



ORIE

Newsletter
Spring 2021

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Muckstadt celebrate his 80th
birthday

**ORIE: THE UNSUNG
ENGINEERING
BEHIND CORNELL'S
SOCIAL DISTANCING**



MESSAGE FROM THE DIRECTOR

While the students are only in Rhodes Hall today in small socially-distanced numbers, they are still learning the same fundamental truths you did when you were here. Seniors are diving deep into their chosen classes (some in-person, some virtual), readying themselves for those first few years on the job. Sophomores are gaining a deeper understanding of physics and chemistry. First-year students are wondering if they can make it through this place.

On the other hand, even in the last few years, a lot has changed in the School of Operations Research and Information Engineering that has very little to do with the pandemic response. Our toolbox for tackling difficult decision-making problems continues to expand. Students still learn about continuous and discrete optimization, probability and statistics and stochastic processes. However, we also added machine learning, reinforcement learning and some neural net applications to our portfolio. The application domains include classical areas of finance, manufacturing and supply chain management, but also newer areas including online marketplace design, health care and the sharing economy (to name just a few). All of this is being re-thought through a modern lens of theoretical advances and in today's data-rich environment.

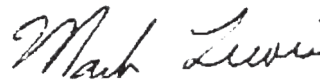
As I am certain you have heard, ORIE has had an outsized impact on Cornell's reopening over the last year leading teams that provided crucial counsel to Cornell's senior leadership. The dedicated faculty, staff and students throughout the university have a new (or maybe renewed) appreciation for what mathematical modeling can do for the world. During this time the usual "hallway buzz" you may remember has moved to a slight murmur. And yet, if you could look through the window at masked students attending office hours, you can see the wheels are still turning! Rest assured we are all excited to see a return to normalcy and be able to welcome you back in the near future!

Aside from our work with the University on the pandemic response, we welcome three news members to our faculty. Nikhil Garg and Omar El Housni have joined our Cornell Tech team as an assistant professor and visiting assistant professor respectively, while Frans Schalekamp—no stranger to Rhodes Hall—returns as a senior lecturer.

Also inside this issue you'll read about some wonderful accomplishments of our faculty and Ph.D., M.Eng. and undergraduate students.

Despite all the challenges we've endured this past year, it has been a remarkable year for all of us in Ithaca and New York City.

Warm regards,



Mark E. Lewis
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ON THE COVER

Cornell turned to its own School of Operations Research and Information Engineering, where faculty and students live and breathe mathematical modeling, optimization, and analysis for data-driven decision making.

THE ORIE MISSION

The School of Operations Research and Information Engineering's mission is to host research programs, a full spectrum of educational programs, and industry outreach activities spanning its eponymous domain.

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As the coronavirus pandemic surged in the spring of 2020, Cornell University leaders faced a critical question as they contemplated an in-person fall semester: Would it even be possible?

It was a question that universities across the nation were grappling with as they tried to imagine what a safe, residential semester would require. Not only would Cornell need to establish a virus-testing protocol, but adhering to health guidelines meant students would have to sit at least 6 feet apart, drastically reducing the university's classroom space. Exactly how much classroom space did Cornell have to work with, and could it accommodate any kind of course schedule?

It was the type of mathematical challenge fit for a logistics consulting firm, or perhaps a challenge better suited for a supercomputer given the looming deadline—just a matter of weeks—to determine the fate of the semester.

For its solution, Cornell turned to its own School of Operations Research and Information Engineering, where faculty and students live and breathe mathematical modeling, optimization, and analysis for data-driven decision making.

With the clock ticking, Cornell needed an exceptional and dependable plan to keep its community socially distanced and safe.

What does 6 feet apart even mean?

To identify options for the fall semester, Cornell assembled the Committee on Teaching Reactivation Options, comprised of faculty, students and staff, including David Shmoys, the Laibe/Acheson Professor of Business Management and Leadership Studies in the School of Operations Research and Information Engineering.

In thinking about how feasible it would be to host in-person classes, the committee knew it was only practical if every student in lectures would be sitting 6 feet apart, recalled Shmoys.

"If a student was in class and it was between their last negative COVID-19 test and a positive test, we didn't want to—from a health regulation standpoint—quarantine the entire class," said Shmoys.

Determining how much classroom space the university had was a capacity planning exercise similar to what Shmoys would assign in one of his undergraduate courses. Except with so little known about coronavirus and the coming semester, it was far from a typical exercise.

"How many instructors would want to hold classes in person and what capacity would we have in order to do that? Which classrooms have fixed seating and which have movable seating? There were all kinds of issues coming into play and we were trying to understand what the limits really looked like," said Shmoys, who added that another challenge was interpreting information about how the virus spreads, such as what 6 feet of social distancing really

The Unsung Engineering Behind Cornell's Social Distancing



David Shmoys, the Laibe/Acheson Professor of Business Management and Leadership Studies, put together an all-star team of faculty and students to help solve Cornell's fall 2020 scheduling dilemma.

meant.

"Is it from the center of the seat to the center of the other seat? Is it from the edge of the seat to the edge of the seat? That one little change of phrase could make a 30% difference in terms of the number of seats that you can fit into an existing space," said Shmoys. As it turns out, the Tompkins County Health Department clarified that proper social distancing measures from the center of one seat to the edge of the next.

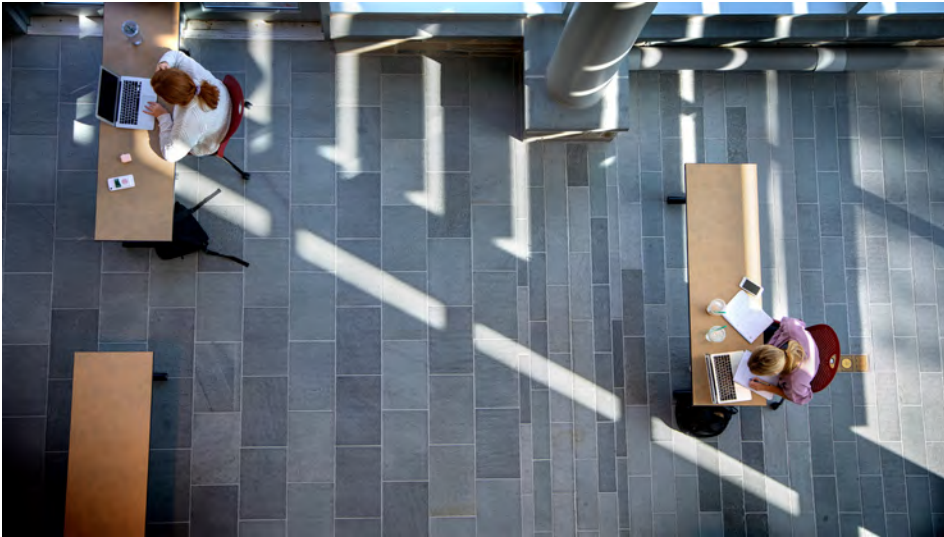
Using an Excel spreadsheet, Shmoys began constructing a simple model with the help of undergraduate student Brian Liu '20, who assisted with data analyses and preparatory estimates. They determined that classrooms would hold roughly eight-to-10-times fewer students than before the pandemic, giving the university the answer it needed: Yes, an in-person semester did appear feasible, but only if course times and locations could be assigned appropriately.

By mid-June, the university had made its decision—the fall 2020 semester would be in-person, offering a variety of modalities, including online and hybrid approaches. Now, Cornell just needed a schedule.

"I hope you weren't planning on doing anything this summer"

As soon as Cornell confirmed its plan for a residential fall semester, Lisa Nishii, vice provost for undergraduate education, turned to Shmoys. "I hope you weren't planning on doing anything this summer," she remembers quipping before asking Shmoys to co-lead the university's Course Roster and Scheduling Team.

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Students meet for class in the Baker Portico in Statler Hall.

“It felt like we were building a parallel university in six weeks,” said Nishii. “All our normal institutionalized practices, the systems, the workflows, all of that totally shattered and we had to start from scratch.”

Co-leading the scheduling team was the university registrar, Rhonda Kitch, who said being faced with building the entire university’s fall 2020 schedule was a daunting task.

“We knew developing the processes and tools needed to successfully build the roster and ultimately hold enrollment in the fall, or pre-enrollment for the spring, required optimization skillsets beyond the capacities within the Office of the University Registrar,” said Kitch.

Shmoys saw the challenge as a class of scheduling problems similar to what he and many faculty members had worked on before. So he assembled an all-star team of his colleagues to contribute to the design and implementation of the schedule, including Oktay Gunluk, professor of practice and former manager of the Mathematical Optimization and Algorithms Group at IBM Research; David Williamson, a professor specializing in optimization problems and scheduling; and Brenda Dietrich, the Geoffrion Family Professor of Practice and former vice president of IBM Research with decades of experience in applied optimization projects.

With the semester slated to begin Sept. 4 and class registration needing to occur before that, the group had just a matter of weeks to build, from the ground up, a schedule that would keep students safe.

Armed with blueprints for 484 classrooms and spaces large enough to be scheduled with more than 10 students, the group divided the problem into two challenges: determine the times of the

classes, and assign the classes to classrooms.

“We went multiple directions simultaneously, so that there were different groups that worked on different approaches,” said Shmoys. “There were many different ways to decompose the problem into smaller problems and we explored some of the most promising ones in parallel because we knew we had a hard deadline and the goal was to be sure that we had something that we could hand to the registrar.”

In a normal practitioner setting, the scheduling challenge would be solved with a draft solution that would then go back to the client for review. Perhaps three or more iterations of the solution would be presented before all of the kinks would be worked out. But the Cornell group didn’t have that luxury.

“We didn’t have time to get things wrong,” said Shmoys. “We had one shot and that was it. We had to get it right.”

“The project kind of spiraled into being a 24/7 process”

While the Office of the University Architect and one of the faculty groups began reviewing classroom blueprints, trying to determine each room’s new capacity, another group began working on building a schedule.

But how can a course be scheduled without knowing if a properly sized room will be available to host it? As a preliminary solution, the group categorized classrooms using a formula to determine how many students they thought each could hold – 16-20, 21-25 and 26-30, for example – hoping they had accurate enough estimates until better data was developed, according to Gunluk.

“The main approach we took was to model this using mixed integer programming,” said Gunluk, referring to a type of model in which some decision variables are not discrete. “And even in that case, you can build different kinds of integer programming models to deal with the same problem.”

Gunluk asked one of his Ph.D. students, Connor Lawless, if he had a couple extra hours to donate to the effort.

“I thought, ‘sure, maybe I’ll read in some data, create a quick graph and get to learn more about scheduling problems,’” recalled Lawless. “Well, the model we were working on ended up being the winning one and from that point onward the project spiraled into being a 24/7 process for a month.”

There were many considerations—different options for class lengths, different combinations of days they could be scheduled

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on, and there was also the challenge of not crowding hallways by scheduling too many classes at the same time in the same building. To do this, the group began to model activity on campus as a function of time of day.

But the main challenge, as Lawless and others saw it, was that Cornell's scheduling had been perfected in an iterative manner over the course of years, with many underlying assumptions baked into the schedule. For instance, almost every junior who takes ORIE 3300 is also taking ORIE 3500. The registrar learned not to schedule those classes together, but over time the reasoning for that separation was lost as the schedule was carried over from one semester to the next.

"There are all these idiosyncratic elements that go into making a schedule that most people, departments included, forget about until they look at a final schedule" said Lawless. "We would assign something like a math class in Schwartz Auditorium and call it a day. But then you'd get waves of complaints arguing that everything from the location to the color or length of a blackboard was all wrong."

The Course Roster and Scheduling Team began hosting weekly town halls with academic departments to flesh out some of the class overlaps to avoid, but department representatives didn't have a strong sense of elective courses in neighboring departments.

"There was this other piece to the project of just how do we use the data that we have to infer the kind of things that historical judgment has allowed us to settle into over time," said Shmoys, who assigned undergraduate student Anders Wikum '21 to find a way to extract as much of that information as possible from previous semesters.

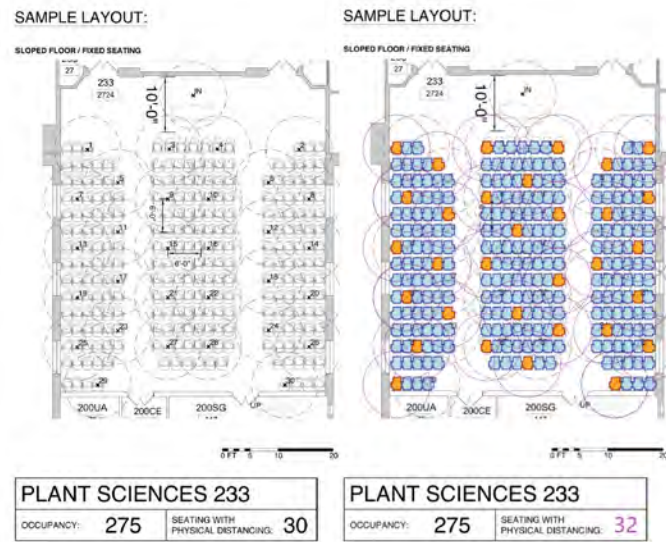
Wikum's job was to "let the data speak" by finding annual trends in which students concurrently enrolled in two courses. Later, he also built a model for assigning office-hour rooms to departments.

"It was all happening so quickly."

As one group of engineers began homing in on a rough schedule, another was trying to develop a more precise list of how many students each classroom could actually hold. It was a tedious process going through each room, one by one, examining the dimensions of the walls and calculating how many desks could fit while meeting health guidelines.

"We had been working with the registrar and Professor Shmoys through the first hundred or so spaces to ensure we were maximizing the number of seats while strictly adhering to health department spacing guidelines, required exit pathways, adequate ventilation and sight-lines for AV," said Margaret Carney, university architect. "We needed a way to automate the process."

Shmoys thought it was an interesting problem he could introduce to his ENGRI 1101 course, which he was updating to



Classroom diagrams shown before and after optimal seating was determined using software developed by Cornell engineers.

include more real-world, computational experiences for students. So he assigned undergraduate student Qihan 'Jody' Zhu '22 to build a class exercise around room capacity, together with operations research doctoral student Sander Aarts.

"It was basically just a maximum independent set at the core of the problem," said Zhu, "If we could also figure out how to automatically recognize seats when given a floor plan, then one thing that we thought we could do better than the architect's office was to speed up the process."

So, Zhu coded a software program that could import classroom blueprints, read the floor plans, and use computer vision to help identify where seats could be placed.

"Jody came back after one week," recalled Robbins, "She found an automated way to identify every seat in a room. This allowed rooms to pack an additional two to three seats compared to the architect's model. It was pretty incredible to see the tool be produced so quickly."

Shmoys, impressed with what his students had created, approached Carney with the software and asked if she was interested in using it.

"When Professor Shmoys offered the assistance of his students and the software program they had invented, I thought he was joking," said Carney. "Luckily, it was no joke, but it was magic, and a great collaboration between architects and engineers," said Carney.

The university offered summer jobs to two prospective engineering students, Kyle Greenberg and Trey Hensel, working with staff at the architect's office, going through each classroom and

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tweaking the software's image recognition to work with different kinds of drawings. In the end, the software helped identify over 400 additional seats that could be used by the university.

"We just kept working on it and eventually got the results the university needed," said Zhu. "Looking back, I'm really proud of the role I played, but at the time, it was all happening so quickly."

"Are we going to have a schedule?"

With proposed course times and capacity determined, and with just days to spare, the groups could now merge their efforts into an initial schedule.

"We were lucky enough to pick a model for the problem that can be solved to optimality in a small amount of time, which means that we could optimally assign all classes to classrooms and times," said Gunluk. "But when you're dealing with a large project like this, this is just the first stop."

As knowledge of the coronavirus evolved, so did the schedule. So when health officials recommended placing 20 minutes between classes instead of 15, the group had to adjust their model. Then, it was recommended that every classroom be sanitized once in the middle of the day, in addition to a deep cleaning overnight. Once again, the model was fine tuned.

"This modeling is partially an art, it's not just math," said Gunluk. "It is important to pick a model that can gracefully handle new information and constraints that come up later."

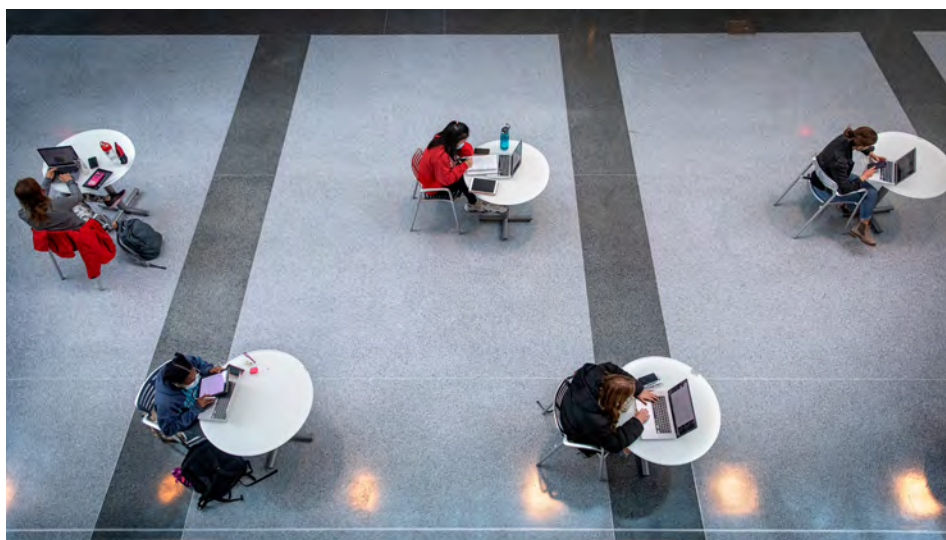
With an initial schedule complete, hundreds of requests for changes began pouring in from the departments, effectively turning the group into a customer service unit. And with each request, accommodating the customer could mean the difference between students getting an in-person lecture and having to go virtual.

"I processed scheduling changes using Connor's model," said Robbins. "We managed them using a Google sheet and by the end, we processed over 250 schedule change requests."

The group tirelessly worked on each request, figuring out how to rearrange classes and hardcoding it into their model.

"Someone would communicate changes back to the departments. Often, they were of the form 'we rescheduled one of the two courses that previously conflicted,'" recalled Robbins. "Their response was usually 'that doesn't work either.' We processed these changes non-stop, every day for about a week."

There was also the matter of scheduling evening prelim exams. With the capacity of classrooms limiting how many prelims could be



Students work at socially distant tables in the Physical Science Building.

given at one time, the unpopular, but necessary, decision of adding Sunday prelims was made.

It was all coming together, but in the last days of developing Cornell's fall 2020 schedule, everything still felt uncertain to the team.

"David would come to our daily meetings and introduce another big hurdle," said Robbins, "and we'd question, 'Are we going to have a schedule? Are we not? Will we even have a semester?' It was an interesting environment to work in, unlike anything I have worked in before."

Nishii was also feeling the pressure. "I called the provost not that long before the start of the fall semester and I said, 'I don't know if we can do it. I don't know if we have enough hours times humans to pull this off.'"

"These are incredible students"

Requests were serviced, hurdles were jumped, and the model was updated again and again. It was all leading to a final effort to merge scheduling data with the registrar's.

Because the decisions of departments, faculty, and teaching graduate students frequently changed as data was being collected through the summer, a systematic data integrity check was required to weed out any undetected errors in the schedule. It was a four-day effort for Shmoys and his team, but finally, the weary group of faculty, students and staff had a completed schedule.

"The work of the past months has been intense," said Kitch, who commended all who collaborated across campus to build the fall schedule. "These individuals have spent hours meeting and collaborating days, nights and weekends to meet goals and

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milestones. I've joked I spent more time in meetings with David than with my own family."

But even with the schedule finalized, the job wasn't complete. As the semester got underway, issues developed in which the group would have to swing back into action.

"Because many of rooms that were being used were brand new to a class, you can have instances where an A/V configuration is almost unusable for a professor's teaching style, or you have a discussion section that's all about conversational Spanish in a lecture hall that turns out to be way too large," said Lawless. "So we handled those as they came in."

As the semester progressed, it became clear that the schedule was working. And after students went home for winter break, the university declared fall 2020 a success. In a message emailed to the Cornell community, Vice Provost Nishii said there was no evidence of instances in which COVID-19 had spread in a classroom setting. And despite a drastic reduction in classroom space, about 60% of students received some form of in-person instruction.

"We were very concerned that first-year students would get the least amount of face-to-face time because they tend to be in larger intro classes, which are more likely to be online because we don't have the space," said Nishii, "but as it turns out, they ended up faring quite well."

Without Shmoys and the other faculty members from the School of Operations Research and Information Engineering, there may not have been an in-person fall semester, according to Nishii. She added that Shmoys' students are especially deserving of recognition.

"They're brilliant," said Nishii. "I hope they understand just how much they're contributing to the functioning of the university. We couldn't have opened without a course roster."

"These are incredible students," added Shmoys. "To see them come together, commit and work incredibly hard, I mean, there were all-nighters that were done along the way to get things where they needed to be. They did it unflinchingly and they delivered."

And yes, the group has already begun scheduling the spring semester and expect it to be even better than the fall because of lessons learned, mostly for the diversity of courses and majors that have specific needs.

"There are always new twists, but the group is up for the challenge," said Shmoys. "It's just so very satisfying to be the beneficiary of this talent, this deep-seeded love of Cornell, and this real sense of heart."

By Syl Kacapyr

The Team

Faculty

- **David Shmoys, Oktay Gunluk, David Williamson, Brenda Dietrich**— Faculty design team for scheduling.
- **Kim Weeden**— Translated data from PeopleSoft and the registrar into forms that could be distributed to the departments.

Doctoral students

- **Connor Lawless**— Led the implementation of the primary optimization models, interfaced with the Office of the University Registrar, and in general, was the backbone of the optimization team.
- **Shijin Rajakrishnan**— Managed the process of tracking the updates on room capacities and other data management issues for room availability, as well as doing early optimization work on classroom layout, which highlighted that improvements to the architects' plans were possible.
- **Matthew Zalesek and Billy Jin**— Worked on the data integrity process, as well as the process of coordinating with the departments' change requests.
- **Varun Suriyanarayana**— Worked on campus visualizations to show intensities of activity on campus as a function of time of day.
- **Sotiris Ntanavaras**— Developed the evening prelim scheduling model, and managed the initial process of constructing the prelim schedule.
- **Sander Aarts**— Worked on the development of the classroom optimization tool, and prototyped its implementation working with College of Engineering.
- **Sam Gutekunst**— Oversaw the two ORIE undergraduates who worked with the Office of the University Architect.

M.Eng. students

- **Vidhisha Nakhwa**— Set up the data collection from the departments and did the first round of pre-processing on all roster changes collected from the departments, and managed the semi-final and final exam scheduling for the fall.
- **Frank Chi and Catherine Wang**— Developed the automatic tools for providing user-friendly outputs of the schedules to the departments. Chi also built the optimization model for one of the decomposition approaches that was built as a backup to the primary approach.

Undergraduate students

- **Anders Wikum**— Developed the data-driven approach to understanding class conflicts and built the model for assigning office-hour rooms to departments. He also built a visualization tool to understand remaining classroom capacity given partial room assignments.
- **Qihan "Jody" Zhu**— Coded a software program that uses computer vision to help identify where seats could be placed as part of the classroom optimization tool.
- **Henry Robbins**— Played the lead role in managing departments' requests for changes to the fall course roster, and developed the room assignment model for exams.
- **Brian Liu**— Assisted with data analyses in doing preparatory estimates during the C-TRO planning phase, including examining the feasibility of optimally grouping first-year students' dormitory assignments based on their course schedule (to establish pods), and also worked with OVPR in trying to understand activity on campus for research reactivation.
- **Trey Hensel and Kyle Greenberg**— Worked on the detailed modeling to use the classroom optimization tool, in conjunction with the Office of the University of Architect, to get more seats in classrooms.
- **Sam Shvets**— Worked on refining the visualization tool for displaying the remaining classroom availability for updates as part of the spring roster development.

During late spring and early summer of 2020, as Cornell administrators pondered whether and how the university should reopen for a residential fall semester, the logistics were daunting and disheartening.

“It was pretty clear that the conditions were likely to be very similar in the fall — that is, the virus would still be present, we would have a population that was susceptible to infection by the virus, and absent putting in place clear mitigation risks, we would be in trouble,” said Provost Michael Kotlikoff, “It was unlikely that we would have what I would [call] a perfect option.”

Less than three weeks before students returned home to complete the semester online, Cornell exceeded its own projections in keeping campus and the surrounding community as safe as possible.

Cornell saw fewer than 200 on-campus coronavirus infections — one-sixth of the 1,200 projected in the university’s initial model. The low rates were achieved through the tireless work of students, university leaders and experts across fields, in cooperation with the Tompkins County Health Department and Cayuga Health System, who devised, deployed and continuously reassessed strategies to effectively fight a formidable and unpredictable virus.

“The semester is going much better than we modeled, and much better than I hoped for,” said Peter Frazier, associate professor in the School of Operations Research and Information Engineering in the College of Engineering, whose team developed the models Cornell used in building its testing strategy.

Among the reasons, he said, is that some things they feared did not actually happen, such as infections spreading in classrooms and residence halls. Students were highly compliant, and frequent testing was effective. The rate of transmission from

Data, Testing Helped Cornell Curb COVID-19

the community beyond Cornell was lower than they’d anticipated, though the number of infections among staff, particularly those who live outside Tompkins County, rose.

“Another reason the overall outcomes have been much better than we expected is that the interventions we put into place got better and better over time,” Frazier said.

For example, the team developed targeted testing for groups at higher risk, in addition to adaptive testing, which tests a wider circle of acquaintances than the Centers for Disease Control and Prevention’s definition of close contacts. And at Cornell Health — using de-identified data culled from patient interactions, as well as information from contact tracing and privacy-protecting public health apps — staff adjusted efforts as they monitored and tracked trends on campus.

“The clinical information Cornell Health clinicians gather in the service of patient care is captured, de-identified and distilled by these new public health modules that allow us to inform understanding of the impact and the risks on the community and support the pandemic response in a unique way,” said Sharon McMullen, assistant vice president of student and campus life for health and well-being.

In partnership with other units — such as Environmental Health and Safety, Human Resources, and University Relations — Cornell Health contributes to the campus public health campaign to boost cooperation with measures such as mask-wearing and physical distancing, McMullen said.

“It couldn’t simply be enforcement-oriented; we had to help people understand and buy into the need for these mitigation efforts,” she said. “Cornell-specific data informs every part of the messaging, which



Associate Professor Peter Frazier

is what makes it so successful.”

Frequent, rapid testing — twice weekly for undergraduates — is the cornerstone of Cornell’s plan, and would not have been possible without the rapidly built Cornell COVID-19 Testing Lab (CCTL), hosted by the College of Veterinary Medicine (CVM). CCTL can process up to 7,000 samples per day using pooled testing, in which five samples are pooled and analyzed together, said Dr. Diego Diel, CCTL director and associate professor in CVM’s Department of Population Medicine and Diagnostic Sciences.

“When we started discussing this, we all realized the only way we would pull this off was if we could do pool testing instead of individual sample testing,” Diel said.

He and others also decided to test students using anterior nasal swabs, which collect samples from the front of the nostril, rather than nasopharyngeal swabs, which collect from deep inside the nose. The slight

ORIE FACULTY NEWS

loss in sensitivity, they believed, would be outweighed by the frequent testing and greater compliance with the less-invasive method — a supposition borne out by students' high testing compliance, said Dr. Gary Koretzky, vice provost for academic integration and professor in the Department of Medicine at Weill Cornell Medicine.

Students complete around 98% of the scheduled tests each day, the data show.

"That says to me: They care. They're part of the solution. They're proud of what it is we've been able to accomplish and they want to see that go forward," Koretzky said.

Last summer, when Frazier was calculating projections based on various frequencies of testing, Koretzky said, each time "my heart would sink further and further, because this was an enormous undertaking."

But the effort has paid off, he said.

"We recognized at the very start that we were entering uncharted waters," Koretzky said. "The things that really have distinguished Cornell's response have been this recognition that asymptomatic individuals can transmit the disease, and you have to test robustly. But it's also that you have to constantly learn. And so what we do is that we examine every single infection on campus, we look at it, and we try to determine what we might learn from it."

By Melanie Lefkowitz



Clockwise from top left: Christopher Wofford of eCornell; Provost Michael Kotlikoff; Sharon McMullen, assistant vice president of student and campus life for health and well-being; Dr. Gary Koretzky, vice provost for academic integration and professor in the Department of Medicine at Weill Cornell Medicine; Dr. Diego Diel, Cornell COVID-19 Testing Laboratory director and associate professor in the College of Veterinary Medicine's Department of Population Medicine and Diagnostic Sciences; and Peter Frazier, associate professor in the School of Operations Research and Information Engineering in the College of Engineering.

ORIE makes big impact on 2020-21 academic year

The School of ORIE spearheaded major efforts that have enabled Cornell to remain open for the 2020-21 academic year.

Center for Data Science for Enterprise and Society

Separately, David Shmoys led a major scheduling effort working with Oktay Gunluk, Brenda Dietrich, and David Williamson, Ph.D. students and undergraduates to reschedule Cornell's Ithaca campus classes. This rescheduling made the low-density campus possible.

To read more about the team's work, please visit [COVID-19 Mathematical Modeling for Cornell's Fall Semester](#).

Cornell engineers are crunching numbers to fight everything from coronavirus to climate change

Data scientists never really know where their work is going to take them. David Shmoys, the Laibe/Acheson Professor of Business Management and Leadership Studies at Cornell Engineering, has applied his mathematical tools to topics ranging from woodpecker populations to bike sharing programs. And when a global pandemic broke out, he was ready to shift his attention to the biggest crisis of our time.

To read more about ORIE's influence, please visit [Big Red Data](#).

ORIE FACULTY NEWS

The 2020 INFORMS Annual Meeting was presented and attended, for the very first time, entirely in a virtual format, prioritizing the health and safety of those attending.

The current pandemic did little to slow down the impact of School of Operations Research and Information Engineering faculty and students who once again continue to rack up accolade after accolade.

Below, is a list of the awards/recognitions ORIE faculty and students received:

- Adrian Lewis, The Samuel B. Eckert Professor of Engineering, won the John von Neuman prize, awarded for a body of work, with fundamental, sustained contributions to theory in operations research and the management sciences. Adrian will receive \$5000, a medallion and a citation for his contribution that has stood the test of time.
- Wes Gurnee '20, founder and Executive Director of Fairmandering, won the INFORMS Undergraduate Research Prize, the top prize given to undergraduates at the INFORMS annual meeting, for the joint paper with David Shmoys, "Fairmandering: A Column Generation Heuristic for Fairness-Optimized Political Redistricting".
- Bhavik Shah '19 (Finalist)—INFORMS Undergraduate Research Prize for "Mixed Integer Linear Programming Under Preference Uncertainty"
- Tiandong Wang, Ph.D. candidate at Cornell University, (Runner-Up)—2020 Doctoral Dissertation Award for Operations Research in Telecommunications and Network Analytics, recognizing outstanding scholarly achievements of young people in the field, for the Ph.D. thesis "Heavy Tail Phenomena in Preferential Attachment Networks"—ORIE 2019,

advisor Sid Resnick. Dr. Wang is currently an Assistant Professor in the Department of Statistics at Texas A&M University.

- Nikhil Garg, joining Cornell Tech as an assistant professor in July 2021, was awarded the George B. Dantzig Dissertation Award, established to encourage academic research combining theory and practice and given for the best dissertation in any area of operations research and the management sciences that is innovative and relevant to practice for his thesis "Designing Marketplaces and Civic Engagement Platforms: Learning, Incentives, and Pricing". Nikhil will be given a monetary award of \$800 for first place.
- Omar El Housni, visiting assistant professor at Cornell Tech, received second place in the 2020 George

CORNELL ORIE @ INFORMS

Nicholson student paper competition, awarded to identify and honor outstanding papers in the field of operations research and the management sciences, for the paper "On the Optimality of Affine Policies in Dynamic Robust Optimization".

- Qiaomin Xie, visiting assistant professor with ORIE, was awarded a Research Award from the Google's Systems and Infrastructure Group. The award comes with an unrestricted gift of \$10,000.



ADRIAN LEWIS WINS JOHN VON NEUMANN PRIZE

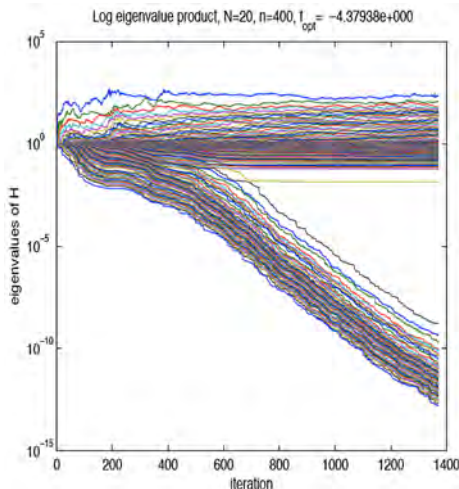
The 2020 INFORMS John von Neumann Theory Prize was awarded to Adrian S. Lewis, the Samuel B. Eckert Professor of Engineering in the School of Operations Research and

Information Engineering at Cornell, “for his fundamental and sustained contributions to continuous optimization, operations research, and, more broadly, computational science. His work has pushed the frontiers of nonlinear optimization and convex analysis and developed path-breaking theory that has led to much subsequent work.”

“This prize represents a pinnacle of my career,” Lewis said. “It is a wonderful honor from my scientific community, one that has left me flabbergasted...”

“I do enjoy crafting an intellectual story. For me, this prize honors a narrative of exciting ideas, blending variational themes and computation, ideas that I was lucky enough to bounce around with many extraordinary co-authors,” said Lewis. “Among them, my early mentor Jon Borwein first taught me about the fundamental role of metric regularity in understanding sensitivity analysis. I wove Jon’s lesson together with ideas of problem robustness, nonsmooth calculus and geometry, and algorithmic speed, in work with Asen Dontchev and Terry Rockafellar (the 1999 prize-winner) that grew into my 2014 talk for the International Congress of Mathematicians.”

Lewis describes how three particularly enjoyable collaborations have dominated his thinking. First, over two decades, Jim Burke and Michael Overton have taught him the interplay between classical matrix analysis, contemporary optimization, systems control, and computational methods. “A single picture (‘spectrum’) serves to illustrate—a quasi-Newton spectrum steadily separating while successfully running a classical smooth algorithm—due in part to 2017 prize-winner Don Goldfarb—on a nonsmooth eigenvalue optimization problem to which, seemingly, it should not apply,” says Lewis. “We still cannot explain this picture.”



Smooth optimization of a nonsmooth objective



Samuel B. Eckert Professor of Engineering Adrian S. Lewis

“Secondly, back in 2004, two gifted European postdoctoral visitors chanced by my office simultaneously,” Lewis said. “Jerome Bolte, Aris Daniilidis, and I confidently predicted eternal obscurity for the resulting study on the Kurdyka-Lojasiewicz inequality—a type of error bound, measuring success in concrete nonsmooth optimization problems. To our happy surprise, this work has grown into a cornerstone of convergence analysis in optimization for machine learning.”

“Lastly, here in my ORIE home, I like to explain, tongue only slightly in cheek, that Dima Drusvyatskiy began his Cornell life in 2008 as my student but ended as my advisor,” Lewis continued.

ORIE FACULTY NEWS

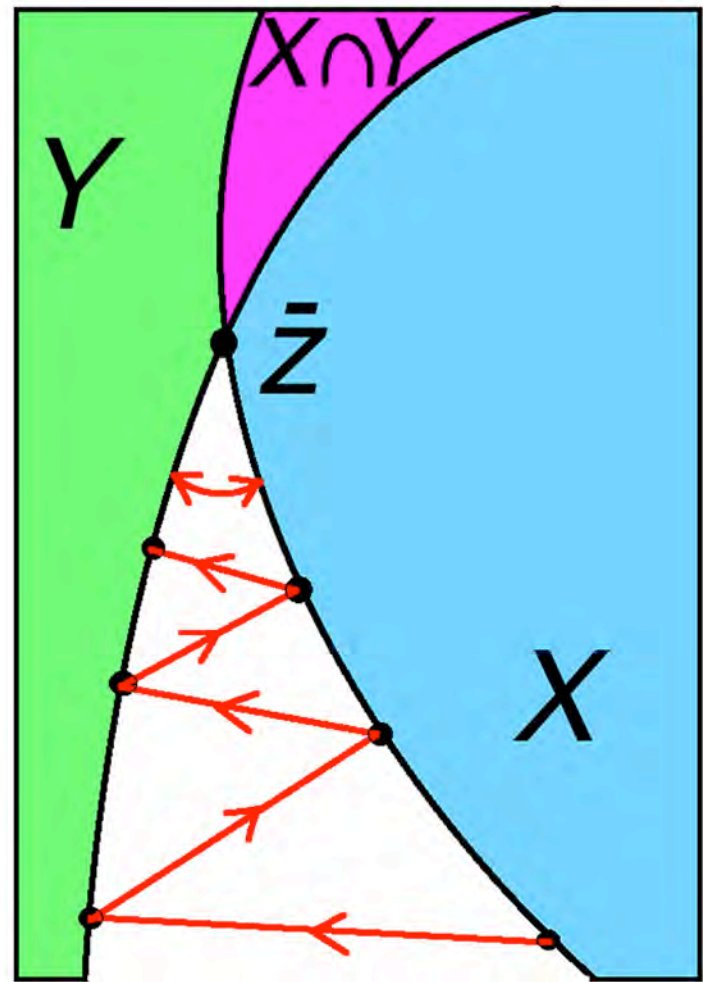
"Dima initially followed my interests (partly with Steve Wright) in the foundations of active set methods in optimization. These techniques date back to the simplex method of George Dantzig, the inaugural prizewinner in 1975. Dima and I quickly moved on to a fruitful collaboration with Alex Ioffe that included a breakthrough in our understanding of how nonconvex alternating projection algorithms converge. Over the last century, researchers regularly rediscover this intuitive technique — see the second picture ('transversal'). Those rediscoveries range from popular contemporary applications in the big data arena all the way back to 1933 when the discoverer was none other than John von Neumann himself."

"Professor Lewis has published seminal work on a wide range of topics including eigenvalue optimization, quasi-Newton algorithms, gradient sampling methods and control, activity identification via partial smoothness, alternating projection methods, conditioning and error bounds, semi-algebraic variational analysis and the Kurdyka-Lojasiewicz inequality, and hyperbolic polynomials," said Pinar Kesknocak, INFORMS president, and Asuman Ozdaglar, INFORMS acting prize committee chair, in a written statement. "The clarity and elegance of his writing is well-known and admired. Through scholarly papers, research monographs, and mentorship, he has influenced several generations of optimization researchers, as well as practitioners."

"His results on convex analysis over Hermitian matrices opened the door to the subdifferential analysis of such functions, as well as to a duality and sensitivity theory for optimization problems with such functions," they continued. "Together with Burke and Overton, he produced a series of papers leading to a deep understanding of the variational behavior of spectral functions, including the spectral radius. His convergence guarantees for alternating/cyclic projection methods, both for convex and nonconvex settings, are used to find a point at the intersection

"This prize represents a pinnacle of my career," Lewis said. "It is a wonderful honor from my scientific community, one that has left me flabbergasted..."

— Adrian Lewis



The method of alternating projections

of finitely many sets, a prototypical problem in computational mathematics."

"A consistent theme in Professor Lewis's work is to bring variational analytic tools and computation closer together. For example, his recent paper, with Drusvyatskiy and Ioffe, proves that under a natural transversality condition, described in variational analytic terms, the method of alternating projections converges linearly locally," Kesknocak and Ozdaglar concluded. "His more recent work has focused on understanding the impact of variational analytic notions of stability on linear/quadratic rates of convergence of Gauss-Newton type methods for minimizing compositions of convex functions and smooth maps. These results have implications for a number of fundamental problems including phase retrieval, matrix factorization, and robust principal component analysis."

Williamson receives COE advising award

Professor David Williamson has received the James M. and Marsha D. McCormick Award for Outstanding Advising of First-Year Engineering Students.

The McCormick Advising Award is the highest award for advising in the college. Williamson was nominated by students in the College of Engineering and selected by a committee within the College of Engineering.

Prior to founding First Manhattan Consulting Group, James M. McCormick '69, '70 M.Eng. worked at McKinsey and Bell Labs. He earned his bachelor's and master's degrees in operations research and industrial engineering. The McCormicks' son, JJ '05, M.Eng. '06, is also a graduate of the College of Engineering.

Professor Williamson has also received the College of Engineering Excellence in Teaching Award three times (2007, 2013, 2016) and has been selected ORIE's Undergraduate Professor of the Year twice (2015-16, 2016-17).

He received his Ph.D. in computer science from Massachusetts Institute of Technology under Professor Michel X. Goemans in 1993. After a postdoc at Cornell under Professor Éva Tardos, he was a research staff member for IBM Research at the T.J. Watson Research Center in Yorktown Heights, N.Y. From 2000-03, he was the senior manager of the Computer Science Principles and Methodologies group at IBM's Almaden Research Center in San Jose, Calif., before moving back Cornell in 2004.



Professor David Williamson

Project will strengthen global supply chains with AI

A new grant will fund Cornell research into developing machine learning and blockchain tools to better understand and support the global supply chain, whose vulnerabilities were exposed by the COVID-19 pandemic.

Andreea Minca, associate professor of operations research and information engineering in the College of Engineering, was awarded a three-year, \$250,000 grant by Axa, the multinational insurance company based in France, for the research.

"In March we were experiencing shortages, especially in some medical devices, because everything had broken down—there was

really a collapse of the supply chains," said Minca, whose usual area of research is in finance and systemic risk.

"This funding will allow us to develop mathematical technology methodology to identify vulnerabilities in global supply chains and in their insurance/reinsurance networks," she said, "so those systems become more robust."

Reinsurance is pooled insurance purchased by insurance companies to protect themselves from large losses stemming from major events. When reinsurers cover primary insurers of the supply chain system, as well as other reinsurers, it creates a complex system; poor design of these systems can lead to catastrophic losses.

Minca's project aims to develop tools for machine learning-based market designs in supply chain networks with reinsurance contracts, in order to identify potential gaps before another pandemic or disaster occurs.

Because these systems are so complex, machine learning is helpful in identifying the structures that could pose systemic risk, Minca said.

Her team will also use mathematical tools to study the design of system insurance, in which entities such as local governments are incentivized to contribute to a "rainy-day fund" that could buffer supply chains in the event of disasters.

Thirdly, the project will design blockchain systems that use geographic information to verify maritime data, to ensure that this data is consistent and accurate across different providers.

"How do you design a system in which people are reporting the location of a shipment, in a context where there are severe restrictions on where the shipments can go because of a pandemic?" Minca said. "You could have closed ports, you could have outbreaks in some areas, and those become no-go zones—all of that needs to be verifiable by multiple parties."

The research, Minca hopes, will help supply chains and the companies that insure them better prepare for future catastrophes with worldwide consequences.

"What was really shocking with COVID-19 was this disjointed supply and demand," she said. "Borders were shutting down, which made it impossible to make and route shipments in an optimal way. To be prepared for that, you need to have some contingency plans, and they need to be financially supported, so things don't break down at the next shock."



Professor Andreea Minca

ORIE FACULTY NEWS

López de Prado appointed to global lead position at ADIA

The Abu Dhabi Investment Authority (ADIA), one of the largest sovereign wealth funds, has appointed Marcos López de Prado, a visiting professor at Cornell Financial Engineering Manhattan, as global head of quantitative research and development.

Professor López de Prado's department is tasked with applying a systematic, science-based approach to developing and implementing investment strategies. This multi-disciplinary team will draw on the latest scientific developments, in areas such as machine learning, big data and high-performance computing.

Professor López de Prado is a recognized expert in financial machine learning. His innovations have covered and connected a wide range of subjects, including overfitting prevention, signal processing, quantum computing, stochastic optimal control, robust convex optimization, and market microstructure. These innovations have resulted in dozens of scientific articles in the leading academic journals, and 13 patents, most of which have been acquired by asset management companies.

At Cornell University, López de Prado teaches financial machine learning within the operations research and information engineering program, and directs multiple student projects. In addition, he is a frequent speaker at Ph.D. programs and Cornell seminars.



Professor Marcos López de Prado

Davis wins Sloan fellowship

School of Operations Research and Information Engineering assistant professor Damek Davis won a 2020 Sloan Research Fellowship from the Alfred P. Sloan Foundation. The fellowship supports early-career faculty members' original research and education related to science, technology, mathematics and economics.

Davis is among the 126 researchers in the United States and Canada who received two-year, \$75,000 fellowships to advance their work.

"A Sloan research fellow is someone whose drive, creativity and insight makes them a researcher to watch," said Adam F. Falk, president of the Sloan Foundation.

Davis studies the mathematics of data science, particularly in the interplay of optimization, signal processing, statistics and machine learning. His research is helping to lay the mathematical foundations of machine learning algorithms, which often succeed in practice although researchers lack a coherent mathematical understanding of why they work and the class of problems one could prove they could solve.



Professor Damek Davis

In his work, he employs an eclectic mix of mathematical tools—including variational analysis, stochastic processes and high-dimensional statistics—to design and analyze non-convex optimization methods, which underlie the most-effective machine learning algorithms. Davis seeks to explain why these methods are so good at training machine learning models, which could provide techniques to help practitioners consistently improve models' performance.

Tardos named to APS

Éva Tardos, the Jacob Gould Schurman Professor of Computer Science and ORIE field member, has been elected to the American Philosophical Society (APS), the oldest learned society in the United States.

Tardos, whose research focuses on algorithms and algorithmic game theory, is best-known for her work on network flow algorithms, approximation algorithms and quantifying the efficiency of selfish routing.

The American Philosophical Society was founded by Benjamin Franklin in 1743 for the purpose of "promoting useful knowledge." The society supports research, discovery and education through grants and fellowships, lectures, publications, prizes and exhibitions.

Past members include George Washington, John Adams, Thomas Jefferson, Thomas Paine, John James Audubon, Charles Darwin, Thomas Edison, Louis Pasteur, Albert Einstein and Robert Frost.



Professor Éva Tardos

ORIE FACULTY NEWS

Garg to join Cornell Tech faculty

Nikhil Garg will be an Assistant Professor of Operations Research and Information Engineering at Cornell Tech starting in July 2021.

Garg's research is at the intersection of computer science, economics, and operations — on the application of algorithms, data science, and mechanism design to the study of democracy, markets, and societal systems at large. His research interests include surge pricing, rating systems, how to vote on budgets, the role of testing in college admissions, stereotypes in word embeddings, and polarization on Twitter.

He has spent time at Uber, NASA, Microsoft, the Texas Senate, and IEEE's policy arm, and most recently was the principal data scientist at PredictWise — which provides election analytics for political campaigns.

Lodi joins Tech campus

Andrea Lodi received his Ph.D. in system engineering from the University of Bologna in 2000 and was a Herman Goldstone Postdoctoral Fellow at the IBM Thomas J. Watson Research Center in Westchester County, N.Y. in 2005-06. He was a full professor of operations research at the Department of Electrical, Electronic and Information Engineering, the University of Bologna between 2007 and 2015. Since 2015, he has been the Canada Excellence Research Chair in "Data Science for Real-time Decision Making" at Polytechnique Montréal.

Professor Lodi's main research interests are in mixed-integer linear and nonlinear Programming and data science and his work has received several recognitions including the IBM and Google faculty awards.

He is the author of more than 100 publications in the top journals of the field of mathematical optimization and data science. He serves as editor for several prestigious journals in the area.

Schalekamp named senior lecturer

Frans Schalekamp rejoined the ORIE faculty as a senior lecturer last summer.

Schalekamp received his Ph.D. in Operations Research from Cornell in 2007. He has worked both in academia and in industry on three continents, and on areas ranging from plant breeding and genetics to logistics. He has held academic positions at the Institute for Theoretical Computer Science at Tsinghua University in Beijing, China, the Department of Mathematics at the College of William & Mary in Williamsburg, Va., and the Computer Science Department at Cornell.

Frans's research interests lie in optimization, both in practice

NEW FACULTY IN ITHACA, NYC

and theory. He has worked on problems in bioinformatics, sensor networks and information science.

El Housni joins Cornell Tech as visiting assistant professor

Omar El Housni is currently a Visiting Assistant Professor at Cornell Tech in Operations Research and Information Engineering.

His research revolves around decision-making under uncertainty where he aims to design robust and efficient algorithms for a wide-range of dynamic optimization problems with applications in revenue management and matching platforms.

El Housni holds a Bachelor's degree in applied mathematics from École Polytechnique (France), and a Master of Science and a Ph.D. in Operations Research from Columbia University.



Nikhil Garg



Andrea Lodi



Frans Schalekamp



Omar El Housni

If you've ever used Uber, then you probably know about surge pricing, times when the fare price suddenly increases for rides originating in a certain location. For riders, a surge can be an unanticipated expense that makes them look for other transportation. For drivers, it represents an opportunity: get to where the surge is happening and make more money.

"If you're a driver and you're far away from the area that is surging, you might consider going there if you can be sure the surge price will remain in effect," says Peter I. Frazier, Associate Professor of Operations Research and Information Engineering. "But you also know other drivers might get there before you and take all the rides, so you might decide not to go."

To Switch or Not

Maybe just enough drivers arrive at the surging location to pick up all the passengers who need a ride. Maybe too few show up, and riders are left waiting in vain. Or perhaps so many drivers decide to follow the surge that some do not get a trip. What can be done to make sure things work well consistently? Frazier, who holds a half-time position at Cornell and also works for Uber as a staff data scientist, is currently researching this supply-and-demand conundrum as a Cornell scholar.

"This sort of question originally came up at Uber, but then I noticed it in other places too: academics choosing whether to start doing research in a hot new area, sellers on eBay choosing whether to start selling a new kind of fad product. Anything where there's a cost of switching into a new area and an uncertain reward that depends on the number of other people that switch." Joining former Cornell colleague Krishnamurthy Iyer and graduate student Pu Yang, Ph.D. '19, Operations Research and Information Engineering, Frazier is analyzing data and building mathematical models to explore the phenomenon.

Along with the research he does for and about Uber, Frazier also works with many different collaborators, such as biochemists and material scientists, on a wide range of problems requiring machine learning, a type of artificial intelligence application that uses data and previous experience to adapt and learn. Frazier's expertise helps narrow down decisions on what kind of data his colleagues should collect for a given purpose.

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Searching for Peptides with a Special Enzymatic Activity

In one such project, Frazier joined with a number of collaborators at the University

HOW WE USE MACHINE LEARNING

of California, San Diego (UCSD) and Northwestern University. The researchers wanted to find short peptides with a specific type of enzymatic activity that allows them to attach or detach molecules to proteins, making them prime candidates for applications such as drug delivery.

"When the people at UCSD approached me, they had examples of longer peptides that had this particular enzymatic activity, but they wanted shorter ones that had the same property," Frazier says. "Initially, they had experimental data for 15 peptides. So we went through rounds where my algorithm would recommend roughly 500 peptides based on the earlier experimental data. We'd test all 500, and then using the data from those 500, we'd run through the algorithm again and get another 500 and test those, and so on."

Using this optimal learning approach, the researchers ultimately developed a method to identify short peptides as selective substrates for enzymes. "What my algorithm does is something humans also can do pretty well for a few things at a time," says Frazier. "A human could probably keep the data on three peptides in their head and judge each peptide on the relevance to the task of being biologically active but also diverse. But to do that simultaneously for 500 peptides would be really tough."



Whether considering the cost of switching to something new or data mining other complex questions, machine learning crunches deep data for answers.

Neural Networks for Predicting the Behavior of Stocks, Web Browsing, Autonomous Vehicles, Much More

Frazier also works on projects dealing with deep neural networks, systems of software patterned after neurons in the brain, with many layers. Neural networks use sophisticated mathematical modeling to process data in complex ways. “Deep neural networks are used for predicting all kinds of things,” he says. “They’re used a lot in hedge funds for predicting movements of stocks. They’re used to predict the behavior of people on the web, and they’re used in autonomous vehicles for things like figuring out whether something is a tree or a stop sign. But they require a lot of fine tuning to get them to work well.”

To train a deep neural network to accurately recognize a stop sign, for instance, you might load a computer program with 100 thousand images; 50 thousand would contain a stop sign and 50 thousand would not contain one. “Then you’d push a button and wait six hours while the program processes the pictures,” Frazier says. “If you set your parameters well, at the end of that time, the program will be able to tell you with 95 percent accuracy whether a picture contains a stop sign or not.”

Figuring out how to set the parameters, however, isn’t all that easy. “You may run your program with 100 thousand pictures for six hours on your supercomputer and realize when it’s done, it doesn’t actually work very well at predicting whether something is a stop sign or not,” Frazier says. “So you try new parameters and run it again. You could spend two weeks doing that. To reduce the time and effort, I create algorithms that can choose the parameters automatically faster than a human would be able to do.” Frazier has

“Then you’d push a button and wait six hours while the program processes the pictures. If you set your parameters well...the program will be able to tell you with 95 percent accuracy whether a picture contains a stop sign or not.”

— Peter Frazier



Associate Professor Peter Frazier holds a half-time position at Cornell and also works for Uber as a staff data scientist.

applied some of his deep neural network algorithms to applications as varied as finding the best website design to increase user traffic and finding the best shape of an airplane wing to optimize a plane’s fuel efficiency.

The Operations Research and Information Engineering Advantage

Frazier decided to pursue operations research and information engineering because he wanted to work on something applicable to everyday questions that would help people and also satisfy his curiosity about the world around him.

“It’s an excuse to learn about whatever seems interesting at the moment, all different application domains,” he says. “I can learn about chemistry and airplanes and autonomous vehicles, and then after a couple of years, I can go do something else. It’s pretty fun.”

By Jackie Swift

While we might be unable to have large get-togethers right now, the current state of affairs didn't stop ORIE faculty, alumni and colleagues from helping Jack Muckstadt, the Acheson/Laibe Professor Emeritus of Business Management and Leadership, celebrate his 80th birthday September 28 via a group Zoom meeting.

After a welcome from Mark Lewis, Professor and Director of ORIE, Kathryn Caggiano, Professor of Practice and Director of ORIE's Master of Engineering program, gave a brief history of her experiences with Jack's career.

"Jack puts people first," Caggiano said of what she's learned from Muckstadt. "Jack meets people where they are — whether you're a Ph.D. student...an undergraduate... or a colleague who wants to chat about life and needs a clearer head than yours at times after some kind of life transforming experience."

ORIE Professor Emeritus Peter Jackson talked about experiential learning at Cornell with Jack. Beginning in the 1980s, Jackson and Muckstadt started working with several others over the next four decades, continually bringing in experts to add to their research.

"There's no person who's had an impact on me in a professional way more than Peter Jackson," Muckstadt commented. "The collaboration we've had over these few decades was a phenomenal time for both of us."

Harvard Business School professor Bob Kaplan Ph.D. '68 touched on Jack's influence on research, focusing on a paper Muckstadt wrote with Jackson and Caggiano in 2007 ("Optimizing Service Parts Inventory in a Multiechelon, Multi-Item Supply Chain with Time-Based Customer Service-Level Agreements"). The paper studied the issue of what parts should be stocked at each location to provide given levels of service;

ALUMNI, COLLEAGUES HELP JACK MUCKSTADT CELEBRATE HIS 80TH BIRTHDAY

how should available stock be allocated throughout the resupply network; and, for repairable parts, how should repair facilities be sized, located and operated. Kaplan said that paper, written more than a decade ago, relates to the current problem of not enough randomized testing for Covid-19 being done in the United States. While there are many testing machines in stock, the components of testing — such as chemical re-agents, glass vials, and swabs — are in short supply.

Muckstadt added that he and Jackson are working on another model with the distribution of vaccines in a timely and effective manner.

"(Jack) made learning interesting, relevant, and practical," said Jeffrey Berg '79, M.Eng. '80. "He also provided his students with lifelong skills — critical thinking, data analysis, how to ask questions, how to decompose complex problems, how to work well with one another in teams, and how to communicate solutions both verbally and in writing."

"As I get older I realize that it is, in fact, the personal experience that lingers," said Elissa Sterry '79 M.S. '80. "I wish I could tell you that I remember more about my inventory class, but I do remember you. And I remember your warm nature. And I just thoroughly enjoyed being one of your students. I always felt you were in my corner and that you wanted me to succeed. You instill confidence in your students. As



Jack Muckstadt, the Acheson/Laibe Professor Emeritus of Business Management and Leadership, celebrated his 80th birthday in September.

a young, female engineer at a time when there weren't many of us, I can't tell you how critically important that was to me and my success."

"It's been a privilege and a blessing of my life to be mentored by you and spending time with you," said Lefteris Iakovou Ph.D. '92. "My definition of success has to do with the ability to have an impact on people's lives. I cannot think of a more successful man than you."

More than 100 former students and colleagues participated to wish Jack a happy birthday.

"Jack I will say this," said Lewis as he wrapped things up. "It is amazing how many people have been influenced by you. Even if you weren't influencing a person directly, there was significant influence one generation removed."

"What a way to spend your birthday," Jack said in closing. "And with people who meant so much to me over time and who contributed so much to my life."

When New York City started to experience a rapid rise in COVID-19 infections and hospitalizations last year, Annabelle Li M.Eng. '11 and her friends mobilized their connections and global resources to help our city. Last spring, they sourced and delivered thousands of N95 and surgical masks, gloves, ISO gowns, and goggles to establishments across boroughs.

"When COVID first affected Wuhan, my family became very concerned. We saw how much suffering the disease brought to those infected and healthcare workers selflessly fighting for their patients. When it started in the U.S., I immediately thought about how this could become a great danger for the healthcare workers here. My friend who works as a nurse said that they were only assigned one N95 mask for three months. That's when I made a decision to help with this cause and donate PPE to healthcare workers," said Annabelle, who earned her Master's degree in financial engineering.

At first, Annabelle was able to connect with an extensive network through her husband's contacts who work in cancer research. After a few donations, the news spread, and hospitals, as well as individual doctors and nurses, started to call. In the first four months, the campaign raised \$6,743, in addition to about \$15,000 worth of PPE donations, all of which have gone to 16 different hospitals, nursing homes, and government entities. This list includes some hard-hit locations like Queens Hospital Center, NYU Langone Brooklyn, Montefiore Medical Center Bronx, Long Island State Veterans Home, and many more.

While her hospital contacts are no longer reporting severe shortages in PPE, Annabelle with her family and friends have no

CFEM ALUMNA STEPS UP TO SUPPORT NYC



The emergency department at NYU Langone Hospital – Brooklyn, which was short of personal protective equipment at the beginning of the pandemic. Due to a lack of donations, the ED relied on the hospital headquarters to distribute supplies. The campaign has donated three times here with hundreds of N95 masks, surgical masks and gowns.

intention to stop their efforts. Now they are pivoting towards those left in great need in the wake of high unemployment rates and business closures – delivering meals at food banks and supporting children's educational needs. If you wish to get involved, please email Annabelle (xiaochangli.y@gmail.com).

ORIE alum launches crowdfunding platform for sustainably driven projects

ORIE graduate Sam Wenger '20 has launched GreenFundr, a crowdfunding platform for sustainably driven projects. Creators post their projects, supporters help fund their ventures, and the Earth sees an uptick in green innovations.

"We want to fight climate change, end environmental degradation, and build a sustainable world," says Wenger.

To learn more about GreenFundr, visit their website at <https://www.greenfundr.com/>.



ALUMNI SPOTLIGHT

James Lee '15 grew up playing League of Legends, which is one of the most played and watched video games in the world. Now, a decade later, the game is his job at Riot Games.

Lee, who is a 2019 alumnus of the master's degree program through the Data Science Institute at Columbia University, interned at Riot Games during graduate school because it combined two of his favorite things: data science and video games. He excelled during the internship and was offered a full-time job as a data scientist. Essentially, he analyzes big data on League players and finds patterns from which he recommends selling discounted game products, such as the latest champion skins, to the right groups of players.

"My daily work is infused with terabytes of data, which we mine to find players with similar interests and patterns," he said. "We use that data pipeline to build recommendation systems for certain players by finding players who are similar to them. We can then offer personalized and discounted content to our loyal players."

Riot Games is based in Los Angeles, and Lee loves the sun and the beach and to play golf and tennis. "It happened kind of organically," he said. "I knew I wanted to live in L.A., I love my job, and I'm living in a city where the sun shines every day. I'm happy." Lee didn't set out to work in the video game industry. As an undergraduate, he studied operations research and information engineering at Cornell University. He also worked for two years at Jet.com, where he developed statistical tools and machine learning algorithms to help executives make business decisions.

But he wanted a deeper understanding of data tools, so he enrolled in the master's degree program through DSI. Looking

ALUMNI SPOTLIGHT: JAMES LEE '15, DATA SCIENTIST @ RIOT GAMES

back, he said, it was a great decision. He had excellent courses, the content from which he uses now to do his job at Riot Games. His favorite courses were Personalization: Theory and Application with Brett Vintch, and Algorithms for Data Science with Eleni Drinea.

"I highly recommend both classes to current students," he said. "They are tough, but excellent classes and teach you techniques that will be applicable to your work as data scientists."



James Lee '15

*Courtesy of Robert Florida
Columbia University
Data Science Institute*

"My daily work is infused with terabytes of data, which we mine to find players with similar interests and patterns. We use that data pipeline to build recommendation systems for certain players by finding players who are similar to them. "

—James Lee '15



It's almost impossible for humans to draw unbiased maps, even when they're trying.

A new mathematical method developed by Cornell researchers can inject fairness into the fraught process of political redistricting — and proves that it takes more than good intent to create a fair and representative district.

The two-step method, described in the paper, "Fairmandering: A Column Generation Heuristic for Fairness Optimized Political Districting," first creates billions of potential electoral maps for each state, and then algorithmically identifies a range of possibilities meeting the desired criteria for fairness.

"Fairmandering" won the INFORMS Undergraduate Operations Research Prize, awarded to the best undergraduate paper, at the Nov. 8-11 INFORMS Annual Meeting, the leading meeting of operations research and analytics professionals. First author is Wes Gurnee '20, now a software engineer at Google.

The American congressional district system empowers politicians to manipulate district boundaries in order to influence election results. Districts may be drawn by the party in power to include large numbers of people in their party, a process known as gerrymandering, swaying the outcome of elections and determining political control at the local and national level.

It's an urgent issue — especially as states prepare for the decennial redistricting next year, based on the results of the 2020 census.

"Advances in data science have helped the parties get better and better at designing districts to keep political control," said co-author David Shmoys, the Laibe/Acheson Professor of Business Management and Leadership Studies in the School of Operations Research and Information Engineering. "We wanted to offer a completely different perspective that goes to the core of what it means to do a fair districting, and to put algorithmic tools in

"FAIRMANDERING" DRAWS FAIR DISTRICTS USING DATA SCIENCE

policy-makers' hands that allow them to do the right thing."

In the research, the largest-ever study of legal congressional district maps, Gurnee and Shmoys sought to create election maps with fair outcomes — those that accurately reflect a state's political leanings, create enough competitive races to ensure accountability and treat each party symmetrically.

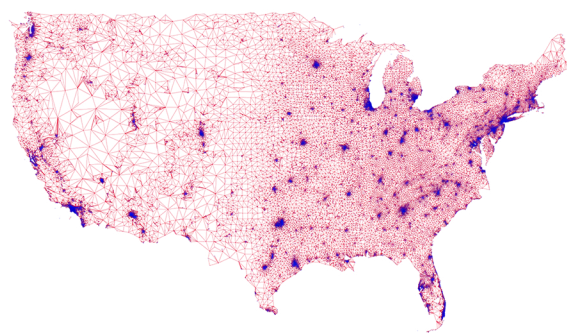
Past research has sought to use computational methods to draw unbiased districts. But these efforts have ignored political and demographic factors, assuming that so-called "compact" districts — those constructed in regular shapes based on location — would be fair.

But even then, the researchers found, the demographic and political composition of the district is likely not representative of the political leanings of the entire state.

"Historically, there has been this belief that a map drawn randomly, with no political bias or partisan data, is inherently fair," Gurnee said. "While it's true that these maps are blind to partisan bias, they're not free from partisan bias."

Rather than making reasonably shaped districts the goal, the researchers built in shape as one factor of their model, which can rapidly generate billions of possible electoral maps for each state.

"You need a rich enough set of ways to put the puzzle together so that you have a diversity of possible outcomes," Shmoys said, "but you also need it to be expressive enough to give you the range of fairness



outcomes that you want."

Once they've generated the maps, the researchers used the tools of integer programming — a mathematical modeling framework for which recent advances allowed them to solve a very large-scale problem — to evaluate the maps for fairness.

Though the researchers chose a balanced representation of political affiliation as their definition of fairness in the study, other demographic factors could be considered. The model could also apply to state and local representative maps, in addition to congressional districts.

Gurnee has started an organization, called Fairmandering, to advance the principles of the research.

"It's not the geographic shape of the district that's important — it's really thinking about more holistic principles of what it means to do a fair districting," Shmoys said. "We're hoping this will really impact the conversation that's going to be taking place state by state over the next year and a half, both at the congressional level and the state legislative level."

By Melanie Lefkowitz

Sam Gutekunst Ph.D. '20 among 18 to receive Engaged Graduate Student Grants

Eighteen Cornell doctoral students, including ORIE's Sam Gutekunst '20, received 2019-20 Engaged Graduate Student Grants totaling \$269,397, which support community-engaged research relevant to their dissertations.

Coming from 13 fields of study, grantees are collaborating with communities around the world, including artists of color in Chicago, deported migrants in Guatemala, women homeworkers in India and young people in New York City.

Gutekunst's project was titled "Winning with Math: Connecting prisoners with mathematical tools for decision-making." Then, using what he learned through the research, Sam worked with Prisoner Express to develop a math reasoning and critical thinking program for incarcerated men and women. The team then surveyed participants to find out how to maximize the impact of the prison-education program.

Seven New York state counties and eight countries were represented in last year's projects.



Sam Gutekunst Ph.D. '20

Charisopoulos earns Leventis scholarship

Fourth-year ORIE Ph.D. student Vasilis Charisopoulos has earned an A. G. Leventis scholarship for the 2020-21 academic year. Charisopoulos' research statement was about composite optimization for robust signal recovery, and efficient spectral methods in large-scale computing.

Charisopoulos received his Diploma in electrical & computer engineering in 2017 from the National Technical University of Athens, Greece, under the supervision of Professor Petros Maragos.



Vasilis Charisopoulos

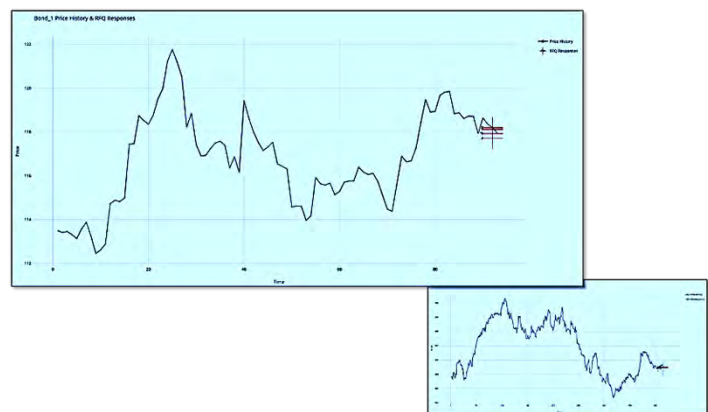
He then spent four months in INRIA (National Institute for Research in Digital Science and Technology) working as a researcher in the TROPICAL team under Xavier Allamigeon and Stephane Gaubert. Charisopoulos came to Ithaca in the fall of 2017 to do his graduate work in the School of Operations Research and Information Engineering and is advised by Assistant Professor Damek Davis. He also works with Austin Benson and Anil Damle in Cornell's Department of Computer Science.

A very competitive scholarship, the Leventis award targets students of Greek descent from any field of study. The A. G. Leventis Foundation awards approximately one scholarship per eight applications. Established in May 1979, the A. G. Leventis Foundation is the outcome of the vision of the Cypriot entrepreneur Anastasios G. Leventis (1902-1978), who laid the bases of its focus on society, education and culture.

Cornell MFEs Compete in Practitioner-Led Course to Build Trading Algorithms

One of the defining characteristics of Cornell ORIE'S financial engineering degree is the semester students spend learning exclusively from financial practitioners. Moreover, the coursework taught by our practitioner instructors changes in line with the quantitative skills most in demand in the financial industry. This, in fact, is what led us to start the Financial Data Science Certificate in the spring of 2016.

Continuing in this tradition, Cornell Financial Engineering



Price graph with student teams' bids produced by their algorithms.

Manhattan introduced a new course called "Trading FX, Rates, and Crypto" in the fall of 2020. The course is taught by Giuseppe Nuti, Head of Machine Learning and AI for UBS Global Markets. The goal of the course is to teach students how to utilize the latest machine

STUDENT NEWS

learning techniques to gain a competitive edge when trading assets outside of the most liquid and most-studied ones (such as equities).

Throughout the semester, students worked on team-based projects by applying machine learning strategies to create algorithms that allow for optimal execution and bidding protocols in bonds and cryptos. One such project asked students to act as market makers and create an algorithm within the Request For Quote (RFQ) market protocol. Specifically, student teams competed in creating an algorithm to bid on a bond where the highest bid with a positive P&L would win a trade. The competition consisted of three parts to reflect different counterparties and varying bond price volatilities.

One team in particular masterfully implemented the probability of trading within the RFQ market protocol. Using XG Boost, the winning team also had an accurate understanding of the likely information asymmetry for each counterparty. When asked what they think about the project and their success in the course, students said, "The course competition was a great, hands-on experience that forced us to think like a market-maker. This project helped us critically use machine learning models, understand their assumptions and shortcomings, and incorporate our understanding of the competitive nature of the markets to be successful market-makers."

The Markets Have Spoken: What Stocks Do Democrats and Republicans Actually Value?

In July 2020, a team of Cornell Financial Engineering Manhattan (CFEM) students won the ninth annual International Association of Quantitative Finance (IAQF) student competition. The students were Vineel Yellapantula, Nikunj Agarwal, Harsh Puria and Subham Behera. The paper was selected to be one of five winning IAQF papers.

The aim of the competition: to construct a DEM portfolio (one that would do well if Biden won), and a REP portfolio (one that would do well if Trump won). Julius Baer, a Swiss private bank, had constructed such portfolios using qualitative methods in early 2020. The students were tasked to develop a quantitative approach.

After discussing multiple solution strategies, including historic election data, sector exchange traded fund (ETF) returns and campaign finance data, the students, advised by Operations Research and Information Engineering (ORIE) faculty member Dr. Sasha Stoikov, tried a more novel approach. The team explored the relationship between financial markets and political betting markets like PredictIt and the Iowa electronic markets. They used features extracted from these betting markets and built a Machine Learning algorithm to construct the DEM and REP portfolios.



The value of election futures contracts fluctuated wildly around the election.

Sometimes a rare event comes along and helps verify an economic theory. The volatile first week of November 2020 provided just one such opportunity to the student team. On November 3, Trump's chances of winning soared, as the initial counts of the election started coming in. On November 4, it was Biden's numbers that started looking unbeatable, as several states turned blue. These two dramatic swings were observed in election futures platforms. Simultaneously, traders in the financial markets moved in and out of stocks, in line with their perceived probabilities of a Trump or a Biden win.

This provided the winning Cornell team with a fresh set of data on which they were able to re-run their analysis. Focusing on sector ETF returns and election futures changes around the election, the students identified the sectors that were the most strongly correlated with a Biden presidency.

The latest data indicate that the financial markets are as polarized as the American people. They also allowed the students to check if their predictions included in their paper had come true. As the students had predicted before the election, sectors like communications and technology were most strongly correlated with a Democratic win and sectors like Financials and Utilities were most strongly correlated with a Republican win.

More interestingly, the markets revealed information that the students had not anticipated with their outdated dataset. Healthcare turned out to be very highly correlated with the DEM probabilities. Real estate, materials and industrials were very highly correlated with the REP probabilities.

Last May, Shengbo Wang '20 was recognized as a 2020 Merrill Presidential Scholar. Wang earned his B.S. in operations research and engineering and earned dean's list honors in each of his six semesters at Cornell.

During his three years in Ithaca, he pursued a Ph.D.-level curriculum with a concentration in probability theory and its application in operations research. A summa cum laude graduate, Shengbo—a native of Chaoyang District, Beijing, China—served as a teaching assistant for ORIE 3510 during the spring 2019 semester.

Wang is one of 35 outstanding seniors recognized as 2020 Merrill Presidential Scholars, who are selected by their college deans for their academic achievements, leadership, and potential to contribute to society. This year's scholars hail from 14 U.S. states as well as India and China. As part of the program, the scholars—who are in the top 1% of their class—share the honor with a high school teacher and a Cornell faculty member who has inspired them and contributed to their academic development.

Under the supervision of ORIE Professor Gennady Samorodnitsky, Wang's senior research project concerns properties of the optimal measure for the large deviation probability of the connectedness of the excursion set of Gaussian processes.

In addition to Professor Samorodnitsky, Wang also honored Jing Ma, one of his teachers at Beijing No. 4 High School,

ORIE SENIOR NAMED 2020 MERRILL PRESIDENTIAL SCHOLAR



Shengbo Wang '20 was recognized as a 2020 Merrill Presidential Scholar.

International Campus.

After graduation, Shengbo began his Ph.D. program in management science and engineering at Stanford University.

CFEM team wins IAQF student competition

Congratulations to our Master in Financial Engineering students for submitting a winning solution to this year's ninth annual Academic Affiliate Membership Student Competition, which is held by the International Association for Quantitative Finance (IAQF).

The Cornell team was one of five that came out on top. Members of Team Quants by Ganges include team captain Nikunj Agarwal M.Eng. '20, Subham Behera M.Eng. '20, Harsh Parsuram Puria M.Eng. '20, and Vineel Yellapantula M.Eng. '20. The team was advised by CFEM senior research associate Sasha Stoikov.

Thirty-six teams representing 20 academic programs submitted papers in response to this year's competition problem, which focused on portfolio analysis. The competition submissions went through a blind, multi-level selection process and were reviewed by a judging panel comprised of IAQF Board Members



STUDENT SPOTLIGHT

When Brittany Stenekes '20 runs the hurdles, she is completely in the moment. "There isn't time in a race

to think, to plan, nor to strategize, yet every movement and every millisecond is important," says the native of Dundas, Ontario. "That is the great challenge of the sport, which I love."

Throughout her athletic career at Cornell, Stenekes has more than risen to the task, breaking school records in the 60-meter and 100-meter hurdles and 400-meter relay, competing in the NCAA Championship preliminaries, and representing her country at the Junior Pan-American Championships in Peru as a member of the Canadian national team.

"What separates Brittany is her focus and determination," says Mike Henderson, the Alan B. '53 and Elizabeth Heekin Harris Head Coach of Women's Track & Field and Cross Country. "She is a great and dedicated athlete with the ability to sort through distraction and overcome obstacles to be at her best when it matters most."

The same traits earned Stenekes a spot in Cornell's 400 Club for high-performing student-athletes after she achieved a 4.0 GPA during her junior year. To Justin Byron, associate head coach for women's track and field, this accomplishment is evidence of her "amazing ability to balance" not only her sport and academics but also volunteer work with youth and elderly in the Ithaca community. "I do not know how she creates the time," he says.

Doing it all with poise is a skill Stenekes worked hard to hone. She arrived at Cornell with four years of track and field under her belt, but aligning college athletics with the demands of her ORIE major posed unfamiliar challenges. She would often miss classes on Fridays to travel to competitions, returning at the end of the weekend with little time to catch up on work. During her

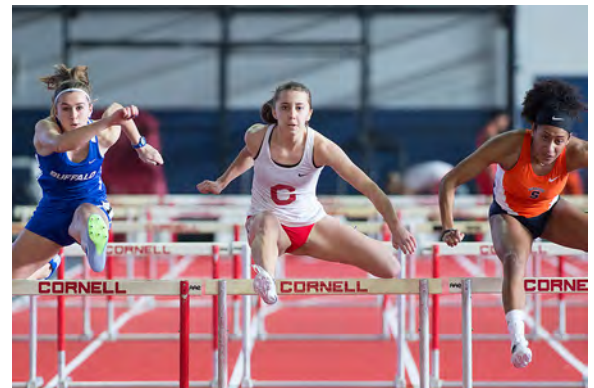
MASTERING LIFE ON THE TRACK AND IN THE CLASSROOM

first semester, she stayed up late studying on many nights, and she struggled in courses. "I soon learned how to work efficiently and proactively," says Stenekes, who became a regular at office hours and started problem sets the day they were assigned.

Her efforts have borne fruit beyond her coursework. "Being an engineer has made me a harder working athlete," she explains. "In engineering there are no shortcuts. It takes a lot of practice and many hours in the library to understand course material. I learned that on the track, a similar commitment is necessary to improve. In my life, track and engineering are symbiotic."

Stenekes credits Cornell with providing an environment where this dual commitment could thrive. "Being an athlete here has been a privilege," she says. "(Retired women's head coach) Coach Rich Bowman and Coach Justin Byron have never wavered in supporting both my academics and athletics" — even if that meant, for example, sending her home from practice to study for an upcoming calculus prelim.

On the academic side, Stenekes — who has particular interests in stochastic processes, simulation and data analytics — initially worried that as an athlete she would not fit into the engineering program. "For the first month, I did not wear 'Cornell Track and Field' attire to class because I anticipated a stereotype that athletes could not handle rigorous academic demands," she recalls. Not only did she prove any such stereotypes groundless — her advisor Jamol Pender, assistant professor in ORIE,



Brittany Stenekes '20 runs the hurdles at Barton Hall.

remembers her as "one of the most engaging and thoughtful students" in his classes, and she has worked as a teaching assistant for several engineering courses — but her concerns were quickly dispelled as her ORIE friends became her biggest cheerleaders.

"My two-year-old son and I had the pleasure of seeing Brittany at a track meet in Barton Hall," says Pender. "Not only did Brittany beat the competition by a wide margin, but the best thing was seeing many of her classmates supporting her during this time, which speaks volumes about how important she is to the ORIE community."

The current pandemic has caused an unexpected and painful end to Stenekes' senior year. "The hardest part has been abruptly saying goodbye to my teammates, many of whom I've seen every day for nearly four years," she says. Nevertheless, Stenekes hopes to attend graduate school in the fall to pursue a master's degree in industrial engineering and management sciences — and to keep competing, either unattached or for the school she ultimately chooses. "I expect running will always be part of my life."

By Olivia M. Hall

CornellEngineering Operations Research and Information Engineering

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SAVE THE DATE **VIRTUAL REUNION 2021** **JUNE 11-12**

Our first-ever Virtual Reunion was a great success last year and allowed even more alumni to participate in innovative and exciting ways. This year we're pulling out all the stops to host the best virtual celebration possible, and you're invited!

