Mathematics & Statistics NEWSLETTER

University of Massachusetts Amherst

2018-2019 Volume 34

INSIDE THIS ISSUE:

UMassAmherst

Mathematics and Statistics

TEACHING MATH IN PRISONS

The following article was published in the Notices of the American Mathematical Society December 2019, and gives a summary of Annie Raymond's extensive activities in teaching mathematics to incarcerated people – Ed.

Teaching inmates college-level mathematics has been one of the most important and rewarding experiences of my career so far. I started in 2016 when I was a postdoc at the University of Washington. The math department received an email from University Beyond Bars (UBB), a local nonprofit that offers college classes to inmates at the Monroe Correctional Complex. The email asked if anyone in the department would agree to volunteer to teach Math 104 (Finite Math) or Math 106 (College Algebra) at the prison.

I had no idea that some prisons offered university-level classes, but my interest was piqued. As a kid, the elementary school I attended consisted of children from the nearby housing projects as well as children from middle-class families. I saw no difference between the kids who came from more affluent families, and those who didn't. Each kid was some unique combination of smart, funny and kind. Still, despite all of us being the same as kids, many of the kids from the projects got caught in the crushing cycle of poverty, and some ended up spending some time in prison. Thinking about all of the potential that had been wasted as a result of structures in place in our society, I volunteered to teach Math 104.

Article continues on page 13

ALUMNI PROFILE

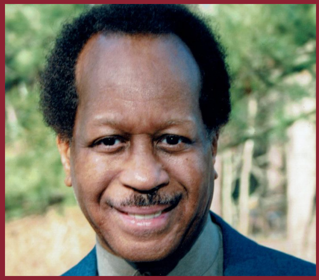
Mike Lopez received an MS in Statistics from our department in 2010. After a PhD at Brown he has made his way to Director of Data and Analytics at the National Football League. He will visit the department in April 2020. As a taster, John Staudenmayer interviewed him by email.

Q. You have the kind of job that quantitatively oriented sports fans dream of. Can you describe how you ended up in your current position?

To be honest, this definitely was not my dream job – whenever I would have been dreaming about jobs, this specific role would not have been around. But with more and more data in the game than ever before, these types of roles are popping up across sport organizations. As one insight into the current NFL, all players have RFID chips in their shoulder pads that track each movement on the field, at roughly 10 frames per second. That's a substantial amount of data for us to learn from.

Primarily, our job is to use football data to make the game better. That starts with on-field data, including game quality, long term changes, and rules changes, and we also touch on officiating, health and safety, and pace of play trends. But we likewise want to grow the overall impact of data in the game as well, so we are in charge of events that help serve core football fans who want to learn more about the game, and who want to play with the data themselves.

Article continues on page 19



Professor Emeritus Floyd Williams

Professor Nate Whitaker

MATHEMATICALLY GIFTED AND BLACK

Department head Nate Whitaker and Professor Emeritus Floyd Williams are among the 28 honorees chosen to feature on the website Mathematically Gifted and Black. Nate's talk in Fall 2019 to the department Math Club on his journey from the shadow of segregation to his current position was well attended and very moving.

MATHEMATICS & STATISTICS NEWSLETTER

EDITED BY
Mark C. Wilson

With special thanks to: Eduardo Cattani, Paul Hacking, Rob Kusner, Alejandro Morales, Ivan Mirkovic, Jenia Tevelev, Ilona Trousdale, named contributors, and those whose names are forgotten but whose contributions are greatly appreciated.

The Department of Mathematics and Statistics publishes its annual newsletter for alumni and friends. You are important, and we want to hear from you! Please contact us at dept@math.umass.edu to share your news, let us know how you are doing, and learn ways to become involved with the Department. Our website is a valuable resource for current happenings and news, so we encourage you to visit us regularly at www.math.umass.edu.

Please send general feedback to markwilson@umass.edu, and feedback on challenge problems to profkusner@gmail.com and schaffler@math.umass.edu.

This year marks a change in editorship. We hope to maintain the standard set by our predecessors. Best wishes to all students, faculty, staff, alumni and friends for 2020!

2019 CHALLENGE PROBLEMS

1. Find all values of the real parameter a, for which the equation

$$\log_a \Big| 6|x-5| - 18 \Big| = 2 + 3\log_a 2 + 2\log_a 3$$

has exactly two real roots.

2. Prove that for any $x, y, z \geq 0$, we have

$$(1+x+y+z)^2 \leq 4(1+x^2+y^2+z^2).$$

When is the inequality strict?

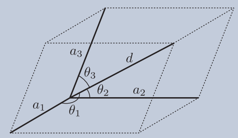
3. Show that the equation

$$x^2 + 19x - y^2 = 0$$

has only one positive integral solution (x, y) and find it.

4. A parallelepiped is a polyhedron with six faces, each of which is a parallelogram. Consider a vertex of a parallelepiped and the diagonal line segment from the vertex to the opposite vertex. Let d be the length of the diagonal. Suppose that, as in the figure, the three edges meeting at the vertex have length a_1, a_2, and a_3 and their angles to the diagonal are θ_1, θ_2, and θ_3, respectively. Show that

$$d = a_1 \cos\theta_1 + a_2 \cos\theta_2 + a_3 \cos\theta_3.$$

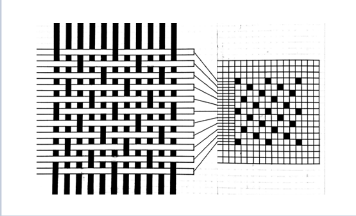


5. Let x_n be one of the numbers from the following sequence:

$$3.3,\ 33.33,\ 333.333,\ 3333.3333, \ldots$$

In other words, x_n has $2n$ decimal digits, all of them equal to 3, with the same number of digits before and after the decimal point. For every n, find the first integer larger than x_n^2.

6. In the process of weaving, vertical threads (warps) are interlaced with horizontal threads (wefts). Every warp and weft should interlace with some threads (since otherwise it can be separated from the fabric).



The satin weave, invented in ancient China, depends on integer parameters $a, b > 1$. Every time the warp intersects the weft, the places for further intersection will be, for every following weft, either a warps to the left or b warps to the right. The picture illustrates the case $a = 2$, $b = 3$ and its standard weaving diagram.

Prove three statements from the Anni Albers' book *On Weaving*:

(a) The greatest common divisor of a and b should be equal to 1;

(b) $a + b$ can be equal to any positive number except $1, 2, 3, 4, 6$.

(c) Let $n = a+b$. Then $\lim_{n\to\infty} f(n) = \infty$, where $f(n)$ is the number of possible satin weaves with fixed n.

DEPARTMENT HEAD'S MESSAGE

I would like to welcome you to our newsletter as Department Head. We have made some exceptional hires and improved our graduate and undergraduate programs. Our graduates have gone off to do outstanding things. We are very proud of our alumni.

A particular area of growth is in our number of undergraduate majors which continually exceeds our expectations. The benefits of majoring in math in the 21st century is recognized more and more by our incoming students. At the present we have over 1000 majors. One can choose from seven concentrations, including Actuarial Science, Applied Math, Computing, Pure Math, Statistics, Teaching and an Individual concentration. Mathematics is also an essential part of any degree at the University, as over 15,000 students take our classes each year.

I am pleased to report, thanks for the hard work of our search committee, we have 4 new, outstanding tenure track Assistant Professors: Maryclare Griffin, Haben Michael, Leili Shahriyari and Ted Westling. Assistant Professor Griffin is a Statistician who examines problems that arise in the context of high dimensional regression, where the number of regression coefficients is quite large relative to the number of observations. Assistant Professor Haben Michael is a Statistician specializing in problems arising in HIV monitoring and treatment, in particular the complications introduced in modeling HIV longitudinal data and diagnostics from repeated experiments. Assistant Professor Leili Shahriyari is an Applied Mathematician and Math Biologist who develops innovative frameworks to systematically employ a combination of machine learning and statistical methods as well as mathematical techniques to arrive at personalized cancer therapies. Assistant Professor Ted Westling is a Statistician specializing in developing semiparametric efficiency theory and nonparametric statistical methods in causal analysis and survival analysis. We also had a very successful year in hiring 5 new outstanding Visiting Assistant Professors: Chris Elliot, Tina Kanstrup, Rafael Montezuma, Padhy Budhinath and Mithun Thudiyangal. In addition, we hired 2 new permanent lecturers: Maria Correia and Garret Cahill. Last but not least, Mark Wilson joined us as a Visiting Associate Professor, and has taken up the job of newsletter editor.

The newsletter allows the department to highlight some of the outstanding work of our faculty in pushing the envelopes of knowledge in Mathematics and Statistics each year. The National Science Foundation recently awarded a collaborative $ 1.5 million grant to the College of Information and Computer Sciences and our department to further develop the foundations of data science in a project that will create an NSF national institute at UMass. Markos Katsoulakis and Patrick Flaherty are Co-PIs on the grant and Anna Liu and Luc Rey-Bellet are senior researchers on the grant. Patrick Flaherty and Leili Shahriyari were awarded NIH grants. Andrea Nahmod is a PI for a Simons Foundation Collaborative Grant studying wave turbulence. Professor Jenia Tevelev received a Fulbright Scholar Award to Chile. Tevelev is conducting research and lecturing at Universidad Catolica de Chile as part of a project called "New Frontiers of Algebraic Geometry". Krista Gile received the College's Outstanding Teaching Award. Daeyoung Kim received the same award in 2018, a fact omitted from the previous newsletter.

Our Colleague Richard Ellis passed July 2, 2018. The department hosted a conference in his honor on April 12, 2019, "Rare Events, Information Theory and Statistical Physics". The distinguished list of speakers were Paul Dupuis (Brown University), Jon Machta (UMass Amherst), Charles Newman (Courant, NYU), Peter Otto (Williamette University), Hugo Touchette (Stellenbosch University, South Africa) and Bruce Turkington (UMass Amherst). This past year we hosted 3 conferences in the Department of Mathematics and Statistics at UMass.

On October 10 and 11, we hosted our first Baillieul Distinguished Lecture. We were fortunate to have as our inaugural speaker Anthony Bloch from the University of Michigan. Dr. Bloch gave two excellent talks. The annual distinguished lecture series is supported by a generous donation by John Baillieul.

Annie Raymond and I co-taught a 3-credit UMass course in finite math at the Hampshire County jail. It was a rewarding experience for us and the inmates. One of the students in a letter stated, *What prompted me to take this math course when presented with the chance was to be able to get off the unit and split my day up as a way to make it go faster. However, I did not expect a life changing experience. I mean who loves math besides Professor Annie and Professor Nate. I can tell you one thing it was not easy and I struggled and wanted to give up so many times. No words can express the pride and joy I felt when I was told I passed. I called my son that is currently struggling in school that I his dad just passed a math course. I have a sense of accomplishment that I lacked in me for a very long time.*

The support of our alumni and friends is invaluable to us. We want to know how you are doing. Please send us your news, or stop in for a visit.

– Nathaniel Whitaker

THE DEPARTMENT BY THE NUMBERS (FALL 2019)

The department is a large and complex place, as you can see from the numbers below.

Tenure system faculty: 42

Female tenure system faculty: 8

Visiting Assistant Professors: 17

Visiting Associate Professor: 1

Lecturers: about 23

Emeritus faculty: 27

Staff: 12

PhD students: 64

MS students: 40

Faculty funded by external research grants: 16

Undergraduate majors: 1007

Students taught 2019-20: about 15000

Regular seminar series: about 14

Floors of Lederle graduate Research Tower containing our faculty: 8

Extra wings of LGRT proposed by administration that we occupy "soon": 2

COMINGS AND GOINGS

New Visiting Assistant Professors in 2019 are: **Rafael Montezuma Cabral, Chris Elliott, Tina Kanstrup, Budinath Padhy, Mithun Thudiyangel.** Also, **Laura Colmenarejo** started as a VAP in January 2019.

Mark Wilson is a new Visiting Associate Professor on a 4-year contract.

There are 3 new permanent lecturers: **Maria Correia, Garret Cahill, Hyunsun Lee** (Mount Ida).

New staff: **Liming Liu:** Administrative Assistant to Head, **Terry Mullen:** Departmental Assistant and Lecturer, **Rachel Aronow,** Research Computing Facilities.

Promotions: **Paul Hacking** to Full Professor, **Anna Liu** to Full Professor, **Hongkun Zhang** to Full Professor, **Matthew Dobson** to Associate Professor with Tenure, **Nestor Guillen** to Associate Professor with Tenure, **Sohrab Shahshahani** reappointed with 4.2 review or Mini-tenure.

Nestor Guillen and **Vince Lyzinski** are on unpaid leave of absence.

NEW FACULTY

Leili Shahriyari joined the Department as an Assistant Professor in September 2019. She develops innovative frameworks to systematically employ a combination of machine learning (ML) and statistical methods as well as mathematical techniques to arrive at unique personalized cancer therapies, which has resulted in an NIH grant. She received a PhD in mathematics from Johns Hopkins University, which was followed by postdocs at UC Irvine and Ohio State University. At Irvine she developed stochastic models to improve understanding of cell dynamics during tumorigenesis, and worked on artificial neural network models for obtaining gene regulatory networks. Before joining UMass, she was Assistant Professor at University of Texas Arlington.

Haben Michael joined the department as an assistant professor in September 2019. His research mainly lies in the field of causal inference. Causal inference develops methods to infer causal relationships without the benefit of fully randomized experiments.

The field has always been of consequence to the social sciences, where randomization is often available, and is increasingly relevant to the tech world, where large amounts of observational data are now available for analysis. Haben's methods have ex-

The department welcomed 4 new Assistant Professors in September 2019: from left to right in the photo, Leili Shahriyari, Haben Michael, Ted Westling, Maryclare Griffin.

tended instrumental variable methods and often draw on semiparametric theory to produce efficient and robust tools. Haben received his PhD in Statistics from Stanford University in 2017 under the supervision of Lu Tian and Ingram Olkin.

Before coming to UMass he spent two years as a post-doctoral fellow, split between Harvard's Biostatistics and Wharton's Statistics departments, under the supervision of Eric Tchetgen.

Ted Westling joined the department as an Assistant Professor in September 2019. His primary research interests lie in developing nonparametric statistical theory and methods, often applied to problems arising in causal inference and survival analysis with observational data. In all his work, Ted aims to understand when and how machine learning methods can be used as part of the process of achieving valid large-sample statistical inference.

Ted received his PhD in statistics from the University of Washington in 2018 under the supervision of Marco Carone. Prior to joining UMass, he was a postdoctoral researcher in the Center for Causal Inference at theUniversity of Pennsylvania. There, he worked with Dylan Small to develop causal inference methods for continuous exposures. He also worked with faculty from the Perelman School of Medicine and the Children's Hospital of Philadelphia to develop and apply statistical methodology to the analysis of pediatric infectious diseases.

Maryclare Griffin joined the department as an assistant professor in September, 2019. Her research interests include high dimensional regression problems, mixed models, and methods for spatio-temporal data.

Maryclare grew up in Massachusetts and is happy to be back after about a decade living in other states. Maryclare received a PhD in statistics from the University of Washington in Seattle in 2018 and recently completed a short postdoc at Cornell University.

DEPARTMENTAL STAFF OVERVIEW

We currently have twelve staff members in the department. They are: Rachel Aronow and Alan Boulanger in Research Computing Facilities, Carla Mokrzecki, Naitian Wang, and Kam Kit Wong in the Business Office, Liming Liu in the Department Head's Office, Jacob Lagerstrom in Academic Advising, and Lisa Bergman, Cathy Russell, Terry Mullen, Sarah Willor, and Ilona Trousdale in Academic Scheduling and Support.

Two long-time staff members left the department in Summer 2018. Director of Research Computing Facilities Ken Pollard, who worked in the department for over 20 years and oversaw many changes and improvements to our IT operations, retired in July 2018. He is currently living in Hadley, MA, where he is involved in many community activities and enjoying his retirement. Assistant to the Department Head Christine Mirabal, who was with the department for almost 5 years, also left in July 2018. She is now working for the Art Department at Amherst College.

We've added several staff members since Summer 2018, as well. As we mentioned in our last newsletter, Naitian Wang joined the department as our new Business Manager in August 2018. Naitian holds Bachelor's and Master's Degrees in Accounting and was previously the Associate Director of Financial Services in the School of Education.

Liming Liu became our new Assistant to the Department Head in October 2018. Liming holds Master's degrees in both Sociology and Political Science and previously worked on campus in the Provost's office. She also teaches college level courses in Chinese Language and Popular Culture and is a member of the International Language Institute of Massachusetts.

More recently, Terry Mullen joined the department in March 2019 to provide much needed support with Academic Scheduling. Terry is a 2017 graduate of our Master's program in Applied Mathematics and is also a lecturer for the department in AY 2019-20.

Rachel Aronow became the newest Research Computing Facilities staff member in May 2019. Rachel is also a graduate of the department's Applied Mathematics Master's program, class of 2019.

We're currently searching for a newly created Career and Academic Advising staff position, and we hope that we'll soon be able to fill a vacancy in Research Computing Facilities.

–Ilona Trousdale, Director of Administration and Staff

NEW M.S. OPTION IN STATISTICS IN THE BOSTON AREA, STARTING FALL 2019

In the Fall of 2019, the University of Massachusetts Amherst began offering the M.S. option in Statistics in the Boston area at the Mount Ida campus in Newton, under the direction of Associate Professor **Erin Conlon.**

This program is an evening program. There are six graduate statistics courses being offered for the 2019-2020 academic year, with more to be added in future years. The current-year courses include Mathematical Statistics I and II, Statistical Computing, Regression Modeling, Statistical Methods for Data Science, and Design of Experiments.

Applications are currently being accepted for the Fall 2020 class. More information on the program is available at: *http://www.math.umass.edu/graduate/statistics*

– Erin Conlon

DEPARTMENTAL CLIMATE COMMITTEE

The Department of Mathematics and Statistics' Climate Committee is dedicated to understanding and improving the professional climate of our department. The committee includes representatives from the faculty, staff, graduate student, and undergraduate student populations, and is working to systematically review and improve the experiences of all these groups.

In the 2018-2019 academic year, the Climate Committee started this work by beginning the process of systematically reviewing the experiences of all department members. The committee created a climate feedback bulletin board, where department members could leave anonymous comments related to climate. The committee also took up the task of surveying the graduate student body and receiving detailed feedback about its experience. Since this survey, a Graduate Student Advisory Council has been created to coordinate graduate student input in departmental matters and improve the graduate student experience. This group has created new academic and social events for graduate students. It will use funds secured by the 2018-2019 Climate Committee to organize pre-talks before departmental seminars. The Graduate Student Advisory Council will also be working with the 2019-2020 Climate Committee to create a new mentoring program for graduate students.

The 2019-2020 Climate Committee is continuing the work started last year by surveying the undergraduate students. In addition, the committee is working to create more opportunities for undergraduate students to interact informally with faculty. The committee is working to gain a broader awareness and understanding of climate issues within the department, and will use this information to plan new trainings for department members, improve communication in the department, and create a more effective department website. We are grateful to be part of a department that cares about the well-being and inclusion of all departmental members, and we look forward to continuing to learn about and improve the climate of our department.

– Krista Gile and Victoria Day

ANDREA NAHMOD NEWS

Professor Andrea R. Nahmod was invited by The Norwegian Academy of Science and Letters as a guest of Professor Karen K. Uhlenbeck for the Abel Prize Ceremonies that took place in Oslo in May 2019. The events included a dinner for mathematicians at the Norwegian Academy of Sciences and Letters; the Abel Prize Ceremony (attended by the King of Norway) at the University of Oslo's Aula Magna, the Abel Lectures, the Norwegian Government's Abel Prize banquet with the King of Norway at Akershus Castle and the Abel Prize party at the Norwegian Academy of Sciences and Letters.

Andrea is a PI of the team that was awarded this year the Simons Foundation Collaboration in Mathematical and Physical Sciences grant to tackle Wave Turbulence. This is a four year 8M grant with possibility of extension for another three years. This collaboration is a joint effort of several groups of leading researchers in mathematics and physics, in the US and the EU, for a systematic coordinated study of wave turbulence in a large scale project. The collaboration director is Jalal Shatah from the Courant Institute at NYU. The team's website is: *https://cims.nyu.edu/wave-turbulence/*

Andrea was featured (one of 27 women mathematicians) in the Notices of the American Mathematical Society as part of Women's History Month, March 2018, Volume 65, Issue 03 and further selected by the AMS Public Awareness Office to be profiled in a special poster for the MathFest, SIAM, and AMS sectional meetings and displayed at 2019 JMM, Baltimore, MD. She was also one of 8 PIs featured by the NSF's Office of Legislative and Public Affairs (OLPA) in Medium's issue on Hispanic/Latinx NSF-funded investigators for Hispanic Heritage Month (October 2018).

The Abel Prize banquet at Arkershus Castle with Karen Uhlenbeck (center)

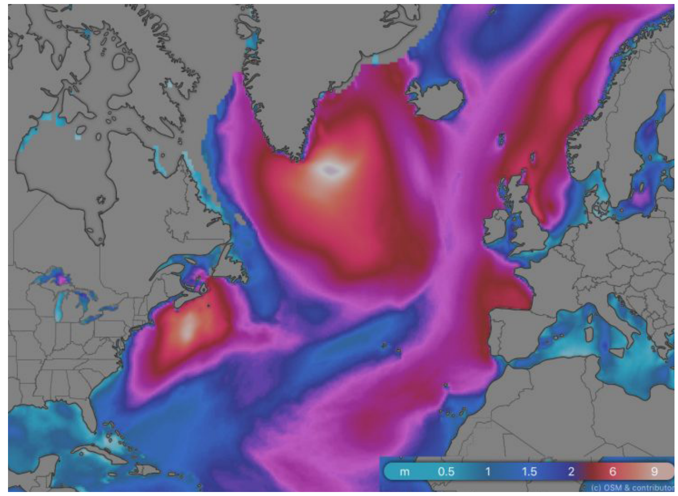


Photo via www.windy.com

GILE & KIM WIN COLLEGE TEACHING AWARD

Krista Gile was one of two awardees for Outstanding Teaching in the College of Natural Sciences annual CNS Outstanding Achievement Awards in May 2019. The citation states:

> *Professor Gile has distinguished herself at all facets of her professional activities. She uses the relationships that she built in service to organizations (including UNAIDS, US CDC, Vietnam CDC, US State Department) to advance the careers of her students. Krista is an excellent academic with a worldview that leads her to support humanitarian efforts with her unique and strong skills as a statistician. She founded a statistics working group involving students and faculty across campus. Graduate students find this working group extremely valuable in their training. Gile is especially passionate about the statistics consulting center, giving high quality statistical service to individuals while at the same time teaching students the art of consulting. She is exceptionally good at weaving together lectures that reach all levels of students in the classroom, facilitating an open environment for collaboration and questions.*

Daeyoung Kim won the same award the previous year, a fact unfortunately omitted from the previous issue of this newsletter. Congratulations Daeyoung and Krista!

NSF DATA SCIENCE FUNDING

The National Science Foundation (NSF) recently awarded a collaborative team led by **Andrew McGregor** (computer science, UMass). This is a three-year, $1.5 million grant to further develop the foundations of data science in a project that will create NSF's national TRIPODS Institute for Theoretical Foundations of Data Science.

Also part of the executive committee with McGregor are Markos Katsoulakis and Patrick Flaherty of our department, and Luc Rey-Bellet is listed as a senior researcher.

One aspect of the TRIPODS project will be to organize summer schools, speaker series, talks by experts in related technical areas and workshops for faculty researchers in other disciplines who want to learn how big data can help them.

Unlike the "practical outcomes" focus of some big data initiatives, the focus of TRIPODS is more on theoretical, mathematical and foundational aspects of data science. The TRIPODS team aims to mathematically prove attributes of a given algorithm such as running time, accuracy and scalability.

Data sets in the sciences, such as genetics and physics, are growing larger every year. For example, a personalized medical device may generate data continuously, 24 hours a day and seven days a week, over a year or longer.

McGregor says, "In statistics the more data you get, the more accurate you can be, but in computer science the more data you get, the longer it will take you to process. That's one reason you need computer scientists and mathematicians working together. When you double the size of the input, we need to know if the algorithm takes twice as long, four times as long or 100 times as long? That's important."

The award is part of the foundation's $17.7 million support for 12 Transdisciplinary Research in Principles of Data Science (TRIPODS) projects, which will bring together the statistics, mathematics and theoretical computer science communities at 14 institutions in 11 states to promote long-term research and training activities in data science that transcend traditional disciplinary boundaries.

In addition to the TRIPODS program, NSF also has two other programs under the umbrella of Harnessing the Data Revolution. One of these is the Ideas Lab, which forms new interdisciplinary teams spread across institutions. New department member Mark Wilson is part of a successful team funded $1.8M over 2 years to study the relation between brain structure and social behavior of humans, using fMRI data, online experiments, and data analysis and simulation. Other team members come from Harvard, Stony Brook, Albany, Chicago, and Minnesota.

OTHER AWARDS

Jenia Tevelev has received a Fulbright U.S. Scholar Program award to research and lecture at Universidad Católica de Chile in Santiago during the 2019-2020 academic year, as part of a project called "New Frontiers of Algebraic Geometry." Jenia thereby adds to his collection of awards, which also contains a Sloan Fellowship, UMass Research Leadership in Action award and a Simons Fellowship!

Pat Flaherty was recently awarded a three-year, $582,883 grant from the National Institutes of Health's (NIH) National Institute of General Medical Sciences to better understand cellular protein homeostasis, the balance between protein creation and destruction. The dysregulation of protein homeostasis is one of the primary paths that allows diseases such as Alzheimer's, Huntington's or Parkinson's to develop. Pat is an expert on statistical tools used to analyze large genomic data sets. He is collaborating on this award with Peter Chien, professor of biochemistry and molecular biology, who is an expert on the highly regulated cellular cleanup system in which specialized proteins called proteases degrade damaged or no-longer-needed proteins a system critical for protein homeostasis. They plan to develop new statistical and computational tools to analyze large-scale genetic experiments to catalog the essential components of this system, which Flaherty and Chien hope will lead to better understanding of pathways important for many human diseases.

Leili Shahriyari has recently been awarded an NIH Grant for "Data-Driven QSP Software for Personalized Colon Cancer Treatment". QSP models are a system of differential equations that model the dynamic interactions between drug(s) and a biological system. These mathematical models provide an integrated "systems level" approach to determining mechanisms of action of drugs and finding new ways to alter complex cellular networks with mono or combination therapy to obtain effective treatments. Since QSP models are a complex system of nonlinear equations with many unknown parameters, estimating the values of the model's parameters is extremely difficult. Existing parameter estimation methods for QSP models often use assembled data from various sources rather than a single curated dataset. These datasets are usually obtained through various biological experiments, in vitro and in vivo animal studies, thus rendering QSP models hard to be practicable for personalized treatments. To the best of our knowledge, no QSP model has been developed for personalized colon cancer treatments. In this project, we propose a unique approach to develop a data-driven QSP software to suggest effective treatment for each patient based on gene expression data from the primary tumor samples.

Congratulations to these and other department members receiving external research grants. The department continues its upward trajectory in attracting funding.

OUTSTANDING STUDENTS HONORED AT 2019 AWARDS DINNER

The Awards Dinner, a highly anticipated social event in the department, was held on campus in April, organized by Paul Hacking.

RECOGNITION OF UNDERGRADUATE ACTIVITIES

Honors Research and Theses: Ji-Hun Hwang (Kevrekidis), Alexander Fischer, Fiona McCann (Charalampidis), Jennifer Sullivan (Charalampidis), Artem Vysogorets (Braden)
Putnam Competition: Sunita Bhattacharya, Long Le, Patrick Lei, Haiyao Liu, Mridul Madan, Nishad Ranade, Daniel Weber, Aubrey Wiederin

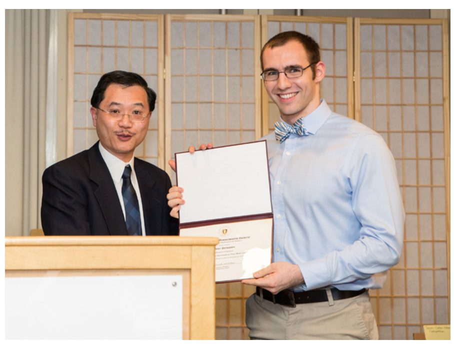
REU (Research Experience for Undergraduates) Program 2018: *Sponsored by Joan Barksdale ('66), Sheila R. Flynn, Nancy Sinclair and faculty grants.*

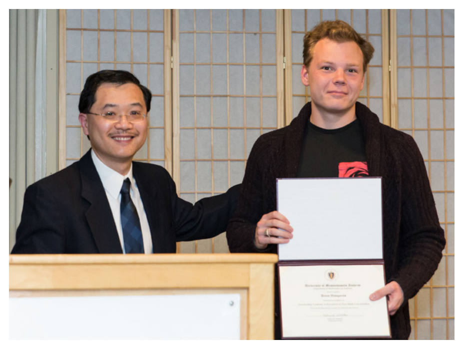
REU in Pure Math: Jeffrey Ayers (Oblomkov), Ojaswin Karthikeyan (Williams), Patrick Lei (Schaffler), Matheau Santana-Gijzen (Oblomkov), Andrew Sharp (Baykur), Wilson Wang (Morales), Daniel Weber (Oblomkov)

REU in Applied Math: Katherine Donoghue (Charalampidis), Wenjie Li (Li), Wenbo Xie (Q-Y. Chen)

REU in Statistics: Collin Giguere (Flaherty)


Siman Wong, Anwesha Saha


Siman Wong, Peter Delmastro


Siman Wong, Artem Vysogorets

Nishad Ranade, Mridul Madan, Paul Hacking, Sunita Bhattacharya, Alexander Fischer


Cory Ward, Panos Kevrekidis


Markos Katsoulakis, Fiona McCann

Patrick Lei, Stathis Charalampidis

Ji-Hun Hwang, Nate Whitaker

Diana Hansen, Nate Whitaker

Anna Liu, Michelle Heeney

Markos Katsoulakis, Jinchao Feng, Anna Liu, Nate Whitaker, Joy Yu, Luc Rey-Bellet

Daniel Weber, Rob Kusner, Katherine Donoghue

UNDERGRADUATE AWARDS

M. K. Bennett Geometry Prize: Thom Barron, Daniel Weber

Jacob-Cohen-Killam Competition: *Sponsored by John Baillieul ('67), James Francis ('86), and Roy Perdue ('73).*

1st Patrick Lei	3rd Sattwik Das
2nd Guanghao Wei	4th Shirui Cao and Qisen Luan

SCUDEM Math modeling Competition: Ji-Hun Hwan, Sharath Ramkumar, Samuel Rosen

Leon Emory Lincoln and Robert Bradley Lincoln Scholarship: Patrick Lei

Marcia Lockhart Ruma Scholarship: Lewei Ding

Don Catlin Award for Outstanding Achievement in Applied & Computational Mathematics: Sarah Brockman, Katherine Donoghue, Robert Jaycox, Matthew Leblanc, Fiona McCann, Alexandre Pelletier, Andrew Sharp, Jennifer Sullivan, Chang Yu, Michael Zhang

The Bob and Lynne Pollack Award for Outstanding Academic Achievement in Actuarial Science: Sean Emerson, Diana Hansen, Jingsheng Huang, Ting-Han Tam, Renée Vartabedian, Nicole White

The Steve and Geni Monahan Student Leadership Award: Jessica Lam, Brenna Walsh

Outstanding Academic Achievement in Pure Math and Individual Concentration: Peter Delmastro, Daniel Weber, Artem Vysogorets, Anwesha Saha

Outstanding Academic Achievement in Statistics: Maxwell Ball, Emily Dzwil, Adam Elghazzawi, Michelle Heeney, Zhaoxia Li, Alexandria Sahagian, Edward Schneeweiss, Johnny Wei, Yingyi Li

Outstanding Academic Achievement in the Teaching Concentration: Eva Gaston, Jessica Gattoni

GRADUATE STUDENT AWARDS

Distinguished Thesis Award: Jinchao Feng (Katsoulakis Rey-Bellet), Cory Ward (Kevrekidis/Whitaker), Joy Yu (Liu)

Distinguished Teaching Award: Sean Hart
Graduate Student Leadership Award: Tori Day

LOCAL CONFERENCES

The department organized a few local conferences in the last year.

On 12 April 2019 the department held a conference "Rare Events, Information Theory and Statistical Physics" to celebrate our late colleague **Richard Ellis.**

The speakers were: Paul Dupuis (Brown University), **Jon Machta** (UMass Amherst), Charles Newman (Courant Institute, NYU), Peter Otto (Williamette University), Hugo Touchette (Stellenbosch University, South Africa) and **Bruce Turkington** (UMass Amherst).

Richard's family including his son Michael Ellis attended for some of the time. This event was supported in part by a generous contribution of Anne and Peter Costa.

More details can be found at: *http://people.math.umass.edu/~nahmod/Rare_Events_InfoTheory_StatsPhysics_Celebrating_Ellis.html*

On April 6, 2019 the department hosted the Discrete Math Day of the Northeast, a biannual regional conference in discrete math under the auspices of the Northeast Combinatorics Network. There were five speakers: Diego Cifuentes (MIT), **Laura Colmenarejo** (UMass Amherst), Pamela Harris (Williams College), Hamed Hatami (McGill), and Lauren Williams (Harvard), six poster presentations, and a discussion on math culture. The conference had a total of 49 participants including 21 women and 6 underrepresented minorities. The local organizers of the conference were **Laura Colmenarejo, Alejandro Morales, Ga Yee Park, Annie Raymond,** Jordan Tirrell (now at Washington College), and Ashley Wheeler (Mt. Holyoke) and the event received support from the NSF and the UMass MSP research support fund.

– Annie Raymond

Yao Li, Luc Rey-Bellet and **Hongkun Zhang** organized and hosted the Second Northeast Conference on Dynamical Systems, held in the department November 15-17 2019. This conference was supported by NSF grant DMS-1900397, and it concentrated on the connection between dynamical systems and mathematical physics.

Two distinguished lectures were given by Giovanni Gallavotti and Konstantin Khanin. Giovanni Gallavotti was awarded with Boltzmann Medal in 2007 and Henri Poincare Prize in 2018. He was an ICM invited speaker in 1986 and a plenary speaker in 1998. Konstantin Khanin was a 2013 Simons Foundation Fellow and an ICM invited speaker in 2018. He also held the Jean-Morlet Chair at the Centre International de Rencontres Mathématiques in 2017.

FIRST BAILLIEUL DISTINGUISHED LECTURE

A new distinguished lecture series has been established starting in Fall 2019 through a generous gift by John and Patricia Baillieul. Every year, the series will host top researchers throughout mathematics and statistics to disseminate important recent de-

DMD attendees 2019, including A. Morales (front left), A. Raymond (2nd row 3rd from left), L. Colmenarejo (next to left), G-Y Park (3 more to left).

Inaugural Ballieul Distinguished Lecturer Anthony Bloch (left), donor and alumnus John Ballieul (right).

velopments in the field. **Dr. Anthony Bloch** gave the first Baillieul Distinguished Lecture. He is the Alexander Ziwet Collegiate Professor of Mathematics and Department Chair at the University of Michigan, and he is a leading scholar in the fields of geometric mechanics and control of mechanical systems with symmetry and authored the graduate textbook Nonholonomic Mechanics and Control. He gave a pair of lectures on Dynamics of Nonholonomic Systems and the Geometry of Integrable Systems and Optimal Control, which included demonstrations of the famous tippe top and rattleback top.

– Matthew Dobson

RESEARCH EXPERIENCES FOR UNDERGRADUATES

The department's REU program recruits students from the five colleges and pairs them with faculty mentors for an eight-week full time research project. Students work either in groups or individually in close collaboration with their faculty mentor. Topics range throughout mathematics and statistics depending on faculty and student interest. This year, we had 14 students and 9 faculty members involved. Students had the opportunity to present their work during a one day miniconference that was open to schools throughout the area. In addition to UMass, students from Amherst College, Smith College, Williams College, Brown University, Yale University, and University of Connecticut contributed, with a total of 29 research presentations given in parallel sessions. We appreciate the financial support of Joan Barksdale, which provides research stipends for many of the students.

Note that Alexei Oblomkov and Matthew Dobson supervised half of the students between them, an impressive contribution!

– Matthew Dobson

SUCCESS IN INSURANCE MODELING COMPETITION

Two doctoral students in mathematics and statistics, Tangxin Jin and Jie Wang, recently brought home the first place trophy to campus after winning the annual Travelers Analytics Case Competition held in late January at the University of Connecticut Storrs.

Sponsored by the insurance firm headquartered in Hartford, the competition presented 71 teams of students from UConn's Storrs and Hartford campuses as well as UMass Amherst with a real-life data set of around 20,000 records with 25 variables each, including such factors as accident reports, driver information, claim details, vehicle information and location of accident. Their task was to use probability theory, predictive modeling and machine learning to predict the likelihood that any given auto accident claim was fraudulent. As Jin explains, "Fraudulent claims are a big problem for insurance companies and mathematical predictive models can identify cases for further scrutiny."

After months of elimination rounds, three finalist teams, one from each campus, progressed to the last round and were judged by insurance company officers and members of its actuarial and advanced analytics teams on presentation of their data exploration, model accuracy, cost assessment and business value.

Tangxin Jin and Jie Wang receiving their award for the Travelers Analytics Case Competition.

Jin says, "It was a great honor for us to bring the trophy back to Amherst. The competition is annual, and it is helpful for students in our department to apply our diverse training and at the same time gain modeling experience by tackling real-life problems. We learn and develop mathematical and computational methods in classes and during our Ph.D. training, but here we applied these tools and training in this competition. We both feel we learned a lot from the real-life data and real-life problems." Each hopes to pursue a career in mathematical sciences in industry.

Wang explains that dozens of teams entered the first phase of the competition last October. She and Jin used advanced machine learning approaches such as Random Forest, Bagging, Adaboost and XGBoost to build variant models. Then they combined several models using ensemble learning methods such as stacking to get better prediction performance.

Based on the resulting predictive models, they found a few important factors such as driver's safety rating, the claim's estimated payout and vehicle price had a large influence on the likelihood that a claim was fraudulent. The company's data scientists said they gained new business insights from Jin and Wang's new "models of models."

Mathematics and statistics department head Nathaniel Whitaker says of the team's accomplishment, "The department is very proud of Jie and Tangxin in winning this competition. This highlights their talent and training. They have a broad range of expertise which will serve them well in the future."

Professors Markos Katsoulakis and Luc Rey-Bellet say that they are very proud of their Ph.D. students' accomplishment, but, Katsoulakis adds, "I am not really that surprised. Jie and Tangxin have mustered a wide-ranging expertise combining applied mathematics, statistics and computing that allowed them to be at the same time creative and practical, ultimately bringing them in at the top of the competition.

This showcases the training of our applied mathematics students, but specifically demonstrates the strong potential of Jie and Tangxin in any future career paths they may choose."

Asked how difficult was the competition, both students said the experience was indeed difficult but also fun. The one stressful element, they note, is that they could see their team's ranking against the other 71 teams each week, and it became increasingly hard to stay on top. In addition to the trophy, the first place team members each brought home certificates and a mini-drone.

TEACHING MATH IN PRISONS continued from cover

A few months later, after having completed some background checks and training sessions as well as having my syllabus approved by the community college awarding the credits to students part of UBB, I taught at the prison for the first time. The men filed in and came one-by-one to introduce themselves. That's when it hit me that I was alone in a room with criminals. Obviously, I knew this would be the case, but I hadn't fully appreciated that fact. For a few minutes, I was literally speechless: I was unable to greet my students, `hi' was too complicated of a word to utter. They finally all sat down and looked up at me expectantly. I finally calmed down: I knew that excited and nervous look, it was the same one students would give me at the beginning of every semester. These men were my students. Any other part of their identity was irrelevant in that moment. With the weight of this realization sinking in, I was able to start teaching.

My first semester went better than I could have ever expected. The course was basically an introduction to discrete mathematics, a topic which is particularly appealing for students who might dislike — and sometimes even fear — mathematics because of courses they have previously taken. With discrete math, we can talk about love, solve fun puzzles, do magic, become better poker players, optimize our lives in many ways and so much more. Most students were at first surprised that these things all related to math, but very quickly, they started seeing every aspect of their lives more mathematically. My students had such a fierce passion and thirst for learning the material. The continuous stream of questions during classes was a testament to their refusal to be satisfied by mere knowledge and to their incomparable commitment to achieve true understanding.

I won't lie: that first semester — and every subsequent time I have taught in a prison — brought its lot of challenges too. The size of the board available would make any mathematician want to cry. The disparity in the students' previous knowledge was much greater than in the most uneven freshman calculus class — some hadn't taken a math class in several decades while others had finished their GED while in prison. Many needed to be taught how to study. The classroom was loud: there was a rock band practicing in the next room, though my own students would sometimes give them a run for their money when arguing about how to solve some problem. I couldn't hold office hours and the students couldn't email me to ask me for help. Most students had full-time jobs at the prison and no quiet place to study the rest of the time. The prison was far away and I had to rely on carpools and buses that would tally up a commute of three hours in total. Classes were three hours long and in the evening, which was challenging for the students and me. I also had to deal with a few correctional officers who thought inmates did not deserve to have this chance and refused to treat them like students. But all of this was amply made up by how enthusiast, dedicated and grateful my students were.

That first course proved to be very effective in making students care about math: my students asked me if I could come back the next semester to teach them again even though the class they had just completed was the only math class required for the associate degree they were completing. I suggested a traditional route: calculus or linear algebra. They requested that I teach them an introduction to proofs instead — I had occasionally shown them some proofs during the semester, and they wanted more. Given that the community college that was granting the students credits did not offer such a class, we settled on a lecture series that would be offered just for fun. Let me emphasize this: inmates took advanced math just for fun. My first students publicized the series so much, that it was standing-room only. It was amazing. After that class, we went back to a more traditional mathematical route since many of them now wanted to get a bachelors of sciences — even Ph.D.'s in some cases — instead of associate degrees, some of them in mathematics. A few of my first students have now been released and are now on their way to achieve their dreams.

The next semester, I went to MSRI for the Geometric and Topological Combinatorics program. My experience with UBB had been so positive that I wanted to find a way to keep teaching inmates. I found out there was a program similar to UBB called the Prison University Project (PUP), and I volunteered with them at the San Quentin State Prison. There are many such programs around the country that are always looking for more mathematicians to volunteer: *http://prisonstudiesproject.org/ lists many of them*. For those who would like to volunteer but who might not have enough time to teach an extra three hours a week, most programs allow for classes to be co-taught by two or three instructors. Tutoring is also another good option that requires a smaller time commitment. It can also be a good option for peridoctoral students who want to volunteer and who do not meet the instructor requirements set by the institute granting the credits for the course. Many programs also offer non-credited classes to prepare the students for the credited courses; those preparatory classes can often be taught by grad students.

Unfortunately, not every prison and jail has a program like UBB and PUP — this is the case of the local jails near me. As I arrived to start my tenure-track position at UMass, I still wanted to keep teaching math to inmates, but there was no such program nearby. A few college classes in different fields had been taught over the years, but nothing with much direction and never any classes in math. It took many months of emailing with the administration at the Hampshire County Jail before they agreed to even meet with me: they were dubious that any of their men would be interested in taking college-level math.

I eventually convinced them to let me run a Math Circle with biweekly meetings where we would focus on the process of doing mathematics, of solving mathematical problems and exploring mathematics together instead of learning set rules. This would be a way of gauging students' interest for a potential course. The Math Circle was a success. The students would talk about it for days after our meetings, and the number of students wanting to attend increased steadily throughout the semester. This convinced the administration that it would make sense to offer a college-level class the next semester.

I was thrilled, but I was also nervous about how I could raise funds to pay for the credits the students would obtain, something that organizations like UBB or PUP usually take care of. One option would have been to go through The Second Chance Pell program, program of the U.S. Department of Education that was launched under Obama, that serves 12,000 inmates a year nationally. Otherwise, there is a ban on federal financial aid for inmates. If this ban were lifted, about 463,000 prisoners would be eligible for a regular Pell Grant. Information on how to start new sites can be found here: *https://experimentalsites.ed.gov/exp/expectations.html.*

I was very lucky that I got help in acquiring an easier source of funding: my department chair, Nathaniel Whitaker, was also very interested in prison education and was able to help me to

It took many months of emailing with the administration at the Hampshire County Jail before they agreed to even meet with me: they were dubious that any of their men would be interested in taking college-level math.

get UMass to lift the tuition fees for our students. My chair had never had the opportunity to teach inmates before, so we decided to co-teach the class together. It was a great experience for all involved.

Being at a small local jail instead of at a big prison both has advantages and disadvantages. Let's start with the negatives. Small jails are less likely to have a higher education program, which results in more fundraising work for those who volunteer. Inmates stay in general in small jails for a shorter amount of time and might be spending a lot of their time in and out of legal proceedings. So class sizes might be quite small — small enough that you might wonder whether this is worth the effort — because not only are there less inmates to begin with, but also few can commit to a full semester of classes. It is even more unlikely that they will be there long enough to complete enough classes while in prison to earn an associate degree (that is, if sufficiently many classes are offered to do so).

UBB is an engine of change chugging within the junkyard. It is impossible to overstate the shift in thinking that takes place in a prisoner's mind once he has been enriched with the potential found in higher learning. A real future has become conceivable, instead of just a dream for someone else.

On the flip side, this means you can spend more time with each student and help them at a critical time of their release when they need support to transition to your own institution or some other local university or community college. The fact that you only teach a few students also makes it more likely that you can convince your institution to lift tuition fees. The small number of students also makes such classes good candidates for inside-out classes: classes where half of the students are inmates, and the other half are students from your institution. For the latter, this offers the opportunity to meet people very different from themselves and change the way they view the world in general as well as their education. After observing how much work the inmates put towards their classes, many are inspired to follow their example to make the most of their college experience, which they also come to regard as an amazing opportunity. For the inmates, an inside-out class offers them a boost in confidence. They get to see that they truly are college students — in classes without outside students, the inmates often falsely believe that the classes are diluted because they are not good enough — and what is more, that they are successful college students. Another advantage of inside-out classes is that your institution might accept to count them as part of your teaching duties. Training for inside-out classes is offered by the Inside-Out Center at Temple University; more information can be found at: *https://www.insideoutcenter.org/training.html.*

So why do all of this? I believe that offering college-level math courses in our prisons is more important than offering any other subject. According to Community College Students Face a Very Long Road to Graduation by Ginia Bellafante, among the general population, about 40 percent of students who start at a 2-year college never finish because they do not complete the one math class they have to take. Math is the roadblock stopping so many people in America from getting a degree. By teaching that class in prison, it gives students a better chance of completing an associate degree either while in prison or after their release.

Moreover, the impact on the students' lives is huge. In the US, 70% of prisoners return to prison within three years. The single most effective way to reduce recidivism is education: inmates that participate in any correctional education programs are 43% less likely to recidivate than those who do not according to: *https://www.rand.org/pubs/research_reports/RR266.html* and earning an associate or bachelor degree while in prison drops the rate of recidivism to 13.7% and 5.6% respectively. Moreover, given that more than 70% of state prisoners have not completed high school, it is clear that our social support systems, including our educational system, have failed so many of these men and women. Offering access to higher education in prisons is one way to attempt to break the cycle of crime and poverty that so many inmates are stuck in.

In the words of UBB student Steve B., "UBB is an engine of change chugging within the junkyard. It is impossible to overstate the shift in thinking that takes place in a prisoner's mind once he has been enriched with the potential found in higher learning. A real future has become conceivable, instead of just a dream for someone else."

If you treat inmates like students, they will become students — and often they will surprise you and even become scholars. They will become inspiring agents of change who we want to see out in our society.

Problem 1. What is the volume of the 2018-dimensional simplex

$$\{(t_1, \ldots, t_{2018}) \in \mathbf{R}^{2018}\,;\, 0 \le t_1 \le \cdots \le t_{2018} \le 1\}?$$

Solution. The n-volume of the n-simplex equals $\frac{1}{n!}$. One way to see this: slice with planes $\{t_n = t\}$ into $(n-1)$-simplices rescaled by t, integrate on $0 \le t \le 1$ to get the n-volume of the n-simplex is $\frac{1}{n}$ times the $(n-1)$-volume of the $(n-1)$-simplex, and apply (reverse) induction in n. But perhaps the most direct way is to subdivide the n-cube, whose n-volume is 1, into $n!$ congruent n-simplices by permuting the n coordinates. (If you object that they overlap slightly, replace them with *open* n-simplices, where the the inequalities are strict: these are *disjoint* and have the same n-volume as the (closed) n-simplices.)

□

2. Given numbers a_1, a_2, a_3, a_4 suppose a_n is defined recursively as

$$a_n = (a_{n-1} + a_{n-2} + a_{n-3} + a_{n-4})/4$$

Show that the sequence $\{a_n\}$ converges and calculate $L = \lim_{n\to\infty} a_n$.

Solution. More generally, we can start with k numbers $a_1, a_2, \ldots, a_k$ and define the sequence using averages $a_n = (a_{n-1} + a_{n-2} + \cdots + a_{n-k})/k$. The key will be to consider groups of k consecutive terms $a_n, \ldots, a_{n+k-1}$ rather than just one term at a time.

We will manage to calculate the limit based on an abstract reasoning that will show that the limit exists. Let M_n and m_n be the maximum and minimum of numbers $a_n, \ldots, a_{n+k-1}$. Notice that a_{n+k} is between m_n and M_n, hence the same is true for all $a_{n+1}, \ldots, a_{n+k}$. This implies that the sequence M_n is decreasing and m_n is increasing. So they converge to numbers $M \ge m$.

Taking averages gets numbers closer together and this can be used to show that $M_n - m_n$ goes to zero. Hence, $m = M$ and then the sequence a_n converges to the limit $L = m$.

Once we know $\lim\ a_n = L$ we will see that L has to be $(a_1 + 2a_2 + \cdots + ka_k)/(1+2+\cdots+k)$. The reason is that the following weighted average $A_n = [a_n + 2a_{n+1} + \cdots + ka_{n+k-1}]/(\sum_1^k i)$ of the n^{th} group does not change with n :

$$(A_n - A_{n+1})(\sum_1^k i) = (a_n + 2a_{n+1} + \cdots + ka_{n+k-1}) - (a_{n+1} + 2a_{n+2} + \cdots + ka_{n+k})$$

$$= (a_n + a_{n+1} + \cdots + a_{n+k-1}) - ka_{n+k} = 0.$$

Now $A_1 = \lim\ A_n = (L + 2L + \cdots + kL)/(1 + \cdots + k) = L.$ □

3. Consider a regular tetrahedron with edges of length 1. What is the length of the shortest loop on its surface which surrounds two vertices?

Solution. By a "loop on its surface which surrounds two vertices" we mean: the loop has no self-intersections, one component of its complement on the surface contains two (say, A and B) of the tetrahedron's four vertices, and another component of the complement contains the other two vertices (C and D). With this clarification, we argue that shortest such loop has length 2. First observe that there *is* such a loop with length exactly 2, namely, any of the rectangular loops on the surface lying in planes parallel to the edges AB and CD. But any other such loop which meanders back and forth among these rectangular loops would be longer. To see this, cut the tetrahedron along the edges AB and CD, as well as along one more edge, say AC: the result unfolds into a parallelogram in the plane, each of the rectangular loops unfold to a straight segment of length 2, and the meandering loop unfolds to a longer curve. (This is a simple example of a "calibration" argument.) □

4. Consider all 3×3 arrays such that (i) entries include all the digits from 1 through 9, and (ii) entries in every row and column are in increasing order. How many such arrays are there?

Solution. Think of such array as a matrix a with entries (a_{ij}), with $1 \leq i, j \leq 3$. Clearly, $a_{11} = 1$ and $a_{33} = 9$. Also, when we remove the main diagonal, what remains are two "hooks" A (upper right corner) and B (left lower corner), each of length 3. Notice that $a_{22} \in \{4, 5, 6\}$, so we distinguish three cases:

Case $a_{22} = 4$. Observe that the array a is determined once we know the three numbers $\{a_{12}, a_{13}, a_{23}\} \subseteq \{2, 3, ..., 8\}$ in the hook A. First, since hooks are linearly ordered there is only one way to position given three numbers in one of the hooks A or B. Second, the numbers in B are determined by those in A as the three remaining numbers in $\{2, 3, ..., 8\}$. So, we only need to count all possible choices choices of $\{a_{12}, a_{13}, a_{23}\}$.

Notice that in positions 12 and 21 we can only use 2 and 3. Finally, once we choose a_{12} as one of these two numbers the set $\{a_{13}, a_{23}\}$ can be any pair from the remaining 4 numbers $4, 5, 6, 7$. Thus, there are $2 \cdot \binom{4}{2} = 12$ possibilities in this case.

Case $a_{22} = 6$ is symmetric so it remains to consider the **Case** $a_{22} = 5$. Here, the hook A can be any triple from the set $\{2, 3, 4, 6, 7, 8\}$ with the exception of $\{2, 3, 4\}$ and $\{6, 7, 8\}$. Thus, there are $\binom{6}{3} - 2 = 18$ possibilities.

In conclusion, there are $12 \cdot 2 + 18 = 42$ such arrays.

Note. This problem is a very particular case of the *Hook length formula* for the number of *Young tableaux* of hook shape. Young tableaux are basic objects of combinatorics related to representation theory and one can (carefully) extend the above reasoning to prove this formula. □

5. Show that the coefficients E_n in the expansion of $f(x) = \sec x + \tan x$ as $\sum_{n=0}^{\infty} E_n \frac{x^n}{n!}$. satisfy $E_0 = E_1 = 1$ and for $n \geq 1$

$$2E_{n+1} = \sum_{k=0}^{n} \binom{n}{k} E_k E_{n-k}.$$

Solution. The two sides in the required identity are coefficients of x^n in expansions of $2f'$ and f^2. So, the identity for $n > 0$ will follow from $2f' = f^2 + 1$. First notice that $1/f = \sec(x) - \tan(x)$, since $\sec^2(x) - \tan(x)^2 = 1$. Then $f' = \sec(x)\tan(x) + \sec(x)^2 = \sec(x)f$. So, indeed $2f' = 2\sec(x)f = (f + 1/f)f = f^2 + 1$. Also, $E_0 = f(0) = 1$ and $E_1 = f'(0) = \frac{1}{2}[f(0)^2 + 1] = 1$.

Note. These numbers E_n form the sequence $1, 1, 2, 5, 16, 61, \ldots$. They are called the *Euler numbers* (see Wikipedia). They appear in discrete mathematics and count the number of permutations of $2n$ elements that are *alternating* (go up and down, up and down,...), For instance for $n = 2$ we have two such: 1324 and 2314. □

6. Let $\mathcal{A}_n$ be the set of all subsets S of $\{1, 2, ..., n\}$ such that S contains the size $|S|$ of S. Let $\mathcal{B}_n$ be the set of all S in $\mathcal{S}_n$ which are *minimal*, i.e., the only T in $\mathcal{S}_n$ that S contains is S itself. Show that the number b_n of elements of the set $\mathcal{B}_n$ is the n^{th} Fibonacci number F_n where $F_1 = 1 = F_2$ and after that $F_n = F_{n-1} + F_{n-2}$.

Solution. The part of $\mathcal{B}_n$ consisting of all $S \in \mathcal{B}_n$ that do not contain n is $\mathcal{B}_{n-1}$. The remainder $\mathcal{R}$ consists of all $S \in \mathcal{B}_n$ that contain n. Such S does not contain 1 because $\{1\} \in \mathcal{A}_n$, so S would not be minimal. So, to S one can associate S' obtained from S by removing n and then also $S'' = S' - 1 = \{x - 1;\ x \in S'\}$. Then S'' lies in $\{1, ..., n-2\}$ and $S \mapsto S''$ gives a bijection of $\mathcal{R}$ and $\mathcal{B}_{n-2}$. So, $b_n = b_{n-1} + b_{n-2}$! Also, clearly $b_1 = 1 = b_2$. □

7. Evaluate $\int_0^{\pi/2} \frac{1}{1+(\tan x)^{\sqrt{2018}}}$.

Solution. Use shorthand $\alpha = \sqrt{2018}$ and rewrite the integral $I = \int_0^{\pi/2} \frac{1}{1+(\tan x)^\alpha}\, dx$ via substitution $x = \pi_2 - u$ as $I = \int_0^{\pi/2} \frac{(\tan x)^\alpha}{1+(\tan x)^\alpha}\, dx$. Then $2I = \int_0^{\pi/2} 1\, dx = \pi/2$. So, $I = \pi/4$ regardless of α !

Note. We managed to calculate this definite integral without knowing indefinite integral, because of a special property of the function (symmetry under $x = \pi_2 - u$). The most famous trick of this kind is the calculation of $J = \int_{-\infty}^{\infty} e^{-x^2/2}\, dx$. Here, $J^2 = \int_{\mathbb{R}^2} e^{-(x^2+y^2)/2}\, dx\, dy$ can be easily calculated by passing to polar coordinates $x = r\cos(\phi)$, $y = r\sin(\phi)$, because of the rotational symmetry of the function $e^{-(x^2+y^2)/2}$. The result $J = \sqrt{2\pi}$ is essential in probability (normal distribution), and then also in number theory (zeta function) and quantum field theory (Feynman integrals). □

ALUMNI PROFILE continued from cover

Q. How do you spend your time in a typical day?

There are large variations based on the day of the week and the week of the year, but it averages out to about 50% in R (split into data wrangling, visualization, and modeling), 25% talking with collaborators, and 25% on other projects (such as event planning, presentations, etc). The calendar is fairly rigid, in that on Monday, everyone cares about what happened over the weekend (so we share data-driven reports), but by Thursday, we have all moved onto next week.

Q. You have a PhD from Brown in Biostatistics, and you were a tenure track professor at Skidmore College. How have mentors and colleagues reacted to your move to the NFL?

I've done sports on the side for more than a decade (as an example, when I was at UMass and learning Poisson regression, I immediately started a project on NHL penalties), so not sure anyone was that surprised. And I'm lucky enough to still teach one course a year at Skidmore as a lecturer. One big perk of working at the league office (as opposed to a team) is that I can publish some of our work, and so in that sense, I still hopefully can contribute to the academic community.

Q. What aspects of your graduate (and undergraduate) education have been the most useful for your current job?

It's extremely humbling to know that no matter how many statistical tools I feel comfortable using, there's always more to learn. Grad school in statistics ensures you are familiar with a much larger framework of options for analyses, and so the ability to know what tools will and will not work (or, perhaps, if you need to write a new approach) is the main benefit. Three approaches that I use disproportionately often: multi-level modeling, data visualization, bootstrapping.

Q. What advice do you have to our current undergraduate and graduate students who are interested in using their mathematical and statistical skills in the field of sports analytics?

The neatest aspect about working in sports is that much of the time that I'm at work, it doesn't really feel like it, as these are questions I'd want to answer regardless of whether or not I am doing it for a job. That said, jobs outside of sports may pay more, come with a better work/life balance, and will allow for more flexibility with respect to where you live. The primary ways into sports analytics are knowing either R or Python, boasting enough (pending the role) statistical expertise, and some level of familiarity with whatever sport you are looking into. In that sense, proving you fit all three of these criteria, say through a class project, an online blog, or a Shiny app, is the easiest way to get your name out there.

Q. As a MA state employee, I'm obligated to ask about the Patriots. Do you think Tom Brady the best quarterback ever or is he the best professional athlete ever?

The probability of both of these being true is greater than 0.

New faculty member
Mark Wilson

APPLIED MATH MASTER'S PROJECTS

The Applied Math master's projects this year were overseen by **Qian-Yong Chen**. There were three group projects, whose titles and abstracts are shown below. The full project reports can be viewed at: *http://www.math.umass.edu/graduate/applied-ms#projects*

Smart Grid

Rachel Aronow, Aaron da Silva, Rose Dennis, George Kevrekidis, Richard Touret, Lance Wrobel

Abstract

Global depletion of resources and increased demand on our electric grid have resulted in a need for innovation in support of an intelligent utility network the Smart Grid. Thus, the enhancement of electrical power interactions for both utilities and customers has become a major focus for current research. At a microscale level, we use gradient boosting models to predict electrical power consumption and solar power generation for a single home. We also develop a dashboard as a visualization tool for this analysis. At a macroscale level, we explore the cost optimization of power dispatch between various energy sources in a simplified model of the German electric grid.

Through these levels of study, we aim to establish a deeper understanding of the potential requirements of a modern Smart Grid.

Cancer Growth Modeling

Michael Barmann, Ryan Wilson, Nick Malloy, Andrew Xiang, Junsang You

Abstract

In this project, we investigate the dynamics of cancer growth and treatment using a combination of statistical, analytical, and numerical approaches. We first review three common models of cancer growth–the Exponential, Power Law, and Gompertz-Laird models – and then fit these models to tumor volume data collected from laboratory mice. We obtain parameter estimates and assess how well each model fits the data. We also employ a Support Vector Regression (SVR) algorithm to predict growth trends based on the given data. Finally, we examine a treatment model adapted from the competitive two-equation Lotka-Volterra system and perform a stability analysis and obtain numerical results.

'Hearing' the Clusters in a Directed Graph"

Chris Brissette, Matthew Gagnon, Brendan Shanahan, James Smith.

Abstract

We examine the generalization of a fully-distributed method for computing spectral clusters to the case of aperiodic strongly-connected digraphs. In doing this we show that the sign of eigenvector components can be obtained via the Fourier series of a local wave-equation relaxation. Further we provide a runtime complexity for this variety of digraphs differing from the undirected case

Work-life balance! Faculty, staff and family members at department Christmas party 2019.

THE BOURBAKI SONG

The following, sung to the tune of "The Battle Hymn of The Republic", originated (first 2 verses and chorus) at University of Chicago in the 1950s. The later verses were written by Mark Wilson and Joel Robbin at University of Wisconsin the 1990s.

Note to faculty and graduate students: I hope to hear this at parties in the department in 2020 — start learning the words now! – Ed.

Historical note: Nicholas Bourbaki was the pseudonymous group of mostly French mathematicians whose books and seminar were very influential in mid-20th century pure mathematics — check them out on Wikipedia.

Analysts, topologists, geometers agree:
When it comes to generality, there's none like Bourbaki!
One theorem by them will equal N by you and me,
Bourbaki goes marching on!

Chorus:
Glory, glory hallelujah,
Their generality will fool ya--
They're axiomatically peculiah!
Bourbaki goes marching on!

To prove that two plus two is four, here is what they do:
They show that A plus B is C if A and B are 2;
We know that C is half of D and D is four times 2,
Bourbaki goes marching on!

[Chorus]

They commenced to write a book to train young analysts,
but in filling in foundations, they encountered many twists.
Though their dream to end in finite time has vanished in the mists,
Bourbaki goes marching on!

[Chorus]

In the glory of the twenties came to be homology:
those groups of Emmy Noether which transfigured you and me.
As she tried to make them cyclic, Bourbaki has made them free!
Bourbaki goes marching on!

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