Newsjournal of the Society for Industrial and Applied Mathematics sinews.siam.org

siam news

Volume 57/ Issue 5
June 2024

Approximate Localized Multidimensional Patterns

By Dan J. Hill and David J.B. Lloyd

Spatially localized patterns offer fascinating insights into the emergence of organized behaviors, from weather fronts and desert vegetation to stop-and-go traffic waves and the buckling of rocket cylinders (see Figure 1). While existing mathematical tools—such as bifurcation analysis and singular perturbation theory—facilitate the study of one-dimensional (1D) localized patterns, the development of equivalent tools in higher spatial dimensions remains a significant challenge and has been a major research area for the past 20 years.

The establishment of mathematical pattern formation as an area of study is often attributed to Alan Turing and his seminal 1952 paper [10] on general two-component reaction-diffusion systems of the form

$$\mathbf{u}_t = \mathbf{D}\Delta\mathbf{u} + \mathbf{f}(\mathbf{u}),$$

where $\mathbf{u} \in \mathbb{R}^2$, $\mathbf{D}$ is a diffusion matrix, Δ is the Laplacian, and $\mathbf{f}$ is a nonlinear function. Towards the end of his life, Turing—who was fascinated by hexagonal patterns in daisies and fluid dynamics—derived a scalar partial differential equation (PDE) that closely resembles the now-standard prototypical model for pattern formation:

$$U_t = -(1+\Delta)^2 U - \mu U + \nu U^2 - U^3, \tag{1}$$

where $U = U(\mathbf{x}, t) \in \mathbb{R}$ and μ and ν are real parameters. This formula, which is known as the Swift-Hohenberg equation (SHE), was derived again 25 years later as a simple model for Rayleigh-Bénard convection [9].

The SHE undergoes a pattern-forming instability at $\mu = 0$ such that for $\mu < 0$, the previously stable trivial state becomes unstable to patterns of the form $\cos(\mathbf{k} \cdot \mathbf{x})$. Here, the *critical wave vector* $\mathbf{k}$ has the same dimension as the spatial coordinate $\mathbf{x}$ and satisfies the condition $|\mathbf{k}| = 1$, which is a key indicator of the increased difficulty in the study of multidimensional patterns; 1D patterns have just two critical wave numbers ($k = 1$ and $k = -1$), whereas patterns in higher spatial dimensions have a continuum of critical wave vectors. We can thus restrict to a finite number of bifurcating modes for 1D patterns, but not for multidimensional patterns. In the case of domain-covering patterns, researchers often overcome this limitation by restricting to solutions that lie on a lattice with a given symmetry. Unfortunately, such an approach fails for multidimensional localized patterns.

Radial Spatial Dynamics Approach

Localized axisymmetric patterns may be the simplest type of multidimensional localized patterns, given that the solution U is rotation invariant and only depends on a single radial variable r. In light of radial spatial dynamics theory [8], we can use radial normal form theory to extend Turing's analysis and explain the emergence of different types of localized radial patterns [5]. Further studies have expanded this approach to three-dimensional (3D) spots [7] and axisymmetric patterns on the

See **Multidimensional Patterns** *on page 3*

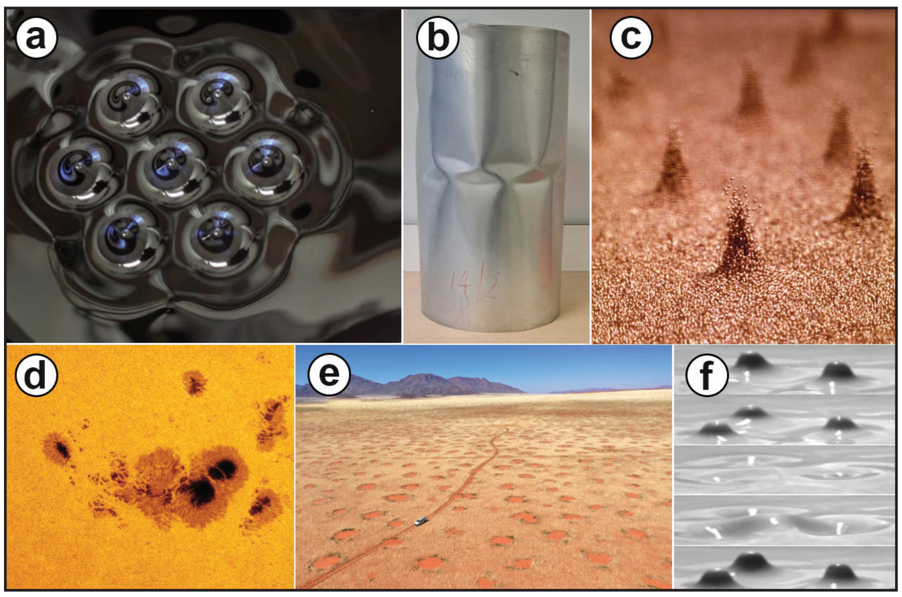


Figure 1. *Various localized patterns in different materials.* **1a.** *A ferrofluid.* **1b.** *A buckling cylinder.* **1c.** *Vertically vibrating granular material.* **1d.** *Sun spots.* **1e.** *Vegetation patches in an arid area.* **1f.** *Vertically vibrating fluid. Figure 1a courtesy of Achim Beetz, 1b courtesy of M. Ahmer Wadee, 1c courtesy of Paul Umbanhowar, 1d courtesy of NASA Goddard Space Flight Center, 1e courtesy of Stephan Getzin, and 1f courtesy of [4].*

Understanding Uncertainty in Glacier Models — Before the Ice Melts

By Matthew R. Francis

Rising ocean levels pose a major threat to coastal cities and island nations around the world [1, 4]. As average global temperatures continue to increase, melting glaciers and sea ice contribute significantly to this urgent problem. For this reason, researchers currently use a wide variety of mathematical and observational techniques to gauge the rate at which ice is melting, the locations at which melting is most severe, and the extent to which those factors affect sea level change.

Unfortunately, the paucity and limited accessibility of important data hampers model development and subsequently complicates forecasting efforts. In turn, scientists must communicate the resulting uncertainty to policymakers and the general public. These connected challenges were the subject of a scientific session[1] at the 2024 American Association for the Advancement of Science (AAAS) Annual Meeting,[2] which took place in Denver, Colo., this February. The speakers discussed ongoing research in Antarctica, which houses much of the planet's ice atop the continent itself, as well as on and in the surrounding ocean (see Figure 1).

"We can use our knowledge of these [ice] models to understand what we *don't* know about them," said Nicole-Jeanne Schlegel of the Geophysical Fluid Dynamics Laboratory[3] at the National Oceanographic and Atmospheric Association (NOAA). By tweaking the parameters of existing physical models of glaciers, she and her colleagues can quantify the largest uncertainties. "[It's] not just the sea level or the [ice distribution] map," Schlegel continued, "but the uncertainty and the way in which models and data together can help each other."

Meanwhile, statistician Won Chang of the University of Cincinnati approaches the problem from a data angle. "Once you create a model, you should now be able to fit that model to the data," he said. "To fit the model to the data [when] many of the important parameters are unknown, you need to be able to adjust those parameters so that the model actually behaves similar to reality. For complicated models—like physical models of Antarctica—you really have to do complicated statistical analysis to actually get those uncertainties."

In a system with multiple parameters that cannot be directly measured, scientists must apply advanced statistical techniques to determine the ranges of possible values that could return the same observational data. Chang seeks to develop user-friendly tools for this challenging, multidimensional problem to assist climate researchers who do not have advanced statistical training.

A Parametric Hydra

Antarctica's ice comprises three basic forms: (i) Land ice, including glaciers; (ii) ice shelves, which extend from land but rest directly on the sea floor; and (iii) sea ice, which is attached to either land ice or ice shelves but floats on ocean water (see Figure 2, on page 4). Sea ice is the most variable of those forms, particularly as climate change drives summer temperatures high enough to melt all of it — even at high latitudes.

Ice shelves are also under threat. In 1986, a 4,000-square-kilometer iceberg broke free of the Filchner Ice Shelf; it was too heavy to float away until 2023, when it finally drifted into the open ocean [5]. Scientists anticipate similar large-scale iceberg calving events—which represent the most dramatic type of Antarctic ice loss, if not the most directly concerning—in the future. In any case, melting ice can increase the volume of the ocean and

See **Glacier Models** *on page 4*

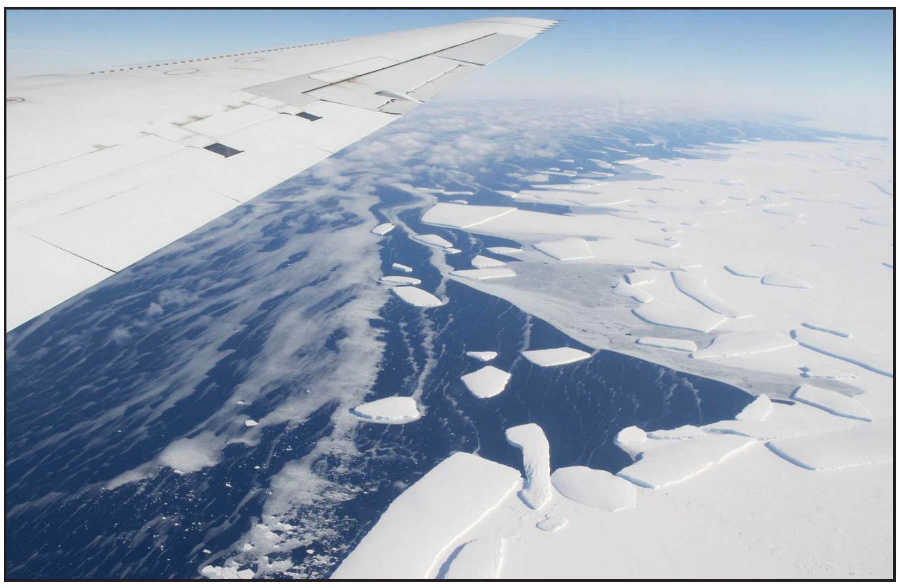


Figure 1. *Aerial view of the West Antarctic ice shelf in 2012, with calving icebergs. Modeling the rate of ice loss from these types of formations requires the estimation of certain parameters that often cannot be measured directly. Photo courtesy of NASA/GSFC/Jefferson Beck.*

---

[1] https://aaas.confex.com/aaas/2024/meetingapp.cgi/Session/31997

[2] https://www.aaas.org/resources/2024-aaas-annual-meeting-archive

[3] https://www.gfdl.noaa.gov

Nonprofit Org
U.S. Postage
PAID
Permit No 360
Bellmawr, NJ

SOCIETY for INDUSTRIAL and APPLIED MATHEMATICS
3600 Market Street, 6th Floor
Philadelphia, PA 19104-2688 USA

siam news
Volume 57/ Issue 5/ June 2024

4 **Beyond Research Talks: Optimizing Your Time at the 2024 SIAM Annual Meeting**
The 2024 SIAM Annual Meeting (AN24) will be an excellent opportunity to meet peers across a variety of research fields, and conference activities extend well beyond the realm of technical presentations. Manuchehr Aminian and Kristin Kurianski overview some of the many student events, mini-tutorials, workshops, panels, and receptions at AN24.

5 **Massachusetts High School Students Lauded for Successful Model of U.S. Housing Crisis**
MathWorks Math Modeling Challenge 2024 addressed the intertwined housing and homelessness crises. A team of five students from Phillips Academy Andover in Massachusetts received first prize—and $20,000 in scholarship funds—for their impressive models that predicted long-term changes in the housing supply and the homeless population.

8 **Euclid's *Elements* Through the Ages**
Ernest Davis reviews *Encounters with Euclid: How an Ancient Greek Geometry Text Shaped the World* by Benjamin Wardhaugh. The book explores Euclid's *Elements* and the way in which people have altered and interacted with it over the course of millennia.

9 **IMSI Long Program Explores Algebraic Statistics and Our Changing World**
Algebraic statistics is a cross-disciplinary area of mathematical science that seeks to answer statistical problems by using algebra-based methods. Sam Hansen describes the Institute for Mathematical and Statistical Innovations' recent program on "Algebraic Statistics and Our Changing World: New Methods for New Challenges."

11 **Integrating Mathematics, Physics, and Art Through Collective Entanglements**
Janet Biggs, Agnieszka Międlar, Joey Orr, and Daniel Tapia Takaki—an artist, mathematician, museum curator, and physicist—discuss their *Collective Entanglements* project and exhibition. This production connects the fields of art, math, and science and specifically focuses on the nuances of the singular value decomposition.

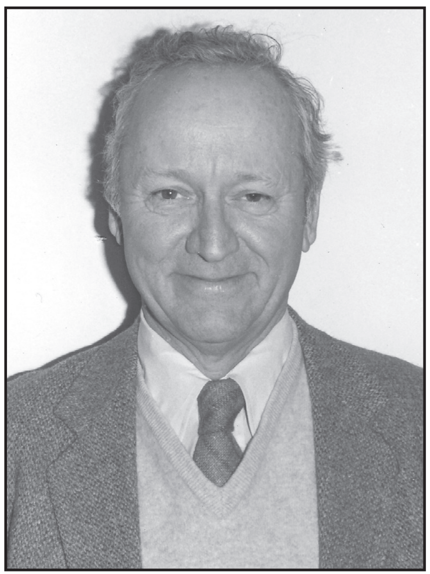
Obituary: Werner C. Rheinboldt

By Jorge Moré and Bernd Simeon

Werner C. Rheinboldt, former Andrew W. Mellon Chair of Mathematics at the University of Pittsburgh and a past president of SIAM, passed away on March 19, 2024. He was 96 years old.

Werner began to study mathematics and physics at Heidelberg University in 1947. He graduated in 1952 and worked at an aircraft laboratory in Duisburg, Germany, before beginning a doctoral program at the University of Freiburg in 1953. He earned his doctoral degree in applied mathematics two years later, in 1955.

Werner left Germany in 1956 for a postdoctoral fellowship with Martin Monroe, director of the Institute for Fluid Dynamics and Applied Mathematics at the University of Maryland (UMD). At the Institute, Werner encountered a variety of mathematical problems from different laboratories in the Washington, D.C., area—such as the Naval Ordnance Laboratory—that fostered his interest in computing.


Werner Rheinboldt, 1928-2024. Photo courtesy of William Layton and Charles Hall.

After his postdoctoral stint at UMD, Werner spent two years at the U.S. National Bureau of Standards' Computation Laboratory before being appointed as director of the Computer Center at Syracuse University in 1959. In early 1961, UMD initiated a search for a director to develop a centralized computing center at the university. Werner interviewed and accepted the position on the condition that the center's mission be expanded to include an education and research program. The search committee agreed, and the *Computer Science Center* was born.

The center's initial phase of development involved constructing a building and writing proposals to obtain a computer. Negotiations with IBM led to the acquisition of an IBM 7090, which was installed and operational in the first two floors of the center by March 1963. In addition to satisfying his directorial duties, Werner was also developing a computer science curriculum and teaching graduate courses. These achievements exceeded all expectations, but for personal reasons he asked the university to search for a new director in 1965. The following year, William F. Atchison replaced Werner as director of the Computer Science Center.

The *IEEE Annals of the History of Computing* provides a fascinating account of the onset of computing and computer science at UMD [3]. This historical review, which was written by Jack Minker, covers the period from 1940 until the establishment of the Department of Computer Science in 1973. Minker notes that the success of computing at UMD was primarily due to Werner.

After stepping down as director of UMD's Computer Science Center, Werner remained at the university as a research professor with a joint appointment in the Computer Science Center and the Institute for Fluid Dynamics and Applied Mathematics. Around this time, he and Jim Ortega—who joined the Center in 1964—formed a research group on algorithms for nonlinear problems. This collaboration resulted in their seminal 1970 publication, *Iterative Solution of Nonlinear Equations in Several Variables*, which laid the foundation for the development of algorithms to solve nonlinear equations and optimization problems [4]. This book became an invaluable reference by providing a unified viewpoint for the local and global convergence of nonlinear iterative methods; the authors' use of Q-order and R-order became the standard measure for the rate of convergence of iterative methods. In 2000, this text was added to SIAM's *Classics in Applied Mathematics* series [4].

Werner developed a strong connection with SIAM over the years. His first editorial position was for the *SIAM Journal on Numerical Analysis*[1] in 1966, just two years after the journal's inception. He was an associate editor until 1997 and a managing editor from 1970 to 1973. Several years later, Werner was elected as SIAM president from 1976 to 1978; he then served as chair of the Board of Trustees from 1985 until 1990.

In 1978, Werner left UMD and was appointed as the Andrew W. Mellon Chair of Mathematics at the University of Pittsburgh. By this time, his numerical analysis research had expanded to include error estimates for finite element methods. Werner worked jointly with Ivo Babuška to develop computable *a posteriori error estimates* for accuracy that are applicable in the design of adaptive finite element solvers. He also began to analyze differential-algebraic systems via a geometric approach that treated the systems as differential equations on manifolds. These efforts inspired Werner to write a book about rigid mechanical systems as differential-algebraic systems [5], as well as an extensive article about the theoretical and numerical analysis of differential-algebraic equations [6] — both with his colleague Patrick Rabier.

In 1990, the Association for Computing Machinery recognized Werner's early education-based endeavors with the ACM-SIGCSE Award for Outstanding Contribution to Computer Science Education. This award acknowledged his contributions as a member of the Curriculum '68 committee, which produced an influential report that outlined the initial recommendations for computer science education and guided the teaching of computer science for at least 10 years thereafter [1]. In 1984, Werner was selected as a Fellow of the American Association for the Advancement of Science; he was later part of the inaugural class of SIAM Fellows in 2009.

After his retirement, Werner returned to Germany in 2007 and accepted an appointment as an honorary professor at the Technical University of Munich (TUM). The Zuse Institute Berlin held a colloquium the following year in honor of his 80th birthday,[2] with presentations that surveyed the impact of his life's work. Werner became a highly regarded member of the TUM faculty and occasionally taught his signature course on "Numerical Algorithms on Manifolds." On informal occasions, students and faculty enjoyed his anecdotes from the early days of computing.

Even before this time, Werner had pursued several professional projects in Germany. He previously served as a member of the Scientific Advisory Board at the Zuse Institute Berlin and translated Peter Deuflhard and Folkmar Bornemann's *Scientific Computing with Ordinary Differential Equations* from German to English [2].

Werner crossed the Atlantic Ocean once more in 2020 and moved back to the U.S. to be with his son Matthew. In addition to Matthew, he is survived by his other son, Michael, and their children and grandchildren. Werner leaves behind a rich legacy of research in mathematics, computer science, and scientific computing that will undoubtedly inspire future generations of researchers. We can only aspire to leave our mark in this world at the same level.

References

[1] Atchison, W.F., Conte, S.D., Hamblen, J.W., Hull, T.E., Keenan, T.A., Kehl, W.B., … Young, D.M. (1968). Curriculum 68: Recommendations for academic programs in computer science: A report of the ACM curriculum committee on computer science. *Commun. ACM*, *11*(3), 151-197.

[2] Deuflhard, P., & Bornemann, F. (2002). *Scientific computing with ordinary differential equations*. In *Texts in applied mathematics* (Vol. 42). New York, NY: Springer.

[3] Minker, J. (2007). Developing a computer science department at the University of Maryland. *IEEE Ann. Hist. Comput.*, *29*(4), 64-75.

[4] Ortega, J.M., & Rheinboldt, W.C. (2000). *Iterative solution of nonlinear equations in several variables*. In *Classics in applied mathematics*. Philadelphia, PA: Society for Industrial and Applied Mathematics.

[5] Rabier, P.J., & Rheinboldt, W.C. (2000). *Nonholonomic motion of rigid mechanical systems from a DAE viewpoint*. Philadelphia, PA: Society for Industrial and Applied Mathematics.

[6] Rabier, P.J., & Rheinboldt, W.C. (2002). *Theoretical and numerical analysis of differential-algebraic equations*. In P.G. Ciarlet & J.L. Lions (Eds.), *Handbook of numerical analysis* (Vol. 8) (pp. 183-540). Amsterdam, the Netherlands: Elsevier.

Jorge Moré is an emeritus Argonne Distinguished Scholar at Argonne National Laboratory and a SIAM Fellow. Bernd Simeon is a professor in the Department of Mathematics at the University of Kaiserslautern-Landau.

---

[1] https://www.siam.org/publications/journals/siam-journal-on-numerical-analysis-sinum

[2] https://www.zib.de/userpage//deuflhard/invitation_WCR.pdf

siam news

ISSN 1557–9573. Copyright 2024, all rights reserved, by the Society for Industrial and Applied Mathematics, SIAM, 3600 Market Street, 6th Floor, Philadelphia, PA 19104-2688; (215) 382-9800; siam@siam.org. To be published 10 times in 2024: January/February, March, April, May, June, July/August, September, October, November, and December. The material published herein is not endorsed by SIAM, nor is it intended to reflect SIAM's opinion. The editors reserve the right to select and edit all material submitted for publication.

Advertisers: For display advertising rates and information, contact the Department of Marketing & Communications at marketing@siam.org.

One-year subscription (nonmembers): Electronic-only subscription is free. $73.00 subscription rate worldwide for print copies. SIAM members and subscribers should allow eight weeks for an address change to be effected. Change of address notice should include old and new addresses with zip codes. Please request an address change only if it will last six months or more.

Editorial Board
H. Kaper, *Editor-in-chief, Georgetown University, USA*
K. Burke, *University of California, Davis, USA*
A.S. El-Bakry, *ExxonMobil Production Co., USA*
J.M. Hyman, *Tulane University, USA*
O. Marin, *Idaho National Laboratory, USA*
L.C. McInnes, *Argonne National Laboratory, USA*
N. Nigam, *Simon Fraser University, Canada*
A. Pinar, *Sandia National Laboratories, USA*
R.A. Renaut, *Arizona State University, USA*

Representatives, SIAM Activity Groups

Algebraic Geometry
K. Kubjas, *Aalto University, Finland*
Analysis of Partial Differential Equations
G.G. Chen, *University of Oxford, UK*
Applied Mathematics Education
P. Seshaiyer, *George Mason University, USA*
Computational Science and Engineering
S. Rajamanickam, *Sandia National Laboratories, USA*
Control and Systems Theory
G. Giordano, *University of Trento, Italy*
Data Science
T. Chartier, *Davidson College, USA*
Discrete Mathematics
P. Tetali, *Carnegie Mellon University, USA*
Dynamical Systems
K. Burke, *University of California, Davis, USA*
Financial Mathematics and Engineering
L. Veraart, *London School of Economics, UK*
Geometric Design
J. Peters, *University of Florida, USA*
Geosciences
T. Mayo, *Emory University, USA*
Imaging Science
G. Kutyniok, *Ludwig Maximilian University of Munich, Germany*
Life Sciences
R. McGee, *College of the Holy Cross, USA*
Linear Algebra
M. Espanol, *Arizona State University, USA*
Mathematical Aspects of Materials Science
F. Otto, *Max Planck Institute for Mathematics in the Sciences, Germany*
Mathematics of Planet Earth
R. Welter, *University of Hamburg, Germany*
Nonlinear Waves and Coherent Structures
K. Oliveras, *Seattle University, USA*
Optimization
A. Wächter, *Northwestern University, USA*
Orthogonal Polynomials and Special Functions
P. Clarkson, *University of Kent, UK*
Uncertainty Quantification
E. Spiller, *Marquette University, USA*

***SIAM News* Staff**
L.I. Sorg, *managing editor, sorg@siam.org*
J.M. Kunze, *associate editor, kunze@siam.org*

Printed in the USA.
siam *is a registered trademark.*

SIAM Task Force Anticipates Future Directions of Computational Science

By Elie Alhajjar and Tanzima Islam

The multidisciplinary field of computational science—which lies at the intersection of mathematics, computing, and various application domains—plays a pivotal role in scientific discovery, industrial innovation, and national security. Its rapidly evolving landscape inspired the 2024 SIAM Task Force Report on the Future of Computational Science,[1] which charts an ambitious growth trajectory for the coming decades. This comprehensive document synthesizes the collective wisdom of a diverse array of Task Force members with firsthand experience in academia, industry, and national laboratories.

The Task Force Report proposes a framework for the holistic discussion of emerging challenges and opportunities at the junction of traditional computational science, artificial intelligence (AI), and high-performance computing (HPC). Relevant challenges include the need for new hardware and software advances, as well as strategic investments to recruit and train diverse talent within the computational science workforce. The report also identifies three areas in which computational science can actively enhance both science and society: (i) Investments in software tools that bolster the impact of exascale computing, (ii) support for data science infrastructures that enable the scalable fusion of data from diverse sources, and (iii) improvements to the reliability and trustworthiness of AI that facilitate its integration with simulations and decision-making processes.

A Critical Juncture in Computational Science

Computational science is currently at a critical juncture that offers significant opportunities for advancement alongside formidable challenges that threaten to impede progress. The advent of exascale computing—a milestone that is heralded by the U.S. Department of Energy's Exascale Computing Project[2] (ECP)—marks a transformative moment for the field (see Figure 1). This leap in computational capability is poised to revolutionize scientific inquiry by enabling simulations of unprecedented fidelity, facilitating real-time data analytics at massive scales, and promoting the exploration of complex phenomena that were previously out of reach.

SIAM's report highlights two noteworthy developments that can accelerate scientific discovery through exascale computing: (i) The emergence of digital twins and (ii) the synergy between AI and computer simulations. The ECP encourages such progress through its extensive provision of exascale-ready software — including tools, libraries, and a diverse suite of applications. However, the community must ensure the

See **Task Force** *on page 6*

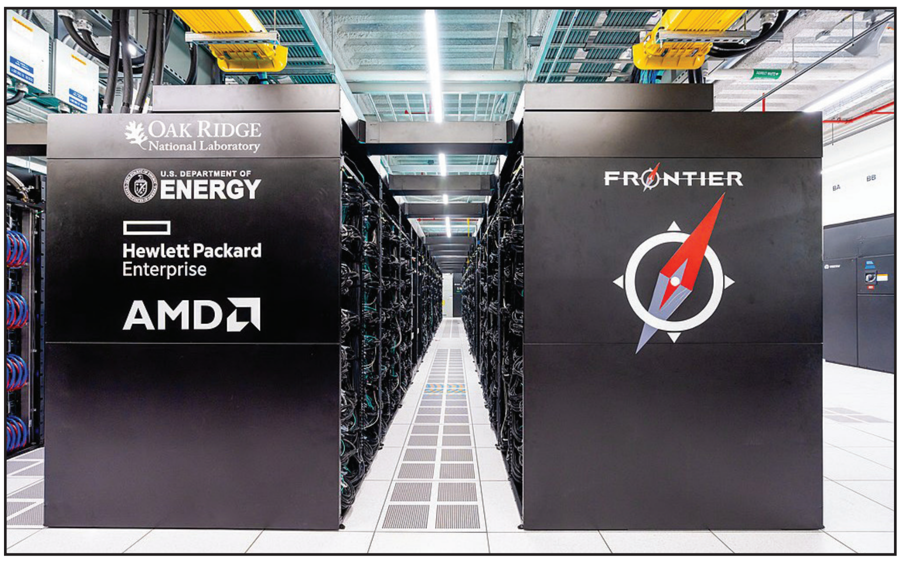


Figure 1. *Hewlett Packard Enterprise Frontier—the Exascale-class HPE Cray EX Supercomputer at Oak Ridge National Laboratory—is the world's first exascale computer. It contains roughly 8.7 million cores and performs 1.19×10^{18} operations per second. Photo courtesy of Oak Ridge National Laboratory under the Creative Commons Attribution 2.0 Generic license.*

---

[1] https://go.siam.org/z6c05l

[2] https://www.exascaleproject.org

Multidimensional Patterns

Continued from page 1

surface of a ferrofluid [3] (see Figure 1a, on page 1). The ferrofluid scenario takes the form of a 3D free-surface problem and represents a significant departure from the simple ordinary differential equation (ODE) structure of the steady axisymmetric SHE. However, many of the necessary analytic tools for the rigorous study of localized axisymmetric patterns in complex problems remain underdeveloped.

What if a solution displays radial localization but is no longer axisymmetric? For example, what if we want to study a pattern of a compact patch of hexagonality that is surrounded by a uniform state (as in Figure 1a, on page 1)? To do so, we can consider solutions of the SHE in (1) that possess *dihedral symmetry* $\mathbb{D}_m$—i.e., invariance under a rotation of $2\pi/m$—so that we can write U as an angular Fourier expansion:

$$U(r,\theta)=\sum_{n\in\mathbb{Z}} u_{|n|}(r)\cos(mn\theta).$$

Projecting the SHE onto each Fourier mode yields an infinite-dimensional system of radial differential equations that is difficult to analyze with standard techniques. However, we can approximate this system via a truncated Fourier expansion

$$U(r,\theta)=u_0(r)+2\sum_{n=1}^{N} u_n(r)\cos(mn\theta), \tag{2}$$

with truncation order $N\in\mathbb{N}$. A 2008 study used this pseudo-spectral approach to numerically obtain and continue various localized dihedral patterns that bifurcate the trivial state at $\mu=0$, with a focus on localized hexagon $(\mathbb{D}_6)$ and rhombic $(\mathbb{D}_2)$ patterns [6]. In Figure 2, we plot the bifurcation curve for localized hexagons and compare it with an axisymmetric spot [5, 6].

Recent work has identified a new approach for localized dihedral patterns that combines radial spatial dynamics with the finite Fourier approximation in (2) [1, 2]. By expanding U in the truncated Fourier series in (2) and projecting onto each Fourier mode, the two-dimensional (2D) PDE in (1) becomes an $(N+1)$-dimensional system of radial ODEs to which we can apply radial normal form theory [5, 7, 8]. This approach proves that the finite Fourier approximation of (1) (with truncation order N) exhibits a localized $\mathbb{D}_m$ pattern that bifurcates from the trivial state [1], provided that we can find a nontrivial solution to the quadratic algebraic system

$$a_n=2\sum_{j=1}^{N-n}\cos\left(\frac{m\pi(n-j)}{3}\right)a_j a_{n+j}+$$
$$\sum_{j=0}^{n}\cos\left(\frac{m\pi(n-2j)}{3}\right)a_j a_{n-j}, \tag{3}$$
$$n=0,1,\dots,N.$$

We can solve this quadratic system explicitly for $N=1,2,3$, thus revealing a wide range of nontrivial patches that will bifurcate from $\mu=0$ (see Figure 3). Interestingly, if m is a multiple of six (including the hexagon case), we can show that localized patches bifurcate for sufficiently large N [1]. We can also extend these results to obtain dihedral ring patterns that bifurcate from the trivial state at $\mu=0$ [2]; in this case, the problem reduces to finding a nontrivial solution to a cubic algebraic system.

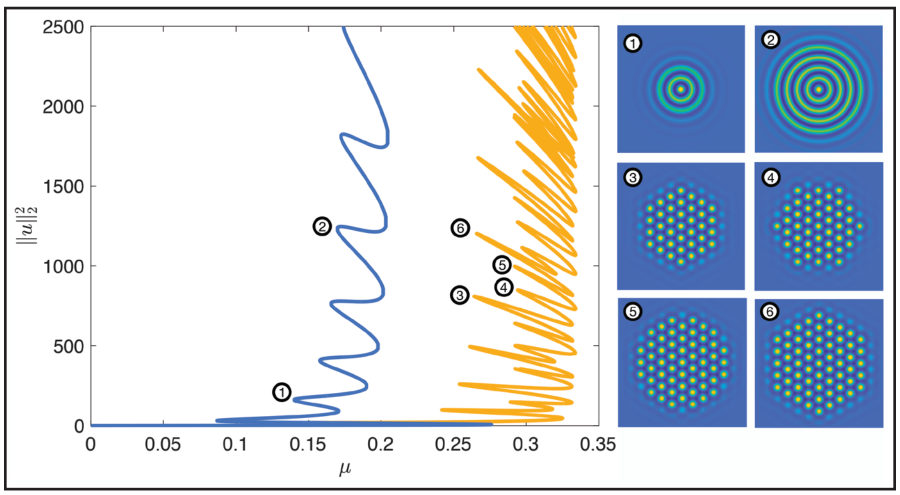


Figure 2. *Numerically continued bifurcation curves of localized spots (in blue) and hexagon patches (in yellow) for the two-dimensional Swift-Hohenberg equation in (1) with $\nu=1.6$. Sample contour plots of the profiles are provided at folds along the curves. Figure courtesy of David Lloyd.*

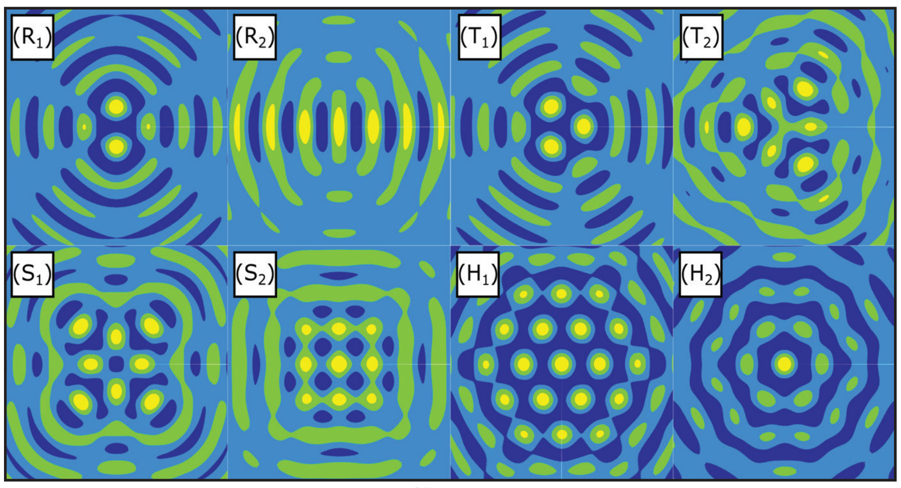


Figure 3. *Localized dihedral patches when $N=2$ in (3). There are two solutions each for rhombic $(R)\sim\mathbb{D}_2$, triangular $(T)\sim\mathbb{D}_3$, square $(S)\sim\mathbb{D}_4$, and hexagonal $(H)\sim\mathbb{D}_6$ patterns. Figure courtesy of [1] under the Creative Commons Attribution 3.0 license.*

Open Problems and the Future

Proving that the finite Fourier approach accurately approximates the 2D SHE is still a major challenge, as is finding a direct proof that localized dihedral patterns bifurcate from the trivial state at $\mu=0$. It is perhaps more realistic to extend recent results [1, 2] to 3D localized patterns. Meanwhile, finding localized hexagons in the ferrofluid problem remains a tantalizing prospect. As evident in Figure 2, the bifurcation curves of the localized hexagon are significantly more complex than those of the axisymmetric spot, though an explanation of this discrepancy is currently beyond our mathematical prowess. Ultimately, however, this field has made tremendous progress in the last 20 years, due in part to the increasing capabilities of numerical simulations. As we continue to study the emergence and behavior of localized multidimensional patterns, our computational results will raise new and interesting questions for mathematicians.

References

[1] Hill, D.J., Bramburger, J.J., & Lloyd, D.J.B. (2023). Approximate localised dihedral patterns near a Turing instability. *Nonlinearity*, *36*(5), 2567.

[2] Hill, D.J., Bramburger, J.J., & Lloyd, D.J.B. (2024). Dihedral rings of patterns emerging from a Turing bifurcation. *Nonlinearity*, *37*(3), 035015.

[3] Hill, D.J., Lloyd, D.J.B., & Turner, M.R. (2021). Localised radial patterns on the free surface of a ferrofluid. *J. Nonlinear Sci.*, *31*(5), 79.

[4] Lioubashevski, O., Hamiel, Y., Agnon, A., Reches, Z., & Fineberg, J. (1999). Oscillons and propagating solitary waves in a vertically vibrated colloidal suspension. *Phys. Rev. Lett.*, *83*(16), 3190-3193.

[5] Lloyd, D., & Sandstede, B. (2009). Localized radial solutions of the Swift-Hohenberg equation. *Nonlinearity*, *22*(2), 485.

[6] Lloyd, D.J.B., Sandstede, B., Avitabile, D., & Champneys, A.R. (2008). Localized hexagon patterns of the planar Swift-Hohenberg equation. *SIAM J. Appl. Dyn. Syst.*, *7*(3), 1049-1100.

[7] McCalla, S.G., & Sandstede, B. (2013). Spots in the Swift-Hohenberg equation. *SIAM J. Appl. Dyn. Syst.*, *12*(2), 831-877.

[8] Scheel, A. (2003). Radially symmetric patterns of reaction-diffusion systems. *Mem. Amer. Math. Soc.*, *165*(786), 1-86.

[9] Swift, J., & Hohenberg, P.C. (1977). Hydrodynamic fluctuations at the convective instability. *Phys. Rev. A*, *15*(1), 319-328.

[10] Turing, A.M. (1952). The chemical basis of morphogenesis. *Phil. Trans. R. Soc. Lond. B*, *237*(641), 37-72.

Dan J. Hill is an Alexander von Humboldt Postdoctoral Fellow at Saarland University in Germany. David J.B. Lloyd is a professor of mathematics at the University of Surrey in England. He received the 2024 T. Brooke Benjamin Prize in Nonlinear Waves[1] from SIAM.

---

[1] https://www.siam.org/prizes-recognition/activity-group-prizes/detail/siag-nwcs-t-brooke-benjamin-prize-in-nonlinear-waves

Beyond Research Talks: Optimizing Your Time at the 2024 SIAM Annual Meeting

By Manuchehr Aminian
and Kristin Kurianski

The SIAM Annual Meeting is an excellent opportunity to meet peers across the broad spectrum of applied and industrial mathematics. Many attendees focus primarily on minisymposia, contributed talks, and invited presentations, which are indeed valuable and important. However, a wealth of other unique, transformative events during the conference will allow participants—especially students and early-career professionals—to actively partake, learn, and engage with one another.

The in-person component of the 2024 SIAM Annual Meeting[1] (AN24) will take place in Spokane, Wash., from July 8 to 12; it is being held concurrently with the 2024 SIAM Conference on Discrete Mathematics[2] and the 2024 SIAM Conference on Applied Mathematics in Education.[3] If you have not yet registered for AN24 and its concurrent meetings, you can do so online.[4] Here, we offer a brief overview of worthwhile happenings beyond the usual research presentations.

Student Days

This series of events[5] occurs throughout the week and provides undergraduate and graduate students with the chance to meet peers and professionals in their fields, attend social gatherings, and network with members of other SIAM student chapters[6] from around the world. The **Student Days Orientation** will take place from 5:00 to 6:00 p.m. on Sunday, July 7, just before the AN24 **Welcome Reception**. A joint **Graduate Student Reception and Industry Reception** is scheduled for Monday, July 8, at 7:45 p.m.

Poster Session

Interacting with poster presenters is often a powerful way to meet new people, familiarize yourself with different fields, and learn about novel approaches to broad scientific challenges. As such, consider attending the **Poster Session and Dessert Reception** from 8:00 to 10:00 p.m. on Tuesday, July 9. Poster sessions offer a valuable opportunity for attendees to fill personal knowledge gaps on topics with which they are unfamiliar. Listening to an oral presentation is a mostly passive activity, but discussing a poster can engender a more communicative, meaningful experience. In the long term, the mathematical tidbits that you absorb from posters may be just as important as your overall depth of knowledge in your own field.

Receptions

Simply put, receptions are open events that loosely center around a theme (and provide light refreshments). These occasions are largely welcoming, rather than exclusionary. Even if you only have a mild interest in or connection to the theme, we encourage you to attend. Beyond the usual Welcome Reception on Sunday, the aforementioned Graduate Student Reception and Industry Reception on Monday, and the Poster Session and Dessert Reception on Tuesday, the **SIAM Fellows Recognition and Reception** will take place on Tuesday, July 9, at 7:45 p.m.; a **Spectra Reception** (hosted by Spectra, the Association for LGBTQ+ Mathematicians[7]) will occur on Tuesday at 8:30 p.m.; and the **Community Reception** will take place on Wednesday, July 10, at 7:15 p.m. after Caoimhe Rooney's **I.E. Block Community Lecture** titled "Go Boldly Where No Math Has Gone Before"[8] (which will be livestreamed and free for those who cannot attend in person). Finally, new this year is an invite-only **Donor Appreciation Reception** on Thursday, July 11, at 6:15 p.m. in honor of those who have made charitable gifts to SIAM.[9] If you are a SIAM donor and plan to attend, please RSVP online.[10]

Workshops

AN24 will feature multiple workshops in several different forms. The **Association for Women in Mathematics** (AWM) will hold minisymposium workshops on Wednesday, July 10, at 8:15 a.m. and 4:00 p.m.; a panel about career advancement on Thursday, July 11, at 8:30 a.m.; and a minisymposterium (with posters by graduate students in

See **Annual Meeting** *on page 5*

---

[1] https://www.siam.org/conferences/cm/conference/an24

[2] https://www.siam.org/conferences/cm/conference/dm24

[3] https://www.siam.org/conferences/cm/conference/ed24

[4] https://my.siam.org/Conference/Listing

[5] https://www.siam.org/conferences/cm/program/student-days/an24-student-days

[6] https://www.siam.org/students-education/student-chapters

[7] https://lgbtmath.org

[8] https://meetings.siam.org/sess/dsp_programsess.cfm?SESSIONCODE=80213

[9] https://www.siam.org/donate

[10] https://forms.office.com/r/f0fWPWegvp

Glacier Models

Continued from page 1

contribute to higher water levels far from its Antarctic origins.

Schlegel noted that most data about ice coverage in Antarctica comes from the surface: melting atop ice sheets, glacier speeds, snowfall levels, and so forth. She also remarked that it is difficult to obtain reliable values for under-ice properties, such as the amount of liquid water beneath glaciers and the topography of the rock under ice. Ice that is several kilometers thick is heavy enough to compress the underlying rock, and a lack of data hinders the documentation of the way in which the surface rebounds as ice melts and shifts.

Meanwhile, ice cores allow researchers to track changes over the course of decades or even centuries; they provide some of the best evidence of humanity's role in climate change but are less helpful for understanding ice dynamics on shorter time spans. "In the last 20 or 30 years, we've seen that ice can flow and change faster than we ever thought," Schlegel said. "What's going on under the ice, how the ice is flowing, how water might get from the surface to the base of the ice — these are the new parameterizations that we need to put in the models to know what will occur over the next decade."

A common model for ice sheets is built upon the Stokes equations:

$$\nabla \cdot \boldsymbol{\sigma} + \rho \mathbf{g} = \mathbf{0},$$

where $\mathbf{g}$ is the gravitational vector and ρ is the ice density [2, 3]. The stress tensor $\boldsymbol{\sigma} = 2\mu\dot{\boldsymbol{\varepsilon}} - p\mathbf{I}$ includes the pressure p, the effective viscosity μ, and the time derivative of the strain tensor $\dot{\boldsymbol{\varepsilon}}$ (along with the identity tensor $\mathbf{I}$). The viscosity and strain are nonlinearly dependent on temperature, as well as on other physical parameters that are not necessarily easy to measure.

These parameters are not just uncertain; they also have overlapping influences on both the mathematics and the observable effects [6]. Understanding this overlap will help researchers design better models, quantify possibilities for decision-makers, and propose new experiments. "You can test the model to see what type of observations would help us be more certain about what's going on," Schlegel said. "Then you can go back to NOAA and NASA and say, 'Hey, we need a satellite that can measure this [property] on this frequency.'"

From Finance to Climate

Better data is essential, but data alone cannot reveal what can or will happen in the coming years or decades. To make such predictions, climate scientists need models, interpretations of simulations, and quantifications of uncertainty.

Chang first applied statistics to financial models while working towards his master's degree, but he later began to collaborate with climate researchers as part of his Ph.D. studies when he realized that the same advanced math is relevant to both topics. Drawing on models that were developed by climatologist David Pollard of the Pennsylvania State University, Chang's AAAS presentation focused on four major unknown parameters: (i) The rate at which ice melts into the ocean, (ii) the rate of iceberg calving, (iii) the coefficient of friction between ice and bedrock, and (iv) the rate at which bedrock rebounds as the ice's weight decreases.

"You're trying to match the data and model outcome, but you don't have one best value [for each parameter]," Chang said. He uses Bayesian methods to generate a multidimensional likelihood density function, for which the best parameter estimates give the maximum likelihood. Since glacier models are complicated and cannot be inverted analytically to produce parameter matches, likelihood fitting involves iteratively changing parameters within the model and running simulations until the density space is fully mapped out.

Of course, this method becomes increasingly unwieldy with more parameters. "One active research goal in the future is to actually create a method that can handle a higher-dimensional parameter space," Chang said. This type of ambitious project would benefit researchers across a variety of fields.

Telling the Statistical Story

The mathematical problem is only the beginning for climate science, and Chang hopes that his work will appeal to researchers beyond the field of statistics. "This Bayesian inversion stuff is great," he said. "But I need to perhaps change the methodology or some of the statistical tools to make it much easier for glaciologists to actually use." He also noted that many current statistical methods are not always directly applicable to dynamical systems, such as glacier or atmospheric models. Chang feels that applied mathematicians and statisticians have much to learn from each other, and their collaborations could potentially yield powerful, reliable models that predict various scenarios about emissions and mitigation efforts.

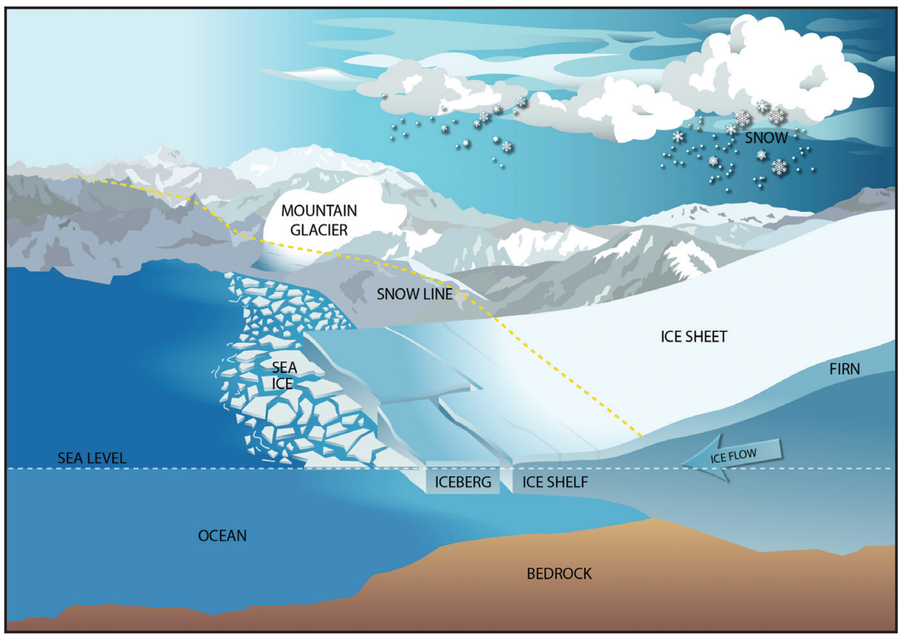


Figure 2. *Diagram of the different types of ice that affect sea level, including floating sea ice, ice shelves, and ice sheets on top of the land. Photo courtesy of NASA/GSFC/Christopher Shuman, Claire Parkinson, Dorothy Hall, Robert Bindschalder, and Deborah McLean.*

Schlegel added that the communication of statistical uncertainty is a major challenge for climate researchers. Politicians, decision-makers, and the general public are typically not interested in *ranges* of possible sea level rise, much less Bayesian likelihoods; they want to know what *will* happen and how to respond. Meanwhile, climate change deniers seize upon statistical uncertainties—an inevitable consequence of science—to cast doubt on the entire enterprise.

Science happens at the intersection of theory, observation, and analysis. When attempting to forecast the future of Antarctic ice and its corresponding effect on sea level rise, understanding and limiting uncertainty at that intersection is the only way to effectively move forward.

References

[1] Cappucci, M. (2019, August 8). Sea level rise is combining with other factors to regularly flood Miami. *The Washington Post*. Retrieved from https://www.washingtonpost.com/weather/2019/08/08/analysis-sea-level-rise-is-combining-with-other-factors-regularly-flood-miami.

[2] Castleman, B.A., Schlegel, N.-J., Caron, L., Larour, E., & Khazendar, A. (2022). Derivation of bedrock topography measurement requirements for the reduction of uncertainty in ice-sheet model projections of Thwaites Glacier. *Cryosphere*, *16*(3), 761-778.

[3] Larour, E., Seroussi, H., Morlighem, M., & Rignot, E. (2012). Continental scale, high order, high spatial resolution, ice sheet modeling using the Ice Sheet System Model (ISSM). *J. Geophys. Res.*, *117*(F1), F01022.

[4] Manzo, D., Zee, G., Uddin, S., & Jovanovic, D. (2021, November 3). Facing dire sea level rise threat, Maldives turns to climate change solutions to survive. *ABC News*. Retrieved from https://abcnews.go.com/International/facing-dire-sea-level-rise-threat-maldives-turns/story?id=80929487.

[5] Mathewson, S. (2023, November 29). Satellites watch world's largest iceberg break away from Antarctica. *Space.com*. Retrieved from https://www.space.com/satellites-watch-worlds-largest-iceberg-move.

[6] Schlegel, N.-J., Seroussi, H., Schodlok, M.P., Larour, E.Y., Boening, C., Limonadi, D., … van den Broeke, M.R. (2018). Exploration of Antarctic Ice Sheet 100-year contribution to sea level rise and associated model uncertainties using the ISSM framework. *Cryosphere*, *12*(11), 3511-3534.

Matthew R. Francis is a physicist, science writer, public speaker, educator, and frequent wearer of jaunty hats. His website is BowlerHatScience.org.

Massachusetts High School Students Lauded for Successful Model of U.S. Housing Crisis

2024 MathWorks Math Modeling Challenge Links Homelessness and the Housing Shortage

By Lina Sorg

As the price of goods and services in the U.S. continues to escalate, consumers are struggling to keep pace with inflation, shortages, and other factors that impact their spending habits. These troubles also extend to the housing market. Over the last several decades, the cost of housing has increased more rapidly than people's incomes — a discrepancy that puts economic pressure on individuals and families who may no longer be able to make rent, purchase a home, or pay an existing mortgage [4]. An overall lack of available housing further complicates this issue and is closely related to another ongoing crisis: homelessness [2, 3].

Homelessness persists in even the wealthiest areas and reached a troubling record high across the U.S. in 2023, having increased by roughly 12 percent from the previous year [2]. Furthermore, a dearth of affordable housing is associated with a 38 percent increase in homelessness in the largest U.S. cities over the last 12 months [1]. There are no quick fixes, as expanding the housing supply is a slow process that requires significant financial investment and administrative planning. Factors such as land restrictions, population growth, financial constraints, and structure longevity all contribute to housing-based policy decisions.

The intertwined nature of the housing and homelessness crises made them a relevant subject for this year's MathWorks Math Modeling Challenge[1] (M3 Challenge), a program of SIAM with MathWorks[2] as its title sponsor. Now in its 19th year, this annual online mathematics competition is open to U.S. high school juniors and seniors as well as sixth form students in England and Wales. Participating teams of three to five students have 14 consecutive hours during Challenge Weekend to address an open-ended mathematical modeling problem and write a report that explains and validates their solutions. All submitted papers then undergo three rigorous rounds of blind judging by an international panel of 120 Ph.D.-level applied mathematicians, who select the finalists. In late April, the nine finalist teams for M3 Challenge 2024 traveled to New York City and defended their solutions in front of a live panel of judges at Jane Street—a quantitative trading firm—to compete for more than $100,000 in scholarship funds.

Three members of the M3 Challenge Problem Development Committee authored the 2024 prompt: Jen Gorman of Lake Superior State University, Chris Musco of New York University (a 2008 M3 Challenge finalist), and Neil Nicholson of the University of Notre Dame. "We spent the better part of nine months trying to come up with the Challenge question," Nicholson said. "The sheer number of stories we saw in the news about housing costs and homelessness—particularly on the West Coast—really made us think about these two ideas. Math modeling is about relationships, and while it's fun to look at a single topic's relationship with time, there's something much more real about looking at how two related topics evolve together over time."

The problem statement[3] involved three related tasks. First, students had to predict changes in the housing supply for two U.S. or U.K. locations over the next 10, 20, and 50 years. Next, they were asked to predict shifts in the homeless population within their two selected areas over the same time frames. Lastly, participants utilized their results to create a model that addressed homelessness in the long term, then considered their model's adaptability to economic recessions, natural disasters, changing migrant populations, and other unforeseen circumstances.

This year's first-place team from Phillips Academy Andover in Andover, Mass., included Angeline Zhao, Tianyi Evans Gu, Anthony Yang, Eric Wang, and Yifan Kang. To address the Challenge problem, the group first applied a logistic model to predict the number of available housing units in Seattle, Wash., and Albuquerque, NM, in 2030, 2040, and 2070. "We initially considered various linear models to model the growth in the number of housing units, but they failed to account for the limited land resources available within the cities," Yang said. "As the number of housing units that can be feasibly built in each city is

See **Housing Crisis** *on page 7*

This year's MathWorks Math Modeling Challenge (M3 Challenge) champion team from Phillips Academy Andover in Andover, Mass., earned $20,000 in scholarship funds for their effective predictions of homelessness and the U.S. housing supply. They presented their winning solution at the M3 Challenge 2024 Final Event in New York City on April 29. From left to right: Yifan Kang, Anthony Yang, Angeline Zhao, Tianyi Evans Gu, and Eric Wang. SIAM photo.

---

[1] https://m3challenge.siam.org

[2] https://www.mathworks.com

[3] https://m3challenge.siam.org/resources/archives/2024-year-at-a-glance/2024-problem-tale-of-two-crises

---

Annual Meeting

Continued from page 4

AWM's Women in Complex and Nonlinear Systems research network) that is concurrent with Tuesday evening's poster session.

The **Workshop Celebrating Diversity** minisymposia will take place on Tuesday, July 9, and Wednesday, July 10, at 8:30 a.m. and 4:00 p.m. While both these and the AWM workshop sessions are technical talks, we highlight them because they represent communities that are especially welcoming and friendly. If you do not yet feel like you have found your community (many of us started out that way), you might be able to make friends at these events.

Panel Discussions

The panel format provides a chance to ask burning questions about your career trajectory, inquire about funding opportunities, and pose other queries that academic programs might not necessarily address. On Monday, July 8, from 8:00 to 10:00 a.m., the SIAM Education Committee will sponsor a panel discussion called **Industrial Needs for Preparing Students**. At 6:45 p.m. that same day, the SIAM Industry Committee will host an **Industry Career Panel**. Finally, the **Panel on Career Advancement at All Stages** on Thursday, July 11, at 8:30 a.m. is part of the aforementioned AWM workshop.

Lightning Talks

Another new element of AN24 is the **Industry Lightning Symposium**. This 30-minute session on Monday, July 8, at 6:15 p.m. will feature two TED-style talks by Gwen Spencer of Netflix and Wotao Yin of the Alibaba Group/Academy for Discovery, Adventure, Momentum, and Outlook, both of whom will speak about their respective experiences in industry.

Minitutorials

The SIAM Education Committee traditionally organizes expert-led minitutorials that serve as introductory walkthroughs for trending topics. The minitutorials at AN24 will take place on Monday, July 8, and Tuesday, July 9, from 4:00 to 6:00 p.m. and cover topics such as best practices for software development, which is important for employment in national laboratories and the corporate sector; automatic differentiation, which underlies data-driven scientific computing and machine learning; computational tools for the analysis of coupled oscillators, which are applicable in fields like neuroscience; and applied topological data analysis, which helps users detect topological structure in data.

AN24 also incorporates three additional 90-minute minitutorials: two related sessions about **Mathematical Contributions to Weather and Climate Modeling** on Tuesday, July 9, and Wednesday, July 10, at 8:30 a.m., and a tutorial about **Optimal Transport and Applications** on Thursday, July 11, at 8:30 a.m.

§

The AN24 program is still evolving, so don't forget to check back online[11] for new updates, which will likely include a movie screening of *Journeys of Black Mathematicians: Forging Resilience* on Monday afternoon and various professional development activities on Thursday. And don't forget that your AN24 registration grants you access to the meeting's online component from July 18 to 20, where you will be able to watch any plenary, prize, or minitutorial talks that you may have missed on site — most of which will involve a live Q&A session with the presenter. Several minisymposia and contributed talks will *only* be available online, so be sure to review the program for topics that interest you.

Lastly, if you will be at AN24 for the entire week, consider allowing yourself some time to explore Spokane![12] Full conference days can be extremely exhausting, and it's quite normal for attendees to take a day to engage in a bit of tourism. The walkability between the Spokane Convention Center and nearby sites allows you to maximize your time. Enjoy tastings at celebrated wineries, indulge in Spokane's thriving food scene, and explore the many attractions of Riverfront Park.

We look forward to the myriad of exciting activities at AN24 and hope to see you there!

Manuchehr Aminian is an assistant professor in the Department of Mathematics and Statistics at California State Polytechnic University, Pomona. His research interests include mathematical modeling, partial differential equations, and mathematical methods in data science. Kristin Kurianski is an assistant professor of mathematics at California State University, Fullerton. Her research interests include mathematical modeling and wave-type phenomena.

Attendees enjoyed an interactive poster session at the 2022 SIAM Annual Meeting, which was held in Pittsburgh, Pa., in July 2022. During the upcoming 2024 SIAM Annual Meeting, which will take place in Spokane, Wash., this July, the Poster Session and Dessert Reception will allow conference-goers and presenters to mingle and discuss cutting-edge research across a wide variety of mathematical areas. SIAM photo.

---

[11] https://meetings.siam.org/program.cfm?CONFCODE=AN24

[12] https://www.youtube.com/watch?v=9SEz5aNDmYM

Task Force

Continued from page 3

sustainability and ongoing enhancement of these tools. Without continuous investment, computational science applications may struggle to adapt to the exascale computing environment and fail to maximize its potential. The report thus advocates for further investments in mathematics, computer science, application science, and system software to support research and development activities that fully leverage the potential of exascale computing.

However, the path forward is riddled with obstacles; an especially pressing challenge is the evolving landscape of HPC. The end of traditional scaling laws—such as Moore's law, which historically drove increases in computing performance—necessitates a paradigm shift towards heterogeneous computing architectures. These architectures promise to sustain the momentum of computational advancements by incorporating specialized hardware and potentially disruptive technologies like quantum processors. But they also introduce enormous complexities that pertain to software compatibility, algorithm optimization, and infrastructure adaptation that require immense care and forward-thinking strategies.

The Data Deluge

In tandem with computational advancements, the Task Force Report highlights data science's transformative potential to propel scientific breakthroughs. Although the surge of data from scientific experiments, sensor networks, and simulations offers exciting new lines of inquiry, this deluge also poses formidable challenges in data management, analysis, and integration. To navigate such a complex data landscape, the report advocates for substantial investments in data science infrastructure and proposes a multi-pronged approach that promotes the development of sophisticated tools and algorithms for the scientific community. In particular, data fusion techniques can effectively synthesize information from disparate sources to enable a more holistic understanding of scientific phenomena. And real-time analytics can process and interpret data streams on the fly — an increasingly important capability in fields that require rapid decision-making, such as environmental monitoring and emergency response.

The report also emphasizes the value of digital twins: high-fidelity virtual models of natural or engineered systems that are continuously updated with real-world data. These models bridge the gap between theoretical research and practical application and offer unparalleled opportunities for simulation, prediction, and optimization. As such, Task Force members envision a future of accelerated scientific inquiry that harnesses the power of data science, computational advancements, digital twins, and other emerging technologies to produce revolutionary discoveries and innovations across various domains.

Artificial Intelligence and Machine Learning

The Task Force Report further illuminates the significance of AI and machine learning (ML) in scientific research. Recent strides in these fields have resulted in potent tools that enhance data analysis, expedite simulations, and yield novel scientific insights. However, focused research efforts are needed to tailor these commercial advancements to the nuanced requirements of scientific applications. Sparse datasets, physical models within AI structures, and the reliability and interpretability of AI-driven scientific outcomes all warrant immediate attention.

Unlike commercial applications that often benefit from vast, densely populated datasets, the scientific community frequently grapples with sparse datasets. These datasets—which are characterized by their limited size, irregular sampling, or incompleteness—pose significant hurdles for traditional AI and ML algorithms that are accustomed to learning from large volumes of data. Beyond the issue of data sparsity, the integration of domain-specific physical laws and principles with the computational prowess of AI algorithms could enhance AI-driven predictions and outcomes. In addition, the importance of reliability and interpretability in this context cannot be overstated. Given their potential real-world implications, AI- and ML-informed decisions must be accurate, transparent, and justifiable.

A Skilled and Diverse Workforce

Finally, the Task Force Report emphasizes the need for a skilled and diverse workforce that can navigate the interdisciplinary terrains of computational science. It notes current shortcomings and advocates for innovative educational programs and initiatives that support new talent from historically underrepresented communities. Diversity within the computational science workforce is critical as both a matter of equity and a strategic imperative because it can inspire innovative solutions and cultivate a deeper, more nuanced understanding of complex scientific problems. By fostering an environment that welcomes and supports diversity, the field of computational science will experience a broader range of insights and approaches and enhance its capacity to tackle new challenges and seize emerging opportunities. Projects that reduce barriers to entry, provide mentorship, and highlight role models will all help to further this cause.

A Call to Action

To support the ultimate vision of the 2024 SIAM Task Force Report on the Future of Computational Science, all computational science stakeholders will need to make strategic investments in technology and research, foster interdisciplinary collaborations, and commit to an inclusive and innovative scientific community. The report's recommendations serve as both a guide for leveraging the immense potential of computational science and a call for sustained U.S. leadership in this vital domain. By embracing this roadmap, the community can create a future wherein computational science continues to serve as a linchpin for scientific advancement, technological innovation, and societal progress.

Acknowledgments: The authors would like to thank Bruce Hendrickson of Lawrence Livermore National Laboratory, chair of the SIAM Task Force on the Future of Computational Science, for his contributions to this article.

Elie Alhajjar is a senior scientist in the RAND Corporation's Engineering and Applied Sciences Department in Washington, D.C., where he leads projects at the intersection of artificial intelligence, cybersecurity, and government. He previously held simultaneous posts as an associate professor in the U.S. Military Academy at West Point and a senior research scientist at the Army Cyber Institute. Alhajjar has a Ph.D. in mathematics from George Mason University. Tanzima Islam is an assistant professor at Texas State University who specializes in maximizing scientific returns through the synergistic use of high-performance computing, artificial intelligence, and machine learning. She holds a Ph.D. from Purdue University and pursued postdoctoral research at Lawrence Livermore National Laboratory (LLNL). Islam's numerous accolades include the Department of Energy's Early Career Award, an R&D 100 Award, LLNL's Science and Technology Award, and Texas State University's Presidential Seminar Award.

See you at the SIAM Annual Meeting!
July 8–12, 2024

Stop by the AMS booth to take advantage of the meeting discount.

AMS AMERICAN MATHEMATICAL SOCIETY
Advancing research. Creating connections.

Housing Crisis

Continued from page 5

limited, we used collected data on developable land in the two cities to estimate the maximum number of housing units, and then used that as the carrying capacity."

After finding an existing carrying capacity for Seattle housing units in the literature, the team used that estimate to calculate their own carrying capacity for Albuquerque. These efforts ultimately led the students to predict a total of 411,600 available housing units in Seattle in 2030, 453,000 in 2040, and 513,000 in 2070. Similarly, they forecasted 261,000 available housing units in Albuquerque in 2030, 270,900 in 2040, and 290,800 in 2070. "When we accounted for random error in our predictions, we found that our errors were at or below five percent for both Seattle and Albuquerque," Yang said. "This means that the inclusion of the carrying capacity helped tremendously in developing accurate and robust predictions."

Next, the Andover students assessed the relationship between homelessness and several different variables. "We recognized that it was probable that a number of factors were likely to influence homelessness," Zhao said. "Rather than attempting to identify a single variable and using that as a prediction, we wanted to account for more of the potential influences." As such, the group conducted a multivariate analysis that indicated a significant correlation between the homeless population and total housing units, occupied housing units, median household income, and median listing price. They then generated a multiple regression model by combining their previous logistic model for housing units with a linear model for median listing price.

"To perform the multiple linear regression, we had to ensure that our predictor variables were themselves linearly independent," Zhao said. "We thus narrowed our factors down to total housing units and median listing price. Using our two predictor variables, we were able to predict the homeless population in 10-, 20-, and 50-year increments." For 2030, 2040, and 2070, their results indicated a respective homeless population of 14,400, 17,100, and 23,200 in Seattle and 3,800, 5,100, and 10,400 in Albuquerque.

Finally, the team created a long-term plan to combat Seattle's homelessness crisis. The students relied on available data and their previous findings to identify potential significant factors with predictive causality for homelessness, then utilized a Granger causality test to test these factors. They determined that the number of housing units, median listing prices, and deaths by opioid use were all significant. "To quantify the impacts these factors could create, we used a multiple linear regression model and adjusted the data points to predict the resulting change in homelessness," Zhao said. "We found that increasing housing units and decreasing deaths by opioid use had the greatest impact, which could be targeted through policy changes to exclusionary zoning laws, housing funds or taxes on high-value properties, or awareness programs or referral mechanisms to decrease substance use."

Their detailed procedure earned the Andover students—who were coached by Khiem DoBa, advisor of the Phillips Academy Math Club—a total of $20,000 in collective scholarship funds. "What I liked most about the winning paper was that the models were not overly complicated," said Musco, who also served as a judge during the Final Event at Jane Street. "For all three problems, the team used and justified tried-and-true techniques. These methods were appropriate for the relatively limited amount of available data, and they were easy to interpret."

This group was the first team from Phillips Academy Andover to compete in M3 Challenge, which made their win especially exciting for both the students and coach. Prior to Challenge Weekend, the students reviewed questions and solutions from previous years; once they learned of their finalist status, DoBa worked closely with them to prepare for the in-person presentation and even enlisted other faculty members to serve as mock judges. "It is essential to expose students to real-world modeling because they will soon be the ones who face the real-world problems," DoBa said. "This was a wonderful opportunity for the students to tackle current issues. In addition, they learned that their mathematical expertise and goodness—a genuine desire to understand and help others in need—are essential in making a positive impact and contributing to their community and the world."

This type of confidence-building experience is precisely the intended outcome of M3 Challenge. The program—which is managed by Karen Bliss, Senior Manager of Education and Outreach at SIAM—seeks to highlight the importance of mathematical modeling in practical settings and motivate participants to consider future careers in applied mathematics, computational and data science, and technical computing. Students have the unique opportunity to utilize all aspects of their mathematical education while simultaneously honing their creativity, communication skills, and problem-solving strategies.

Encouraged by their first-place finish, the Andover team is excited to further hone their abilities and compete again next year. "M3 Challenge equipped us with some of the most important skills of the 21st century, skills that we will no doubt rely on every day in our future lives," Gu said. "It truly feels as if the work we were doing throughout the Challenge is tangible and immediately impactful. There is a real sense of empowerment — that the things we learn and the skills we spend time developing have an important place in applications in the real world."

At this year's MathWorks Math Modeling Challenge (M3 Challenge) Final Event, which took place on April 29 in New York City, the M3 Challenge 2024 champion team from Phillips Academy Andover in Andover, Mass., explains their models of the housing and homelessness crises in the U.S. and fields questions from a panel of judges. From left to right: Eric Wang, Angeline Zhao, Yifan Kang, Anthony Yang, and Tianyi Evans Gu. SIAM photo.

Phillips Academy Andover's winning solution paper is available online,[4] as is their final presentation.[5]

References

[1] Colburn, G., & Aldern, C.P. (2022). *Homeless is a housing problem: How structural factors explain U.S. patterns*. Berkeley, CA: University of California Press.

[2] De Sousa, T., Andrichik, A., Prestera, E., Rush, K., Tano, C., & Wheeler, M. (2023). *The 2023 annual homelessness assessment report (AHAR) to Congress.* Washington, D.C.: U.S. Department of Housing and Urban Development. Retrieved from https://www.huduser.gov/portal/sites/default/files/pdf/2023-AHAR-Part-1.pdf.

[3] Kelly, M.L., Venkat, M., Fink, K., & Troop, W. (2024, April 23). Housing experts say there just aren't enough homes in the U.S. *NPR*. Retrieved from https://www.npr.org/2024/04/23/1246623204/housing-experts-say-there-just-arent-enough-homes-in-the-u-s.

[4] Ludden, J. (2024, January 25). Housing is now unaffordable for a record half of all U.S. renters, study finds. *NPR*. Retrieved from https://www.npr.org/2024/01/25/1225957874/housing-unaffordable-for-record-half-all-u-s-renters-study-finds.

Lina Sorg is the managing editor of SIAM News.

---

[4] https://m3challenge.siam.org/wp-content/uploads/CHAMPION_17645.pdf

[5] https://www.youtube.com/watch?v=E3jik0u-mKs

Take Advantage of SIAM's Visiting Lecturer Program

Hearing directly from working professionals about research, career opportunities, and general professional development can help students gain a better understanding of the workforce. SIAM facilitates such interactions through its Visiting Lecturer Program (VLP), which provides the SIAM community with a roster of experienced applied mathematicians and computational scientists in academia, industry, and government. Mathematical sciences students and faculty—including SIAM student chapters—can invite VLP speakers to their institutions to present about topics that are of interest to developing professional mathematicians. Talks can be given in person or virtually.

The SIAM Education Committee[1] sponsors the VLP and recognizes the need for all members of our increasingly technological society to better understand the achievements and potential of mathematics and computational science.

Points to consider in advance when deciding to host a visiting lecturer include the choice of dates; speakers; topics; and any additional or related activities, such as follow-up discussions. It is important to familiarize lecturers with their audience—including special interests or expectations—so they can refine the scope of their talks, but just as crucial to accommodate speakers' suggestions so the audience can capitalize on their experience and expertise. Read more about the program and view the current list of participants online.[2]

---

[1] https://www.siam.org/about-siam/committees/education-committee

[2] https://www.siam.org/students-education/programs-initiatives/siam-visiting-lecturer-program

---

The John von Neumann Prize Lecture

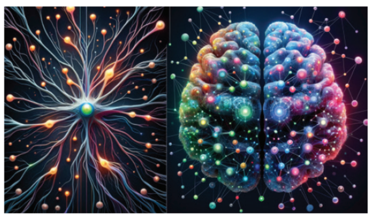
JORGE NOCEDAL

Northwestern University, United States

July 9, 2024 • 2:30–3:30 p.m. Pacific Daylight Time
2024 SIAM Annual Meeting, Spokane, Washington, United States

Exploring the Mysteries of Deep Neural Network Optimization

In 1961, Minsky perceived a fundamental flaw within the burgeoning field of artificial neural networks. He doubted that such a nonlinear system could be effectively trained using gradient methods, because unless the "structure of the search space is special, the optimization may do more harm than good." Fast forward to today, and we observe deep neural networks — far more complex than those envisioned at the field's inception — being successfully trained with methods akin to gradient descent. It has, indeed, become evident that the objective function displays a highly benign structure that we are only starting to comprehend.



This image was created by GPT-4 using the following instructions by Nocedal: "Create an image of the neurons in the brain next to an image of an artificial neural network."

In his lecture, Nocedal aims to summarize our current understanding of this enigmatic optimization process. He will explore a diverse array of themes, including intrinsic dimensionality, the optimization landscape, and implicit regularization, and will highlight key open questions, all within the context of residual networks and generative models.

Register for AN24 and attend the lecture: *go.siam.org/an24*

Jorge Nocedal of Northwestern University, United States, is the 2024 recipient of the John von Neumann Prize, the highest honor and flagship lecture of SIAM. He will present his prize lecture at the 2024 SIAM Annual Meeting, taking place July 8–12, 2024.

siam | Society for Industrial and Applied Mathematics

Euclid's *Elements* Through the Ages

BOOK REVIEW

By Ernest Davis

Encounters with Euclid: How an Ancient Greek Geometry Text Shaped the World. *By Benjamin Wardhaugh. Princeton University Press, Princeton, NJ, July 2021. 416 pages, $29.95.*

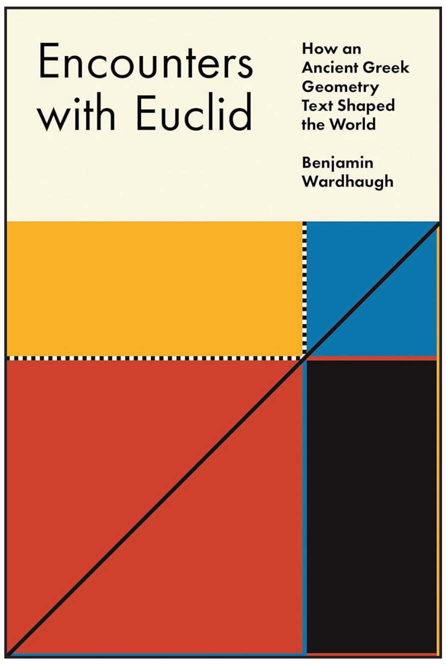
Euclid's *Elements*—a mathematical treatise that comprises 13 separate books—is perhaps the most influential science or math text prior to Nicolaus Copernicus' *On the Revolutions of Heavenly Spheres*. In the two millennia since its composition, Euclid's tome has played a central role in countless elementary education curricula. Many students around the world—including numerous budding mathematicians and scientists—found it to be an enchanting introduction to the wonders of mathematics and rigorous proof; many others cursed it as horrible, meaningless drudgery. Euclid's proofs are often seen as the paradigm for deductive argument. "As certain as a proposition in Euclid" is a byword for inarguable validity.

Yet despite his prominence, almost nothing is reliably known about Euclid's life. He must have lived around 300 BCE. In addition to the *Elements*, three mostly intact books (*Optics*, *Data*, and *Phaenomena*) and four lost books (*Conics*, *Pseudaria*, *Porisms*, and *Surface Loci*) are attributed to him with varying degrees of confidence. Euclid is plausibly said to have been part of the court of Ptolemy I in Alexandria, but everything else about him is legend that dates from many centuries after his death.

Moreover, the original Greek text of the *Elements* is exceptionally hard to recover — much more so than many of the great ancient Greek works of philosophy, literature, and history. Since it is a textbook rather than a work of literature, teachers felt free to make additions and corrections (which were not always accurate) or omit material that they felt was superfluous. Furthermore, copyists who were mathematically uninformed and did not understand the diagrams introduced all kinds of errors into both the text and figures. More knowledgeable editors may have corrected these mistakes at a later date, but their corrections might have taken the text even further from the original.

As a particular example, Greek mathematician Theon of Alexandria produced an edition of the *Elements* in the fourth century CE. Benjamin Wardhaugh describes this version in *Encounters with Euclid*:

> [Theon] cleaned up and smoothed out difficulties. He chose between variant versions of the texts, or combined the variants together ... He filled in gaps, real or imagined. While the Homeric editors saw themselves standing outside the epic tradition, mathematicians of later Alexandria tended to behave as though Euclid was a colleague, and they themselves members of a still-living tradition. Instead of textual purity and fidelity ("what did Euclid really write?") they prized correctness, completeness, and usability.



Encounters with Euclid: How an Ancient Greek Geometry Text Shaped the World. By Benjamin Wardhaugh. Courtesy of Princeton University Press.

In one specific instance, Theon notes that he inserted his own original proof. In other cases, however, it is essentially impossible to know which parts of the texts were Euclid's and which were added or changed by Theon or additional editors, copyists, and printers.

Wardhaugh's *Encounters with Euclid* is an account of how people have engaged with the *Elements* over millennia — what they thought of the work and how they studied, taught, edited, emulated, admired, or objected to it. Each chapter comprises roughly one episode in this long history.

In my opinion, the most interesting and useful chapters are those that deal with people whose engagements with the *Elements* were particularly deep. For instance, the chapter on Theon of Alexandria is excellent, as is the chapter on Arethas of Patras—a 10th-century Byzantine bibliophile who commissioned and annotated what is now the oldest surviving complete copy of the *Elements*—and the chapter on Erhard Ratdolt, who produced a beautiful printed edition in 1482 (see Figure 1, on page 9).

Christopher Clavius—a 16th-century Jesuit, scientist, Platonist philosopher, and one of the few contemporaries that Galileo admired—produced his own edition of the *Elements*. Under his influence, the text became part of the Jesuit educational curriculum. Wardhaugh writes:

> Thus, the nearly quarter of a million children and adolescents in Jesuit care at any given moment would now be exposed to Euclid's *Elements* in Clavius' version; and as well as Clavius' students at Rome and the long line of Jesuit mathematicians, the order would also go on to educate such non-Jesuits interested in mathematics as Descartes, Laplace, Diderot, and Voltaire. Clavius' love for Euclid, and his distinctive vision of the *Elements*, would shape mathematical culture for two centuries.

Encounters with Euclid also includes excellent chapters on philosopher Baruch Spinoza and polymath Isaac Newton, both of whom modeled major texts—*Ethics* and *Philosophiæ Naturalis Principia Mathematica*, respectively—on Euclid. Another interesting chapter centers on the debate in 19th-century England about whether the *Elements* is a suitable geometry textbook. Mathematician Augustus De Morgan argued strongly in favor of Euclid, and author Charles Dodgson (better known by his pen name, Lewis Carroll) wrote a book called *Euclid and His Modern Rivals* that mocked competing geometry textbooks. However, they and other Euclid supporters lost the battle in the early 20th century.

Encounters with Euclid actually corrected a major misimpression of my own. I had thought that Euclid's logical gaps—other than concerns about the parallel postulate—were not discovered until the drive toward rigor in the 19th century. On the contrary, medieval and early modern mathematicians were troubled by these issues and attempted to fix them. The complete axiomatization was finally realized in David Hilbert's 1899 *Grundlagen der Geometrie*, which Wardhaugh astonishingly fails to note.

Regrettably, other chapters seem less successful. Quite a few of them are short biographies of otherwise interesting

See **Euclid's *Elements*** *on page 9*


JOURNALS OF THE IMA

ACADEMIC.OUP.COM/IMAMAT
IMA Journal of Applied Mathematics

ACADEMIC.OUP.COM/IMAMAN
IMA Journal of Management Mathematics

ACADEMIC.OUP.COM/IMAMCI
IMA Journal of Mathematical Control and Information

ACADEMIC.OUP.COM/IMAJNA
IMA Journal of Numerical Analysis

ACADEMIC.OUP.COM/IMAIAI
Information and Inference: A Journal of the IMA

ACADEMIC.OUP.COM/TEAMAT
Teaching Mathematics and its Applications

ACADEMIC.OUP.COM/IMATRM
Transactions of Mathematics and its Applications: A Journal of the IMA

ACADEMIC.OUP.COM/IMAMMB
Mathematical Medicine and Biology: A Journal of the IMA

INTERESTED IN PUBLISHING IN AN IMA JOURNAL?
You may be able to publish your paper Open Access using funds available through your institution's agreement with OUP.
SCAN THE QR CODE TO FIND OUT IF YOUR INSTITUTION IS PARTICIPATING.

INSTITUTE OF MATHEMATICS & ITS APPLICATIONS
OXFORD UNIVERSITY PRESS

IMSI Long Program Explores Algebraic Statistics and Our Changing World

By Sam Hansen

As the name suggests, algebraic statistics is a cross-disciplinary area of mathematical science. Researchers in this space seek to answer statistical problems by using algebra-based results and methods, such as the treatment of polynomials from algebraic geometry, structures like rings and ideals from commutative algebra, and networks from combinatorics. Although the field of algebraic statistics is relatively new, it has already proven to be useful in applications like biology, network analysis, and algorithm design — and its reach and influence are continuing to grow.

To accelerate this steady growth, the Institute for Mathematical and Statistical Innovation[1] (IMSI) recently hosted a long program on "Algebraic Statistics and Our Changing World: New Methods for New Challenges,"[2] which took place at the University of Chicago from September to December 2023. IMSI—which is the newest of six math research institutes that are funded by the National Science Foundation—is characterized by its distinct focus on applications of math and statistics in the context of major societal challenges. Applied mathematicians and statisticians always play a prominent role in its scientific activities, which are cross-disciplinary in nature. For "Algebraic Statistics and Our Changing World," these individuals convened with life scientists—phylogeneticists, plant pathologists, epidemiologists, and the like—as well as econometricians, economists, social scientists, and experts in a variety of other disciplines.

Over the course of three months, the program brought together more than 180 researchers from around the world for five workshops—including an apprenticeship week—and various seminars and reading groups. The organizers intentionally provided opportunities for early-career participants to network and connect with more seasoned attendees. The content focused on the application of algebraic statistics to multiple critical issues, such as the connection between patterns of genetic change and evolution and the relationship between economic networks and social inequities.

Throughout "Algebraic Statistics and Our Changing World," five different working groups advanced research in their respective areas: (i) Causality, (ii) Machine Learning (ML) Thresholds of Colored Gaussian Graphical Models, (iii) Game Theory, (iv) Incomplete U-statistics for Phylogenetic Models, and (v) Neurovarieties of Rational Neural Networks. Participants have already deposited two dozen research preprints on arXiv[3] that reflect their work during the long program. In addition, more than 100 talks—many of which are now publicly available as part of IMSI's video collection[4]—helped to expand participants' knowledge of algebraic statistics throughout the course of the three-month event. Also worth noting is a weeklong workshop that spotlighted the emerging field of algebraic economics and convened experts in game theory, econometrics modeling, random networks, and causal analysis. The corresponding sessions and dialogues established algebraic game theory and causal inference as two pillars of this burgeoning area.

Four specific presentations particularly illustrated the diverse applications of algebraic statistics. During the opening workshop—an "Invitation to Algebraic Statistics and Applications"[5]—Kathlén Kohn of the KTH Royal Institute of Technology gave a talk titled "What Will Happen in Neural Networks???"[6] Kohn explored the potential use of ML for the solution of polynomial systems, which is a complicated topic. Although neural networks are powerful tools that can solve a multitude of problems with sufficient computational time and resources, the computer vision community has not seen a breakthrough in this area for at least 10 years — despite its employment of ML for relevant problems. Kohn's titular question was so provocative that the Neurovarieties working group decided to focus on the related topic of neural net expressibility, which impacts the computational structures that underlie many ML applications. While the working group was not able to answer the original question, participants did identify a key part of the puzzle: We don't know what type of distance needs to be minimized between a set of real-world data and the points that are modeled by a neural net.

Another highlight of the program involved the multispecies coalescent (MSC) model, which "provides a powerful framework for a number of inference problems using genomic sequence data from multiple species, including estimation of species divergence times and population sizes, estimation of species trees accommodating discordant gene trees, inference of cross-species gene flow, and species delimitation" [1]. During the "Algebraic Statistics for Ecological and Biological Systems" workshop,[7] John Rhodes of the University of Alaska Fairbanks spoke about "Inferring the Tree-like Parts of a Species Network Under the Coalescent."[8] Rhodes discussed recent work with Elizabeth Allman of the University of Alaska Fairbanks; Hector Baños of California State University, San Bernadino; and Jonathan Mitchell of the University of Tasmania to utilize the MSC model and identify genetic flow and evolutionary histories from genetic data (see Figure 1). In a similar vein, the working group on Incomplete U-statistics applied the network version of the MSC model to phylogenetic data and subsequently employed incomplete U-statistics. The continued development of this work could be very influential, as selecting appropriate statistical models and tests for phylogenetic data is historically difficult.

Finally, a major highlight of "Algebraic Statistics and Our Changing World" was the field's connection to social science. For example, Weslynne Ashton of the Illinois Institute of Technology presented on "Justice, Equity and the Circular Economy"[9] in the context of food distribution during the "Algebraic Economics" workshop.[10] Ashton's talk challenged participants to consider appropriate types of data, suitable models, and—most importantly—the integration of justice and equity into algebraic statistics applications. Eric Auerbach of Northwestern University later introduced a new yet related topic during

See **Algebraic Statistics** *on page 10*

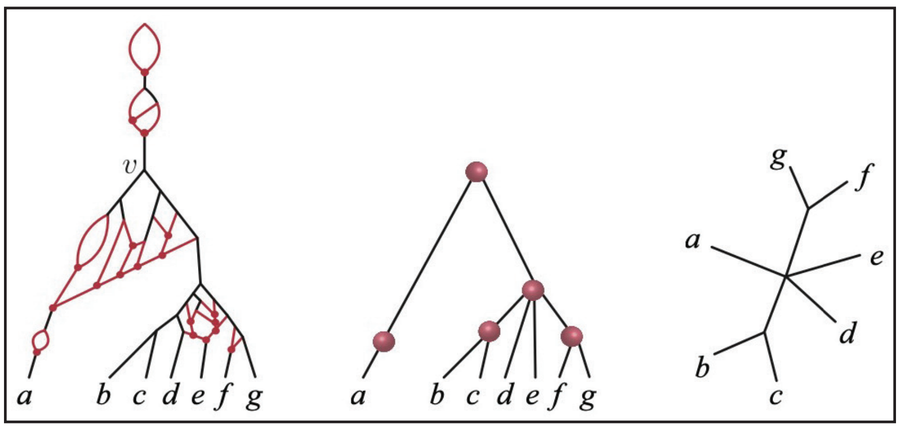


Figure 1. *Example of the "tree of blobs" simplification method for phylogenetic network inference. John Rhodes of the University of Alaska Fairbanks discussed this method during a talk about "Inferring the Tree-like Parts of a Species Network Under the Coalescent" during the Institute for Mathematical and Statistical Innovation's long program on "Algebraic Statistics and Our Changing World," which took place last year at the University of Chicago. Figure courtesy of John Rhodes.*

---

[1] https://www.imsi.institute

[2] https://www.imsi.institute/activities/algebraic-statistics-and-our-changing-world

[3] https://arxiv.org

[4] https://www.imsi.institute/videos

[5] https://www.imsi.institute/activities/invitation-to-algebraic-statistics-and-applications

[6] https://www.imsi.institute/videos/what-will-happen-in-neural-networks

[7] https://www.imsi.institute/activities/algebraic-statistics-for-ecological-and-biological-systems

[8] https://www.imsi.institute/videos/inferring-the-tree-like-parts-of-a-species-network-under-the-coalescent

[9] https://www.imsi.institute/videos/justice-equity-and-the-circular-economy

[10] https://www.imsi.institute/activities/algebraic-economics

---

Euclid's *Elements*

Continued from page 8

people whose interactions with Euclid were not especially noteworthy. Hrotsvitha of Gandersheim was an extraordinary medieval poet and dramatist in the 10th century, but her only connection to Euclid is a play that mentions perfect, deficient, and abundant numbers. George Eliot was a great novelist, but being reminded that the protagonists of *The Mill on the Floss* disliked their study of Euclid does not do much for my understanding of either the novelist or the novel. Max Ernst's "Euclid" painting and Euclid's remote relation to designer Elsa Schiaparelli's couture likewise did not interest me. On the other hand, Wardhaugh's short chapter on polymath Mary Fairfax Somerville led me to her fascinating memoirs [1], so I owe him a great debt just for that.

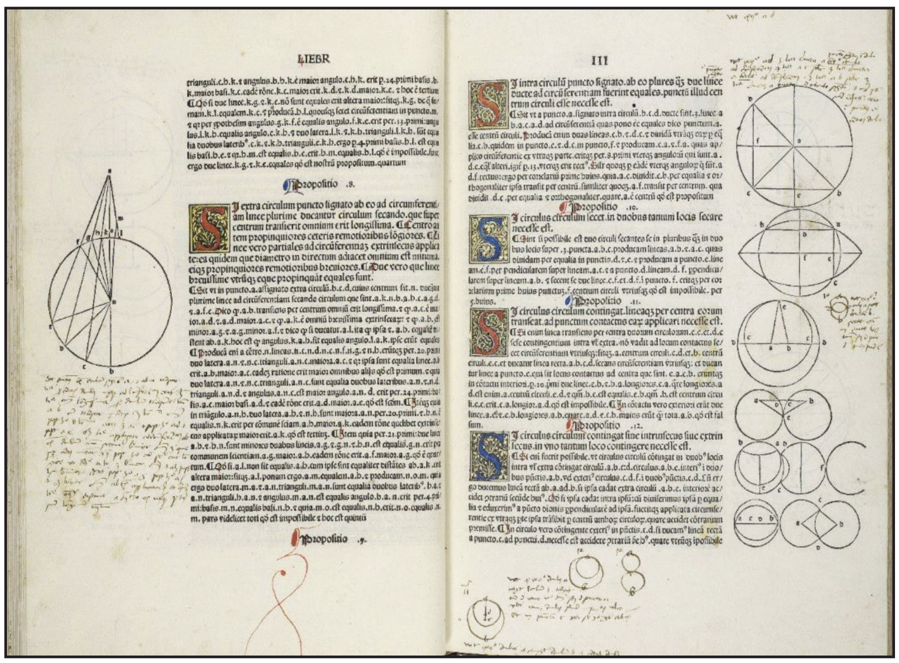


Figure 1. *A spread of pages from an edition of Euclid's Elements that was printed in Venice in 1482, with extensive mathematical illustrations. Throughout the centuries, readers of the text added their own notes in the margins. This edition is on exhibit at the Folger Shakespeare Library in Washington, D.C., this summer. Figure courtesy of the Folger Shakespeare Library.*

Incidentally, the flyleaf references Abraham Lincoln—who studied the *Elements* in his 40s and was proud to have mastered it—but the book neglects to mention him at all. In fact, *Encounters with Euclid* becomes increasingly focused on Great Britain in the 18th and 19th centuries. The U.S. is completely absent from the narrative until 1922, when Edna St. Vincent Millay wrote her poem "Euclid alone has looked on Beauty bare."

Overall, Wardhaugh's book is surprisingly disengaged from the actual mathematical content of the *Elements*; it does not quote or analyze any proofs and comments on very few propositions. Two of Euclid's most famous results—his proof that there are infinitely many prime numbers, and the Euclidean algorithm for the greatest common divisor—are not mentioned at all. It would also have been interesting to read a direct comparison between the proof styles of Euclid and other classical mathematicians. Finally, the text contains 34 images of book pages and other artifacts, but the quality of the reproductions is not especially good.

Let me also frivolously suggest that the next edition include some lighthearted discussion of Euclid parodies. I can think of two candidates offhand: Lewis Carroll's *The Dynamics of a Particle*, which focuses on party politics ("Let it be granted that a speaker may digress from any one point to any other point"); and Stephen Leacock's *Boarding-House Geometry* ("Any two meals at a boarding-house are together less than two square meals"). I'm sure that other such examples exist.

Yet despite these minor shortcomings, *Encounters with Euclid* is enjoyable and informative. Wardhaugh's prose is clear and elegant, and each chapter begins with a charming, evocative vignette that is written in the historical present with an impressionistic style. The book contains a lot of fascinating material with which I was not familiar, and the short sketches of the different intellectual worlds that Euclid touched—Alexandria in 300 BCE, Alexandria again in 400 CE, Baghdad in the 10th century, Beijing in the 17th century, and so forth—are vivid. If you are interested in the transmission of classic Greek mathematics throughout the centuries, it is certainly worth reading.

References

[1] Somerville, M. (2001). *Queen of science: Personal reflections of Mary Somerville* (D. McMillan, Ed.). Edinburgh, Scotland: Canongate Books.

Ernest Davis is a professor of computer science at New York University's Courant Institute of Mathematical Sciences.

An Exploration of Dynamics and Bifurcation in Networks

By Martin Golubitsky
and Ian Stewart

FROM THE SIAM BOOKSHELF

The following is a brief description from the authors of Dynamics and Bifurcation in Networks: Theory and Applications of Coupled Differential Equations,[1] which was published by SIAM in 2023. The book acknowledges recent scientific interest in network-based modeling, addresses the past two decades of developments in the formalism of network dynamics, and investigates the influence of a network's architecture and symmetry on the behavior of dynamical systems.

Dynamics and Bifurcation in Networks: Theory and Applications of Coupled Differential Equations examines the qualitative features of solutions to admissible systems of ordinary differential equations (ODEs) that are supported by a fixed network, i.e., a directed graph or digraph (more generally, we can assign "types" to nodes and edges that the ODE must preserve). Examples of simple networks include a bidirectional ring of two identical nodes and a unidirectional ring of three nonidentical nodes (see Figure 1).

The admissible systems for these two networks are as follows:

$$\text{(a)}\ \begin{array}{rcl}\dot{x} & = & f(x,y)\\ \dot{y} & = & f(y,x)\end{array} \qquad \text{(b)}\ \begin{array}{rcl}\dot{x} & = & f(x,y)\\ \dot{y} & = & g(y,z)\\ \dot{z} & = & h(z,x)\end{array}. \tag{1}$$

The two-node system in (1a) is *homogeneous* because the $\dot{x}$ and $\dot{y}$ node functions are identical, as indicated by the matching node and edge symbols. The three-node system in (1b) is *fully inhomogeneous* because the $\dot{x}$, $\dot{y}$, and $\dot{z}$ node functions are generally different, as indicated by the distinct node and edge symbols. The three-node digraph implies that the time evolution of the x node depends on the states of the x and y nodes but not of the z node, and so on.

We claim that differences frequently exist between the generic features of the solutions to admissible systems that correspond with individual networks. Here, "generic" refers to typical behavior in the world of *admissible* ODEs for the digraph in question. For additional context, we know that there are more than 1.5 million six-node digraphs. Even if our claim about different dynamics for different networks is only partially valid, the corresponding mathematical problem is huge.

We make two assertions: (i) Applications often lead to admissible systems of a fixed network, and (ii) admissibility often leads to generically interesting mathematics. Here, we use Hopf bifurcation from dynamical systems theory to describe an example of each assertion. Suppose that a stable equilibrium loses its stability when a pair of simple, purely imaginary eigenvalues of the Jacobian matrix cross zero with nonzero speed. Hopf bifurcation affirms that a unique branch of small-amplitude periodic solutions emanates from the bifurcation point.

The two-node example implies that periodic solutions with period T—where $y(t)=x(t+T/2)$—are unsurprising. Also, two nodes i and j in a given network $\mathcal{G}$ are *equivalent* if a path connects i to j and another path connects j to i; a component of $\mathcal{G}$ is called an *equivalence class*. The subsequent theorem illustrates the interaction between networks and dynamics. Let $\mathcal{H}$ be an equivalence class of $\mathcal{G}$. A periodic solution is of type $\mathcal{H}$ if $x(t)$ oscillates in every node within $\mathcal{H}$ or downstream from $\mathcal{H}$, but is stationary in all remaining nodes. The theorem is thus as follows: For each component $\mathcal{H}$ in the fully inhomogeneous network $\mathcal{G}$, a certain type of Hopf bifurcation leads generically to $\mathcal{H}$-type periodic solutions.

Next, we sketch an application to *binocular rivalry* — a psychophysics experiment wherein a subject is shown two different images. More precisely, the subject's right eye is exposed to one image and their left eye is exposed to the other; the individual then records the image that they perceive (known as the *percept*) over time. The subject typically perceives one image and then the other, with continuous alternation throughout the experiment. Although the reported alternation is not usually periodic, binocular rivalry models often focus on finding a periodic alternation of the images. The model equations typically take the form

$$\begin{array}{rcl}\dot{a}^E & = & f(a^E,a^H,b^E)\\ \dot{a}^H & = & g(a^E,a^H)\\ \dot{b}^E & = & f(b^E,b^H,a^E)\\ \dot{b}^H & = & g(b^E,b^H),\end{array} \tag{2}$$

where each two-dimensional node a and b has an activity variable $*^E$ and a fatigue variable $*^H$.

In this model, the subject perceives the a percept when $a^E > b^E$ and the b percept when $a^E < b^E$. States where $a^E = b^E$ are called *fusion states;* the model does not choose a percept in this case. Many studies that examine these equations' rich dynamics are available in the literature [1, 2, 5, 7].

One particular study involves two specific binocular rivalry experiments [4]. In the first experiment, one eye is shown an image of a monkey and the other is shown an image of a jungle scene with overlaid text (see Figure 2). Based on the network in (1a), a perceived alternation does indeed occur between the two images.

In the second experiment, three lines subdivide the rectangular monkey-text images into six wedges that are then reassembled into two *scrambled* rectangles (see Figure 3). This modified exercise yields a curious result. While subjects do perceive the expected alternation between the scrambled images, they also surprisingly perceive an alternation between the original, unscrambled images.

Why does this happen? Hugh Wilson proposed a homogeneous network model in which this outcome—i.e., alternation between both the standard and scrambled monkey-text images—is unsurprising [6, 7]. Chapter 23 of *Dynamics and Bifurcation in Networks*, titled "Binocular Rivalry and Visual Illusions," explores this question in more depth.

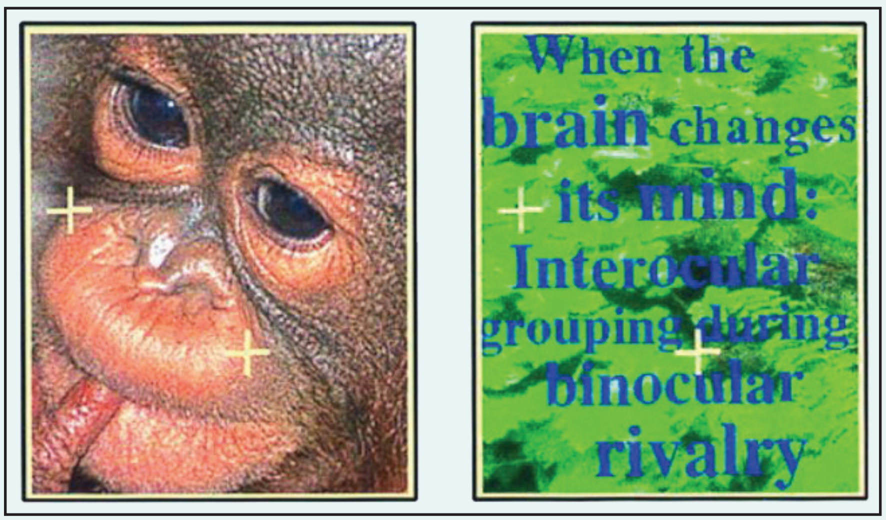


Figure 2. *The two different images that subjects see in the monkey-text experiment. Figure reprinted from [4]. Copyright (1996) National Academy of Sciences.*

Dynamics and Bifurcation in Networks provides an extensive introduction to the examples, theory, and applications of network dynamics. Each chapter commences with an introductory section that helps readers isolate parts of the material that are not necessarily essential on a first perusal. At the beginning of the book, a 16-page preface orients readers to the more extensive material.

Enjoy this passage? Visit the SIAM Bookstore[2] to learn more about Dynamics and Bifurcation in Networks: Theory and Applications of Coupled Differential Equations[3] and browse other SIAM titles.

References

[1] Curtu, R. (2010). Singular Hopf bifurcations and mixed-mode oscillations in a two-cell inhibitory neural network. *Physica D: Nonlin. Phenom.*, *239*(9), 504-514.

[2] Curtu, R., Shpiro, A., Rubin, N., & Rinzel, J. (2008). Mechanisms for frequency control in neuronal competition models. *SIAM J. Appl. Dyn. Syst.*, *7*(2), 609-649.

[3] Diekman, C.O., Golubitsky, M., & Wang, Y. (2013). Derived patterns in binocular rivalry networks. *J. Math. Neurosci.*, *3*(1), 6.

[4] Kovács, I., Papathomas, T.V., Yang, M., & Fehér, Á. (1996). When the brain changes its mind: Interocular grouping during binocular rivalry. *Proc. Natl. Acad. Sci.*, *93*(26), 15508-15511.

[5] Laing, C.R., & Chow, C.C. (2002). A spiking neuron model for binocular rivalry. *J. Comput. Neurosci.*, *12*(1), 39-53.

[6] Wilson, H.R. (2007). Minimal physiological conditions for binocular rivalry and rivalry memory. *Vision Res.*, *47*(21), 2741-2750.

[7] Wilson, H.R. (2009). Requirements for conscious visual processing. In M. Jenkin and L. Harris (Eds.), *Cortical mechanisms of vision* (pp. 399-417). Cambridge, U.K.: Cambridge University Press.

Martin Golubitsky is an emeritus professor of mathematics at the Ohio State University. He is the founding editor-in-chief of the SIAM Journal on Applied Dynamical Systems and a past president of SIAM. Ian Stewart is an emeritus professor of mathematics at the University of Warwick in the U.K. He has published more than 200 research papers, authored many popular mathematics books, and is a Fellow of the Royal Society.

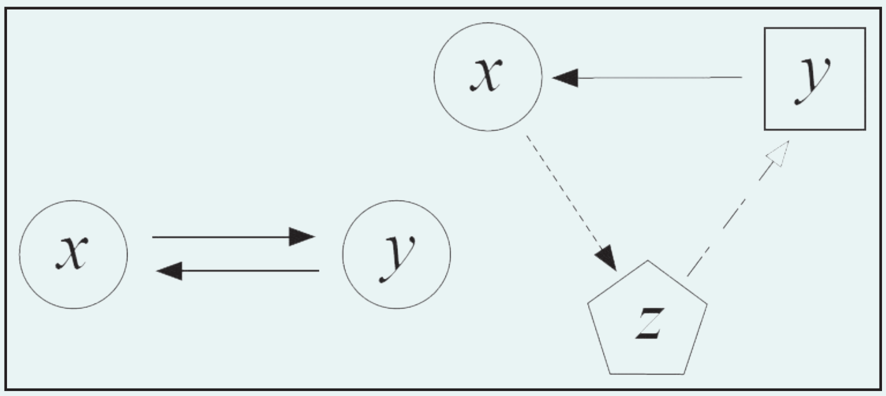


Figure 1. *Examples of some of the types of networks in Dynamics and Bifurcations in Networks: Theory and Applications of Coupled Differential Equations. Figure courtesy of the authors.*

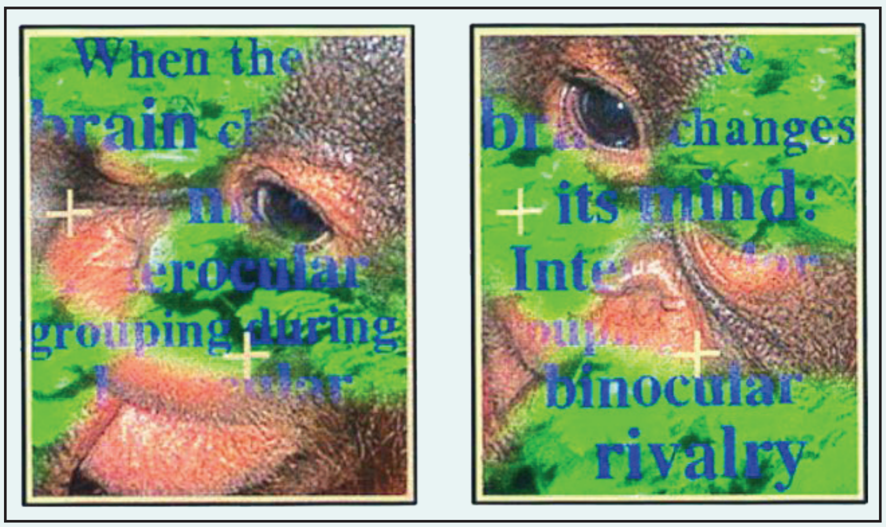


Figure 3. *In the scrambled monkey-text experiment, subjects view altered versions of images from the original exercise in Figure 2. Figure reprinted from [4]. Copyright (1996) National Academy of Sciences.*

---

[1] https://epubs.siam.org/doi/book/10.1137/1.9781611977332

[2] https://epubs.siam.org

[3] https://epubs.siam.org/doi/book/10.1137/1.9781611977332

Algebraic Statistics

Continued from page 9

the talk "Identifying Socially Disruptive Policies," which took place at the same workshop. Specifically, Auerbach used network data to identify social disruptions and discussed cases wherein a network-based method identified policies for which the disruption effect was much larger than previously thought.

"Algebraic Statistics and Our Changing World: New Methods for New Challenges" is a great example of the type of scientific exploration that IMSI makes possible. Participants explored both the theoretical and practical aspects of recent developments in this rapidly growing field, forged new connections, and recast problems from across disciplines into algebraic statistics to accelerate forward growth. We are excited to see where both the attendees and the discipline will go next.

Acknowledgments: IMSI is supported by a grant from the Division of Mathematical Sciences at the U.S. National Science Foundation.

References

[1] Jiao, X., Flouri, T., & Yang, Z. (2021). Multispecies coalescent and its applications to infer species phylogenies and cross-species gene flow. *Natl. Sci. Rev.*, *8*(12), nwab127.

Sam Hansen is the Director of Communications and Engagement at the Institute for Mathematical and Statistical Innovation, which is hosted at the University of Chicago.

Integrating Mathematics, Physics, and Art Through Collective Entanglements

By Janet Biggs, Agnieszka Międlar, Joey Orr, and Daniel Tapia Takaki

Applied mathematics occasionally manifests in unexpected, beautiful ways. One such example is the collaborative *Collective Entanglements*[1] project, which is the physical culmination of an exciting journey of art, math, and science. In 2016, the Spencer Museum of Art at the University of Kansas (KU) secured funding for its new Arts Research Integration (ARI) program,[2] which connects artists with high-level research projects in the sciences and humanities to promote interdisciplinary practices, generate an effective dialogue about subjects that directly impact daily life, and appeal to the general public. As per the Spencer Museum's website,[3] the ARI program recognizes "that the creation of art is a research methodology in its own right, and one that has much to contribute to the study of our world." Joey Orr became the program's first Curator for Research the following year, and high-energy nuclear physicist Daniel Tapia Takaki of KU was later appointed as an ARI Faculty Fellow. Tapia Takaki then recruited mathematician Agnieszka Międlar (now at Virginia Tech) as another ARI Faculty Fellow, while Orr contacted New York-based artist Janet Biggs[4] — whose deep experience with interdisciplinary teamwork and familiarity with the European Organization for Nuclear Research (CERN)[5] made her an especially valuable asset.

In 2020, the artist, physicist, mathematician, and museum curator began to meet regularly via Zoom to discuss potential directions for their atypical partnership, and a long-term collaboration was born. Our joint efforts resulted in the *Collective Entanglements* project, which utilizes time-based media to explore critical questions in high-energy physics and applies innovative mathematical methods to the production of video and performance. In April 2022, *Collective Entanglements* unveiled its inaugural public programming,[6] which featured keynote talks, panels led by graduate students, and comprehensive roundtable dialogues. Subsequent exhibitions have expanded upon the themes of the project, and additional showcases are currently in preparation. Throughout this endeavor, we questioned the meanings of "fundamental" and "time" and asked ourselves questions like *What is art? Is mathematics an art?* and *Can physics create art?* But most importantly, we explored these questions together.

Collaborative productions present interesting challenges in the integration of multidisciplinary research methodologies, as each discipline brings its own language and structure. Can cross-disciplinary collaboration be generative and substantive for every contributing field while still furthering scientific discovery? Early on, Biggs decided to work *collectively* with Międlar and Tapia Takaki rather than create an independent piece of art; no other team in ARI's history had ever undertaken such a challenge. She emphasized the importance of joint conversations to generate work based on everyone's expertise and substantively contribute to each respective field. While some collectives opt to use another discipline's research as an illustrative communication tool or inspiration for personal production, such approaches discount the transformative possibilities of complex shared research and experimentation.

As a nuclear physicist, Tapia Takaki intended to investigate fundamental questions about the initial state of protons and ions at high energies. While he hoped to explore quantum mechanics in new ways that extended beyond the restricted conditions in nature that often draw physicists' focus, he also remained open to novel queries and approaches. Because large fundamental questions cannot be properly addressed in a vacuum, collaborative projects are immensely valuable for physics research; all scientists must also explore their work from unique perspectives and challenge themselves to study areas that they might otherwise ignore.

As our conversations began, each team member explained their individual work and research questions. We then took turns describing what we had heard each other say, which served as an exercise in listening, trust building, and vocabulary sorting. Although the collective had its inaugural joint public presentation during the 2020 National Conference of the Alliance for the Arts in Research Universities[7] (a2ru), it was nearly a year before we were ready to embark on our first true experiment: a livestreamed performance[8] titled *Singular Value Decomposition*[9] that was presented by Cristin Tierney Gallery at Onassis ONX Studio in New York City (see Figure 1).

Installations and performances were integral components of our research process, and risk-taking remained at the forefront of our investigations. As such, we ran our culminating *Collective Entanglements* exhibition[10]—installed in KU's 3,000-square-foot Beren Center auditorium—as an experiment. The exhibition featured an immersive, multichannel, synchronized video installation (see Figure 2) and interactive whiteboards that captured visitor data. Six screens surrounded a central column, inviting viewers to move around the installation and observe imagery that was inspired by the emergent phenomenon of *time*. The interactive whiteboards, panels, and lectures by visiting scholars Roger Malina (University of Texas at Dallas) and Tim Davis (Texas A&M University) initiated a dialogue between various communities and the public about the role of art-based research, art in science, and science in art. These conversations exposed misinterpretations and conflicting understandings of shared language; illuminated unfamiliar terms, concepts, and theories; removed hesitancies; and ultimately encouraged clear communication across disciplines. While the exhibition at KU has concluded, *Collective Entanglements* has since been presented at the Sarasota Art Museum of Ringling College in Sarasota, Fl., and is under preparation for a future showing in Virginia.

A significant component of *Collective Entanglements* is the singular value decomposition (SVD): a well-established matrix

See **Collective Entanglements** *on page 12*

Figure 2. *Artist Janet Biggs, mathematician Agnieszka Międlar, and physicist Daniel Tapia Takaki debuted the Collective Entanglements exhibition at the University of Kansas' Spencer Museum of Art in 2022. The experience included a six-channel video installation with sound, as well as interactive whiteboards for visitors. Photo by Ryan Waggoner © Spencer Museum of Art.*

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% load the whole music piece, i.e., extract signal data from the audio file
[sample_data, sample_rate] = audioread('FLOATING_POINT_NUMBER_SYSTEM.wav');

% extract the signal characteristics
numberOfsamples = size(sample_data,1);
numberOfchannels = size(sample_data,2);

% set the block size
blockSize = 2^10;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% Preprocessing of the original signal data
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% append zeros to the signal data such that the number of samples
% is divisible by the block size
numberOfzeros = blockSize - mod(numberOfsamples,blockSize);
expanded_data = [sample_data; zeros(numberOfzeros,numberOfchannels)];

% reshape the signal data
reshaped_data = reshape(expanded_data, size(expanded_data,1) / blockSize,
blockSize*numberOfchannels);

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% Singular Value Decomposition
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% determine the original rank of the signal data
original_rank = rank(reshaped_data);
```

Figure 1. *The multimedia livestreamed performance of Singular Value Decomposition—developed in 2021 by artist Janet Biggs, mathematician Agnieszka Międlar, and physicist Daniel Tapia Takaki—featured music and dance interpretations by multiple artists, including violinist Earl Maneein (pictured here). Photo courtesy of Janet Biggs.*

---

[1] https://www.spencerart.ku.edu/iari/inquiries/collective-entanglements

[2] https://www.spencerart.ku.edu/ari

[3] https://www.spencerart.ku.edu

[4] https://www.jbiggs.com

[5] https://home.cern

[6] https://arts.cern/article/collective-entanglements-opens-spencer-museum-art

[7] https://a2ru.org/event/2020-a2ru-national-conference

[8] https://www.cristintierney.com/events/26/video

[9] https://www.jbiggs.com/singular-value-decomposition

[10] https://www.spencerart.ku.edu/iari/inquiries/collective-entanglements#Exhibition

AWM

Does your organization or institution value equity in the mathematical sciences?
Partner with us to have an even greater impact!

Your membership or sponsorship helps us:

- Support student chapters, mentor networks, research networks, and workshops
- Award grants for research and conference travel
- Advocate for policies that support STEM funding, and an inclusive environment in STEM fields
- Encourage and support young women in their mathematics education, and assist and support their teachers and schools

Post your job ads with AWM to reach our population and affirm that a balanced workplace matters!

Corporate sponsorship benefits include:

- Free individual memberships
- Discounts on advertising
- Recognition at select AWM events
- Recognition on the AWM website

Learn more about corporate sponsorships, institutional and individual memberships at awm-math.org

George Washington University SIAM Student Chapter Explores Data Science and Deep Learning

By Wangbo Luo and Yanxiang Zhao

In April 2024, the George Washington University (GW) SIAM Student Chapter[1] hosted its 5th Annual Conference on Applied Mathematics: Emerging Trends in Data Science and Deep Learning.[2] During the event, which took place on GW's main campus, speakers from both academic and industrial settings in the greater Washington, D.C., metro area presented their recent work in applied mathematics, with a particular focus on data science and deep learning.

Since its establishment in 2014, the GW SIAM Student Chapter has consistently organized talks, conferences, and social events to promote applied mathematics and computational science in and around Washington, D.C. The chapter began to host regular conferences in 2017, with subsequent events in 2018, 2019, 2023, and 2024. For the first time, the 2024 conference adopted a specific theme and opted to concentrate on data science and deep learning. We plan to maintain this approach in the future and feature a distinct research area at each forthcoming annual meeting.

The 2024 conference attracted more than 20 attendees, including professors, postdoctoral researchers, undergraduate and graduate students from local universities, and research scientists from the technology industry. This gathering—which served as a platform for distinguished scientists to present their recent findings in the realm of data science and deep learning—also allowed attendees to network, exchange research insights, discuss career developments, and establish potential collaborations.

The invited speakers included two postdoctoral researchers, four graduate students, and one industrial research scientist, all of whom came from three local universities and one technology corporation. The presenters addressed a variety of engaging topics, as follows:

- Dong An (Joint Center for Quantum Information and Computer Science at the University of Maryland, College Park): "Quantum Algorithms for Linear Differential Equations"
- Rohit Khandelwal (George Mason University): "The Obstacle Problem: Optimal Control and Elliptic Reconstruction"
- Jessica Masterson (George Mason University): "Modeling and Optimization Applied to Cryopreservation"
- Zezheng Song (University of Maryland, College Park): "A Finite Expression Method for Solving High-dimensional Committor Problems"
- Derek (Binshuai) Wang (GW): "Identifying Similar Thunderstorm Sequences for Airline Decision Support Using Optimal Transport Theory"
- Yaqi Wu (GW): "Supervised Gromov-Wasserstein Optimal Transport"
- Jingjing Xu (Amazon): "An Introduction to Advertising Technology."

Each speaker delivered a 25-minute presentation that was followed by a brief question-and-answer period to facilitate a dialogue with audience members. "I was honored to present my recent work at this conference and learn from the presentations of other speakers," Khandelwal said. "I am looking forward to attending the annual conference next year if possible."

The GW SIAM Student Chapter would like to thank SIAM and the Department of Mathematics at GW for their financial support of this event. Stay tuned for the 2025 annual conference, which will explore a new theme in applied mathematics and computational science.

Wangbo Luo is a Ph.D. candidate in the Department of Mathematics at George Washington University (GW). He is president of the GW SIAM Student Chapter. Yanxiang Zhao is an associate professor of mathematics at GW. He is the founding faculty advisor of the GW SIAM Student Chapter.

Attendees of the George Washington University (GW) SIAM Student Chapter's 5th Annual Conference on Applied Mathematics: Emerging Trends in Data Science and Deep Learning pose together on the GW campus in April 2024. Photo courtesy of Conglong Xu.

---

[1] https://blogs.gwu.edu/gwsiam/main-2

[2] https://blogs.gwu.edu/gwsiam

Collective Entanglements

Continued from page 11

analysis tool [5] that allows physicists to understand phenomena that were not clearly captured by CERN's Large Hadron Collider (LHC). By distinguishing signals from background noise and assembling many instances of low-rank signals, we reconstructed a state prior to the LHC's captured event, i.e., the *initial state*. We combined time-based media like video and performance with novel numerical linear algebra techniques—such as the higher-order SVD (HOSVD) [2] for tensor-train structured data [3]—in order to consider the probability of sequences and their potential initial states and ultimately produce relevant video and performance pieces. Manipulating video files in MATLAB[11] also permitted us to explore related aspects of high-energy physics and quantum mechanics.

The *Collective Entanglements* six-channel, high-definition video and sound installation raised many additional questions. In one portion of the work, we utilized tensor-train decomposition [1] and applied a HOSVD to a video to obtain a radically different effect. While the SVD effectively introduced data as both a material and formal element of the artwork itself, the additional dimensions in this part of the installation pertained to channel and time. This alteration, which had a "thickening" effect on the images (see Figure 3), raised important questions about phenomena that were physically present but no longer visually represented [4].

Although artistic practice as a fundable academic research category is beginning to grow, the coalescence of visual arts with other disciplines to address today's global problems is still in its infancy. Since the Spencer Museum of Art is embedded within a university, the ARI program is an active participant in the school's research ecology at the level of question formation and research design. ARI also views artistic practice as its own particular type of research method with its own history, just like any other discipline; conversely, however, artistic endeavors often lead with practice (which then gives rise to questions and theories), rather than relying on more traditional scientific theory testing.

By working beyond the confines of any one particular discipline, scientists and artists can practice fluency and criticality in the context of their own subjects. They may find reasons to question assumptions instead of simply repeating them, which can reveal new insights and expose unacknowledged prejudices from a field's historical development. But interdisciplinary collaboration is a long process, and individuals should be prepared to spend time building trust and collegiality beyond their own disciplinary homes. As real-world challenges become more complex and increasingly embedded in larger issues like social justice and global human rights, it is critical that scientists expand the nuance and fluency of their knowledge practices.

Figure 3. *In 2022, the Collective Entanglements exhibition at the University of Kansas' Spencer Museum of Art—created by artist Janet Biggs, mathematician Agnieszka Międlar, and physicist Daniel Tapia Takaki—featured videos that were altered with numerical linear algebra techniques, such as the higher-order singular value decomposition. Photo by Ryan Waggoner © Spencer Museum of Art.*

References

[1] Al Daas, H., Ballard, G., Cazeaux, P., Hallman, E., Międlar, A., Pasha, M., …, Saibaba, A.K. (2023). Randomized algorithms for rounding in the tensor-train format. *SIAM J. Sci. Comput., 45*(1), A74-A95.

[2] De Lathauwer, L., De Moor, B., & Vandewalle, J. (2000). A multilinear singular value decomposition. *SIAM J. Matrix Anal. Appl.*, *21*(4), 1253-1278.

[3] Oseledets, I.V. (2011). Tensor-train decomposition. *SIAM J. Sci. Comput.*, *33*(5), 2295-2317.

[4] Prendes, A. (2022, September 2). Cross-culture collaboration at CERN and the Spencer Museum. *Arts at CERN*. Retrieved from https://arts.cern/article/cross-culture-collaboration-cern-and-spencer-museum.

[5] Stewart, G.W. (1993). On the early history of the singular value decomposition. *SIAM Rev.*, *35*(4), 551-566.

Janet Biggs is a research-based interdisciplinary artist who is known for her immersive work in video, film, and performance. Her projects navigate the territory between art, science, and technology and focus on individuals in extreme landscapes and situations. Biggs' work, which has received support from the John Simon Guggenheim Memorial Foundation and the National Endowment for the Arts, has been exhibited at museums and institutions around the world. Agnieszka Międlar is an associate professor of mathematics at Virginia Tech. Her research explores computational mathematics and scientific computing, with a focus on numerical linear algebra. Międlar holds an M.Sc.Eng. in computer science from Wrocław University of Science and Technology and a Ph.D. in mathematics from the Technical University of Berlin. She was an Arts Research Integration (ARI) Faculty Fellow at the University of Kansas' Spencer Museum of Art in spring 2021. Joey Orr is the Mellon Curator for Research at the Spencer Museum of Art, where he directs the ARI program. He previously served as the Andrew W. Mellon Postdoctoral Curatorial Fellow at the Museum of Contemporary Art Chicago. Orr holds an M.A. from the School of the Art Institute of Chicago and a Ph.D. from Emory University. Daniel Tapia Takaki is a high-energy nuclear physicist and a professor of physics at the University of Kansas. He is a member of the ALICE (A Large Ion Collider Experiment) collaboration at CERN's Large Hadron Collider, where he studies strong gluon fluctuations in the proton and lead nuclei to understand quantum chromodynamics and determine the initial state of ultra-relativistic protons and ions at high energies. Tapia Takaki also works for the Electron-Proton/Ion Collider collaboration at Brookhaven National Laboratory.

---

[11] https://www.mathworks.com/matlabcentral/fileexchange/47726-video-processing-tutorial

Like and follow us!

siam® Society for Industrial and Applied Mathematics

InsideSIAM
Conferences, books, journals, and activities of Society for Industrial and Applied Mathematics

siam | CONFERENCES

A Place to Network and Exchange Ideas

Upcoming Deadlines

THE FOLLOWING CONFERENCES ARE CO-LOCATED:

siam 2024

SIAM Annual Meeting (AN24) with Online Component

July 8–12, 2024 | Spokane, Washington, U.S.
Online Component July 18–20, 2024
go.siam.org/an24 | #SIAMAN24

ORGANIZING COMMITTEE CO-CHAIRS
Michael P. Friedlander, *University of British Columbia, Canada*
Anna Mazzucato, *Pennsylvania State University, U.S.*

SIAM Conference on Discrete Mathematics (DM24)

July 8–11, 2024 | Spokane, Washington, U.S.
go.siam.org/dm24 | #SIAMDM24

ORGANIZING COMMITTEE CO-CHAIRS
Peter Keevash, *University of Oxford, United Kingdom*
Blair D. Sullivan, *University of Utah, U.S.*

SIAM Conference on Applied Mathematics Education (ED24)

July 8–9, 2024 | Spokane, Washington, U.S.
go.siam.org/ed24 | #SIAMED24

ORGANIZING COMMITTEE CO-CHAIRS
Mario Banuelos, *California State University, Fresno, U.S.*
Roummel Marcia, *University of California, Merced, U.S.*

AN24, DM24, and ED24 EARLY REGISTRATION RATE DEADLINE
June 10, 2024

AN24, DM24, and ED24 HOTEL RESERVATION DEADLINE
June 10, 2024

SIAM Conference on Mathematics of Data Science (MDS24)

October 21–25, 2024 | Atlanta, Georgia, U.S.
go.siam.org/mds24 | #SIAMMDS24

ORGANIZING COMMITTEE CO-CHAIRS
Eric Chi, *Rice University, U.S.*
David Gleich, *Purdue University, U.S.*
Rachel Ward, *University of Texas at Austin, U.S.*

EARLY REGISTRATION RATE DEADLINE
September 18, 2024

HOTEL RESERVATION DEADLINE
September 18, 2024

siam 2025

ACM-SIAM Symposium on Discrete Algorithms (SODA25)

January 12–15, 2025 | New Orleans, Louisiana, U.S.
go.siam.org/soda25 | #SIAMDA25

PROGRAM COMMITTEE CO-CHAIRS
Yossi Azar, *Tel-Aviv University, Israel*
Debmalya Panigrahi, *Duke University, U.S.*

SUBMISSION DEADLINE
July 5, 2024

Information is current as of May 15, 2024. Visit *siam.org/conferences* for the most up-to-date information.

Students and Early Career Researchers: Apply Now for Conference Support

SIAM is dedicated to giving students and early career professionals the support they need to be successful. The SIAM Travel Awards Program awards $240,000+ in conference travel funding yearly to these two groups. Apply now at *siam.smapply.org/prog/travel_awards_program*.

Upcoming SIAM Events

SIAM Conference on the Life Sciences
June 10–13, 2024
Portland, Oregon, U.S.
Sponsored by the SIAM Activity Group on Life Sciences

SIAM Conference on Mathematics of Planet Earth
June 10–12, 2024
Portland, Oregon, U.S.
Sponsored by the SIAM Activity Group on Mathematics of Planet Earth

SIAM Conference on Nonlinear Waves and Coherent Structures
June 24–27, 2024
Baltimore, Maryland, U.S.
Sponsored by the SIAM Activity Group on Nonlinear Waves and Coherent Structures

EASIAM Annual Meeting 2024
June 28–July 1, 2024
University of Macau

SIAM Activity Group on Equity, Diversity, and Inclusion Business Meeting
July 29, 2024 at 12:00 p.m. / Online
Sponsored by the SIAM Activity Group on Equity, Diversity, and Inclusion

2024 SIAM Annual Meeting
July 8–12, 2024
Online Component July 18–20, 2024
Spokane, Washington, U.S.

SIAM Conference on Applied Mathematics Education
July 8–9, 2024
Spokane, Washington, U.S.
Sponsored by the SIAM Activity Group on Applied Mathematics Education

SIAM Conference on Discrete Mathematics
July 8–11, 2024
Spokane, Washington, U.S.
Sponsored by the SIAM Activity Group on Discrete Mathematics

ICERM-SIAM Workshop on Empowering a Diverse Computational Mathematics Research Community
July 22–August 2, 2024
Providence, Rhode Island, U.S.

SIAM Conference on Mathematics of Data Science
October 21–25, 2024
Atlanta, Georgia, U.S.
Sponsored by the SIAM Activity Group on Data Science

ACM-SIAM Symposium on Discrete Algorithms
January 12–15, 2025
New Orleans, Louisiana, U.S.
Sponsored by the SIAM Activity Group on Discrete Mathematics and the ACM Special Interest Group on Algorithms and Computation Theory

SIAM Symposium on Algorithm Engineering and Experiments
January 12–13, 2025
New Orleans, Louisiana, U.S.

SIAM Symposium on Simplicity in Algorithms
January 13–14, 2025
New Orleans, Louisiana, U.S.

SIAM Conference on Computational Science and Engineering
March 3–7, 2025
Fort Worth, Texas, U.S.
Sponsored by the SIAM Activity Group on Computational Science and Engineering

FOR MORE INFORMATION ON SIAM CONFERENCES: *siam.org/conferences* siam | MEMBERSHIP

Network | Access | Outreach | Lead

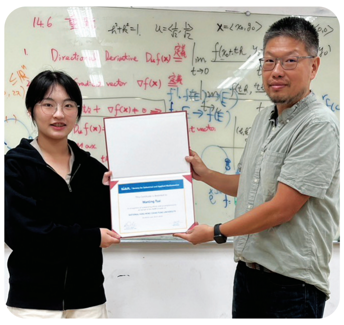
Recipients Named for Annual SIAM Student Chapter Certificates of Recognition

SIAM Student Chapter Certificates of Recognition were awarded to students who made outstanding contributions to their SIAM Student Chapters. This program recognizes the importance of student contributions in creating and sustaining exciting chapters, acknowledges students' efforts within the greater SIAM community, and provides a noteworthy commendation for students to add to their portfolio for career building.

SIAM congratulates all the recipients and thanks them for their contributions to the development and growth of the SIAM Student Chapters program.

Emma Nal of Stellenbosch University received the certificate of recognition from Professor Nick Hale, chapter representative.

The Math Department Chair and the Dean of Nazarbayev University presented Dilnaz Ualiyeva with the student chapter certificate.



Te-Sheng was awarded the student chapter certificate at National Yang Ming Chiao Tung University, Taiwan.

SIAM welcomes our newest student chapters:

- Oklahoma State University
- Universidad de Costa Rica
- Texas State University
- Universidad de Rosario
- University of Massachusetts Amherst
- Loyola University Chicago

2024 SIAM Student Chapter Certificate of Recognition recipients:

Nargis Abbasi, Sukkur IBA University
Nikita Aleksandrova, California State University, Sacramento
İlkyaz Aslanöz, Middle East Technical University
Boluwatife Awoyemi, Texas Tech University
Ahmet Kaan Aydin, University of Maryland, Baltimore County
Yasmine Beck, Trier University
Jeddy Bennett, Brigham Young University
Eloise Bray, University of Sheffield
Jakub Cach, Charles University
Edo Calvello, California Institute of Technology
Mustafa Canıtez, Sabancı University
Giuseppe Carere, University of Potsdam
Keoni Castellano, University of Nevada Las Vegas
Chuqi Chen, Hong Kong University of Science and Technology
Clayton Coonrod, Case Western Reserve University
Allison Cruikshank, Duke University
Anna Curran, Imperial College London
Zhao Ding, Wuhan University
Dewayne Dixon, Howard University
Eric Eng, The Cooper Union for the Advancement of Science and Art
Xiang (Mark) Gao, Utah State University
Allyson Gwiazda, Eastern Washington University
Ruiyu Han, Carnegie Mellon University
Katherine Henneberger, University of Kentucky
Julio Hernandez, California State University, Fresno
Caroline Hills, University of Notre Dame Du Lac
Jarrett Hobbs, University of Arkansas
Anna Ivagnes, SISSA
Wadud Khan, New York City College of Technology Student Chapter
Brian Knight, University of California, Davis
Ekaterina Knyazeva, Montclair State University
Raphael Kuess, Berlin Area Chapter
Theophilus Kwofie, Arizona State University
Rocío Ladrón de Guevara, Pontificia Universidad Católica de Chile
Sang-Eun Lee, Tulane University
Shengtong Liang, Peking University
William Little, Kennesaw State University
Xiaoyu Liu, Purdue University
Alejandro Malla, University of Evansville, Indiana
Austin Marstaller, Southern Methodist University and University of Texas at Dallas
Alex McManus, University of Colorado Boulder
Kristina Moen, Colorado State University
Sima Moshafi, Georgia State University
Siqiao Mu, Northwestern University
Jocelyn Ornelas Munoz, University of California, Merced
Vahid Nateghi, Magdeburg Otto-von-Guericke-Universität Magedeburg
Emma Nel, Stellenbosch University
Olaoluwa Ogunleye, Clarkson University
Abigail Orozco, University of Houston
Graham Pash, University of Texas at Austin
Gabriel Pinochet-Soto, Portland State University
Hannah Potgieter, Simon Fraser University
Vikrant Pratap, University of Galway
Noah B Reef, California State Polytechnic University, Pomona
Alban Bloor Riley, University of Manchester
Meghan Romines, William Carey University
Omar Saldana, University of Texas Rio Grande Valley
Ashley Schwartz, San Diego State University
Jeremy Shahan, Louisiana State University
Tasnia Shahid, University of Strathclyde
Shambhavi Singh, Jaypee University of Information Technology
Kashvi Srivastava, University of Michigan
Jacopo Stringara, Politecnico di Milano
Sasha Tafolla, California State University, Fullerton
Keisuke Taga, Waseda University
Tianyun Tang, National University of Singapore
Jacob Thomas, Illinois Institute of Technology
Marah-Lisanne Thormann, University of Southampton
Moyi Tian, Brown University
Brian Toner, University of Arizona
Wanling Tsai, National Yang Ming Chiao Tung University
Sandra Annie Tsiorintsoa, Clemson University
Dilnaz Ualiyeva, Nazarbayev University
Elijah William Valverde, San Francisco State University
Jonathan Valyou, Florida State University
Alina Vu, Colgate University
Yiran Wang, Chinese University of Hong Kong
Svenja Josephine Westermann, Heidelberg University
Yu-Tan Wu, National Central University
Conglong Xu, George Washington University
Yixuan Zhang, Hong Kong Polytechnic University

CALL FOR SIAM PRIZE NOMINATIONS

2025 Major Awards

- AWM-SIAM Sonia Kovalevsky Lecture
- George Pólya Prize for Mathematical Exposition
- Germund Dahlquist Prize
- I.E. Block Community Lecture
- Ivo & Renata Babuška Prize*
- James H. Wilkinson Prize in Numerical Analysis and Scientific Computation
- Jerald L. Ericksen Prize*
- John von Neumann Prize
- Ralph E. Kleinman Prize
- SIAM/ACM Prize in Computational Science and Engineering
- SIAM Industry Prize*
- SIAM Student Paper Prizes
- W. T. and Idalia Reid Prize

*First time being awarded

Nominate a colleague at *go.siam.org/prizes-nominate*

Open dates and deadlines may vary.
For details visit: *siam.org/deadline-calendar*

siam PRIZES AND AWARDS

FOR MORE INFORMATION ON SIAM MEMBERSHIP: ***siam.org/membership***

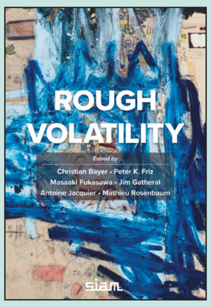
siam | BOOKS

Quality and Value in Mathematical Science Literature

New

Rough Volatility

Christian Bayer, Peter K. Friz, Masaaki Fukasawa, Jim Gatheral, Antoine Jacquier, and Mathieu Rosenbaum, Editors

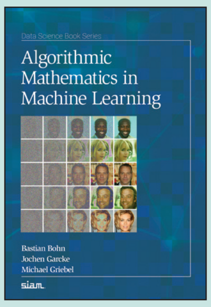


Volatility has traditionally been modeled as a semimartingale, with consequent scaling properties, but a new paradigm has emerged, whereby paths of volatility are rougher than those of semimartingales. According to this perspective, volatility behaves as a fractional Brownian motion with a small Hurst parameter. *Rough Volatility* is the first book to offer a comprehensive exploration of the subject, organizing the material to reflect the subject's development and progression. It contributes to the understanding and application of rough volatility models by equipping readers with the tools and insights needed to delve into the topic and explores the motivation for rough volatility modeling and provides a toolbox for its computation and practical implementation.

2023 / xxviii+263/ Softcover / 978-1-61197-777-6
List $85.00 / SIAM Member $59.50 / FM02

Algorithmic Mathematics in Machine Learning

Bastian Bohn, Jochen Garcke, and Michael Griebel



This unique book explores several well-known machine learning and data analysis algorithms from a mathematical and programming perspective. The authors present machine learning methods, review the underlying mathematics, and provide programming exercises to deepen the reader's understanding. They provide new terminology and background information on mathematical concepts, as well as exercises, in "info-boxes" throughout the text. Application areas are accompanied by exercises that explore the unique characteristics of real-world data sets.

2024 / xii + 225 pages/ Softcover / 978-1-61197-787-5
List $64.00 / SIAM Member $44.80 / DI03

Order online: *bookstore.siam.org*

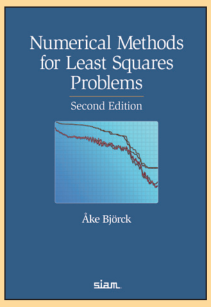
Or call toll-free in U.S. and Canada: 800-447-SIAM; worldwide: +1-215-382-9800

If you live outside North or South America, order from *eurospanbookstore.com/siam* for speedier service and free shipping. Eurospan honors the SIAM member discount. Contact customer service (*service@siam.org*) for the code to use when ordering.

Forthcoming Titles

Numerical Methods for Least Squares Problems, *Second Edition*

Åke Björck

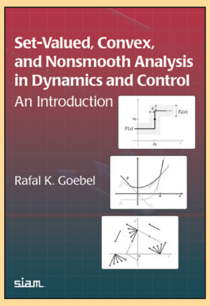


The first edition was the leading reference on the topic for many years. The updated second edition provides an in-depth and up-to-date treatment of direct and iterative methods for solving different types of least squares problems and for computing the singular value decomposition. It covers generalized, constrained, and nonlinear least squares problems as well as partial least squares and regularization methods for discrete ill-posed problems. The bibliography of over 1,100 historical and recent references provides a comprehensive survey of past and present research in the field.

2024 / xiv + 494 pages / Softcover / 978-1-61197-794-3 / List $89.00 / SIAM Member $62.30 / OT196

Set-Valued, Convex, and Nonsmooth Analysis in Dynamics and Control: *An Introduction*

Rafal K. Goebel



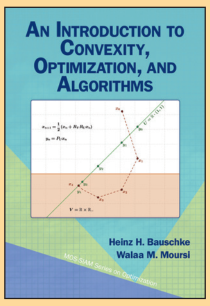
Set-valued analysis, convex analysis, and nonsmooth analysis are relatively modern branches of mathematical analysis that have become increasingly relevant in current control theory and control engineering literature. This book serves as a broad introduction to analytical tools in these fields and to their applications in dynamical and control systems and is the first to cover these topics with this scope and at this level. Both continuous-time and discrete-time mutlivalued dynamics, modeled by differential and difference inclusions, are considered.

2024 / xiv + 221 pages / Softcover / 978-1-61197-797-4 / List $72.00 / SIAM Member $50.40 / OT197

Also of Interest

An Introduction to Convexity, Optimization, and Algorithms

Heinz H. Bauschke and Walaa M. Moursi

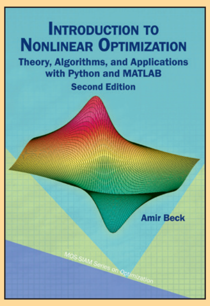


This concise, self-contained volume introduces convex analysis and optimization algorithms, with an emphasis on bridging the two areas. It explores cutting-edge algorithms that have applications in machine learning, signal processing, image reconstruction, and other fields. It contains algorithms illustrated by Julia examples and more than 200 exercises. Clear explanations and step-by-step algorithmic descriptions facilitate self-study for individuals looking to enhance their expertise in convex analysis and optimization.

2024 / xii + 186 pages / Softcover / 978-1-61197-779-0 / List $60.00 / SIAM Member $42.00 / MO34

Introduction to Nonlinear Optimization: *Theory, Algorithms, and Applications with Python and MATLAB, Second Edition*

Amir Beck

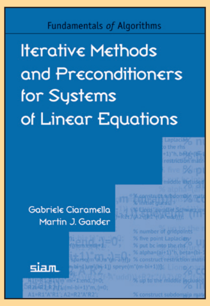


Built on the framework of the successful first edition, this book serves as a modern introduction to the field of optimization. The author provides the foundations of theory and algorithms of nonlinear optimization and presents a variety of applications from diverse areas of applied sciences. The book gradually yet rigorously builds the connections between theory, algorithms, applications, and actual implementation and contains several topics not typically included in optimization books.

2023 / xii + 354 / softcover / 978-1-61197-761-5 / List $84.00 / SIAM Member $58.80 / MO32

Iterative Methods and Preconditioners for Systems of Linear Equations

Gabriele Ciaramella and Martin J. Gander

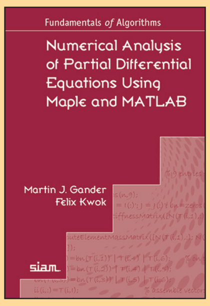


Iterative methods use successive approximations to obtain more accurate solutions. This book gives an introduction to iterative methods and preconditioning for solving discretized elliptic partial differential equations and optimal control problems governed by the Laplace equation, for which the use of matrix-free procedures is crucial. As a textbook, it gives a clear focus for the teaching methodology, which presents historical background, derives complete convergence estimates for all methods, illustrates and provides MATLAB codes for all methods, and studies and tests all preconditioners first as stationary iterative solvers.

2022 / x + 275 pages / Softcover / 978-1-611976-89-2 / List $79.00 / SIAM Member $55.30 / FA19

Numerical Analysis of Partial Differential Equations Using Maple and MATLAB

Martin J. Gander and Felix Kwok



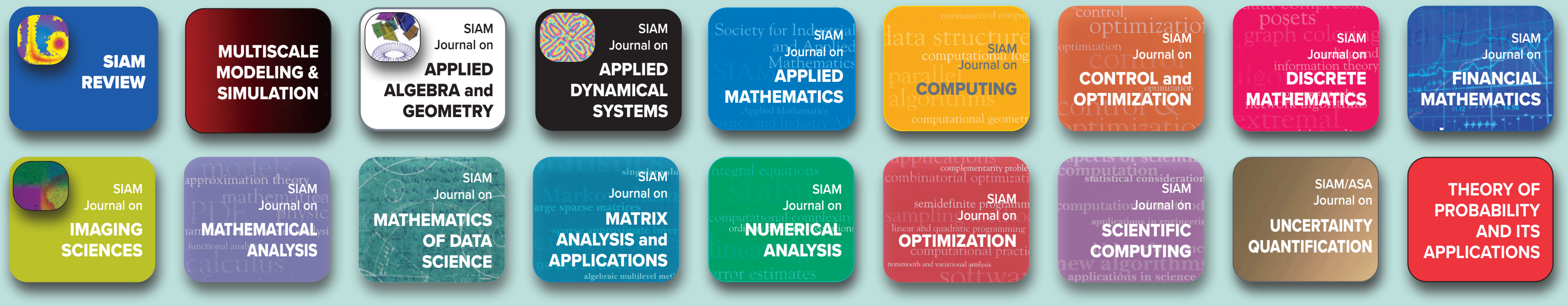
This book provides an elementary yet comprehensive introduction to the numerical solution of partial differential equations (PDEs). Detailed descriptions of the four major classes of discretization methods for PDEs, self-contained convergence proofs for each method, and runnable MATLAB code for each of the discretization methods and exercises are included.

2018 / ix + 151 pages / Softcover / 978-1-611975-30-7 / List $68.00 / SIAM Member $47.60 / FA12

FOR MORE INFORMATION ON SIAM BOOKS: ***siam.org/books***

siam® | JOURNALS

Where You Go to Know and Be Known



Recently Posted Articles

SIAM REVIEW

Computational Methods for Large-Scale Inverse Problems: A Survey on Hybrid Projection Methods
Julianne Chung and Silvia Gazzola

MULTISCALE MODELING & SIMULATION: A SIAM Interdisciplinary Journal

Effective Heat Transfer Between a Porous Medium and a Fluid Layer: Homogenization and Simulation
Michael Eden and Tom Freudenberg

Resonant Modal Approximation of Time-Domain Elastic Scattering from Nano-Bubbles in Elastic Materials
Bochao Chen, Yixian Gao, Yong Li, and Hongyu Liu

SIAM Journal on APPLIED ALGEBRA and GEOMETRY

Multitriangulations and Tropical Pfaffians
Luis Crespo Ruiz and Francisco Santos

Algebraic Experimental Design: Theory and Computation
Elena S. Dimitrova, Cameron H. Fredrickson, Nicholas A. Rondoni, Brandilyn Stigler, and Alan Veliz-Cuba

Robust Geometric Modeling of 3-Periodic Tensegrity Frameworks Using Riemannian Optimization
Matthias Himmelmann and Myfanwy E. Evans

SIAM Journal on APPLIED DYNAMICAL SYSTEMS

Flocks with Nonlinear Inherent Dynamics under Fixed and Switching Digraphs
Jiu-Gang Dong

Splitting of Separatrices for Rapid Degenerate Perturbations of the Classical Pendulum
Inmaculada Baldomá, Tere M-Seara, and Román Moreno

Global Stability of SIR Model with Heterogeneous Transmission Rate Modeled by the Preisach Operator
Ruofei Guan, Jana Kopfová, and Dmitrii Rachinskii

SIAM Journal on APPLIED MATHEMATICS

Modeling of Electronic Dynamics in Twisted Bilayer Graphene
Tianyu Kong, Diyi Liu, Mitchell Luskin, and Alexander B. Watson

Stability of a Capillary Circular Cylinder between Two Parallel Cylinders
Rafael López

Local Perception and Learning Mechanisms in Resource-Consumer Dynamics
Qingyan Shi, Yongli Song, and Hao Wang

SIAM Journal on COMPUTING

Further Collapses in TFNP
Mika Göös, Alexandros Hollender, Siddhartha Jain, Gilbert Maystre, William Pires, Robert Robere, and Ran Tao

Sublinear Time Approximation of the Cost of a Metric *k*-Nearest Neighbor Graph
Artur Czumaj and Christian Sohler

Online List Labeling: Breaking the $\log^2 n$ Barrier
Michael A. Bender, Alex Conway, Martín Farach-Colton, Hanna Komlós, William Kuszmaul, and Nicole Wein

SIAM Journal on CONTROL and OPTIMIZATION

Optimal Moral-Hazard-Free Reinsurance Under Extended Distortion Premium Principles
Zhuo Jin, Zuo Quan Xu, and Bin Zou

Feedback and Open-Loop Nash Equilibria for LQ Infinite-Horizon Discrete-Time Dynamic Games
Andrea Monti, Benita Nortmann, Thulasi Mylvaganam, and Mario Sassano

Input-to-State Stability for Bilinear Feedback Systems
René Hosfeld, Birgit Jacob, Felix L. Schwenninger, and Marius Tucsnak

SIAM Journal on DISCRETE MATHEMATICS

The Maximal Running Time of Hypergraph Bootstrap Percolation
Ivailo Hartarsky and Lyuben Lichev

Rainbow Bases in Matroids
Florian Hörsch, Tomáš Kaiser, and Matthias Kriesell

A Simple Path to Component Sizes in Critical Random Graphs
Umberto De Ambroggio

SIAM Journal on FINANCIAL MATHEMATICS

Short Communication: Utility-Based Acceptability Indices
Marcin Pitera and Miklós Rásonyi

Relative Wealth Concerns with Partial Information and Heterogeneous Priors
Chao Deng, Xizhi Su, and Chao Zhou

SIAM Journal on IMAGING SCIENCES

Generalized Nonconvex Hyperspectral Anomaly Detection via Background Representation Learning with Dictionary Constraint
Quan Yu and Minru Bai

Exploring Structural Sparsity of Coil Images from 3-Dimensional Directional Tight Framelets for SENSE Reconstruction
Yanran Li, Raymond H. Chan, Lixin Shen, Xiaosheng Zhuang, Risheng Wu, Yijun Huang, and Junwei Liu

SIAM Journal on MATHEMATICAL ANALYSIS

Extended Hadamard Expansions for the Airy Functions
Jose Luis Alvarez-Perez

On the Temperature Distribution of a Body Heated by Radiation
Jin Woo Jang and Juan J. L. Velázquez

On the Optimal Shape of a Thin Insulating Layer
P. Acampora, E. Cristoforoni, C. Nitsch, and C. Trombetti

SIAM Journal on MATHEMATICS of DATA SCIENCE

Rigorous Dynamical Mean-Field Theory for Stochastic Gradient Descent Methods
Cédric Gerbelot, Emanuele Troiani, Francesca Mignacco, Florent Krzakala, and Lenka Zdeborová

Structural Balance and Random Walks on Complex Networks with Complex Weights
Yu Tian and Renaud Lambiotte

Learning Functions Varying along a Central Subspace
Hao Liu and Wenjing Liao

SIAM Journal on MATRIX ANALYSIS and APPLICATIONS

Spectral Analysis of Preconditioned Matrices Arising from Stage-Parallel Implicit Runge–Kutta Methods of Arbitrarily High Order
Ivo Dravins, Stefano Serra-Capizzano, and Maya Neytcheva

A Note on the Randomized Kaczmarz Algorithm for Solving Doubly Noisy Linear Systems
El Houcine Bergou, Soumia Boucherouite, Aritra Dutta, Xin Li, and Anna Ma

Conditioning of Matrix Functions at Quasi-Triangular Matrices
Awad H. Al-Mohy

SIAM Journal on NUMERICAL ANALYSIS

Implicit and Fully Discrete Approximation of the Supercooled Stefan Problem in the Presence of Blow-Ups
Christa Cuchiero, Christoph Reisinger, and Stefan Rigger

Asymptotic Compatibility of a Class of Numerical Schemes for a Nonlocal Traffic Flow Model
Kuang Huang and Qiang Du

An Asymptotic Preserving Discontinuous Galerkin Method for a Linear Boltzmann Semiconductor Model
Victor P. DeCaria, Cory D. Hauck, and Stefan R. Schnake

SIAM Journal on OPTIMIZATION

Pragmatic Distributionally Robust Optimization for Simple Integer Recourse Models
E. Ruben van Beesten, Ward Romeijnders, and David P. Morton

Clarke's Tangent Cones, Subgradients, Optimality Conditions, and the Lipschitzness at Infinity
Minh Tùng Nguyễn and Tiến-Sơn Phạm

Dual Descent Augmented Lagrangian Method and Alternating Direction Method of Multipliers
Kaizhao Sun and Xu Andy Sun

SIAM Journal on SCIENTIFIC COMPUTING

Spectral Deferred Correction Methods for Second-Order Problems
Ikrom Akramov, Sebastian Götschel, Michael Minion, Daniel Ruprecht, and Robert Speck

A Multiscale Hybrid Method
Gabriel R. Barrenechea, Antonio Tadeu A. Gomes, and Diego Paredes

Point Spread Function Approximation of High-Rank Hessians with Locally Supported Nonnegative Integral Kernels
Nick Alger, Tucker Hartland, Noemi Petra, and Omar Ghattas

SIAM/ASA Journal on UNCERTAINTY QUANTIFICATION

Wavelet-Based Density Estimation for Persistent Homology
Konstantin Häberle, Barbara Bravi, and Anthea Monod

Computing Statistical Moments Via Tensorization of Polynomial Chaos Expansions
Rafael Ballester-Ripoll

Nonasymptotic Bounds for Suboptimal Importance Sampling
Carsten Hartmann and Lorenz Richter

FOR MORE INFORMATION ON SIAM JOURNALS: ***epubs.siam.org/journals***