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

siam news

Volume 55/ Issue 1
January/February 2022

Origami and the Structure of Materials

By Huan Liu, Paul Plucinsky, Fan Feng, Arun Soor, and Richard D. James

The world's population is growing approximately linearly by about 80 million individuals per year, leaving less and less space per person on average. Perhaps this growth is responsible for an explosion of interest in origami—the art of paper folding—with applications that range from stents to canoes and even buildings. Origami is basically a fitting game. We already know a lot about the rules for smoothly bending and twisting a sheet of paper, as this is the classic subject of locally isometric mappings in differential geometry. *Continuity* is required for origami — these mappings must fit together at the creases.

Differential geometry *per se* is not quite as helpful for this purpose as one might think. It focuses on quantities that are intrinsic, i.e., that do not depend on parameterization. But in origami design, we usually wish to find the particular parameterization that actually describes the origami structure, which we often fold from a flat sheet with a crease pattern. Ideally, we want the full recipe for the sheet's continuous folding—a homotopy, if it exists—to guarantee that the structure is deployable. A Lagrangian approach is therefore fruitful, especially if we also seek to calculate the forces and moments that contribute to the folding.

Such logic brings origami design surprisingly close to the methods that researchers apply to understand the structure of materials at both the atomistic and continuum levels [7]. At the continuum level, a material's underlying crystal structure imposes a symmetry that phase transformations can break, often by passing to a subgroup. This group-subgroup relation describes a family of symmetry-related distortions that are possible at a phase transformation. It also leads to a fitting problem: How can we fit together the different distortions? Atomistic-level arrangements of atoms—such as quasicrystals—suggest unusual origami designs that highlight undeveloped areas of applied mathematics.

The exploitation of discrete symmetries is a powerful tool for both origami design and the study of phase transformations. To explain the simplest method, consider a discrete group of isometries:

$$g_1 = (\mathbf{Q}_1 | \mathbf{c}_1), \quad g_2 = (\mathbf{Q}_2 | \mathbf{c}_2), \ldots, \quad g_n = (\mathbf{Q}_n | \mathbf{c}_n). \tag{1}$$

Here, $\mathbf{Q}_1, \ldots, \mathbf{Q}_n$ are 3×3 orthogonal matrices, $\mathbf{c}_1, \ldots, \mathbf{c}_n$ are three-dimensional vectors, and the group can be finite or infinite ($n = \infty$). $(\mathbf{I}|0)$ is the identity, $g_1 g_2 = (\mathbf{Q}_1 | \mathbf{c}_1)(\mathbf{Q}_2 | \mathbf{c}_2) = (\mathbf{Q}_1 \mathbf{Q}_2 | \mathbf{c}_1 + \mathbf{Q}_1 \mathbf{c}_2)$ is the multiplication rule, and the

See **Origami** *on page 4*

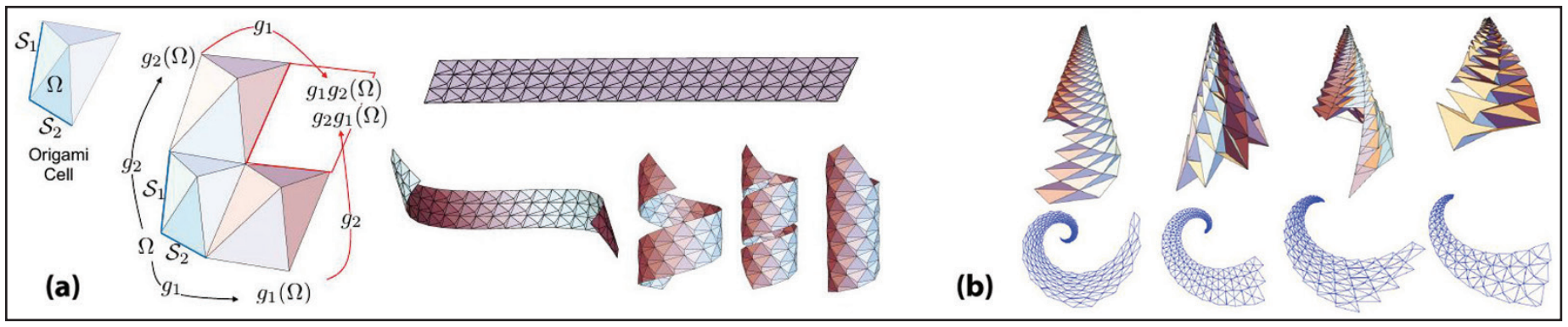


Figure 1. *Group orbit procedure with various tiles and helical/conformal groups.* **1a.** *Group orbit procedure with a Miura tile and helical group.* **1b.** *Group orbit procedure with various tiles and a conformal group. The unfolded crease pattern is shown in blue. Figure 1a adapted from [3], 1b courtesy of the authors.*

Multi-agent Simulations and Vaccine Allocation Strategies

By Jiangzhuo Chen, Stefan Hoops, Parantapa Bhattacharya, Dustin Machi, and Madhav Marathe

Epidemic science pertains to the development of models, technologies, and decision support tools to understand and control the spread of disease. This area of research is especially critical as the COVID-19 pandemic continues to cause significant social, economic, political, and health-related impacts across the globe. In a previous article,[1] we outlined an epidemiological approach that is rooted in network science and data-driven modeling. Here we discuss the challenges of such an approach's implementation during an evolving pandemic in the context of the vaccine prioritization problem, and outline our recent efforts to develop operational models that support policymaking.

We focus on networked models, which consider epidemic spread on an undirected social interaction network $G(V, E)$ over a population V; each edge $e = (u, v) \in E$ implies that individuals (also called nodes) $u, v \in V$ interact. The susceptible-infected-recovered (SIR) model on graph G represents a dynamical process wherein each node is in either an S, I, or R state. Infection can potentially spread from u to v along edge $e = (u, v)$, with a probability of $\beta(e, t)$ at time t after u becomes infected — conditional on node v remaining uninfected until time t. $I(t)$ denotes the set of nodes that become infected at t.

The basic vaccine allocation problem involves deciding *who* to vaccinate and *when* to do so. The objective is to minimize the number of infections, hospitalizations, or deaths [4, 6]. This basic problem is computationally challenging on its own, but it becomes progressively more complex as we consider some of the following real-world constraints [2, 3]:

- **Production Restrictions:** Vaccines are available in limited quantities for a set amount of time. We must thus consider two time-varying processes (epidemic and vaccine production) when prioritizing vaccines.
- **Prioritization:** This problem invites an ethical element. Should vaccine distribution aim to slow disease progression or reduce mortality? The latter usually suggests age- and health-based allocation, while the former implies allocation that targets potential super-spreaders.
- **Immune Profile:** This topic raises several pertinent questions: Who should get the vaccine? What dosage is needed (one or two dose regimens)? Are booster shots necessary? If so, when? And who should receive boosters?
- **Hesitancy:** Some individuals are hesitant about vaccination for various reasons.

Additional complications include lack of timely data, incomplete understanding of disease and immunological processes, social interventions, genomic variations, and vaccine sharing within a country and between countries. The creation of models that assess various vaccine allocation strategies hence becomes a complex system problem that should address five distinct challenges: (i) Most natural problems are

See **Vaccine Allocation** *on page 3*

[1] https://sinews.siam.org/Details-Page/networked-epidemiology-for-covid-19

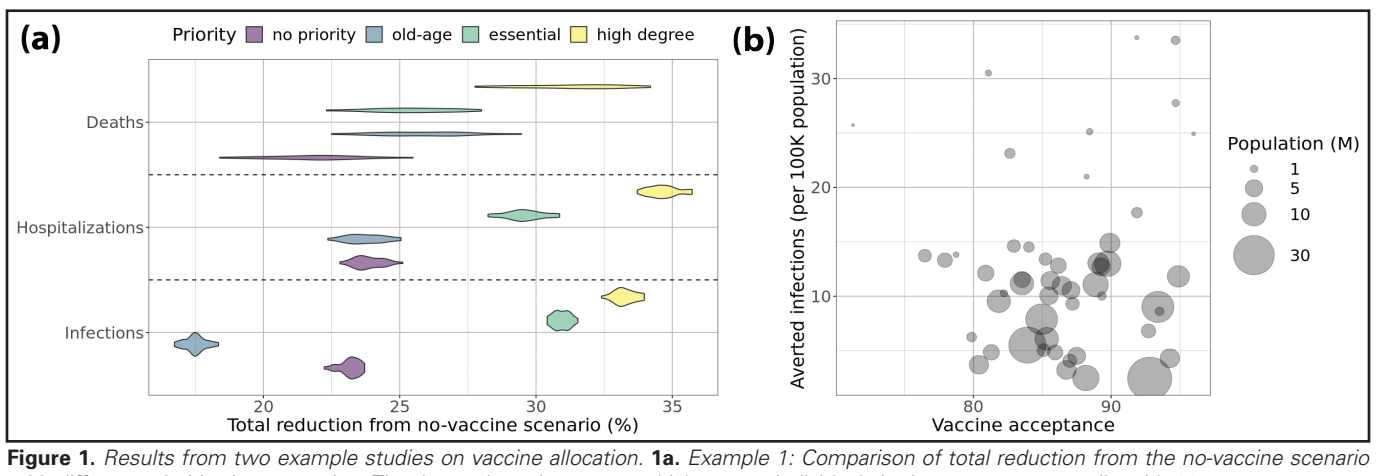


Figure 1. *Results from two example studies on vaccine allocation.* **1a.** *Example 1: Comparison of total reduction from the no-vaccine scenario with different prioritization strategies. The degree-based strategy, which targets individuals in the uppermost quartile with 60 percent accuracy, outperforms the other approaches. The no-priority strategy—which vaccinates randomly selected people—more successfully reduces infections than the old-age strategy, which targets those who are at least 50 years old. However, the opposite is true in the context of death reduction. When it comes to reducing hospitalizations, strategies that target essential workers and high-degree individuals outperform both the no-priority and old-age approaches.* **1b.** *Example 2: Bubble chart that depicts correlations between vaccine acceptance, averted infections, and population size of all 50 U.S. states and Washington, D.C. Although infection aversion does not have an obvious correlation with vaccine acceptance, smaller states seem to have larger (normalized) infection aversions. Figure courtesy of Jiangzhuo Chen.*

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

siam news
Volume 55/ Issue 1/ January/February 2022

Introducing SIAM's Incoming Leadership

By Lina Sorg

At the end of 2021, SIAM members voted to select the society's newest leadership. SIAM is pleased to announce the incoming President-Elect and Vice President-at-Large, returning Secretary, and new and returning members of the Board of Trustees and Council.

The President-Elect joins the SIAM cabinet in 2022 and will serve as President from January 1, 2023 to December 31, 2024. The Vice President-at-Large and Secretary began their first and second respective terms on January 1 and will remain in office until December 31, 2023. Members of the Board of Trustees and Council will retain their positions until December 31, 2024.

Here, the 2022 leadership—all of whom have remained highly involved with the SIAM community over the years—share their reactions, passions, and goals for their time in office. Their initial candidate statements are available online.[1]

President-Elect

Sven Leyffer (Argonne National Laboratory): "I am honored and excited to serve the SIAM community as its next president. As we move beyond the pandemic, I look forward to enhancing our diverse, exciting, and vibrant conferences and broadening access to in-person meetings with new virtual opportunities. I am excited about new initiatives that strengthen the presence of industry in SIAM, cementing our unique role as a bridge between industry and academia. I will also work with SIAM leadership to nurture SIAM's dedication to principles of equity, diversity, and inclusion that better us all."

Vice President-at-Large

Gitta Kutyniok (Ludwig Maximilian University of Munich): "I feel truly honored to be elected as Vice President-at-Large and am very much looking forward to serving SIAM in this role. One of my main goals is to pave the way for SIAM to meet current and future challenges. Such challenges include the rapidly growing impact of artificial intelligence (AI) on various areas of industrial and applied mathematics, and the recognition of mathematics' role in the field of AI. Of particular importance to me is also ensuring the continuous growth of our activity groups and sections on an international scale, strengthening their roles as vibrant research communities, and enlarging our prize and Fellows programs to support top researchers in their careers and showcase research highlights beyond our community."

Secretary

Susan E. Minkoff (University of Texas at Dallas): "I am honored to serve a second term as SIAM Secretary. Ensuring that the many SIAM committees are well manned (and womanned) is a big responsibility, but hard-working vice presidents, committee chairs, and my colleagues on the Committee on Committees and Appointments (CCA)—as well as the many SIAM volunteers who are willing to serve on these committees—make it a rewarding task. I invite SIAM members who are interested in serving on SIAM committees to reach out to myself, other officers, or members of the CCA to volunteer in this way."

SIAM Board of Trustees

Alison Ramage (University of Strathclyde): "I am delighted to have been re-elected to the SIAM Board and am very grateful to the membership for their support. SIAM staff have done a fantastic job of adapting to the enormous challenges of the last few years, and I look forward to working with them again as we move ahead with exciting new initiatives in areas like hybrid conferences and international outreach."

Beatrice Riviere (Rice University): "It is a true honor to serve on the SIAM Board of Trustees. SIAM's platform provides wonderful support for collaboration between scientists from academia, industry, and government laboratories. As the community continues to experience a long-term global pandemic, SIAM's impact is more important than ever. I will work to ensure that SIAM increases the diversity of its members, strengthens the involvement of industry and government labs with its activities, and ultimately remains a dynamic and inclusive community."

Chi-Wang Shu (Brown University): "I am honored to serve on the SIAM Board of Trustees. SIAM is unique in its position as a vehicle to facilitate the exchange of ideas and promote major research directions in mathematics that members can use in application fields. The power of mathematics in guiding and improving modeling, analysis, and computation in science and engineering cannot be overemphasized. In return, scientific applications can provide important insights into the kind of mathematics that is desired and facilitates breakthroughs in applications. I look forward to contributing to the further promotion of SIAM as a platform that fosters collaborations between applied mathematicians and scientists in other disciplines."

SIAM Council

Natalia Alexandrov (NASA Langley Research Center): "It is a great honor to continue serving the SIAM community as a member of the SIAM Council. During my second term, I will focus my efforts in two directions: (i) expanding student awareness of important problems in the area of increasingly widespread autonomous systems that are governed by software, and (ii) strengthening interdisciplinary connections between SIAM and engineering societies like the American Institute of Aeronautics and Astronautics. Both efforts bring much-needed mathematical attention to critical, interdisciplinary problems of today and tomorrow."

Inga Berre (University of Bergen): "Understanding gained through the application of mathematics and computational science is becoming ever more important. I am honored and delighted to support this development as a member of the SIAM Council. I look forward to engaging in further advancement of our platforms for research communication and dissemination. An important area for me is the way in which we provide value to an increasingly diverse group of SIAM members, with emphasis on students and early-career researchers."

Evelyn Sander (George Mason University): "I am excited to serve on the SIAM Council and extremely honored by the trust that members have placed in me. My primary focus for the Council is on making changes within SIAM that are designed to increase representation and inclusion in applied mathematics. Careful work within the Society can have a large impact for groups that have been traditionally underrepresented in the field of mathematics. Another key item is the future of conferences; SIAM has an opportunity to lead the way in balancing the burden of travel with the value of in-person interactions."

Carola-Bibiane Schönlieb (University of Cambridge): "I am excited and honored to serve on the SIAM Council. I strongly support the development of mathematics in close collaboration with application experts and the promotion of mathematics through its important applications. Therefore, I am fond of the SIAM philosophy of communication with researchers in other disciplines and the value of interdisciplinary research. I aim to continue the excellent work of the current leadership, with my heart invested in showcasing the highlights of our research, encouraging early-career researchers, improving diversity in mathematics, and fostering dialogue and idea exchange within our mathematical community."

The dedication of SIAM's elected members contributes to the Society's forward-moving progress and continued achievements. SIAM offers a heartfelt "thank you" to the entire slate of outstanding candidates for their willingness to serve the SIAM community, and to the SIAM members who cast their votes in last year's election.

Lina Sorg is the managing editor of SIAM News.

[1] https://sinews.siam.org/Details-Page/meet-siams-newest-leadership-19

Clockwise from top left: President-elect: Sven Leyffer; Vice President-at-large: Gitta Kutyniok; Secretary: Susan Minkoff; SIAM Board of Trustees: Alison Ramage, Beatrice Riviere, and Chi-Wang Shu; and SIAM Council: Natalia Alexandrov, Inga Berre, Evelyn Sander, and Carola-Bibiane Schönlieb. Photos courtesy of the elected individuals.

siam news

ISSN 1557–9573. To be published 10 times in 2022: 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 Kristin O'Neill 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 address change only if it will last six months or more.

Printed in the USA.

Vaccine Allocation

Continued from page 1

computationally hard; (ii) data is sparse, noisy, lagged, and incomplete; (iii) decisions must be made in near-real time, often with conflicting and evolving objectives; (iv) interventions must be implementable in the real world; and (v) decisions and epidemics coevolve, therefore motivating the need for a robust optimization framework.

Our overall modeling approach addresses these challenges with five steps:

- **Step 1:** Build a digital twin of the social contact network that is statistically similar to the real-world network but preserves individuals' privacy and confidentiality.
- **Step 2:** Initialize the digital twin with ground data.
- **Step 3:** Use simulations that are oriented in high-performance computing to calibrate and execute a statistical experimental design that studies the specific decision-theoretic question.
- **Step 4:** Create aggregate statistics from the simulation outputs to compare with measured data.
- **Step 5:** Analyze the simulated data—often in combination with the extended digital twin—to obtain policy insights [2, 3, 5].

Evaluating Vaccine Prioritization Based on Age and Social Networks

We consider the advantages of vaccine allocation based on individuals' degrees (number of social contacts) and weighted degrees (total social proximity time) [3]. When COVID-19 vaccines first became available in the U.S. in early 2021, there was a limited supply. A key question was thus as follows: How can we optimally prioritize vaccine allocation to best reduce infections, hospitalizations, and deaths?

To study this query, we utilize a computational experiment on a digital twin of Virginia. We initialize the simulations with (i) an age-stratified COVID-19 disease model; (ii) nodes that represent either susceptible individuals, prior infections, or current infections based on county-level data of daily confirmed cases stratified by age group; and (iii) individual-level compliance with nonpharmaceutical interventions (NPIs) like mask wearing, social distancing, virtual learning for students, and voluntary home isolation of symptomatic cases.

We simulate different vaccine prioritization strategies and compare them with the baseline scenario wherein vaccines are not available. We find that targeting high-degree individuals yields significantly more reductions in infection, hospitalization, and death than allocations with no prioritization or those that prioritize older people or essential workers. Degree-based vaccine allocation is also effective with low vaccine efficacy or relaxed social distancing measures; it is even successful when we cannot accurately estimate node degrees. In fact, this type of allocation works better than the other strategies even when we can only identify 60 percent of the nodes in the first quartile in terms of degree.

The effectiveness of degree-based prioritization stems from the structural changes that occur in the contact network due to vaccination. Consider the snapshot networks at different time points where the edges that are incident on vaccinated or recovered nodes are removed because the disease cannot transmit on them. Unlike other strategies, degree-based vaccination leads to a sparser snapshot network with lower node degrees and a smaller spectral radius (first eigenvalue). Vaccinating high-degree nodes protects those individuals and confers a higher level of indirect protection on the many neighbors with whom they interact. In the context of other prioritization schemes, one can still sub-select individuals with a large amount of social contacts to prioritize vaccine distribution in case of limited supply. See Figure 1a (on page 1) for details.

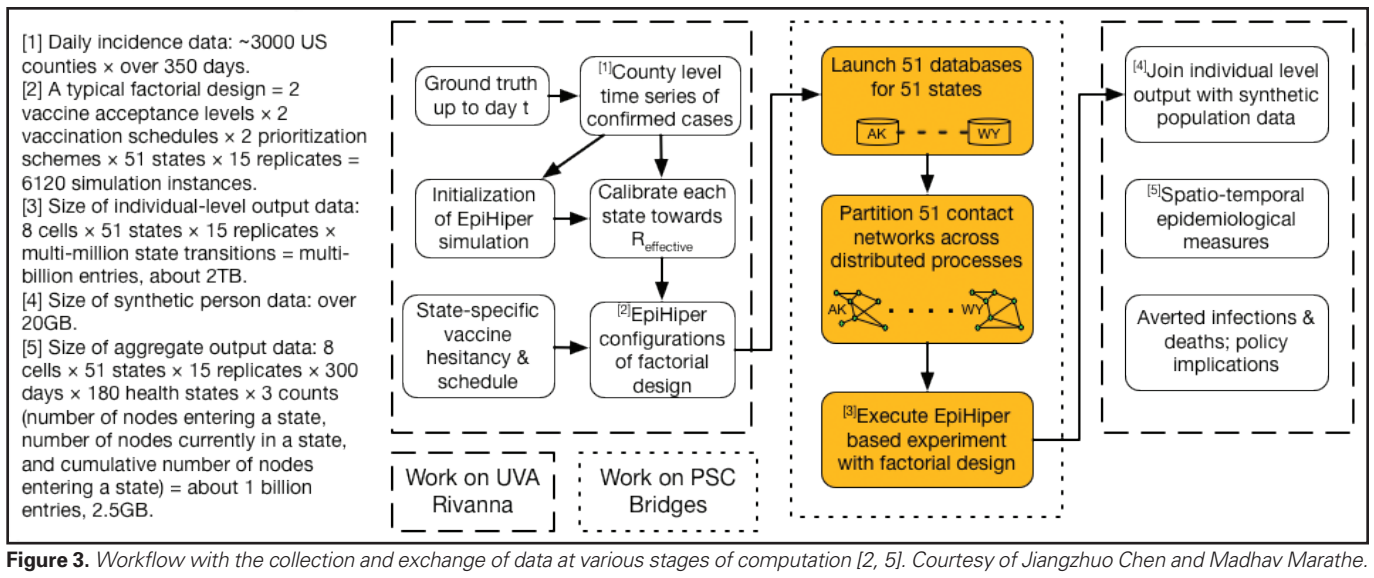


Figure 3. *Workflow with the collection and exchange of data at various stages of computation [2, 5]. Courtesy of Jiangzhuo Chen and Madhav Marathe.*

Evaluating Vaccine Allocation Strategies in Light of Hesitancy

Now we employ artificial intelligence (AI)-driven agent-based models to consider the role of vaccine hesitancy in controlling COVID-19's spread in the U.S. [2]. In mid-2021, vaccination in the U.S. shifted from a supply-side problem to a demand-side problem due to vaccine hesitancy. We study this issue with a simulation experiment on a digital twin of the U.S., including all 50 states and Washington, D.C. First, we initialize the simulations with the same approach as before based on county-level, age-stratified cases and with basic NPIs in place. We also assign a vaccination schedule—i.e., the number of people receiving each vaccine (Johnson & Johnson, Pfizer, or Moderna) on a weekly basis—to every state based on state vaccine hesitancy levels. The hesitancy level determines the final cumulative fraction of the population that is fully vaccinated. We examine two different trajectories of weekly vaccinations towards the same final coverage: (i) accelerated and (ii) accelerated then decelerated. We also investigate the impact of increasing vaccine acceptance by 10 percent in each state.

Again, we compute the reductions in infection, hospitalization, and death due to vaccination when contrasted with the baseline scenario wherein vaccines are not available. We then compare these scenarios in different settings and find that the number of averted infections/deaths—normalized by population size—is not always greater in states with higher vaccine acceptance. In fact, a significant *negative* correlation exists between averted infections/deaths and population size. We also discover that the accelerated-decelerated vaccination schedule leads to a smaller reduction of infections/deaths when compared to the accelerated vaccination schedule. This result highlights the health and human costs of vaccine hesitancy and demand saturation. Finally, we realize that increasing the vaccine acceptance rate by 10 percent in each state yields significantly larger reductions in infections/deaths, even with the accelerated-decelerated vaccination schedule. See Figure 1b (on page 1) for a visual depiction.

High-performance Computing, AI, and Network Science

National agent-based models naturally employ AI techniques to support epidemic science. Another application of AI occurs within the synthesis of a contextualized digital twin of the underlying social contact network. The networked agent-based models utilize multi-theory behavioral and disease progression models, and the social contact network's digital twin is the result of a complex data-driven machine learning process [3]. The use of data-driven techniques—which gather, process, and integrate relevant data from websites—is important in an operationally relevant real-time scenario. More information about how our models are combined in an ensemble is available online at the COVID-19 Scenario Modeling Hub.[2]

High-performance computing plays a crucial role in our work. Figure 2 displays mean runtimes and memory usage for simulations in one of the studies of all 50 states, thus demonstrating that the requirements scale linearly for the range of pertinent population sizes [1, 2, 5]. Many of our workflows are executed simultaneously on two supercomputers due to the cycles provided by the University of Virginia's Research Computing Center (Rivanna) and the Pittsburgh Supercomputing Center (Bridges) as a part of the National Science Foundation's Extreme Science and Engineering Discovery Environment (XSEDE)[3] project. Figure 3 illustrates the overall data flow between the two supercomputers and the specific steps that occur on each machine [5].

Our specific workflow uses approximately 20,000 cores on Bridges and 3,000 cores on Rivanna. When we first employed the pipeline, we were granted access to 30,000 cores on Bridges each night. However, this level of generous access was of course not sustainable and we now reserve about 7,000 cores on Bridges. As a result of this change, we relied on packing methods to pack jobs efficiently on the cluster from fall 2020 [5]. Our current approach is an online scheduling method that utilizes both machines as cycles become available [1]. This new allocation scheme better shares the machines with other users and carries out more reliable computations.

In this article, we describe a data-driven AI approach that leverages advances in network science and high-performance computing to support ongoing COVID-19 pandemic response efforts in real time. Real-time epidemic science is a nascent field, and we aim to outline early steps toward the realization of relevant goals.

[2] https://covid19scenariomodelinghub.org/viz.html

[3] https://www.xsede.org

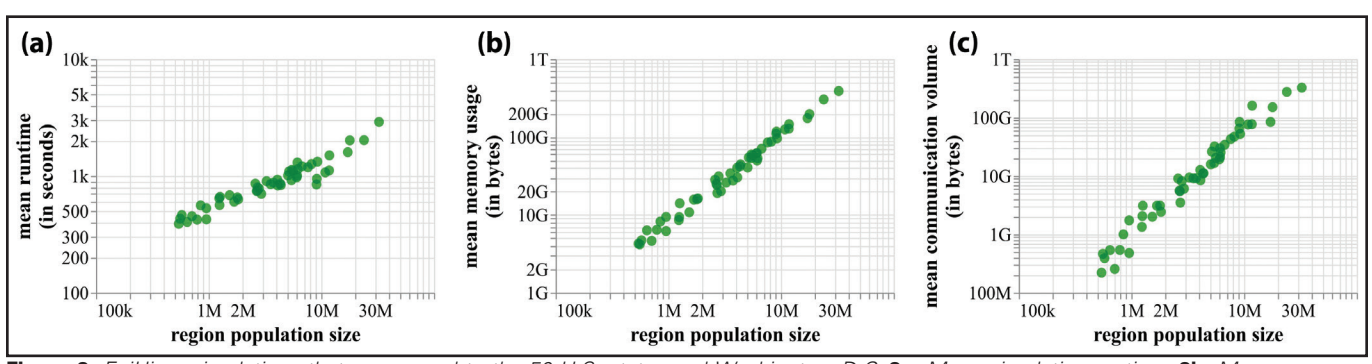


Figure 2. *EpiHiper simulations that correspond to the 50 U.S. states and Washington, D.C.* **2a.** *Mean simulation runtime.* **2b.** *Memory usage.* **2c.** *Communication volume. Figure courtesy of Parantapa Bhattacharya.*

Acknowledgments: The authors thank members of the Biocomplexity Institute's COVID-19 Pandemic Response Team at the University of Virginia (UVA); UVA's Network Systems Science and Advanced Computing Division; UVA's Research Computing Center; Shawn Brown and Tom Maiden of the Pittsburgh Supercomputing Center; John Towns of the Extreme Science and Engineering Discovery Environment; and our partners at the Centers for Disease Control and Prevention, Virginia Department of Health, National Science Foundation, and COVID-19 Scenario Modeling Hub. This work was partially supported by the NIH Grant R01GM109718, VDH Grant PV-BII, VDH COVID-19 Modeling Program, VDH-21-501-0135, NSF Grant OAC-1916805, NSF CCF-1918656, CCF-1917819, NSF RAPID CNS-2028004, NSF RAPID OAC-2027541, DTRA subcontract/ARA S-D00189-15-TO-01-UVA, and NSF XSEDE TG-BIO210084.

References

[1] Bhattacharya, P., Chen, J., Hoops, S., Machi, D., & Marathe, M. (2021). *Data-driven scalable pipeline using national agent-based models for real-time pandemic response and decision support*. Paper presented at the International conference for high performance computing, networking, storage, and analysis, St. Louis, MO.

[2] Bhattacharya, P., Machi, D., Chen, J., Hoops, S., Lewis, B., Mortveit, H., ... Marathe, M. (2021). AI-driven agent-based models to study the role of vaccine acceptance in controlling COVID-19 spread in the US. In *2021 IEEE international conference on big data*. Institute of Electrical and Electronics Engineers.

[3] Chen, J., Hoops, S., Marathe, A., Mortveit, H., Lewis, B., Venkatramanan, S., … Marathe, M. (2021). Prioritizing allocation of COVID-19 vaccines based on social contacts increases vaccination effectiveness. Preprint, *medRxiv*.

[4] Eubank, S., Guclu, H., Kumar, V.S.A., Marathe, M.V., Srinivasan, A., Toroczkai, Z., & Wang, N. (2004). Modeling disease outbreaks in realistic urban social networks. *Nature*, *429*(6988), 180-184.

[5] Machi, D., Bhattacharya, P., Hoops, S., Chen, J., Mortveit, H., Venkatramanan, S., … Marathe, M.V. (2021). Scalable epidemiological workflows to support COVID-19 planning and response. In *Proc. 35th IEEE international parallel and distributed processing symposium*. Institute of Electrical and Electronics Engineers.

[6] Marathe, M., & Vullikanti, A.K.S. (2013). Computational epidemiology. *Commun. ACM*, *56*(7), 88-96.

Jiangzhuo Chen and Stefan Hoops are research associate professors in the Network Systems Science and Advanced Computing Division of the University of Virginia's Biocomplexity Institute. Parantapa Bhattacharya is a research scientist in the Network Systems Science and Advanced Computing Division of the Biocomplexity Institute. Dustin Machi is a senior software architect in the Network Systems Science and Advanced Computing Division of the Biocomplexity Institute. Madhav Marathe is an endowed Distinguished Professor in Biocomplexity, director of the Network Systems Science and Advanced Computing Division in the Biocomplexity Institute, and a tenured professor of computer science at the University of Virginia.

Origami

Continued from page 1

notation is traditional. We can apply a group element $g=(\mathbf{Q}\,|\,\mathbf{c})$ to an origami tile $\mathcal{T}$ (or a collection of tiles) in the obvious way: $g(\mathbf{x})=\mathbf{Q}\mathbf{x}+\mathbf{c},\quad \mathbf{x}\in\mathcal{T}$. The apparently unusual group product simply corresponds to a composition of mappings: $g_1g_2(\mathbf{x})=g_1(g_2(\mathbf{x}))$.

Abelian isometry groups are a natural tool for fitting things together. Imagine a tile, a collection of tiles, or any set whatsoever: $(\Omega\subset\mathbb{R}^3)$. Suppose that there are two disjoint subsets of $\mathcal{S}_1,\mathcal{S}_2\in\partial\Omega$, and that two commuting isometries g_1,g_2 satisfy $g_1(\mathcal{S}_1)\subset\partial\Omega$ and $g_2(\mathcal{S}_2)\subset\partial\Omega$. By construction, $g_1(\Omega)$ fits perfectly onto Ω at $g_1(\mathcal{S}_1)$ and $g_2(\Omega)$ fits perfectly onto Ω at $g_2(\mathcal{S}_2)$. But since $g_1g_2=g_2g_1$, $g_1g_2(\Omega)$ thus fits perfectly onto *both* $g_1(\Omega)$ and $g_2(\Omega)$ at $g_1g_2(\mathcal{S}_2)$ and $g_1g_2(\mathcal{S}_1)$ respectively. The Abelian isometry group builds the whole structure by iterating this process. According to the group property, each image of Ω fits together perfectly with its four neighbors. And the tiles are identical, which is a welcome feature for people who actually make and transport the tiles in a real application. Figure 1 (on page 1) illustrates the "group orbit procedure" with Ω as a partly-folded quad origami. The two commuting generators yield a helical group.

In terms of deployability, we want the whole homotopy rather than a single configuration. One component of this ambition is easy. If we consider only piecewise linear, isometric deformations between the creases and perform pairwise fitting at the edges of individual tiles, we can at least hope to conduct the fitting with isometries. Deployability is hence reduced to the question of whether there are sufficiently many free parameters in both the group and unit cell Ω to make the whole structure deformable. Surprisingly, such freedom often exists; Figure 1a (on page 1) illustrates this point with two commuting isometries and a unit cell that collectively allow the structure to be folded continuously from a flat strip to a cylinder. We can also generate this outcome with two commuting conformal transformations: $g_1=(\lambda_1\mathbf{Q}_1\,|\,\mathbf{c}_1)$, $g_2=(\lambda_2\mathbf{Q}_2\,|\,\mathbf{c}_2)$, $\lambda_1,\lambda_2\in\mathbb{R}$. The group product is again a composition of mappings in Figure 1b.

How do these concepts relate to the structure of materials? At the continuum level, we can adapt the aforementioned group orbit procedure. We begin with a deformation $\mathbf{y}:\Omega\to\mathbb{R}^3$, $\Omega\subset\mathbb{R}^3$ (rather than the full homotopy) and consider two Abelian isometry groups; one acts on Ω and the other acts on $\mathbf{y}(\Omega)$. As a simple case, consider $\mathbf{t}\in\mathbb{R}^3$ and a translation group t^i, $i\in\mathbb{Z}$, $t^i(\mathbf{x})=\mathbf{x}+i\mathbf{t}$ that acts on Ω and a circle group $h^i=(\mathbf{Q}^i\,|\,0)$, $i=1,\ldots,n$, $\mathbf{Q}^n=\mathbf{I}$ that acts on $\mathbf{y}(\Omega)$. Suppose that we arrange $h(\mathbf{y}(t^{-1}(\mathbf{x}))=\mathbf{y}(\mathbf{x}),\quad \mathbf{x}\in\mathcal{S}$ on the overlap region $\mathcal{S}=t(\Omega)\cap\Omega$. The groups then build the whole structure for us: $\mathbf{y}(\mathbf{x})=h^i\mathbf{y}(t^{-i}(\mathbf{x}))$, $\mathbf{x}\in t^i(\Omega)$, $i=1,\ldots,n$. To yield a homotopy $\mathbf{y}(\mathbf{x},t)$, we again need sufficient flexibility of the groups and allowable deformations.

Figure 2 illustrates an experimental example with exactly these groups: two variants of a tetragonal phase of a ferromagnetic NiMnGa alloy [5]. It is difficult to experimentally achieve the full homotopy from a rectangular bar in this case; the row of permanent magnets at the top of the figure is instrumental.

How might we achieve Figure 2's reversible phase transformations in nanostructures? One idea involves using two helical groups to generate helical atomic structures, then fitting them together along a helix. We can in fact do so for the green and blue lattices in Figure 3. But the structure is rigid; the interfaces cannot move without slip — i.e., without atoms losing their nearest neighbors. This is always the case when we attempt to fit two helical phases together at a (nondegenerate) helix. On the other hand, inserting the red phase in Figure 3—an exact reflection/"twin" of the blue phase across a horizontal plane and therefore equally stable by the invariance of quantum mechanics—makes the phase transformation possible. Figure 3 illustrates the way in which all atoms retain their nearest neighbors in the process. We suggest that this motion is a viable route to reversible phase transformation in nanotubes.

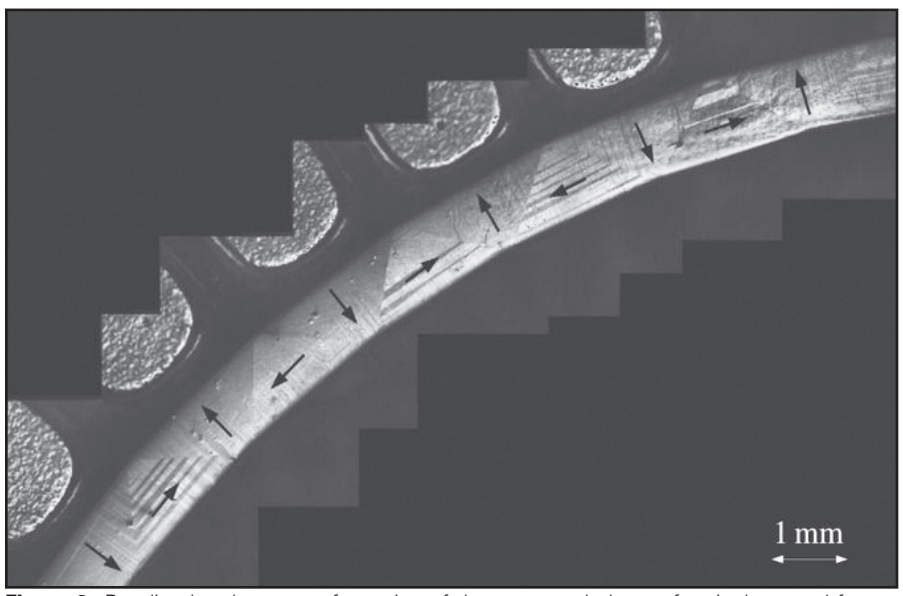


Figure 2. *Bending by phase transformation of the tetragonal phase of a single crystal from a NiMnGa alloy. The arrows depict the direction of magnetization. Figure courtesy of [5].*

Building some elastic energy into an origami structure to bias it towards a particular shape is often a valuable approach [1]. Most elegantly, we can introduce elastic energy by allowing curved, locally isometric mappings between the creases. Again, the Lagrangian approach and group orbit procedure provide powerful methods of synthesis and analysis. The fitting is subtler than before, with careful consideration of the rulings on each side of the crease and exploitation of the additional freedom when the crease itself undergoes a locally isometric mapping. Figure 4 offers some examples that use circle groups for both the reference domain Ω and deformed domain $\mathbf{y}(\Omega)$. We can fold all of these examples isometrically from a flat sheet.[1]

Kirchhoff's nonlinear plate theory—a wonderfully simple and accurate theory—allows us to calculate the elastic energy of these curved origami structures [4]. The finite energy deformations of Kirchhoff's theory are precisely locally isometric mappings.

Can we use the mathematics and inspiration of origami design to suggest completely new kinds of materials? A central idea for material design—and one that is well represented by the periodic table—is that atoms "like to see identical environments." In other words, an isometry can map any atom's full atomic environment to that of any other atom. From a (challenging) mathematical perspective, we can view this property as an intermediate step in the proof of a general crystallization theorem. The property is also evident in the designs of Figures 1 through 4 (excluding Figure 1b); corresponding points on each tile experience the same environment.

A Penrose tiling relaxes this idea. Because there are only two tiles, each node in the tiling sees a finite number of local environments. As the local environment's diameter grows, the number of different local environments grows as well. The presence of a few local environments is an acceptable situation for materials in both energetic and kinetic terms, as evidenced by the existence of quasicrystals. Reidun Twarock and Tom Keef's analysis of virus structure [8] proposes another way to ensure that most atoms in the structure see one of several local environments: use an infinite *non-discrete* isometry group and carefully select elements while avoiding the accumulation points. Since we have minimal knowledge of these non-discrete groups—let alone how to select the elements—there is plenty of room for investigation.

[1] An animation in the online version of this article shows the full homotopy in the case of a translation group on Ω and a helical group on $\mathbf{y}(\Omega)$.

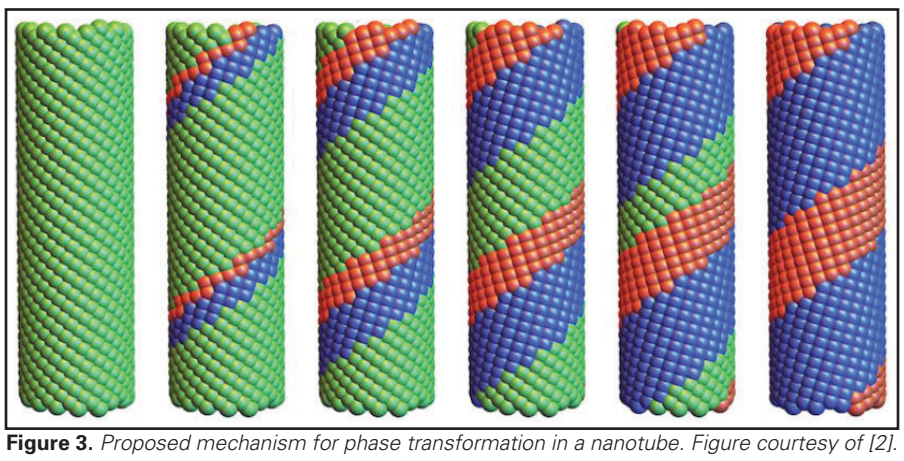


Figure 3. *Proposed mechanism for phase transformation in a nanotube. Figure courtesy of [2].*

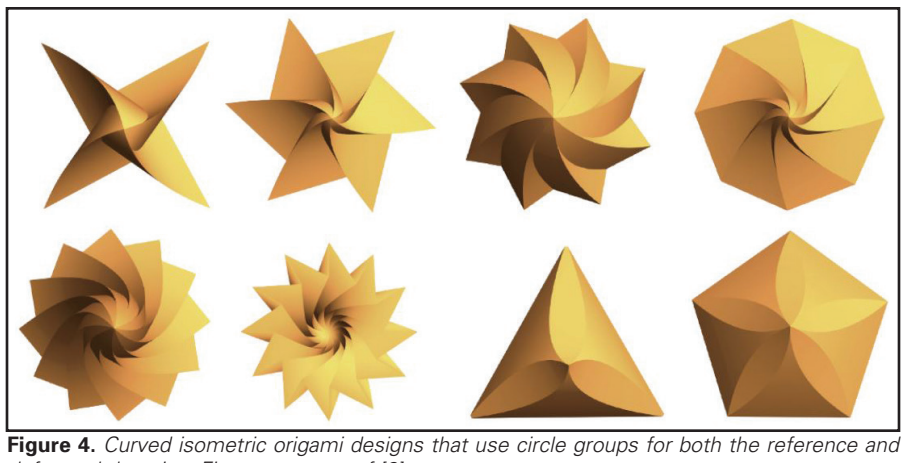


Figure 4. *Curved isometric origami designs that use circle groups for both the reference and deformed domains. Figure courtesy of [6].*

Huan Liu is a graduate student at the University of Minnesota who performs research on the design of materials that both inspire and are inspired by origami. Paul Plucinsky is an assistant professor at the University of Southern California who works on problems at the interface of materials science, mechanics, and applied mathematics. Fan Feng is a postdoctoral researcher at the University of Cambridge who focuses on the geometric evolution and mechanics of liquid crystal elastomers. Arun Soor is a graduate student at the University of Oxford who works on algebraic number theory. Richard D. James is a Distinguished McKnight University Professor in the Department of Aerospace Engineering and Mechanics at the University of Minnesota, where he studies the mathematical design of materials. He can be reached at james@umn.edu.

References

[1] Bende, N.P., Evans, A.A., Innes-Gold, S., Marin, L.A., Cohen, I., Hayward, R.C., & Santangelo, C.D. (2015). Geometrically controlled snapping transitions in shells with curved creases. *PNAS*, *112*(36), 11175-11180.

[2] Feng, F., Plucinsky, P., & James, R.D. (2019). Phase transformations and compatibility in helical structures. *J. Mech. Phys. Solids*, *131*, 74-95.

[3] Feng, F., Plucinsky, P., & James, R.D. (2020). Helical Miura origami. *Phys. Rev. E*, *101*(3), 033002.

[4] Friesecke, G., James, R.D., & Müller, S. (2002). A theorem on geometric rigidity and the derivation of nonlinear plate theory from three-dimensional elasticity. *Comm. Pure Appl. Math.*, *55*(11), 1461-1506.

[5] Ganor, Y., Dumitrică, T., Feng, F., & James, R.D. (2016). Zig-zag twins and helical phase transformations. *Philos. Trans. R. Soc. A*, *374*(2066), 20150208.

[6] Liu, H., & James, R.D. (2022). Design of origami structures with curved tiles between the creases. Preprint.

[7] Liu, H., Plucinsky, P., Feng, F., & James, R.D. (2021). Origami and materials science. *Philos. Trans. R. Soc. A*, *379*(2201), 20200113.

[8] Twarock, R., & Keef, T. (2010). Viruses and geometry: Where symmetry meets function. *Microbiol. Today*, *37*(1), 24-27.

Acting in the Ecosystem of Applied Mathematics in Colombia

By Carlos Díez

The Colombia Section of SIAM (CoSIAM)[1] models its range of actions as the first octant of a Cartesian space, framed in three axes. The first axis corresponds to the section's target audience: undergraduate students, graduate students, and professionals. The second axis addresses the areas of action: motivation, training, research, and networking. And the third axis comprises the sectors that CoSIAM hopes to impact: academia and the real world.

Within this framework, the section's operational plan envisages several events that have even commenced—with some necessary adjustments—during the ongoing COVID-19 pandemic (see Figure 1).

The oldest of these events is the Math Modeling Challenge,[2] a competition during which teams of undergraduate and graduate students from different universities and programs use mathematics and computer science techniques to solve real-world problems under time and resource constraints. This methodology promotes multidisciplinary work and enriches participants' teamwork and project development skills. It also introduces students to a variety of angles and potential solutions to important societal issues. This year's challenge—which focused on a problem related to stochastic dynamical systems—took place completely virtually and attracted 16 teams for a total of 62 individuals from various regions of Colombia. Several days before the event, participating students can access a massive open online course that is related to the topic of the forthcoming problem. These courses are available on CoSIAM's YouTube channel.[3]

Readers who wish to learn more about CoSIAM's Math Modeling Challenge can view our recent article that was published in *Mathematics*,[4] titled "SIAM-Colombia MMC: A Challenge-based Math Modeling Learning Strategy"[5] [1].

Another recurring CoSIAM event is the Workshop and International Seminar on Complexity Sciences[6] — a specialized, multi-institutional, and interdisciplinary academic event for the development of applied mathematics research in Colombia. Experts who attend obtain specialized feedback that strengthens their scientific work. In 2021, more than 40 people—including attendees and speakers from various regions of Colombia and several other parts of the world—partook in the workshop. Researchers presented interesting papers and established collaborative networks during this event, which took place online.

Finally, we highlight the School of Applied and Industrial Mathematics,[7] which offers three short courses in applied mathematics and enables attendees to share interdisciplinary experiences in applied and industrial math. 96 participants attended the 2021 iteration of this event, which featured courses on dynamics in electrical systems, blockchain and smart contracts, and quadratic optimization and support vector machines. Each course lasted 12 hours and took place virtually. This year's courses—as well as those from previous years—are accessible on YouTube.[8]

These are just some of the actions of the Colombia Section of SIAM. More information about CoSIAM's various activities to promote applied and industrial mathematics in Colombia is available online.[9]

Figure 1. *Examples of three activities that the Colombia Section of SIAM (CoSIAM) sponsors to advance industrial and applied mathematics in Colombia. Figure courtesy of Carlos Díez.*

References

[1] Méndez-Romero, R.A., Bueno-Carreño, D.H., Díez-Fonnegra, C., & Redondo, J.M. (2021). SIAM-Colombia MMC: A challenge-based math modeling learning strategy. *Math., 9*(13), 1565.

Carlos Díez is a professor at Fundación Universitaria Konrad Lorenz in Colombia. He is the treasurer of the Colombia Section of SIAM.

[1] https://www.siam.org/membership/sections/detail/colombia-section-of-siam-cosiam
[2] https://www.cosiam.net/mmc-cosiam
[3] https://go.siam.org/xLYa53
[4] https://www.mdpi.com/journal/mathematics
[5] https://www.mdpi.com/2227-7390/9/13/1565
[6] https://www.cosiam.net/wiscs-cosiam
[7] https://www.cosiam.net/emai-2021
[8] https://go.siam.org/xLYa53
[9] https://www.cosiam.net

A Conversation with Ron Buckmire, SIAM's First Vice President for Equity, Diversity, and Inclusion

In January 2021, SIAM officially welcomed Ron Buckmire—a professor of mathematics and the Associate Dean for Curricular Affairs at Occidental College—as its first Vice President for Equity, Diversity, and Inclusion (EDI). Ron has been heavily involved in numerous SIAM committees over the years and brings ample experience from his time in both academia and with the U.S. government. His first term as VP for EDI ends December 31, 2022.

The VP for EDI works to expand SIAM membership across all demographics, support equity and inclusion within SIAM programs and activities, and ensure that SIAM is effectively serving its entire diverse community. The position is a voting member of the SIAM Council and collaborates with SIAM leadership and the VPs for Industry, Education, Publications, Science Policy, and Programs, as well as members of the Diversity Advisory Committee[1] and the Membership Committee.[2]

Lisa Fauci of Tulane University—who oversaw the creation of the VP for EDI position when she was SIAM President—recently sat down for a conversation with Ron. They discussed his longstanding dedication to SIAM, past employment at the National Science Foundation (NSF), passion for increasing the participation of underrepresented individuals in mathematics, and ideas for the remainder of his first term. Here they share their conversation with *SIAM News*.

Lisa Fauci: How did you first become involved with SIAM?

Ron Buckmire: I earned my B.Sc., M.Sc., and Ph.D. from Rensselaer Polytechnic Institute (RPI). Because RPI is very much oriented around engineering and applied mathematics, it was sort of expected that students in the Department of Mathematical Sciences join SIAM. The 1993 SIAM Annual Meeting in Philadelphia, Pa., was my first conference, and I graduated with my Ph.D. the following year. When I became a professor, I naturally retained my SIAM membership.

The first SIAM committee to which I was appointed was the Education Committee.[3] I then joined the Diversity Advisory Committee and have since been involved with SIAM at various levels. I previously served as the program director for the SIAM Activity Group on Applied Mathematics Education[4] and even co-organized the 2020 SIAM Conference on Applied Mathematics Education, which unfortunately was cancelled due to COVID-19. I am also the outgoing chair of the Membership Committee.


Ron Buckmire, SIAM's Vice President for Equity, Diversity, and Inclusion.

LF: As an applied mathematician in training at RPI, you were expected to become a member of SIAM. How can we make that expectation more widespread for applied mathematicians at other institutions, including undergraduate institutes with a mix of applied and pure mathematics?

RB: One of the most important changes that I am hoping to implement with SIAM's executive director, Suzanne Weekes, is to encourage more math folks to join SIAM. If you are an applied mathematician, SIAM should be your primary society. We can promote this mindset by making SIAM a welcoming place for all types of applied mathematicians and computational/data scientists. We want to appeal to individuals who work in the field of applied mathematics and perform math as part of their jobs in business, industry, and government laboratories — not just in academia.

Joining and participating in a community of individuals like SIAM is validating, especially for applied mathematicians and/or computational scientists whose departments are comprised primarily of pure mathematicians. SIAM members know that the work they do is important and applicable to a myriad of real-world situations, and this affirmation is valuable to young and early-career mathematicians who are just getting started.

LF: You've spent some time as a program director at NSF. What insights does that experience bring to your role as VP for EDI?

RB: NSF is a great source and supporter of innovation and excellence in mathematics throughout the U.S. It provides its employees with a bird's-eye view of the best, most interesting scientific ideas and programs across the country.

Many people don't realize that between a third and a half of NSF program officers are temporary at any given time. NSF uses the term "rotators" to describe these individuals, whose responsibilities and titles are very similar to "permanent" program officers. Rotators are typically people with Ph.D.s (usually employed at academic institutions) who spend one to four years working at NSF while on leave from their home institution. I was a rotator from 2011 to 2013 and a permanent program officer from 2016 to 2018 in the Division of Undergraduate Education[5] (DUE), which falls within the Directorate for Education and Human Resources.

Working at NSF is incredibly rewarding, and I encourage people to apply there all the time. The Foundation is always looking for more rotators; readers of *SIAM News* might be more familiar with the Division of Mathematical Sciences[6] (DMS) than the DUE, but many of the projects and assignments are similar in both divisions. As a DUE program officer responsible for mathematics education, I often worked with DMS program officers. We co-funded projects, sat in on each other's panels, and conducted outreach together at large conferences like the Joint Mathematics Meetings.[7] Program officers have a lot of leeway and substantial autonomy when making funding recommendations; when the division director approves such recommendations, the money eventually goes to the principal investigators and sponsoring institutions. My time at NSF inspired me to seek positions with more responsibility at my home institution and in the broader national mathematics community.

NSF has an entire Office of Equity and Civil Rights.[8] In fact, most federal agencies in the U.S. government have a paid person on staff whose job is very similar to my volunteer position as SIAM's VP for EDI: to think about diversity and inclusion in multiple ways and within all aspects of the organization's activities. The federal government is ahead of many other institutions in terms of implementing these types of practices. This fact was really eye opening for me.

LF: What would you like SIAM members to know about SIAM's current EDI efforts?

RB: I think that SIAM does a lot in the area of EDI that members aren't necessarily aware of. For example, the Workshop Celebrating Diversity (WCD)—a yearly event at the SIAM Annual Meeting that is

See **Ron Buckmire** *on page 6*

[1] https://www.siam.org/about-siam/committees/diversity-advisory-committee
[2] https://www.siam.org/about-siam/committees/membership-committee
[3] https://www.siam.org/about-siam/committees/education-committee
[4] https://www.siam.org/membership/activity-groups/detail/applied-mathematics-education
[5] https://www.nsf.gov/div/index.jsp?div=DUE
[6] https://www.nsf.gov/div/index.jsp?div=DMS
[7] https://www.jointmathematicsmeetings.org
[8] https://www.nsf.gov/od/oecr

Reservoir Simulation and the Mathematics of Oil Recovery

By Zhangxing Chen

The following is a brief and timely reflection from the author of Reservoir Simulation: Mathematical Techniques in Oil Recovery,[1] which was published by SIAM in 2007 as part of the CBMS-NSF Regional Conference Series in Applied Mathematics.[2] The text addresses classical reservoir engineering and basic reservoir simulation methods. It also presents an overview of various types of flows and includes a detailed glossary of petroleum engineering terms.

FROM THE SIAM BOOKSHELF

Reservoir Simulation: Mathematical Techniques in Oil Recovery evolved from a series of lectures that I delivered at the 2006 NSF-CBMS Regional Research Conferences in the Mathematical Sciences,[3] where I spoke about multiphase flows in porous media and reservoir simulation. The text is appropriate for senior undergraduate students and first-year graduate students in geology, petroleum engineering, and applied mathematics. It can also serve as a reference book for geologists, petroleum engineers, applied mathematicians, and scientists in petroleum reservoirs. Employees in the petroleum industry can even use *Reservoir Simulation* as a handbook for modeling and simulation.

The book's 10 chapters correspond to my 10 respective lectures at the NSF-CBMS conference. Chapter one offers an introduction to classical reservoir engineering and basic reservoir simulation. In chapter two, I review a glossary of terms that are common in the area of reservoir simulation. With the exception of chapter four, chapters three through nine present the governing differential equations and their numerical solutions for single-phase, two-phase, black oil (three-phase), single-phase with multi-components, compositional, and thermal flows. For each of these flows, the text (i) gives the basic flow and transport equations; (ii) states the corresponding rock and fluid properties; (iii) discusses peculiar features of the equations; (iv) diligently describes the procedure for obtaining their numerical solutions; and (v) addresses difficulties and practical issues in the solutions. Specifically, the book studies the treatments of rock, fluid, and rock/fluid properties at the internal boundaries of gridblocks in great depth.

Chapter four describes the well constraints that contribute to the numerical simulations of each flow, and chapter ten summarizes several practices in reservoir simulation — including data gathering and analysis, selection of a simulation model, history matching, and reservoir performance prediction. This final chapter also provides examples for each numerical solution that carry out the discretization procedure in detail for the finite difference method; other work presents the finite volume and finite element methods in a similar fashion [1].

Previous researchers have widely used mathematical models to predict, understand, and optimize complex physical processes for the modeling and simulation of multiphase fluid flows in petroleum reservoirs. These models are important when one seeks to understand the fate and transport of chemical species and heat. Armed with this knowledge, practitioners in the petroleum industry then apply the models in order to design enhanced oil recovery strategies.

Reservoir Simulation focuses on the modeling and simulation of multiphase flow in porous media, the derivation of mathematical models, the use of numerical methods to solve these models, and applications to petroleum recovery. One can even extend the presented mathematical techniques for conventional oil and gas reservoirs to unconventional oil and gas reservoirs, such as tight and shale oil and gas, coalbed methane, and gas hydrate.

Reservoir simulation has become a standard predictive tool in the petroleum industry, as it can obtain accurate performance predictions for hydrocarbon reservoirs under different conditions. A single hydrocarbon recovery project involves a capital investment of hundreds of millions of dollars, and companies must assess and minimize the risk that is associated with its selected development and production strategies. This risk includes important factors — like the complexity of a petroleum reservoir and the fluids that fill it, an understanding of hydrocarbon recovery mechanisms, and the applicability of selected strategies. Researchers can account for these important factors in reservoir simulation by inputting data into a simulation model.

Determining the simulation process involves three major interrelated stages. First, one must develop a set of mathematical model equations that incorporate the necessary physics and chemistry to describe the essential features of flow and transport processes in petroleum reservoirs. Second, well-posed equations with clearly expressed solutions enable the establishment of robust numerical models. These models must be stable, accurate, and able to reliably generate solutions that demonstrate basic physical and chemical features without introducing spurious phenomena. Third, researchers must design computer algorithms and codes to efficiently solve the large-scale systems of algebraic equations that arise from the numerical models. As consumers around the world look to greener, cleaner, and more efficient sources of fuel in response to climate change, reservoir simulation will play an increasingly important role in the petroleum industry.

My hope is that the readers of *Reservoir Simulation: Mathematical Techniques in Oil Recovery* will join me in exploring and understanding the mathematical and computational foundations that comprise reservoir simulation.

Enjoy this passage? Visit the SIAM Bookstore[4] to learn more about Reservoir Simulation: Mathematical Techniques in Oil Recovery[5] and browse other SIAM titles.

Visual representation of the integration of reservoir modeling, big data, and virtual reality. Photo courtesy of Zhangxin Chen.

References

[1] Chen, Z., Huan, G., & Ma, Y. (2006). Computational methods for multiphase flows in porous media. In *Computational science and engineering* (Vol. 2). Philadelphia, PA: Society for Industrial and Applied Mathematics.

Zhangxing Chen holds two research chairs at the University of Calgary: Alberta Innovates Industrial Chair in Reservoir Modeling and NSERC/Energi Simulation Senior Industrial Research Chair in Reservoir Simulation. He is a Fellow of the Royal Society of Canada, the Canadian Academy of Engineering, and the Engineering Institute of Canada, as well as an Academician of the Chinese Academy of Engineering. Chen has received numerous awards, including the Killam Professor Award, CAIMS-Fields Industrial Mathematics Prize, and Gerald J. Ford Research Fellowship.

[1] https://my.siam.org/Store/Product/viewproduct/?ProductId=737

[2] https://my.siam.org/Store/Home/BookSeries/2

[3] https://www.cbmsweb.org/archive/NSF/2006_conf.htm

[4] https://my.siam.org/Store

[5] https://my.siam.org/Store/Product/viewproduct/?ProductId=737

Ron Buckmire

Continued from page 5

organized by a subcommittee of SIAM's Diversity Advisory Committee—has been around for nearly 30 years. WCD consists of a series of several minisymposia on various topics in industrial and applied mathematics; researchers from historically excluded and currently underrepresented communities attend these sessions and give presentations about their ongoing projects. This is just one way that SIAM has increased the diversity of attendees at its Annual Meeting — be sure to check out this programming at the 2022 SIAM Annual Meeting,[9] which will take place in a hybrid format this July in Pittsburgh, Pa.

Upon realizing that not many WCD participants remained engaged with SIAM after the workshop—and thanks to your leadership and suggestions, Lisa, during your time as SIAM President—SIAM established the MGB-SIAM Early Career (MSEC) Fellowship.[10] MSEC is a collaboration between Mathematically Gifted & Black[11] (MGB) and SIAM that will "promote long-term engagement of MSEC Fellows within SIAM and their continued success within the wider applied mathematics and computational sciences community." Five to eight MSEC Fellowships will be awarded each year; recipients will receive free SIAM membership throughout the Fellowship's three-year duration and discounted membership in the subsequent four years. They will also receive travel support and free registration for the Annual Meeting and one additional SIAM conference of their choosing (in the U.S. or Canada), during which they will co-organize one or more minisymposia in their research areas. Fellows will also present a talk at a WCD session. Applications for the first round of MSEC Fellows closed in November 2021, and we look forward to announcing their names in early 2022.

LF: How are you using the VP for EDI role to represent SIAM within the wider mathematics community?

RB: TPSE Math[12] is currently working on developing resources to help the mathematical sciences community assess and improve their EDI efforts. These resources are based upon SEA Change,[13] a program of the American Association for the Advancement of Science to propel the transformation of science, technology, engineering, and mathematics fields in colleges and universities so that they better reflect EDI. As SIAM's representative in the TPSE Math working group, I have been helping to create these resources for the broader mathematical community.

I am also involved with EDI in the mathematics community in various other capacities. For instance, I am on the corresponding EDI committees of the Mathematical Association of America, American Mathematical Society, and the Mathematical Sciences Research Institute. I think that I bring many reciprocal synergies to SIAM by holding these additional volunteer positions.

LF: What are some of your goals for the remainder of your time as SIAM's first VP for EDI?

RB: My primary goal as VP for EDI is to do what I do in every administrative or volunteer position that I hold. Specifically, I try to "leave the campground cleaner than I found it;" in other words, I aim to leave the organization better than when I joined it. With respect to EDI at SIAM, I want to help move the needle in the positive direction by increasing diversity and inclusion in all of the Society's primary activities: awards, conferences, publications, membership, etc. In fact, one of my first major actions has been to convene a working group—formally called the Diversity, Equity, and Inclusion Strategic Task Force—to create a report that summarizes recommendations to enhance SIAM's EDI efforts in the short term (six to 18 months). This report has been produced and submitted to SIAM's Board of Trustees and Council for review. During the remainder of my first term, I will be working to get these recommendations enacted.

If I continue as VP for EDI for a second term, the next step would be a more comprehensive strategic plan that discusses and maps out SIAM's EDI efforts on a longer time scale. I ultimately want to set SIAM on a trajectory towards continuous, measurable, and significant improvement in the realm of EDI for the foreseeable future.

SIAM News thanks Lisa Fauci and Ron Buckmire for their time and contributions to this piece.

[9] https://www.siam.org/conferences/cm/conference/an22

[10] https://www.siam.org/students-education/programs-initiatives/mgb-siam-early-career-fellowship

[11] https://mathematicallygiftedandblack.com

[12] https://www.tpsemath.org

[13] https://seachange.aaas.org

A New Milestone for SIAM Student Chapters in 2021

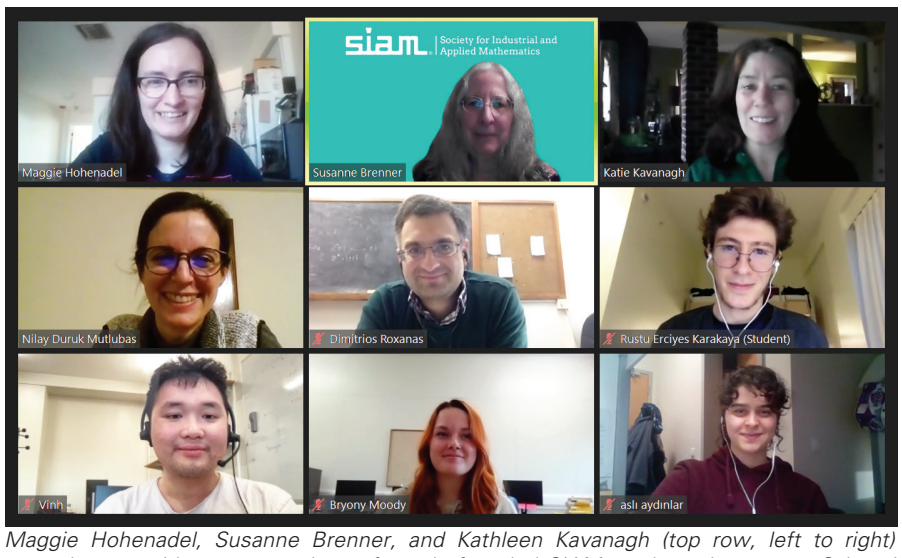
By Susanne C. Brenner and Kathleen Kavanagh

The number of SIAM student chapters[1] has grown steadily in recent years. 2021 was a landmark year for the program, as the number of student chapters surpassed 200. In fact, SIAM ended 2021 with a total of 208 chapters.

To mark this milestone, we hosted a series of "Meet and Greet" sessions with the help of Maggie Hohenadel, SIAM's Student Chapter and Fellows Coordinator. Three Zoom sessions took place in the fall of last year with chapters that formed in 2021. In October, we met with faculty advisors and officers from the student chapters at California State University, Fullerton; Universidad Nacional Autónoma de México; and Georgia Gwinnett College. In November, we met with representatives from student chapters at Eastern Washington University, Pohang University of Science and Technology (POSTECH), and San Francisco State University. During our final meeting later in November, we connected with the chapters at Sabancı University and the University of Sheffield.

We discussed opportunities and procedures for SIAM chapters within the SIAM community at each of these meetings. We also highlighted the Visiting Lecturer Program,[2] wherein mathematicians in industry, business, and government visit/meet with student chapters and give inspirational and informative talks on topics that are of interest to early-career individuals in the field. In addition, we showcased SIAM conferences as a means to learn about emerging topics in applied mathematics, build professional networks, and become more involved with the scientific community. In particular, we introduced the new chapter officers to Student Travel Awards[3] and the opportunities at conference "Student Days," including undergraduate research sessions.

During our conversations, representatives spoke about various events that their chapters have hosted and detailed their plans for the future. Many chapters had already invited speakers for seminar talks and intend to organize additional seminars and lecture series. Some participants talked about the possibility of serving as mentors for modeling contests and partaking in science fairs. Incidentally, a significant number of undergraduate student leaders comprise the new 2021 chapters, many of whom are currently training for the Consortium for Mathematics and Its Applications' (COMAP) Mathematical Contest in Modeling;[4] SIAM awards multiple prizes for the COMAP competition.[5] We in turn pointed to the MathWorks Math Modeling Challenge, a program of SIAM, as a possible source of resources and training materials.[6]



Maggie Hohenadel, Susanne Brenner, and Kathleen Kavanagh (top row, left to right) recently met with representatives of newly founded SIAM student chapters at Sabanci University and the University of Sheffield to discuss opportunities and procedures. Additional photos of other student chapter meetings are available online.

Several chapters also organized conferences and joint events. The University of Sheffield Student Chapter hosted an online conference last summer, and the POSTECH Student Chapter co-sponsored a joint online SIAM student chapter conference with the Peking University Student Chapter. Other chapters are currently planning to pursue regional events — and possibly even a nationwide event.

The SIAM student chapters that formed in 2021 are definitely off to an impressive start with a wide array of activities. We hope to welcome even more chapters in 2022. Furthermore, SIAM is planning to host the traditional student chapter breakfast with leadership during the 2022 Annual Meeting[7]—which will take place both online and in Pittsburgh, Pa., in July—and intends to schedule several virtual Zoom chapter get-togethers in 2022. We look forward to these activities and hope that all chapters participate in the upcoming events.

Susanne C. Brenner is a professor of mathematics at Louisiana State University and the President of SIAM. Kathleen Kavanagh is a professor of mathematics at Clarkson University and the Vice President for Education at SIAM.

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

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

[3] https://www.siam.org/conferences/conference-support/siam-student-travel-awards

[4] https://www.comap.com/undergraduate/contests

[5] https://www.siam.org/prizes-recognition/student-prizes/detail/siam-award-in-the-mathematical-contest-in-modeling

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

[7] https://www.siam.org/conferences/cm/conference/an22

SIAM Celebrates the 70th Anniversary of Its Incorporation

2022 marks the 70th anniversary of SIAM's formal establishment and incorporation — much has changed since then! The idea of a professional organization for mathematicians in industry and government first arose in November 1951 at an assembly of the American Institute of Electrical Engineers. This concept was well-received by attendees, and the inaugural organizational meeting for the budding society took place in December. During this gathering, members of the organizing committee settled on the name "Society for Industrial and Applied Mathematics," in part because it lent itself well to an interesting acronym: SIAM.

SIAM's first three meetings took place in March, April, and May of 1952 at the Drexel Institute of Technology (now Drexel University). William Francis Gray Swann, director of the Franklin Institute's Bartol Research Foundation and SIAM's first conference speaker, delivered his talk on "Mathematics, the Backbone of Science" to an audience of roughly 180 individuals.

On **April 30,1952**, SIAM was officially incorporated in the State of Delaware with three key purposes: (i) *further the application of mathematics to industry and science*, (ii) *promote basic research in mathematics that leads to new methods and techniques for industry and science*, and (iii) *provide media for the exchange of information and ideas between mathematicians and other technical/scientific personnel*. The bylaws were completed in June 1952 and the election of SIAM's first officers, trustees, and council members took place that October. Elected officers included **William E. Bradley** (president), **Grace M. Hopper** and **George W. Patterson III** (vice presidents), **Emil Amelotti** (treasurer), and **I. Edward Block** (secretary). By the following year, SIAM had six corporate members and about 350 individual members; that number has since increased to more than 14,500 members in the U.S. and around the world.

The SIAM that we know has grown immensely since its incorporation as a local entity 70 years ago. The society now hosts approximately 15 conferences in applied and computational mathematics each year; publishes 18 peer-reviewed research journals that receive more than 6,000 annual submissions; and sponsors numerous activity groups, student chapters, programs, and funding initiatives that benefit its rich international community.

Thank you for being a part of SIAM's journey. We look forward to even more progress and development in the next 70 years!

Emerging From the Storm: SIAM Publications in Strong Health

By Kivmars Bowling

2021 was yet another intense year, and I hope that you and yours fared well. Disruptions associated with the COVID-19 pandemic have affected SIAM Publications in various ways, but here I want to share some of the exciting developments and innovations that are underway as we hopefully begin to emerge from the storm.

Submissions to SIAM journals remain incredibly robust. 2020 set a record high with more than 6,000 submissions, and 2021 approached that level again with the arrival of more than 5,900 papers. The last two years have thus exceeded all previous years in terms of the number of authors who sought publication in SIAM journals. This achievement speaks to the outstanding quality and high regard in which authors and researchers hold SIAM publications.

This submission level also begets increased pressure for the incredibly hard-working journal editors-in-chief, Editorial Board members, and editorial support staff. I want to thank everyone for their continued work and commitment. Journals are ultimately communities of people who continuously share ideas, and the strength of the SIAM community is both striking and appreciated. Compared to 2020, journal article downloads in 2021 increased by at least 10 percent and were set to exceed pre-pandemic levels — a feat that once more attests to the high quality and global demand of SIAM journals among readers around the world.

As always, the new year brings various editorial transitions. SIAM extends its sincere gratitude to the outgoing journal editors-in-chief for all of their work during their tenure and warmly welcomes their successors (see Figure 1).

The SIAM Books program has experienced both positive and negative impacts from COVID-19. While print sales have faced a sharp decline in both 2020 and 2021—indeed, printing itself has been hit with industry-wide challenges in the last year—e-book sales have risen dramatically due to high demand among institutional libraries that are expanding their online resources. It remains to be seen whether this reaction reflects a permanent shift, but we do expect print sales to recover as the world rebounds from the pandemic.

Moreover, it was heartening to see our book acquisition editors start attending in-person conferences again at the end of 2021. We hope that the vital in-person conversations with potential book authors will continue to grow in 2022. If you have any ideas for monographs or textbooks, please contact Elizabeth Greenspan (Executive Editor of SIAM Books) at **greenspan@siam.org**. SIAM also intends to publish more general interest books in the future, so do get in touch if you have ideas.

Although 2021 brought many pandemic-related disruptions, it allowed us to make progress in the following key areas.

Equity, Diversity, and Inclusion

SIAM announced its new Name Change Policy[1] for all authors of SIAM publications in early September 2021. SIAM respects that authors may seek to change their names for reasons such as marriage, divorce, alignment with gender identity, or religious conversion. Authors can now initiate a name change by contacting **namechange@siam.org**. Those who do so will not be asked to specify the reason, and legal proof of the name change is not required. However, SIAM may request information to reasonably establish the author's identity.

In addition to establishing our own Name Change Policy, SIAM joined the National Laboratories Name Change Initiative For Published Research Outputs.[2] This effort supports researchers who wish to change their names on published research outputs.

In 2020, SIAM joined the "Joint commitment for action on inclusion and diversity in publishing."[3] All major commercial publishers and many societies have now joined this industry-wide group. Committees continue to develop standardized recommendations that consider the types of demographic data that should be collected and explore ways to do so meaningfully, all while addressing privacy issues.

SIAM Digital Library Upgrade

The upgrade to the SIAM Digital Library—which hosts our journals, books, and proceedings—is well underway and scheduled to go live in the first quarter of 2022. This upgrade will deliver an array of new features, including responsive design, related content recommendations, an Extensible Markup Language (XML) full-text versions of articles in addition to PDFs, enhanced support for digital supplementary materials like embedded video and code, and an integrated SIAM online bookstore that will allow SIAM to sell e-books directly to individuals for the first time.

Open-access Business Models

SIAM continues to remain compliant with open-access mandates from research funders. For example, *all SIAM journals are Plan S-compliant via the green open-access route*. Various open-access business models are emerging across the publishing industry, ranging from gold open access/transformative agreements to "Subscribe to Open." All have pros and cons that we must carefully consider to ensure that SIAM publications maintain the highest quality and remain financially sustainable in the future. To that end, SIAM is currently creating a data warehouse to disambiguate our datasets and analyze each institution's publication and subscription activities with the society. This warehouse will enable us to model potential ways forward while simultaneously safeguarding the quality and standards for which SIAM is known.

Expanding ORCID Peer Reviewer Recognition

Following a successful pilot in 2020, all SIAM journals now permit referees to recognize and log their SIAM peer-review

See **SIAM Publications** *on page 10*

[1] https://www.siam.org/publications/journals/related/journal-policies/detail/siam-name-change-policy

[2] https://diversity.lbl.gov/namechange

[3] https://www.rsc.org/new-perspectives/talent/joint-commitment-for-action-inclusion-and-diversity-in-publishing

Publication	Outgoing Editor-in-Chief	Incoming Editor-in-Chief
SIAGA	Bernd Sturmfels	Jan Draisma
SIIMS	Miki Elad	Gabriele Steidl
SINUM	Angela Kunoth	Mark Ainsworth
SISC	Jan Hesthaven	Hans De Sterck

Figure 1. *The outgoing and incoming editors-in-chief for the SIAM Journal on Applied Algebra and Geometry (SIAGA), SIAM Journal on Imaging Sciences (SIIMS), SIAM Journal on Numerical Analysis (SINUM), and SIAM Journal on Scientific Computing (SISC).*

SIAM Texas-Louisiana Section Holds Fourth Annual Meeting

By Yifei Lou

The SIAM Texas-Louisiana Section[1] (SIAM TX-LA) recently held its fourth annual meeting[2] (TXLA21) in South Padre Island, Texas. The University of Texas Rio Grande Valley's (UTRGV) College of Sciences and School of Mathematical and Statistical Sciences hosted the three-day conference, which took place in early November 2021. SIAM contributions provided travel support for three plenary speakers, 21 travel awards for undergraduate/graduate students and postdoctoral researchers, and cash prizes for outstanding posters. The meeting attracted an impressive 275 attendees.

The conference agenda consisted of a career panel discussion, three plenary lectures, a poster session, and more than 50 minisymposia. Topics addressed a wide spectrum of applications that included biomedicine, life and social sciences, image processing, and data science. Presenters reported on cutting-edge methodologies and computational algorithms such as algebraic and geometric approaches, model order reduction, finite element methods, and deep learning. The meeting was an engaging in-person affair; in fact, it was the first in-person conference for many participants since the beginning of the COVID-19 pandemic.

The first special event was a career panel with panelists Cristina Villalobos, associate dean of UTRGV's College of Science; Victoria Huynh, senior director in the Science and Research Department at PROS; and Michael Chertkov, chair of the Program in Applied Mathematics at the University of Arizona. The career panel attracted a large number of students and early-career researchers who sought to broaden their career opportunities and hone the necessary skill sets to achieve their goals.

Lisa Fauci of Tulane University delivered a plenary lecture titled "Buckling, Mixing, Swimming, Dissolving: Adventures with Helices at the Microscale" that was open to the public. Fauci, who was the SIAM Past President at the time of the meeting, also gave a speech during the conference dinner.

Rachel Ward of the University of Texas at Austin and Alejandro Aceves of Southern Methodist University presented the other two plenary lectures. Ward spoke about "Data-driven Forecasting in Complex Systems: A Tale of Two Approaches Using Kernels and Random Projections," and Aceves provided a whirlwind tour of the history of dynamical systems approaches for climate change models that culminated in his own recent contributions. Both talks engaged their audiences and stimulated a series of interesting questions and discussions.

Students, postdoctoral researchers, and professors displayed over 40 posters during the poster session. Three graduate students went home with monetary awards for outstanding posters: Madhu Gupta of the University of Texas at Arlington received first place, Ziheng Chen of the University of Texas at Austin received second place, and Amir Targholizadeh of UTRGV received third place. Kaylee Terrell and Dashon Mitchell of Tarleton State University won the prize for the best undergraduate poster.

The conference organizing committee consisted of a local UTRGV group, the SIAM TX-LA section officers, and the section's district liaisons. The local UTRGV Organizing Committee was chaired by Vesselin Vatchev and included Dambaru Bhatta, Baofeng Feng, Eleftherios Gkioulekas, Kristen Hallas, Zhijun Qiao, and Kristina Vatcheva. TXLA21 received positive feedback from participants, who praised the choice of venue, broad scientific program, and safety precautions in light of COVID-19. Its success has encouraged the SIAM TX-LA section officers and liaisons to begin planning for the fifth annual meeting in 2022.

Yifei Lou is an associate professor in the Department of Mathematical Sciences at the University of Texas at Dallas. She currently serves as secretary of the SIAM Texas-Louisiana Section.

[1] https://www.siam.org/membership/sections/detail/siam-texas-louisiana-section-siam-txla

[2] https://www.siam.org/conferences/cm/conference/txla21

A lively poster session in the hotel lobby at the 4th Annual Meeting of the SIAM Texas-Louisiana Section. Photo courtesy of Kristina Vatcheva.

Former SIAM President Lisa Fauci of Tulane University delivers remarks during dinner at the 4th Annual Meeting of the SIAM Texas-Louisiana Section. Photo courtesy of Yifei Lou.

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 industry, government, and academia. Mathematical sciences students and faculty—including SIAM student chapters—can invite SIAM VLP speakers to talk about topics that are of interest to developing professional mathematicians. The ongoing pandemic has made the VLP an even more valuable resource. As many departments rethink their procedures due to the current climate, why not host a SIAM visiting lecturer for a virtual talk?

The SIAM Education Committee sponsors the VLP and recognizes the need for all members of our increasingly technological society to familiarize themselves with the achievements and potential of mathematics and computational science. We are grateful to the accomplished applied mathematicians who have graciously volunteered to serve as visiting lecturers.

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. Organizers can reach out directly to speakers and must address these points when communicating with them. It is important to familiarize speakers with their audience—including special interests or expectations—so that they can refine the scope of their talks, but just as crucial to accommodate speakers' suggestions so that the audience can capitalize on lecturers' expertise and experience. Read more about the program and view the current list of speakers online.[1]

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

Math and Basketball: Landing My Dream Job as a Data Scientist

By Ivana Šerić

CAREERS IN MATHEMATICAL SCIENCES

I've loved both basketball and mathematics ever since I was a child. I grew up in Split, Croatia — a city with a long and rich basketball tradition. Basketball has been part of my family long before I was born; my father played when he was young and my older brothers started playing at an early age. After witnessing a few of their practices and trying the sport myself, all I wanted was to become a professional basketball player.

When I was 12 years old, I watched a National Collegiate Athletic Association (NCAA) women's basketball game for the first time. Tamika Catchings of the University of Tennessee instantly became my favorite player, and I was enthralled with the fans' energy and excitement in the arena. From that day on, my dream was to study and play basketball in the U.S. However, I knew that I needed to earn an athletic scholarship in order to do so.

Off the court, mathematics was always my favorite subject in school. I appreciated the logic and sets of relevant rules, but also the creativity that is necessary to follow the rules, stay within their boundaries, and still find a path to a solution. Another reason why I liked mathematics in elementary school was because once I understood the concept, I didn't need to study anymore; this meant that I had more time for basketball.

When it came time to choose a high school, I had two options: a less demanding school that would allow extra time for basketball or a more challenging, math-focused one that would better prepare me for college. I chose the school with the advanced math and science program, which meant that I had to limit the amount of time that I spent on basketball practice every day. Nevertheless, I never missed a practice and studied whenever I could. One year later, I moved to Požega to play with their team in the top Croatian league and transferred to another high school with a demanding math and science program. I did not want to have to focus on just basketball *or* mathematics.

My dream of attending college in the U.S. became a reality by pure coincidence. Living in Croatia, I didn't know any college coaches in the U.S. and wasn't even sure how the teams recruited their players. By the time I sent a DVD of one of my games, most coaches had already filled their roster spots. I thus began working on an alternative plan to study and play basketball in Croatia. But in early July, I received an email from a family friend with a valuable connection. This friend knew someone from New York who in turn knew a coach who was looking to recruit additional players — Margaret McKeon, who had just become the head coach of the women's basketball team at the New Jersey Institute of Technology (NJIT). I sent her a recording of a game and she offered me a full scholarship. In a way, I was lucky that my previous contacts were unsuccessful. NJIT made it possible for me to study math and play basketball, both at a very high level; NJIT has a strong applied mathematics program and its athletic program had recently transitioned to NCAA Division 1.

Throughout most of my undergraduate education, I intended to play professional basketball and then become a math teacher once my athletic career was done. However, several injuries hindered my success on the basketball court. I was also becoming increasingly aware of the unlikelihood of pursuing professional women's basketball, simply because the opportunities to play at a high level and make a living are so scarce. I ultimately began to turn to my math career much sooner than I had originally hoped. During my senior year at NJIT, one of my professors—Eliza Michalopoulou—suggested that I take a few graduate courses in place of my electives; these courses would also count towards my degree requirement if I opted to stay at NJIT for graduate school. At the same time, I was taking a capstone class that introduced me to academic research. I started to think that a research career might be fun.

Inspired by conversations with multiple NJIT professors, I decided to apply for NJIT's Ph.D. program after my senior-year basketball season. At the time, Shahriar Afkhami and Lou Kondic—who became my thesis advisors—were working on fluid dynamics research that involved modeling, computation, and collaboration with experimentalists from other universities. For the first time since I started learning math and playing basketball, I left one and focused all of my energy on the other. However, I did play recreational basketball during the first three years of graduate school.

While working on my thesis in computational fluid dynamics (CFD), I began to research possible job prospects upon graduation. I found that National Basketball Association (NBA) teams were hiring data scientists to work with their basketball operations departments and use data to devise game-day strategies. Unfortunately, I wasn't studying data science. Shortly thereafter, I stumbled upon Coursera: free university courses that anyone can take online. I promptly enrolled and started to explore data science. Luckily, CFD provided me with most of the necessary skills for the subject; I already knew how to write code, process large data files and extract

See **Math and Basketball** *on page 12*

Ivana Šerić played on the women's Division 1 basketball team as an undergraduate student at the New Jersey Institute of Technology (NJIT). Photo courtesy of NJIT.

SIAM Publications

Continued from page 8

work in their ORCID[4] accounts. The ORCID records indicate that they have served as a reviewer for a particular SIAM journal but of course do not reveal the specific article in question. More than 700 referees have already taken advantage of this opportunity since the option became available; this number represents about 35 percent of total referees.

Prophy's Referee-finding Tool

SIAM is cooperating with Prophy Science to integrate its referee-finding tool[5] within EJPress, our manuscript submission system. In the near future, *SIAM Journal on Scientific Computing*[6] (*SISC*) editors will be able to search for reviewers whose expertise aligns with the paper that is under review. In an earlier SIAM trial, editors found this tool to be helpful and noted that it sometimes led them to reviewers upon whom they did not previously call. If Prophy proves successful for *SISC* editors, we will consider implementing it for all SIAM journals.

Please Recommend *SIMODS* to Your Library

After a very successful launch period, the *SIAM Journal on Mathematics of Data Science*[7] (*SIMODS*) will join the SIAM collection of subscription journals in 2022. Jobs in data science are projected to increase by an impressive 30 percent in the next decade, so we expect *SIMODS* to go from strength to strength.

To ensure that you and your colleagues continue to have access, *please recommend SIMODS to your institutional library* by downloading this recommendation form[8] and forwarding it to your librarian. Your faculty support is key to this journal's success. If you have any questions, reach out to Patricia Hartner (SIAM's Manager of Institutional Sales and Licensing) at **hartner@siam.org**. Answers to frequently asked questions about *SIMODS* are also available online.[9]

Finally, I close with one last request: always be sure to download SIAM articles from the SIAM journals platform when you are logged into your institution (whether remotely or by IP address when on campus). Every downloaded SIAM article demonstrates the value of SIAM resources and acts as a vote for your library to retain SIAM journals. In these times of pressured budgets, librarians are looking increasingly closely at the number of times users download articles from SIAM journals. In some cases, librarians have even cancelled SIAM subscriptions without informing the faculty.

I look forward to seeing and speaking with more of you in person next year. In the meantime, feel free to reach out to me at **bowling@siam.org** with any questions or comments.

Kivmars Bowling is the Director of Publications at SIAM.

[4] https://orcid.org
[5] https://www.prophy.science/referee-finder
[6] https://epubs.siam.org/journal/sjoce3
[7] https://epubs.siam.org/journal/simods
[8] https://go.siam.org/FJR0Cc
[9] https://sinews.siam.org/Details-Page/siam-journal-on-mathematics-of-data-science-frequently-asked-questions

SIAM Recognizes Two New Project NExT Fellows to Advance Faculty Development

By Kathleen Kavanagh, Katherine Harris, and Chase Mathison

SIAM continues to support the professional development of junior faculty, particularly in the areas of teaching and applied mathematics education. For example, the SIAM Activity Group on Applied Mathematics Education[1] (SIAG/ED) seeks to advance the progress and practice of educational courses, programs, and resources in applied mathematics. In 2020, SIAM began to annually sponsor two Project NExT (New Experiences in Teaching) Fellows in an effort to further encourage early-career faculty. Project NExT[2] is a program of the Mathematical Association of America (MAA) that supports the professional development of new or recent Ph.D.s in the mathematical sciences. According to the MAA, the program "addresses all aspects of an academic career: improving the teaching and learning of mathematics, engaging in research and scholarship, finding exciting and interesting service opportunities, and participating in professional activities."

Katherine Harris, Beloit College.

An excellent education in applied mathematics is the first step in preparing graduates for the workforce. Junior faculty have the chance to actively inspire and empower students from different backgrounds to solve complex, real-world problems, thus cultivating a universal appreciation of mathematics. Project NExT therefore intends to equip its Fellows with the right resources and training experience to thrive in academic settings. Participants also build a network of peers and mentors as they explore their new careers.

After their selection, each cohort of Project NExT Fellows participates in a three-day workshop in late July or early August, right before MAA MathFest at the end of the summer. They then partake in a similar workshop that precedes MathFest—and more workshops during the event—the *following* year. Last year's workshop topics included building and sustaining a local learning population, overcoming math anxiety in the classroom, charting one's career course, creating a vibrant and inclusive community, orienting the classroom around inquiry, and teaching proof as a way of knowing. Project NExT Fellows also had the opportunity to meet with their teaching support groups during the workshops; these meetings continued periodically throughout the year. In addition, they organized Project-NExT-sponsored sessions at both MathFest and the Joint Mathematics Meetings (JMM).

The 2022 SIAM Project NExT Fellows are Katherine Harris (Beloit College) and Chase Mathison (Shenandoah University). Harris is an assistant professor of mathematics and computer science at Beloit College. Her research interests fall at the intersection of computer algebra, applied algebra, numerical algebraic geometry, and symbolic computation. She earned her Ph.D. at North Carolina State University, where she developed hybrid symbolic-numeric algorithms to solve problems in real algebraic geometry. Harris believes that promoting applications of mathematical theories is vital to student engagement in the field at small liberal arts colleges like Beloit. She is excited to incorporate these ideas into her classrooms and better prepare students for careers in both academia and industry.

Harris' membership in the SIAM Activity Group on Algebraic Geometry[3] has been foundational to her development as a research mathematician. She is interested in the way in which SIAM programs like SIAG/ED will pair with her Project NExT Fellowship to make mathematical communities more inclusive for undergraduate students—especially those from underrepresented groups—who are in the early stages of their careers. Project NExT has already provided Harris with a valuable cohort, dedicated mentors, and ample resources on topics like inquiry-oriented and project-based learning — all of which she believes will benefit her and her students.

Chase Mathison is in his second year as an assistant professor of mathematics at Shenandoah University. His research interests include inverse problems in medical imaging and microlocal analysis applications to thermoacoustic tomography. He earned his Ph.D. from Purdue University, where he studied thermoacoustic tomography with circular integrating detectors and sampling in thermoacoustic tomography under the direction of Plamen Stefanov. As an educator, Mathison believes that exposing students to fascinating and challenging real-world applications of mathematics is the best way to promote mathematical learning. He is a member of SIAG/ED and finds this group to be incredibly helpful in improving his teaching skills.

Chase Mathison, Shenandoah University.

Project NExT's most recent three-day workshop provided Mathison with valuable information about new teaching techniques, including mastery-based grading; he hopes to implement this method in the spring. The Fellowship has also allowed him to meet fellow colleagues and share in the common interests and challenges of being a new faculty member. Mathison is looking forward to attending JMM in 2022, partaking in more Project NExT workshops, and meeting other NExT-ers in person.

Candidates who are interested in applying for the Project NExT Fellowship must submit a personal statement, research statement, one-page curriculum vitae, and letter of support from their department chairs. Applicants must hold a recent Ph.D. in mathematics, statistics, mathematics education, or another math-intensive field; in addition, they should have a teaching position and experiences, attitudes, ideas, and leadership abilities that would benefit the cohort. To be considered for SIAM sponsorship, applicants must indicate their SIAM membership on the application. An MAA committee makes all final Project NExT Fellow selections. The next application deadline is April 15, 2022; more information about the program and application process is available online.[4]

One exceptional faculty member can have a far-reaching positive impact within SIAM and among the broader scientific research community. SIAM is excited to contribute to excellence in applied mathematics education for the next generation's interdisciplinary mathematicians. Interested parties may also wish to attend the upcoming SIAM Conference on Applied Mathematics Education,[5] which will take place in a hybrid format jointly with the 2022 SIAM Annual Meeting[6] this July in Pittsburgh, Pa.

Kathleen Kavanagh is a professor of mathematics at Clarkson University and the Vice President for Education at SIAM. Katherine Harris is an assistant professor of mathematics and computer science at Beloit College. Her research interests fall at the intersection of computer algebra, applied algebra, numerical algebraic geometry, and symbolic computation. Chase Mathison is an assistant professor of mathematics at Shenandoah University. His research interests include inverse problems in medical imaging and microlocal analysis applications to thermoacoustic tomography.

[1] https://www.siam.org/membership/activity-groups/detail/applied-mathematics-education

[2] https://www.maa.org/programs-and-communities/professional-development/project-next

[3] https://www.siam.org/membership/activity-groups/detail/algebraic-geometry

[4] https://www.maa.org/programs-and-communities/professional-development/project-next

[5] https://www.siam.org/conferences/cm/conference/ed22

[6] https://www.siam.org/conferences/cm/conference/an22

Professional Opportunities and Announcements

*Send copy for classified advertisements and announcements to **marketing@siam.org**. For rates, deadlines, and ad specifications, visit **www.siam.org/advertising**.*

*Students (and others) in search of information about careers in the mathematical sciences can click on "Careers" at the SIAM website (**www.siam.org**) or proceed directly to **www.siam.org/careers**.*

Seeking an Exceptional Mathematician

I believe that I have discovered several very short possible proofs of three very difficult conjectures: the $3x+1$ Conjecture, Fermat's Last Theorem (FLT) (which is actually a conjecture), and Goldbach's Conjecture. Only FLT has already been proved — with a proof of more than 100 pages.

In the past four years, hundreds of people have visited the possible proofs online. Only the proof for Goldbach's Conjecture has received any claims of an error — two in all, both a result of misunderstandings of the argument.

All of my possible proofs are based on the same simple strategy: find a structure that contains all possibilities and shows important relationships between them.

I am all too aware of the skepticism with which academic mathematicians regard the efforts of outsiders (my degree is in computer science, and for most of my career I have been a researcher in the computer industry). My only hope is to find a mathematician with the insight to see that my possible proofs are at least worthy of serious consideration, and the courage to join me in preparing a paper that contains at least one of them for submission to a journal.

Papers containing the possible proofs are located at **occampress.com**.

— *Peter Schorer,* peteschorer@gmail.com

Reflecting on a Year of Digital Communications

By Becky M. Kerner

We have just closed out the first-ever year during which nearly all SIAM events took place virtually — phew! As we reflect on the past year and its challenges, it is uplifting to see that we have certainly learned a great deal.

I was continually impressed by how quickly our community adapted and came together to maintain productivity on valuable work and collaborations, all by taking advantage of the technology at our fingertips. From virtual conferences, panels, career fairs, and committee meetings to productive exchanges of information through Engage,[1] activity group webinars, social media, *SIAM News*, emails, and more — 2021 was definitely a year of online communication. The SIAM Marketing and Communications team had our work cut out for us, and we took the opportunity to push ourselves and challenge our thinking, explore new ways of doing things, and adapt novel technologies to keep the community together virtually. Here are some of this year's Marketing milestones.

Career Fairs

Have you attended a career fair at a SIAM conference in previous years? These events have historically occurred in person, so 2021 marked our first-ever virtual fairs! We are proud to have hosted two virtual career fairs last year—in March and November—that offered hundreds of jobseekers the opportunity to network with representatives from leading companies and organizations. In total, we hosted 27 companies and 750 participants, which resulted in nearly 1,800 engaging conversations during the fairs. If you think that your company may be interested in partnering with SIAM as a sponsor or participating in our next career fair, email **marketing@siam.org**!

Virtual Conferences

SIAM achieved another first in 2021 by holding all major conferences completely virtually.[2] You may have been one of the nearly 10,000 people who participated in a virtual conference; if so, thank you for your engagement! Although virtual events are undoubtedly different from in-person gatherings, SIAM staff worked hard to find a platform and structure that allowed for collaboration and learning, even when attendees were not face-to-face with each other. We had more than 63,500 visits to our virtual event platforms this year and 5,000+ visits to the exhibit halls, where attendees connected with our sponsors and corporate partners; we also hosted over 6,000 virtual talks. In 2022, we'll be embarking on a new journey to master hybrid conferences. Check our conference calendar[3] for up-to-date conference listings and details.

MathWorks Math Modeling Challenge (M3 Challenge)

SIAM's M3 Challenge spotlights applied mathematics and technical computing as powerful problem-solving tools and viable, exciting professions. Michelle Montgomery, the M3 Challenge Project Director, started the program 17 years ago; since then, SIAM's Marketing and Communications team has managed it under her direction. 2021 was a milestone year for M3 Challenge because it marked the contest's international expansion — participation is now open to students in England and Wales as well as the U.S. Of the 535 participating teams in 2021, 57 of them hailed from outside the U.S. We also held the final event virtually—for the first time in M3 Challenge history—during which top teams presented their solutions and SIAM staff, judges, special guests, and student representatives spoke (see Figure 1). Nearly 52,000 students have partaken in M3 Challenge to date, after which 25 percent of them report that they are more likely to pursue a degree/career in STEM. The contest has awarded $1.65 million in scholarships to over 3,300 students. Visit the M3 Challenge website[4] to learn more about how you can volunteer as a judge or submit a problem topic.

Social Media and Video Engagement

Do you follow us on Facebook,[5] Twitter,[6] LinkedIn,[7] and YouTube[8]? We now have a combined 68,000 followers on these platforms and our M3 Challenge channels, all of whom are keeping up-to-date with SIAM happenings and general math in the news. In 2021, we added upwards of 70 videos to our YouTube channel—many of which are from virtual panels, conference talks, and webinars—and had an impressive 202,000+ views of SIAM videos on YouTube (amounting to 6,300+ hours of watch time)! We also produced a video[9] about mathematics' importance in the development of the COVID-19 vaccine, which features SIAM member Jeffrey Sachs of Merck & Co., Inc. Visit us on YouTube to browse our full collection of educational videos. We were also thrilled to see that our monthly *Unwrapped*[10] e-newsletter was opened more than 150,000 times in 2021 — a 50 percent increase from the prior year. Thank you for staying engaged!

Public Relations

We've distributed several national press releases that featured our community's research on topics that were especially timely in 2021, including vaccination and social distancing protocols,[11] student debt,[12] and gerrymandering.[13] These efforts landed media coverage in *Forbes*, *WCGO Radio Chicago*, *Patch*, *NPR*, *Radio Health Journal*, and *California Business Journal*, among many others. If you come across any recent *SIAM News* or journal articles that are of great public interest, please email **marketing@siam.org** with the article or link.

Our community was more involved than ever in 2021, and applied mathematics and computational science have remained at the forefront of much crucial ongoing research around the world. Thank you for your continued important work, which allows us to communicate the value and significance of mathematics to a broader audience. Cheers to another productive year ahead!

Becky M. Kerner is the Director of Marketing and Communications at SIAM.

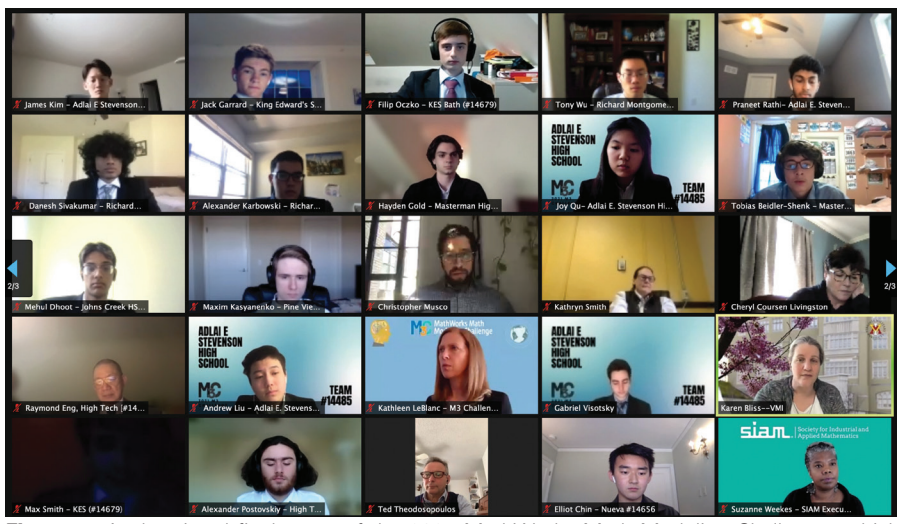


Figure 1. *At the virtual final event of the 2021 MathWorks Math Modeling Challenge, which took place in April 2021, top teams presented their solutions and SIAM staff, judges, special guests, and student representatives delivered remarks.*

[1] https://engage.siam.org/home

[2] https://sinews.siam.org/Details-Page/the-continued-evolution-of-siam-conferences

[3] https://www.siam.org/conferences/calendar

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

[5] https://www.facebook.com/SocietyforIndustrialandAppliedMath

[6] https://twitter.com/TheSIAMNews

[7] https://www.linkedin.com/company/societyforindustrialandappliedmathematicssiam

[8] https://www.youtube.com/user/SIAMConnects

[9] https://go.siam.org/otIGXo

[10] https://sinews.siam.org/Happening-Now/Unwrapped

[11] https://sinews.siam.org/Details-Page/metapopulation-model-accounts-for-asymptomatic-spread-of-covid-19

[12] https://sinews.siam.org/Details-Page/finding-the-optimal-way-to-repay-student-debt

[13] https://sinews.siam.org/Details-Page/every-vote-counts-it-depends-where-you-draw-the-line-says-leading-nc-mathematician-ahead-of-fall-redistricting

Math and Basketball

Continued from page 10

summary information, and create visualizations from data. I was then able to expand my machine learning knowledge via additional online courses. Although I knew that securing a job in the NBA was a very long shot, I figured that learning data science would be helpful regardless.

I began to apply for data science jobs with different NBA teams during my last year of graduate school. At the same time, I was also applying for postdoctoral openings, teaching positions, and other data science gigs in industry. Despite keeping all of my options open, I had no responses for months. Suddenly—right before my thesis defense—I received three offers in one week, including one from the Philadelphia 76ers. Here was a chance to have both math and basketball in my life again! Accepting the position was an easy decision.

Although the data evolution in U.S. sports commenced with baseball, NBA teams began to invest in the procurement of more game data in the mid-2000s. They collaborated with third-party providers to obtain player tracking data — coordinates of players and the ball in 25 frames per second. In 2013, the NBA decided to formally contract with the providers to attain data for all games. Suddenly, basketball went from about 400 rows of data per game from box score and play-by-play to roughly one million rows of data per game from player tracking.

During my four years with the Philadelphia 76ers, my research and development team consisted of mathematicians, software developers, and computer scientists. We worked on collaborative projects that provided data-driven information to the front office staff: the general manager and executive team, performance science team, medical team, and coaches. Our work consisted of quick analyses, long-term research projects, and general software development. I utilized various skills from my mathematics education, including modeling of physical systems (e.g., shot trajectories and the motion of players on the court), statistical modeling (e.g., regression and random forests), programming (e.g., Python, HTML, and CSS), and data visualization. In addition, writing scientific papers during graduate school prepared me to generate data-driven reports.

Last year, I joined Overtime Elite (OTE)[1] — a transformative new sports league that offers the world's most talented young basketball players a better pathway towards becoming professional athletes. We are currently in our first season and have just built a new 103,000-square-foot state-of-the-art facility that includes two NBA-sized practice courts, a separate court for games, classrooms for the school, a full-size weight room, a training room, and offices for all employees. I lead the OTE's Strategy and Research group, which supports the Basketball Operations group in all data-related tasks. Joining the league at its onset allowed me to be involved in many projects that are already completed in the NBA. Some of these projects include determining the sports technology companies with which to partner, partaking in discussions about game rules and schedules, building balanced rosters, deciding which data to share with NBA scouts, and so forth. Joining a new league and leaving a well-established organization like the NBA was risky, but the experience I have gained thus far has been well worth the risk.

As a lifelong athlete, working in sports is truly a dream come true for me. As a mathematician, I'm thankful for the chance to show the world that math is cool. One of the biggest changes I noticed when I started working in professional basketball was people's reactions when they asked about my job. When I was a graduate student, individuals frequently told me that they hated math. Now they are amazed that I have such a "cool" job. I see this response as a benefit of my career; I can use it to change people's minds about mathematics and introduce them to its many exciting real-world applications.

The Overtime Elite (OTE) league provides transformative opportunities for talented young basketball players. Ivana Šerić (far right) leads the OTE's Strategy and Research group, which supports the Basketball Operations group in all data-related tasks. Photo courtesy of Ivana Šerić.

[1] https://www.overtimeelite.com

Ivana Šerić currently leads the Strategy and Research team at Overtime Elite. She received her B.S. and Ph.D. degrees from the New Jersey Institute of Technology, where she was a four-year starter for the women's basketball team during her undergraduate years.