PLENARY TALKS
ABSTRACTS

Rodrigo Bañuelos (Purdue University)
Looking for randomness in all the wrong places

In 1980, Johnnie Lee released his hit country song "looking for love in all the wrong places." That year I began my graduate studies at UCLA and shortly thereafter I was looking for (and finding) randomness in all the "wrong places." This talk will illustrate various mathematical places where, surprisingly, beautiful connections to, and applications of, randomness (probability) can be found. These connections, not so apparent on the surface, lie at the interface of spectral theory and the geometry and analysis of the Laplacian and closely related nonlocal operators. Nonlocal operators arise when the Brownian motion, which "goes" with the Laplacian, is replaced by other Lévy processes. They have been studied extensively in recent years by probabilsts and analysts in areas of pure and applied mathematics.

Jesús De Loera (University of California, Davis)
Variations of Carathéodory theorem for Integer Optimization

Geometry has been an important pillar of the theory of optimization algorithms (e.g., think of Ellipsoid method). My talk will show this continues to be the case today by focusing on one influential theorem, Carathéodory's theorem from 1905. In its most basic form it describes the size of a minimal linear combination representing a vector in a cone and it is among the most fundamental results in Convex Geometry and it has seen many variations and extensions. I will review some variations of Carathéodory's theorem that have interesting applications in integer optimization. E.g., given a system $Ax=b, x\geq 0$, what is the size of the sparsest solution integer? Integral versions of Carathéodory's theorem improve prior bounds and show some of the fascinating structure of sparse integer solutions of Diophantine equations. Another example will be the use of in augmentation algorithms for optimization. Our new results are joint work with Chris O'Neill, Jon Lee, Raymond Hemmecke, Iskander Aliev, Timm Oertel, Frederic Eisenbrand, and Robert Weismantel.

Rochelle Gutiérrez (University of Illinois at Urbana-Champaign)
Rehumanizing Mathematics: A Vision for the Future

For far too long, we have embraced an "equity" standpoint that has been poorly defined (Gutiérrez, 2002) or constantly shifting (NCTM, 2008). It has been difficult to assess progress beyond closing the achievement gap or recruiting more diverse students into the mathematical sciences. Instead, we should rehumanize mathematics, which considers not just access and achievement, but the politics in teaching and mathematics. This approach begins with 1) acknowledging some of the dehumanizing experiences in mathematics for students and teachers and 2) how students could be provided with windows and mirrors onto the world and ways of relating to each other with dignity. As such, we can begin to think differently about student misconceptions, teachers as identity workers, and why it is not just that diverse people need mathematics but mathematics needs diverse people (Gutiérrez, 2002; 2012). In this talk, I focus on two areas for rehumanization: 1) teaching/learning and 2) scholars and everyday citizens.

With respect to teaching and learning, I present eight dimensions of a rehumanized mathematics classroom: participation/positioning; cultures/histories; windows/mirrors; living practice; broadening maths; creation; body/emotions; and ownership. Then, I offer ways for mathematicians and mathematics educators to take risks in ensuring those dimensions happens in small and large ways. In addition, with the recent national attacks on mathematics education scholars who address social justice and whiteness, I explain a bit about my case and then offer ways to rehumanize our field to affect scholars and everyday citizens. In particular, I highlight how understanding our history (e.g., how scientists in the 1970s stood for political and social action) as well as creating greater alliances between mathematicians and mathematics education scholars might allow us to take greater risks in our everyday work.

Ryan Hynd (University of Pennsylvania)

Adhesion dynamics and the sticky particle system

We will consider collections of point masses that only interact via perfectly inelastic collisions. As such collections conserve mass and momentum, they will correspond to solutions of an appropriate system of differential equations. These equations have been used in astronomy to model the expansion of matter without pressure and they also play a central role in the theory of optimal mass transport. In this talk, we'll discuss how to derive the equations, show how to find solutions in some cases and present some open problems.

Lily Khadjavi (Loyola Marymount University)

Policing in Los Angeles and the issue of racial profiling

Although racial profiling is not legal, polls indicate that most Americans believe it is a regular police practice, a perception so common that the practice of stopping a driver of color has been nicknamed by some as a DWB, or ''Driving while black or brown.'' The nature of these stops--and any perception of bias--is of paramount importance in understanding relationships between law enforcement and local communities, especially in communities of color.

Data which were collected by the Los Angeles Police Department under a Consent Decree with the U.S. Department of Justice provide a prime opportunity to better understand police practice, well beyond counting who is stopped. Every year over 800,000 stops are made by the police in the city of Los Angeles; an empirical snapshot reveals search and frisk rates far exceeding the national average. We look at the story this data tells us and consider these stops with regard to Fourth Amendment police practice. For example, when a driver is pulled over, the stop may include a frisk or search but only if certain legal criteria are satisfied. Who is searched, and under what basis? Are particular drivers asked to consent to a search, thereby waiving their Fourth Amendment rights? Who declines? Statistical analysis not only illuminates racial and ethnic disparities in stops, frisks, searches, and outcomes, but also points to concrete policy recommendations.

Edgar Lobaton (North Carolina State University)

From Cyborg-Insect to Human Motion: Topological Data Analysis Applied to Time Series

Topological Data Analysis has been applied to a number of problems in order to study the geometric and topological structure of point cloud data. In this talk, we discuss their application to the analysis of time series from cyborg-insect and human motion. These tools allow us to identify different type of motion behaviors from the agents, and can help us identify geometric structure of their surroundings. The mathematical framework developed allows us to derive bounds on the sampling of the data space in order to ensure recovery of the correct topological information, and also provide guarantees on the robustness of these quantities to perturbations on the data.

Ivelisse Rubio (University of Puerto Rico)

Exploring, generalizing and applying the covering method

The divisibility of exponential sums has been used to characterize and prove properties in coding theory, cryptography and solvability of polynomial equations. In general, algebraic methods to estimate the p-divisibility of exponential sums over finite fields are non-elementary. The covering method provides an elementary and intuitive way to determine p-divisibility, which is particularly convenient in the applications. In this talk I will give an overview of the covering method for computing the p-divisibility of exponential sums and explain how it can be used in some applications. I will also mention other two problems and how I have re-visited them at different times during the last 30 years!

SCIENTIFIC SESSIONS

ALGEBRA AND NUMBER THEORY

LOCATION: IPAM LECTURE HALL 1200

Session Organizers: Dagan Karp (Harvey Mudd) and Adriana Salerno (Bates College).

Session Speakers: Rosemary Guzman (University of Chicago), Pamela Harris (Williams College), Pablo Solis (Stanford University), Bianca Thompson (Harvey Mudd College), and Anthony Varilly-Alvarado (Rice University).

SCHEDULE - FRIDAY, MARCH 9

2:00 - 2:25 Rosemary Guzman (University of Chicago)

2:30 - 2:55 Pablo Solis (Stanford University)

3:00 - 3:30 Coffee Break (Grand Ballrooom)

3:30 - 3:55 Bianca Thompson (Harvey Mudd College)

4:00 - 4:25 Anthony Varilly-Alvarado (Rice University)

4:30 - 4:55 Pamela Harris (Williams College)

ABSTRACTS

Rosemary Guzman (University of Chicago)

The quantitative geometry of k-free hyperbolic 3-manifold groups

Consider a discrete, torsion-free subgroup Γ of the orientation-preserving isometry group of hyperbolic 3-space. We will examine the case where Γ is cocompact and has the “k-free property,” which is to say that every subgroup of rank less than or equal to k is free. The quotient M of hyperbolic 3-space modulo Γ defines a closed, orientable hyperbolic 3-manifold, whose fundamental group is isomorphic to Γ via the canonical isomorphism. A celebrated theorem of Mostow states that if M, N are two closed, connected, orientable, hyperbolic n-manifolds which are homotopy equivalent in dimensions $n \geq 3$, then M, N are equivalent up to isometry.

This unique geometric-topological relationship has been the framework for many important results, including notable results providing lower bounds on the volume of M, and results relating volume to homology. We will discuss a new quantitative-Mostow-Rigidity-type result relating to $k \geq 5$-free hyperbolic 3-manifold groups and their associated quotient manifold as mentioned above.

Pamela Harris (Williams College)

Invisible Lattice Points

This talk is about the invisibility of points on the integer lattice \(\mathbb{Z} \times \mathbb{Z} \), where we think of these points as (infinitely thin) trees. Standing at the origin one may notice that the tree at the integer lattice point \((1, 1) \)blocks from view the trees at \((2, 2), (3, 3) \), and, more generally, at \((n,n) \) for any \(n \in \mathbb{Z}_{\geq 0} \). In fact any tree at \((l,m) \) will be invisible from the origin whenever l and \(m \) share any divisor \(d \), since the tree at \((\ell/D, m/D) \), where \(D = \text{gcd} (\ell, m) \) blocks \((l, m) \) from view. With this fact at hand, we will investigate the following questions. If the lines of sight are straight lines through the origin, then what is the probability that the tree at \((\ell, m) \) is visible? Meaning, that the tree \((\ell, m) \) is not blocked from view by a tree in front of it. Is possible for us to find forests of trees (rectangular regions of adjacent lattice points) in which all trees are invisible? If it is possible to find such forests, how large can those forests be? What happens if the lines of sight are no longer straight lines through the origin, i.e. functions of the form $f(x) = ax$ with $a \in \mathbb{Q}$, but instead are functions of the form $f(x) = ax^b$ with b a positive integer and $a \in \mathbb{Q}$? Along this mathematical journey, I will also discuss invisibility as it deals with the underrepresentation of women and minorities in the mathematical sciences and I will share the work I have done to help bring more visibility to the mathematical contributions of Latinx and Hispanic Mathematicians.

Math work is joint with Bethany Kubik, Edray Goins, and Aba Mbirika. Diversity work with Alexander Diaz-Lopez, Alicia Prieto Langarica, and Gabriel Sosa.

Pablo Solis (Stanford University)

Hunting Vector Bundles on P1 x P1

Motivated by ideas in commutative algebra, Eisenbud and Schreyer conjectured there should be vector bundles on P1 x P1 with natural cohomology and prescribed Euler characteristic. I'll give some background on vector bundles and explain what natural cohomology means and prove the conjecture in "most" cases.

Bianca Thompson (Harvey Mudd College)

An Accessible guide to Uniform Bounds of Twists

The study of discrete dynamical systems boomed in the age of computing. We could suddenly compute high iterates of functions and look at their behavior over time. We could create the beautiful fractal, the Mandelbrot via iterating 0 in the function z^2+c and allowing c to vary. This gives mathematicians a wealth of questions to explore. One question tied to the Mandelbrot set is how many rational points points have iterates that end in a cycle as we allow c to vary? Is this number of rational points uniformly bounded as c varies? It turns out this is a hard question to answer. Instead we will explore places where this question can be answered; special families of rational functions, twists.

Anthony Varilly-Alvarado (Rice University)

Diophantine Equations and Algebraic Geometry

Diophantine equations are often profitably studied through the lens of Algebraic Geometry. Geometric insights can shed light on the structure of solutions to these equations (or the lack thereof). Using examples such as Fermat's Last Theorem, I will explain how a geometric perspective leads to some deep conjectures on the number theory of spaces defined by polynomial equations.

SCIENTIFIC SESSIONS

MATHEMATICAL BIOLOGY

LOCATION: ROOM 2408

Session Organizers: Selenne Bañuelos (CSU Channel Islands), Carrie Diaz Eaton (Unity College), and Alicia Prieto Langarica (Youngstown State University).

Session Speakers: Sara Del Valle (Los Alamos National Laboratory), German Enciso Ruiz (UC Irvine), Emilia Huerta-Sanchez (UC Merced), Christian Laing (Navigate BioPharma), and Joseph Teran (UCLA),

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SCHEDULE - FRIDAY, MARCH 9

2:00 - 2:25 Joseph Teran (UCLA)

2:30 - 2:55 Emilia Huerta-Sanchez (UC Merced)

3:00 - 3:30 Coffee Break (Grand Ballrooom)

3:30 - 3:55 German Enciso Ruiz (UC Irvine)

4:00 - 4:25 Sara Del Valle (Los Alamos National Laboratory)

4:30 - 4:55 Christian Laing (Navigate BioPharma)

ABSTRACTS

Sara Del Valle (Los Alamos National Laboratory)

Real-time Social Internet Data to Guide Disease Forecasting Models

Abstract: Globalization has created complex problems that can no longer be adequately forecasted and mitigated using traditional data analysis techniques and data sources. Disease spread is major health concern around the world and it is compounded by the increasing globalization of our society. As such, epidemiological modeling approaches need to account for rapid changes in human behavior and community perceptions. Social media has recently played a crucial role in informing and changing people's response to the spread of infectious diseases. Recent events such as the 2014-2015 Ebola epidemic and the 2015-2016 Zika virus epidemic have highlighted the importance of reliable disease forecasting for decision support. In this talk, I will discuss a framework that combines clinical surveillance data with social Internet data and mathematical models to provide probabilistic forecasts of disease incidence. In addition, I will demonstrate the value of Internet data and the real-time utility of our approach.

German Enciso (UC Irvine)

Cell Fate Decision in Chlamydia Trachomatis

Chlamydia trachomatis is the most common cause of bacterial sexually transmitted infection. It can also infect the eyes and is a major cause of blindness in many developing countries. During the infection of a mammalian host, Chlamydia must decide when to proliferate and when to convert into a differentiated form, since the differentiated form is the only form to survive outside the host but cannot reproduce. We study the question of Chlamydia cell fate regulation using experimental data as well as stochastic mathematical modeling.

Emilia Huerta-Sanchez (UC Merced)

The landscape of archaic variants in present-day humans

From fossil data, we know that Neanderthals lived in Eurasia before modern humans migrated there from Africa. Neanderthals and modern humans inhabited the same continent for several thousands of years. Recent studies, using DNA sequence data from Neanderthals and modern humans, have shown that present-day humans carry traces of Neanderthal DNA providing evidence that Neanderthals interbred with modern humans. While the surviving Neanderthal DNA within a single individual is small, their DNA is harbored in genes involved in metabolism, skin pigmentation, the immune system and hypoxia potentially having a big impact. In this talk, I will discuss how we can use computational approaches to study the distribution of these variants in present-day humans to provide new insights into their biology and evolutionary history.

Christian Laing (Navigate Biopharma)

Analysis of RNA tertiary structure and tertiary motifs: Insights into RNA prediction

In recent years, many exciting discoveries have exposed the versatility of RNA. Clearly more findings are yet to come given the many novel non-protein-coding transcripts recently identified, and the structure-function relationship that exists within RNA molecules emphasizes the necessity to build more efficient computer programs to predict their structure. In this talk, I present a study on solved 3D RNA molecules, which aims to determine structural patterns and design rules that can help predict their 3D shape.

Specifically, an exhaustive analysis on the structural arrangements of RNAs revealed the existence of higher-order motifs built by a combination of smaller sub-motifs. Also it was noticed that motifs occur rarely isolated, and would rather cooperate with each other to stabilize RNAs architecture. These findings have helped recognize new levels of organization in RNA structure.

In addition, to better understand how local interactions influence global conformations of RNA 3D structure, the structure of all known RNA junctions was analyzed according to their base pair configurations, and 3D motif formation. All four-way junctions were classified into nine families according to their topology. Interestingly, it was found that junctions are composed of recurrent helical configurations, and their helical elements tend to arrange in roughly parallel and perpendicular patterns.

Furthermore, a data mining technique known as random forest was used to predict the coaxial helical stacking and junction families by using length and sequence information from known 3D junctions. The results give a reasonable prediction accuracy (~80%). These prediction scores constitute a dramatic improvement over previous attempts, and comprise an important step towards RNA 3D structure prediction.

Joseph Teran (UCLA)

Elastoplasticity Simulation with the Material Point Method

Hyperelastic constitutive models describe a wide range of materials. Examples include biomechanical soft tissues like muscle, tendon, skin etc. Elastoplastic materials consisting of a hyperelastic constitutive model combined with a notion of stress constraint (or feasible stress region) describe an even wider range of materials. In these models, the elastic potential energy only increases with the elastic part of the deformation decomposition. The evolution of the plastic part is designed to satisfy the stress constraint. A very interesting class of these models arise from frictional contact considerations. I will discuss some of the mathematical aspects of these models and present some recent results and examples in computer graphics and virtual surgery applications. I will also talk about practical simulation of these materials with recent novel Material Point Methods (MPM).

SCIENTIFIC SESSIONS

TOPICS IN CONTEMPORARY DISCRETE MATHEMATICS

LOCATION: BRUIN RECEPTION ROOM (BRR)

Session Organizer: Jesús De Loera (University of California, Davis)

Session Speakers: Anastasia Chavez (University of California, Davis), Diego Cifuentes (Max-Planck Institute for Mathematics in the Sciences), Laura Escobar (University of Illinois at Urbana-Champaign), Jose Israel Rodriguez (University of Chicago), and Pablo Soberon (Northeastern University).

SCHEDULE - FRIDAY, MARCH 9

2:00 - 2:25 Laura Escobar (University of Illinois at Urbana-Champaign)

2:30 - 2:55 Jose Israel Rodriguez (University of Chicago)

3:00 - 3:30 Coffee Break (Grand Ballrooom)

3:30 - 3:55 Diego Cifuentes (Max-Planck Institute for Mathematics in the Sciences)

4:00 - 4:25 Anastasia Chavez (University of California, Davis)

4:30 - 4:55 Pablo Soberon (Northeastern University)

ABSTRACTS

Anastasia Chavez (University of California, Davis)

Dyck Paths and Positroids from Unit Interval Orders

It is well known that the number of non-isomorphic unit interval orders on $[n]$ equals the n-th Catalan number. Using work of Skandera and Reed and work of Postnikov, we show that each unit interval order on $[n]$ naturally induces a rank n positroid on $[2n]$. We call the positroids produced in this fashion \emph{unit interval positroids}. We characterize the unit interval positroids by describing their associated decorated permutations, showing that each one must be a $2n$-cycle encoding a Dyck path of length $2n$. We also give a combinatorial description of the f-vectors of unit interval orders. This is joint work with Felix Gotti.

Diego Cifuentes (Max-Planck Institute for Mathematics in the Sciences)

Graphical structure in polynomial systems: Chordal networks

The sparsity structure of a system of polynomial equations or an optimization problem can be naturally described by a graph summarizing the interactions among the decision variables. It is natural to wonder whether the structure of this graph might help in computational algebraic geometry tasks (e.g., in solving the system). In particular, the notion of chordality and treewidth play a pivotal role in related areas such as numerical linear algebra, database theory, constraint satisfaction, and graphical models. Our main contribution is the introduction of a new representation of structured polynomial systems: “chordal networks”. Chordal networks provide a computationally convenient decomposition of the system into simpler (triangular) polynomial sets, while maintaining its underlying graphical structure. We illustrate through examples from different application domains that algorithms based on chordal networks can significantly outperform existing techniques.

Laura Escobar (University of Illinois at Urbana-Champaign)

Brick varieties and polytopes

Abstract: The n-dimensional associahedron is a simple polytope with vertices corresponding to the triangulations of a convex (n+3)-gon. Pilaud and Santos defined the brick polytopes and used them to construct the associahedron. I will define the brick variety, show how these polytopes are constructed from this variety, and give consequences of the construction.

Jose Israel Rodriguez (University of Chicago)

Factoring graphs, matrices, and polynomials as tensor products

The tensor or Kronecker product of two matrices is well-known. The tensor product of two graphs is one whose adjacency matrix is given by the tensor product of the adjacency matrices of the respective graphs. The tensor product of two (univariate) polynomials is one whose companion matrix is given by the tensor product of the companion matrices of the respective polynomials. These tensor products are category-theoretic products in the respective categories. We discuss how graphs, matrices, and polynomials may be factored into irreducible factors with respect to these tensor products. We use the Newton--Girard formulas and homotopy continuation to find the decomposition. This is joint work with Lek-Heng Lim.

Pablo Soberon (Northeastern University)

A gem in discrete geometry: Tverberg's theorem

Tverberg's theorem is a central result of combinatorial geometry. It has far-reaching applications and variations, and has been a source of interesting open problems for over fifty years. During this talk I will describe some of my favorite variations, the different ideas involved in their proofs and how they have shaped my mathematical journey.

SCIENTIFIC SESSIONS

TOPOLOGY: NEW TRENDS IN APPLICATIONS AND THEORY

LOCATION: GRAND BALLROOM

Session Organizers: Javier Arsuaga (UC Davis) and Robin Wilson (Cal Poly Pomona)

Session Speakers: Ncolas Garcia Trillos (Brown University), Fabiola Manjarrez (National Autonomous University of Mexico), Angélica Osorno (Reed College), Jose Perea (Michigan State University), and Luis Valdez-Sanchez (University of Texas at El Paso).

SCHEDULE - FRIDAY, MARCH 9

2:00 - 2:25 Jose Perea (Michigan State University)

2:30 - 2:55 Fabiola Manjarrez (National Autonomous University of Mexico)

3:00 - 3:30 Coffee Break (Grand Ballrooom)

3:30 - 3:55 Luis Valdez-Sanchez (University of Texas at El Paso)

4:00 - 4:25 Nicolas Garcia Trillos (Brown University)

4:30 - 4:55 Angélica Osorno (Reed College)

ABSTRACTS

Nicolas Garcia Trillos (Brown University)

Graph-based methods in machine learning and their continuous counterparts

Abstract: Many machine learning procedures aimed to extract information from data can be defined as precise mathematical objects that are constructed in terms of the data. It is often assumed that the data is “big” in complexity but also in quantity, and in this “large amount of data’’ setting, a basic mathematical concept that one can explore is that of closure of a given class of statistical procedures (i.e. what are the limiting procedures as the number of data points available goes to infinity.) In this talk, I will explore this notion in the context of graph-based methods. Examples of such methods include minimization of Cheeger cuts, spectral clustering, and graph-based bayesian semi-supervised learning, among others.

Fabiola Manjarrez (National Autonomous University of Mexico)

Genera of tunnel number one satellite knots

Tunnel number one satellite have been characterized by a 4-tuple of integers. In this talk I will show an algorithm to compute the genus of such knots from the 4-tuple.

This is joint work with Mario Eudave, Enrique Ramírez and Jesús Rodríguez.

Angélica Osorno (Reed College)

Systems of fixed points and equivariant homotopy theory

I will describe the classical result of how to recover the homotopy theory of a space with an action of a group G from the homotopy theory of its system of fixed points. Then I will describe the analogous recent result of Guillou and May for genuine equivariant G-spectra, I will then show how to use this result to construct a new equivariant infinite loop space machine, whose input data is in terms of fixed points. This is joint work with Anna Marie Bohmann.

Jose Perea (Michigan State University)

Topological Time Series Analysis

Time varying observations are ubiquitous in today's data rich world; examples include real-valued time series (like sound and speech), video data, dynamic networks, etc.

I will show in this talk how techniques from nonlinear time series analysis, dynamical systems, and computational topology can be combined to generate topological summaries describing the dynamics underlying such systems. Several applications in areas such as biology, speech sciences and artificial intelligence will be discussed.

Luis Valdez-Sanchez (University of Texas at El Paso)

Surgery on knots in the 3-sphere

Any closed and orientable 3-manifold can be constructed by performing surgery on the knot components of some link in the 3-sphere. More specifically, by Thurston's work, the complement of any knot in the 3-sphere is either a Seifert, toroidal, or hyperbolic 3-manifold, and all but finitely many (exceptional) surgeries on a knot with hyperbolic complement yield hyperbolic 3-manifolds. In this talk we give a brief overview of the surgery construction on knots in the 3-sphere and some of the old and current topological and geometric questions that arise from it.