forces, emerge from the underlying energy landscape. This course will address some of the fundamental connections between energy and dynamics while also touching on interesting research questions. We will derive energy conserving Hamiltonian systems as well as damped dynamics and investigate bifurcations in the energy function with applications in ferromagnetic systems.

(Newhall - cont.)

Adding noise to these systems, we will look at basic properties of Brownian motion, form a Langevin system, and derive the steady state Gibbs distribution and mean noise-induced transition time; both are functions of the energy and temperature of the system.

The same Gibbs distribution can also be formed using the Metropolis Hastings algorithm and we will investigate the equivalence of dynamics coming from the Langevin stochastic differential equation and the Metropolis Hastings created Markov chain under certain limits. Intriguing research questions are raised when increasing the dimension of the underlying energy landscape. A basic knowledge of (undergraduate course in) ordinary differential equations and probability would be helpful.

Speakers from Institutes

Cheng Cheng

SAMSI

Bio: Cheng Cheng got her Ph.D. in Mathematics in 2017 at University of Central Florida. She is a second-year postdoc at SAMSI affiliated with Duke University. Her research interests are applied and computational harmonic analysis such as phase retrieval, distributed sampling theory in signal processing.

Title: Nonsubsampled Graph Filter Banks and Distributed Implementation

Abstract: Graph signal processing provides an innovative framework to process data on graphs. A proper definition of the down-sampling and up-sampling procedures is not obvious especially when the residing graph is of large order and complicated topological structure. In this talk, I consider nonsubsampled graph filter banks (NSGFBs) which does not include down-sampling and up-sampling procedures, to process data on a graph in a distributed manner. For an NSGFB on a graph of large order, a distributed implementation has significant advantages, since data processing and communication demands for the agent at each vertex depend mainly on the topological structure of its small neighborhood. In this talk, I will introduce an iterative distributed algorithm to implement the proposed NSGFBs. Based on NSGFBs, we also develop a distributed denoising technique which is demonstrated to have satisfactory performance on noise suppression.

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Veronica Ciocanel

MBI

Bio: Veronica Ciocanel received her PhD in Applied Mathematics from Brown University in 2017, where her work focused on modeling spatial differentiation in early developing organisms such as frog oocytes. She joined the Mathematical Biosciences Institute at Ohio State as a Postdoctoral Fellow, and in 2018 she was selected as a President's Postdoctoral Scholar at The Ohio State University. At OSU, she collaborates with Dr. Adriana Dawes (Mathematics, Molecular Genetics) to develop agent-based models providing insight into motor-filament interactions, which are key in formation of contractile rings in the worm reproductive system. In addition, she collaborates with Dr. Anthony Brown (Neuroscience) to develop stochastic models of axonal transport kinetics through nodes of Ranvier. She also enjoys student mentoring and outreach and has founded an undergraduate mathematical modeling contest at OSU.

Title: Modeling the Cytoskeleton Roads in Intracellular Transport

Abstract: The cellular cytoskeleton is essential in proper cell function as well as in organism development. These polymers provide the elaborate roads along which most intracellular protein transport occurs. I will discuss several examples where mathematical modeling, analysis, and simulation tools help us study and understand the interactions between these filaments roads and motor proteins in cells. In neurons, neurofilaments navigate axons and their constrictions to maintain a healthy speed of neuronal communication. We develop stochastic models that may provide insights into transport mechanisms through axonal constrictions. In the reproductive system of the worm C. elegans, we use agent-based modeling to study how myosin motors interact with actin filaments to maintain contractile rings that allow passage and nutrient transport for developing egg cells. In addition, we have recently become interested in using topological data analysis tools to assess maintenance and establishment of these ring structures.

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Jo Nelson

IAS/PCMI/Rice University in the Speaker

Bio: Jo Nelson received her PhD in 2013 from the University of Wisconsin - Madison under Mohammed Abouzaid. She previously held concurrent appointments, in part as an NSF postdoctoral fellow, at the Institute for Advanced Study (2013-2016), the Simons Center for Geometry and Physics (2014), and Columbia University (2013-2018). Jo studies symplectic and contact topology, a field, which has its origins in the study of classical mechanical systems. Understanding the evolution and distinguishing transformations of these systems necessitated the development of global invariants of symplectic and contact manifolds. Her research primarily concerns providing foundations and applications for contact invariants stemming from nonequivariant and (circle) equivariant constructions of contact homology. Contact homology is built out of closed orbits of Reeb vector fields and counts of solutions to a nonlinear Cauchy-Riemann equation, which interpolates between closed Reeb orbits. Reeb vector fields are Hamiltonian-like vector fields, whose flow lines are solutions to Hamilton's equations of motion, as they conserve energy. Closed Reeb orbits are of particular interest because they can be used to describe local distance minimizing "loops."

Title: Contact Invariants and Reeb Dynamics

Abstract: Contact geometry is the study of certain geometric structures on odd dimensional smooth manifolds. A contact structure is a hyperplane field specified by a one form which satisfies a maximum nondegeneracy condition called complete non-integrability. The associated one form is called a contact form and uniquely determines a Hamiltonian-like vector field called the Reeb vector field on the manifold. I will give some background on this subject, including motivation from classical mechanics. I will also explain how to make use of J-holomorphic curves to obtain a Floer theoretic contact invariant, contact homology, whose chain complex is generated by closed Reeb orbits. This talk will feature numerous graphics to acclimate people to the realm of contact geometry.

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Annie Raymond

MSRI

Bio: Annie Raymond is an assistant professor at the University of Massachusetts in Amherst. Originally from Montreal, she studied math and music at MIT as an undergrad before pursuing a Ph.D. in mathematics at the Technische Universitaet in Berlin and a postdoc at the University of Washington. At any given moment, you will most likely find her thinking about extremal graph theory and sums of squares---perhaps while riding her bicycle or playing the piano---or reflecting on education in prisons, on how to increase diversity in STEM and on how to bake the perfect sourdough.

Title: Symmetry and Graph Profiles

Abstract: We often think of graphs and of their global properties in a very visual way. This works fine for smaller graphs, but for most real-world applications, the underlying graphs are very large---sometimes so large that their data cannot fit on a computer. In that case, how can one understand such a graph and its global properties? One way is to think about it locally. Given a large graph G, create a vector recording the induced density in G of every small graph in some fixed finite list of graphs. We can think of this vector as the coordinates of G in the space of the smaller graphs. This way of thinking about large graphs immediately raises two questions. First, how are local and global properties related? In other words, given the coordinates of G, what are global properties of G? Second, what is even possible locally? Say you want to create a graph with certain local distributions, can it be done? I am interested in the second question and, in this talk, I will explore its connections to extremal graph theory and symmetric sums of squares. This is joint work with Greg Blekherman, Mohit Singh and Rekha Thomas.

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Henry Segerman

ICERM

Bio: Henry Segerman is a mathematician, working mostly in three-dimensional geometry and topology, and a mathematical artist, working mostly in 3D printing. He is an associate professor in the Department of Mathematics at Oklahoma State University, and author of the book "Visualizing Mathematics with 3D Printing".

Title: Illustrating Mathematics at ICERM

Abstract: In Fall 2019, the Institute for Computational and Experimental Research in Mathematics (ICERM) will host a semester on Illustrating Mathematics - developing computational techniques to illustrate mathematical ideas. I will talk about some interesting recent work involving mathematical illustration, and some of the objectives for the semester program.

Pablo Suárez-Serrato

IPAM

Bio: Mathematics degree from UNAM in Mexico City (2002), Masters (Part III, 2003) and PhD (2007) in Cambridge University, Researcher (Investigador Titular) at the Instituto de Matematicas UNAM since 2009, tenured 2016. Carried out long research stays in LMU Univestity of Munich, CIMAT Guanajauto, Max Planck Institute for Mathematics Bonn, UPC Barcelona, University of Nantes, ETH Zurich, IPAM in UC Los Angeles, and UC Santa Barbara. Interests lie in geometry and topology, and the applications they can have to data, networks, and the analysis of cultures.

Title: Taming the Homotopy of Networked Data

(Serrato – cont.)

Abstract: Whether comparing networks to each other or to random expectation, measuring similarity is essential to understanding the complex phenomena under study. However, there is no canonical way to compare two networks. Having a notion of distance that is built on theoretically robust first principles and that is interpretable with respect to important features of complex networks would allow for a meaningful comparison between different networks. We introduced an efficient new measure of graph distance, based on the marked length spectrum. It compares the structure of two undirected, unweighted graphs by considering the lengths of non-backtracking cycles. We show how this distance relates to structural features such as presence of hubs and triangles through the behavior of the eigenvalues of the non-backtracking matrix, and we showcase its ability to discriminate between networks in both real and synthetic data sets. By taking a topological interpretation of non-backtracking cycles, this work presents a novel homotopical application of topological data analysis to the study of complex networks.

This is joint work with Leo Torres and Tina Eliassi-Rad, from Northeastern University.

Michael Young

AIM

Bio: Michael Young is an Associate Professor of Mathematics at Iowa State University. He had his PhD in Mathematical Sciences from Carnegie Mellon University. He studies topics in Discrete Mathematics, including graph theory, combinatorics, and game theory. He has also begun working in the equity aspects of mathematics education.

Title: Rainbow Numbers for $x_1 + x_2 = kx_3$ in ¢$_n$.

(Young – cont.)

Abstract: For positive integers n and k, the *rainbow number* $rb(¢_n, k)$ is the fewest number of colors needed to guarantee a rainbow (i.e. distinctly colored) triple of the equation $x_1 + x_2 = kx_3$ for cyclic groups $¢_n$. Butler et. al. determined the rainbow number for 3-term arithmetic progressions ($k = 2$). In this talk, we will discuss the rainbow numbers for other values of k.

First we consider the Schur equation ($k = 1$) and find that $rb(¢_p, 1) = 4$ for all primes greater than 3 and that $rb(¢_n, 1)$ can be calculated exactly from the prime factorization of n. For a general k we find the exact value of $rb(¢_p, k)$, for every prime p and positive integer k. We also find that when k is prime, $rb(¢_n, k)$ can be calculated exactly from the prime factorization of n.