INDUSTRIAL AND SYSTEMS ENGINEERING

SPRING NEWSLETTER 2022

See What's New at Mohler Laboratory, Home of ISE!

LEHIGH UNIVERSITY | P.C. Rossin College of Engineering and Applied Science

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ISE DEPARTMENT NEWSLETTER SPRING 2022

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Dear Lehigh ISE Community,

I hope everyone is having an enjoyable spring!

I am excited to share all of the wonderful news buzzing out of Lehigh ISE these past few months. Our amazing faculty, students, alumni continue to make impactful contributions with their research, projects, and awards.

In this Spring 2022 mid-year newsletter we highlight our newest faculty member, Professor **Akwum Onwunta** and introduce to you some of our more recent adjunct faculty professors, **Amy Nyberg**, **Rafael Parades**, and **Brent Peterson**.

We congratulate team Lehigh 502 Marcos Leal Wittkowsky, Jose Andres Castillo Anzueta, and Rodrigo Gonazlez Masselli along with Professors **Ana I. Alexandrescu** and **Karmel S. Shehadeh** for presenting their projects at the annual Healthcare Systems Process Improvement Conference in January 2022 and placing 3rd in the Flex Sim Student Simulation.

We also applaud Lehigh ISE PhD student, Mertcan Yetkin who was co-awarded the prestigious COIN-OR Cup 2021 as part of the team Gravity for his contribution to open-source software development.

Did you know that a foundation of machine learning (the stochastic gradient method) had its' origin traced back to one of our own Lehigh ISE faculty, Professor **Sutton Monro**? You will want to learn more about this exciting connection and how ISE faculty Professor Frank E. Curtis along with CSE Professor Sihong Xie are modernizing, advancing and adapting algorithms for organizations that use them.

Our commitment to excellence in research is evidenced through our funding. Professors **Daniel P. Robinson** (PI) and **Frank E. Curtis** (Co-PI) received a three-year grant from the NSF Division of Mathematical Sciences to design, analyze, implement, and validate a new optimization framework.

Professors Frank E. Curtis (PI) and Daniel P. Robinson (Co-PI) in collaboration with University of Michigan Albert S. Berahas have been awarded a three-year-half million dollar award from the Office of Naval Research (ONR) to design and analyze next-generation algorithms for solving problems aligned with the interests of ONR's Mathematics, Computer and Information Sciences (MCIS) Division.

Professor **Tamás Terlaky** is working on a National Science Foundation Division of Computing and Communication Foundation Collaborative Research project with Purdue University researchers to enhance the research community understanding of the complexity of quantum computing.

Through the launch of **Lehigh Industrial Liaison Program (ISEi)** we continue our long standing tradition of industrial collaboration through three-ongoing initiatives: ISE Client-Driven Student Projects, ISE Career Fair, and Industrial Events. Stay tuned as we report on the success of these programs and more.

A project close to my heart, the **Mohler Laboratory renovations**, I am delighted to announce are now complete. The upgrades to conference rooms, classrooms, and common offer a more contemporary feel, provide access to better equipment and technology and provide a sense of community to ISE's home.

This past fall we welcomed ISE alumna **David Burdakin** who gave the ISE Distinguished Lecture for Excellence in Industry Spencer C. Schantz Public Lecture: Great Business...How do they do it? Dave was honored at a cocktail reception and dinner at Iacocca Hall Wood Dining Room.

Because of your generous support the ISE Department is able to new programs such as the ISE Academy, invest in technology and provide inviting spaces for study and research. We could not do what we do without your continued support!

Thank you all for your continued support and commitment to ISE. We could not do what we do without your generous contributions of time, talent, and monetary support.

LUIS NUNES VICENTE
ISE Department Chair

ISE FACULTY *news*

AKWUM ONWUNTA

Lehigh ISE welcomed new Assistant Professor, Akwum Onwunta

The Industrial and Systems Engineering (ISE) Department welcomed **Dr. Akwum Onwunta** as Tenure-Track Assistant Professor fall 2021. Akwum is a computational scientist who has been working on quantitative credit risk modeling, Bayesian statistical inverse problems, and optimization problems governed by differential equations.

Akwum received his PhD in Applied Mathematics from the Otto von Guericke University and Max Planck Institute for Dynamics of Complex Technical Systems, Magdeburg, Germany, in 2016. Prior to joining ISE, he held Postdoctoral Research Associate positions at George Mason University (GMU), Fairfax and the University of Maryland (UMD), College Park. His postdoctoral research was funded by the Air Force Office of Scientific Research (AFOSR) at GMU and National Science Foundation (NSF) at UMD.

Akwum was also a quantitative risk analyst at Deutsche Bank in Germany. His work at the Deutsche Bank was partially funded by a prestigious Marie Curie early-stage research fellowship from 2007 to 2010, and it resulted in a PhD in 2010 in Economics from the Justus Liebig University, Giessen, Germany.

Akwum's diverse and rich background is best described by his pre-doctoral education. He obtained an MS in Physical and Mathematical Analysis from the University of Stellenbosch, South Africa, in 2006. He then successfully completed a graduate program on Mathematical Models in Economics at the University of Paris I, Panthéon-Sorbonne, France. Akwum obtained his BS in Mathematics from Michael Okpara University of Agriculture, Umudike, Nigeria, in 2003.

His recent research contributions in deep learning and random models for dynamical systems fit well into the research program of the ISE Department, and it will help consolidate the Department in the top rankings of industrial engineering. Additionally, Akwum's vast teaching and lecturing experience will establish him as a key contributor and an inspirational model for our students.

Akwum recently shared his thoughts about joining ISE. "I look forward to contributing meaningfully to the growth and development of ISE at Lehigh by delivering high quality performance in scientific research, teaching and service to the university community. Given my interdisciplinary backgrounds in optimization, uncertainty quantification, and statistical inverse problems, I am committed to developing efficient techniques for tackling challenging problems arising in operations research, as well as in computational science and engineering. Lehigh University is indeed a great place with distinguished scholars; thus, I am not only incredibly excited to join the ISE Department at Lehigh, but also deeply passionate to collaborate with other ISE faculty in training next generations of researchers and engineers of world class reputation".

Meet the new Lehigh ISE adjunct faculty

AMY NYBERG

Amy Nyberg joined the ISE Department in spring 2021 as an adjunct professor teaching Financial Management in Healthcare in the Healthcare System Engineering Master's Program. Professor Nyberg is the SVP of Ambulatory Services for Lehigh Valley Health Network and President of Coordinated Health, now part of LVHN following acquisition in 2019. She previously served as CH's Chief Integration Officer leading the organization's expansion in Northeast Pennsylvania and Western New Jersey, and introducing innovative approaches to care coordination resulting in high quality patient outcomes and significant reduction in cost.

Ms. Nyberg's career has been focused on strategy and process innovation and she is passionate about transforming health care delivery in order to simplify processes, improve quality and reduce cost.

Amy holds a B.A. in English Literature from Arizona State University and an MBA in Health Administration from the University of Colorado. She is also actively involved in the community and has volunteered with the American Heart Association, and served on the board and as chair of two independent schools.

RAFAEL PARADES

Rafael Parades joined the ISE Department in fall 2020 as an Adjunct Professor teaching Operations Management. Professor Parades is a Lehigh alumnu having earned his MBA with distinction in 2003 and M.Eng. in Industrial Engineering through a Fulbright Scholarship in 2000. He is currently Director of Operations, Logistics and Technical Services at Bosch Rexroth. His broad industry experience includes Masco Corporation, Motorola, Maytag, Agere, and West Grand. Rafael has extensive knowledge and experience in operations, lean manufacturing, supply chain, project management, advanced and big data analytics, and continuous improvement. He has a passion for developing strong teams and talent. Rafael is a Fulbright Scholar and certified in Lean Six Sigma Black Belt.

BRENT PETERSON

Brent Peterson joined the ISE Department in spring 2020 an adjunct professor teaching Applied Data Mining. Professor Peterson was the manager of an Advanced Analytics, Europe and Asia at Air Products. Brent and his team served as advanced analytics consultants to the businesses in each region. During his almost 40 year career at Air Products, Brent has worked on wide range of business analytics problems including: supply chain optimization, time series forecasting, machine learning, text mining, network optimization, pricing optimization, production planning and scheduling using SAP APO, SAP Materials Management, sales & operations planning, multi echelon inventory optimization, market segmentation, direct B2B marketing, survey sampling & design, experimental design, conjoint analysis, and discrete event simulation.

Brent holds a B.S. degree in Systems Analysis from Miami University (Ohio), as well as, an M.S. degree in Operations Research and Statistics from Rensselaer Polytechnic Institute.

Lehigh ISE team places 3rd in an international simulation competition

Congratulations to the team Lehigh 502 **Marcos Leal Wittkowsky**, **Jose Andres Castillo Anzueto**, **Rodrigo Gonzalez Masselli** and Lehigh ISE Professors **Ana I. Alexandrescu** and **Karmel S. Shehadeh** for winning 3rd place in the **International FlexSim Student Simulation Competition**. Their project involved solving a "real-world" healthcare situation case study using a simulation model to compare three different operational models for a busy emergency department and make recommendations for optimal process flow, staffing, and scheduling.

Forty teams signed up to participate, but only 17 submitted solutions, from which the finalists were chosen. On January 22, 2022, The Lehigh 502 team had a chance to present their project in Orlando, FL, at the annual Healthcare Systems Process Improvement Conference, organized by the **IISE Society for Health Systems (SHS)**. The Society for Health Systems is a society of the Institute of Industrial and Systems Engineers (IISE) that seeks to improve lives through enhanced health and care delivery systems throughout the world focusing on continuous improvement, innovation, strategic and systems thinking in healthcare.

Team Lehigh 502 impressed the judges with the clarity of their presentation and their results and were able to take home the 3rd place prize (which includes bragging rights **and** cash).

Jose, Marcos, and Rodrigo are all from Guatemala, where the area code is 502 - hence their team name.

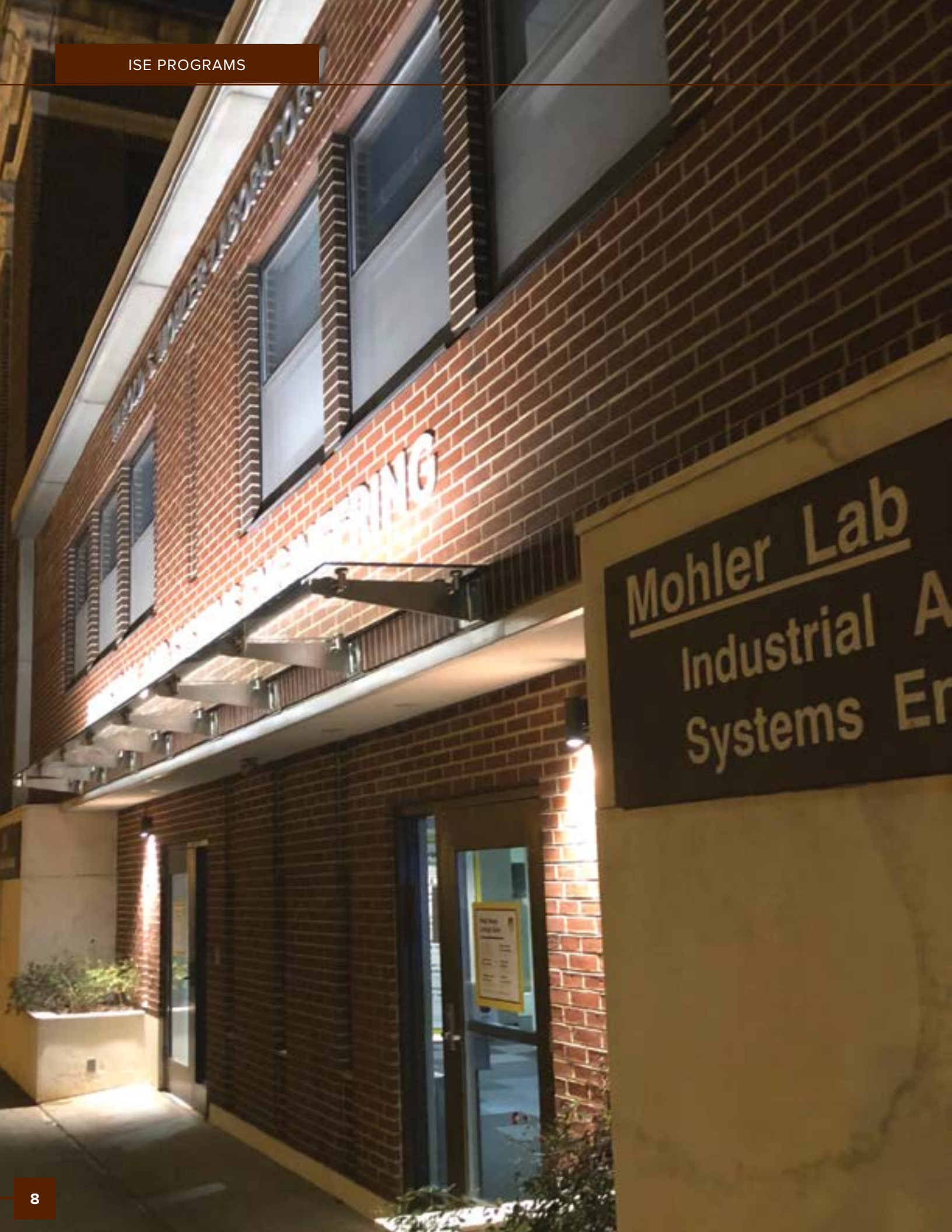
MERTCAN YETKIN

Lehigh ISE PhD student receives a prestigious award for open source software development

The Lehigh ISE Department is pleased to announce that ISE PhD student Mertcan Yetkin was co-awarded the **COIN-OR Cup 2021** as part of the team Gravity for his contribution to open-source software development. The **COIN-OR Cup** is given annually by the COIN-OR Foundation to the developers of impactful open-source software within the operations research community.

Mertcan was co-awarded for his contributions to the open-source software project Gravity, coordinated by Hassan Hijazi. Gravity is linked to
COIN-OR, and implements a free modeling language capable of utilizing COIN-OR solvers such as Ipopt, Bonmin, and Couenne.

"I am honored to be a part of this team, and thankful to have the opportunity to contribute to the operations research community. I had the chance to be involved in the project during my internship at Los Alamos National Laboratory while working with Hassan." says Mertcan.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LEHIGH HAS BEEN ON THE FOREFRONT OF MACHINE LEARNING

since ISE Prof. Sutton Monro's celebrated 1951 contribution

SUTTON MONRO

"The stochastic gradient method is the workhorse of machine learning—and thus most of artificial intelligence," says **Luis Nunes Vicente**, Timothy J. Wilmott Endowed Chair Professor and Chair of the Department of Industrial and Systems Engineering in Lehigh University's P.C. Rossin College of Engineering and Applied Science.

The stochastic gradient method is an optimization algorithm that essentially fine-tunes models used in large-scale applications of machine learning (ML), whether that's a streaming service suggesting what movie to watch next, or a credit card company monitoring online transactions to detect fraud.

You might call stochastic gradient the secret sauce of machine learning. And the "recipe," says Luis Nunes Vicente, has a not-so-well-known Lehigh connection. The main idea of the stochastic gradient method was derived in a **seminal 1951 paper** published in T*he Annals of Mathematical Statistics* by University of North Carolina mathematician Herbert Robbins and his graduate student Sutton Monro. A few years later, Monro would join the Lehigh ISE faculty and go on to teach industrial engineering for 26 years, retiring in 1985.

This outstanding contribution is so f**oundational to current machine learning applications and research**—Luis Nunes Vicente compares it to Louis Pasteur and vaccines—that it is underappreciated. If crediting it properly weren't generally overlooked by the ML field, the department chair says, the paper would likely be among the most highly cited scientific works ever. Still, he says, the paper has been cited more than 10,000 times.

Today, another Lehigh ISE professor, **Frank E. Curtis**, an expert in continuous mathematical optimization, is leading the charge to modernize and advance the use of the stochastic gradient method in machine learning, with support from a new NSF grant. And his colleague **Sihong Xie** in the Department of Computer Science and Engineering is one of many Rossin College researchers applying the stochastic gradient technique in their groundbreaking work.

Improving predictive accuracy

In basic terms, a machine learning algorithm works by creating a model that learns from the historical data it's been fed to make predictions about new data it receives. But the process usually goes very poorly in the beginning, which is to be expected, says Curtis, who is a founding member of the OptML (Optimization and Machine Learning) Research Group at Lehigh.

For example, an image classification algorithm might initially misinterpret a picture of a cat as a dog. The typical solution, Curtis says, is to feed the machine more and more data so the algorithm can update its model in a way that it can make better predictions.

In the field's parlance, machines learn through what's called a "loss function," which measures the predictive accuracy of a model for a given set of data. If predictions deviate too much from actual results, the loss function is represented mathematically as a very large number.

The job of the data scientist is to minimize the loss function—i.e., to reduce the degree of error in those predictions. That's

FRANK E. CURTIS

SIHONG XIE

what "optimization" means in the context of ML, explains Curtis, and it's critical to advancing the technology that is driving innovation in areas such as medical diagnostics, autonomous vehicles, and speech recognition, just to name few.

With the stochastic gradient method (the approach pioneered by Robbins and Monro), the loss function used by the algorithm acts as a kind of barometer, gauging accuracy with each iteration of updates to its model, and continually adjusting it to yield the smallest possible error.

In the image classification example, it would be a very slow process for a computer to go through all the images in a data set, Curtis says, and then update its model (a full-on "wash, rinse, repeat" approach).

The magic of the Robbins-Monro algorithm, he says, is that it employs a sampling method.

"What that means is," Curtis says, "rather than going through all the data first and then updating its model, the algorithm randomly chooses a small bit of it and uses that to update it; and then it grabs another random bit of data, and does it over and over again until it has gone through all the data."

You might call the stochastic gradient the secret sauce of machine learning. And the "recipe" says Luis Nunes Vicente, has a not-so-well known Lehigh connection.

By using a stochastic gradient method, the machine ends up processing the same amount of data as other methods, but many more updates of the model that have led to improvements in its predictive accuracy will have been done. Essentially, you get a better result more quickly with the same amount of computation.

Increasing transparency in decision-making

In machine learning, "these optimization algorithms are becoming more and more important, for two reasons," says Sihong Xie, an assistant professor of computer science and engineering. "One is that, as the data sets become larger and larger, you cannot process all the data at the same time; and the second reason is that we can formulate an optimization problem that will analyze why the machine learning algorithm makes a particular decision."

The latter is particularly important when applying machine learning to make decisions involving human users. Xie and his research group are investigating the transparency of machine learning models, because, as he explains, despite all of the advances driven by the technology in recent years, there are still significant open questions to be addressed.

One of them is that the algorithms that can learn from data and make predictions are still somewhat of a black box to the end user.

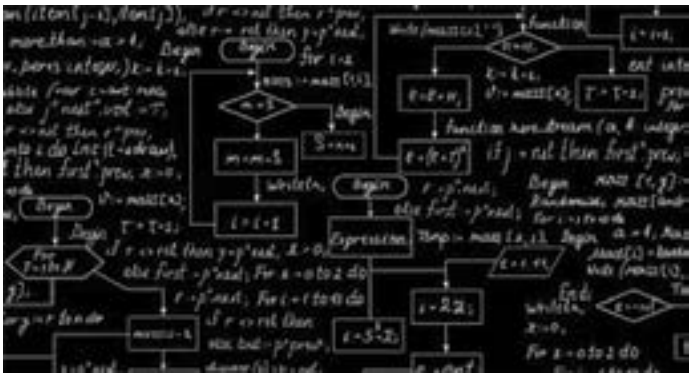
For example, imagine that you and a colleague are on a social network of job-seekers, akin to LinkedIn. You're both in the same field, and equally qualified, but as you discuss your prospects over a cup of coffee, it's clear that your friend has been seeing more high-quality job postings than you have.

It makes you wonder: What information did the site's algorithm use to generate the recommendations in the first place?

And are you not seeing some postings because of your age or your gender or something in your past experience? If so, the algorithm that produced the recommendations is suboptimal because its results are unfairly discriminatory, says Xie.

In late 2021, Xie's PhD students Jiaxin Liu and Chao Chen presented the results of their work at two renowned meetings on information retrieval and data mining (Liu, at the ACM International Conference on Information and Knowledge Management, and Chen, at the IEEE International Conference on Data Mining).

The team found that the current state-of-the-art model, known as a "graph neural network," can actually exacerbate bias in the data that it uses in its decisions. In response, they developed an optimization algorithm using the stochastic gradient method—Lehigh ISE Professor Sutton Monro's



contribution once again—that could find optimal trade-offs among competing fairness goals that would allow domain experts to select a trade-off that is least harmful to all subpopulations.

For example, the algorithm could be used to help ensure that selection for a specific job was unaffected by the applicant's sex while potentially still allowing the company's overall hiring rate to vary by sex if, say, women applicants tended to apply for more competitive jobs.

The team's work on explainable graph neural network adopted the stochastic gradient method to find human-friendly explanations of why the machine learning model makes favorable or unfavorable decisions over different subpopulations.

Designing 'adaptive algorithms'

While Xie and his team continue to work on fair and transparent algorithms for the populations impacted by them, Curtis and his team are working on making those same algorithms more efficient for the companies, governments, and institutions that use them.

Curtis, who was a recipient of the 2021 Lagrange Prize in Continuous Optimization, one of the field's top honors, will continue his work supported by a new **$250,000 grant** from the National Science Foundation. The project will develop modern improvements to the stochastic gradient method.

According to the project description, "despite the successes of certain optimization techniques, large-scale learning remains extremely expensive in terms of time and energy, which puts the ability to train machines to perform certain fundamental tasks exclusively in the hands of those with access to extreme-scale supercomputing facilities."

"One downside of the stochastic gradient method is that it requires a lot of 'tuning,'" Curtis says, "which means that, for example, Google may need to run the algorithm a very large number of times with different parameter settings in order to find a setting in which the algorithm actually gives a good result."

This tuning can essentially waste hours, weeks—even months—of computation, which translates into a lot of wasted electrical power. It's one of the reasons that only the big internet companies can afford to train very large-scale models for complicated tasks.

"For our project," Curtis says, "we are designing 'adaptive' algorithms that adjust their parameter settings during the training process, so that they might be able to offer equally good solutions, but without all the wasted effort for tuning."

Lehigh ISE launced the Indus

Enhancing Communications to Facilitate Industrial Collaboration

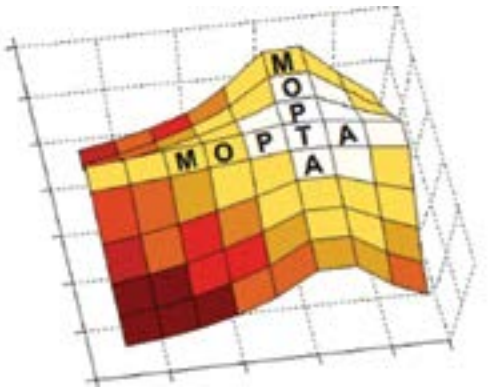
The **Lehigh ISE Industrial Liaison Program** (ISEi Program for short) aims at enhancing communications to facilitate industrial collaboration and cooperation. Our relationships with industry and surrounding communities provide fresh perspectives and problem-solving applications from our best engineering minds, exposing our students to real-world problems and practical experience. Through collaboration with industry, we understand better the challenges of today and anticipate the needs of tomorrow.

Lehigh ISE has a long tradition of industrial collaboration. Three on-going initiatives are highlighted:

1. ISE Client-Driven Student Projects.
The ISE undergraduate senior capstone project has been directed by our companion **Enterprise Systems Center** (ESC), where our Leadership courses are also managed. ESC provides a professional platform for industrial projects and a vast network of enterprise opportunities. Our capstone project is indeed client driven and increasingly more *interdisciplinary*. More and more of our master's students take their project courses at the ESC.

2. ISE Career Fair.
Our career fair has been successfully organized every fall. It has been targeted at senior undergraduate and master's students. Consulting companies have been participating intensively, in addition to a diverse array of companies interested in our ISE students. '

strial Liaison Program (ISEi)



3. Industrial Events.

Our flagship conference, **Modeling and Optimization: Theory and Applications** (MOPTA), held every August since 2009, has been a great forum to exchange research discoveries and has been instrumental to market ISE. A new 1-2 day event, iMOPTA, is held every year, to present and discuss industrial innovation and the research behind it. Major goals include identifying new industry partners and participating in setting new industry standards. The event nurtures more applied research collaboration and exposes our accomplishments and industrial potential to the outside world.

Our **Healthcare Systems Engineering Program** has been running a very successful series of annual Healthcare Systems Engineering Symposiums since 2014, in collaboration with the **Lehigh Valley Business Coalition on Healthcare** (LVBCH), on the challenges of healthcare, from delivery systems and cost structure to inequitable access and mental health. These events foster interdisciplinary collaboration by bringing the systems perspective to complex healthcare subjects.

The ISEi Program moves the needle of our collaboration with the industry to position us at the forefront of the greater challenges that spark industrial innovation. We harness our own resources through a more intensive cooperation with inspiring industrial partners. The Lehigh ISE Department is excited to see where the next discoveries will take us!

Mohler Lab renovations optimize facility for collaboration

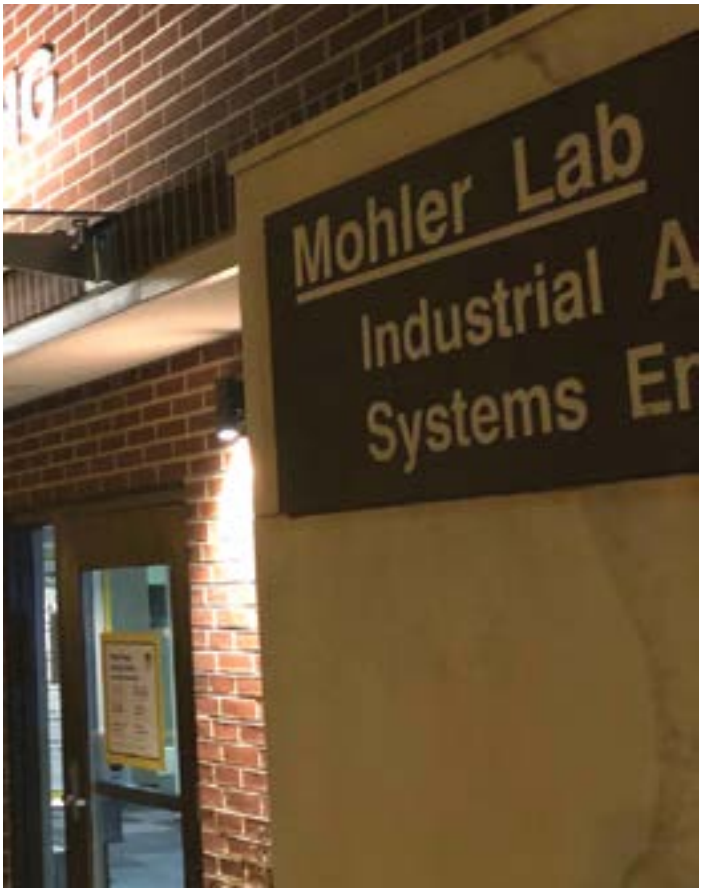
Renovations to Lehigh's Harold S. Mohler Laboratory have made the home of **Lehigh's Department of Industrial and Systems Engineering (ISE)** a more high-tech, comfortable, and functional environment for learning and research.

"Improvements like these make an impact on the educational enterprise," says **Luis Nunes Vicente**, Timothy J. Wilmott '80 Endowed Faculty Professor and ISE department chair, who led efforts to upgrade the facility over the past three years. "Today, thanks to an investment of approximately $250,000 from the department, students and faculty have greater access to advanced equipment, more inviting common spaces, and easier scheduling."

The overall goal, says Luis, was to bring a more contemporary feel to Mohler Lab while fostering a greater sense of community within its walls.

Lehigh purchased the four-story building at the corner of Packer and Brodhead avenues (which was originally the home of Congregation Brith Sholom and still retains distinctive 1920s features such as stained glass windows) in the 1980s and dedicated it to ISE alum Harold S. Mohler '48, who served as a university trustee for more than a decade.
Recent improvements focus on areas that facilitate communication and collaboration, says Luis. In particular, two new smart conference rooms were created for communications and brainstorming. Both rooms feature AI-powered video conferencing, which is essential, he says, for conducting hybrid meetings with both in-person and remote attendees.

Renovated offices provide bright, modern workspaces for graduate students and visiting researchers. Digital signage conveys timely information and adds to the contemporary look. And updates to common spaces, including furnishings in the main lobby and the Gott Lounge (named after ISE alum Edwin H. Gott '29, former U.S. Steel CEO), offer students hospitable environments for solo study, group work, or socializing between classes.



Classrooms and computer labs have been optimized with features such as wall-to-wall whiteboards and enhanced projector capabilities—improvements that might seem mundane to outsiders but, says Luis, show that the spaces have been "tuned to perfection" for teaching the advanced analytics and optimization of ISE.

Even small changes—such as increasing storage capacity and organization as well as ensuring the overall work and learning environment, he says.

The updates also extend to the building's exterior: Mohler's brick and marble facade has been professionally cleaned and enhanced with the addition of highly visible signage and a sleek, lighted awning that provides protection from inclement weather. A section of the front sidewalk was also redone to improve accessibility.

When Mohler Lab was dedicated in 1986, it was dubbed a "facility of the future." Ensuring that it stays that way is a departmental priority, says Luis.

"These efforts are part of an ongoing process to maintain and improve ISE's facilities. It's a process that has and will continue to be important to our department."

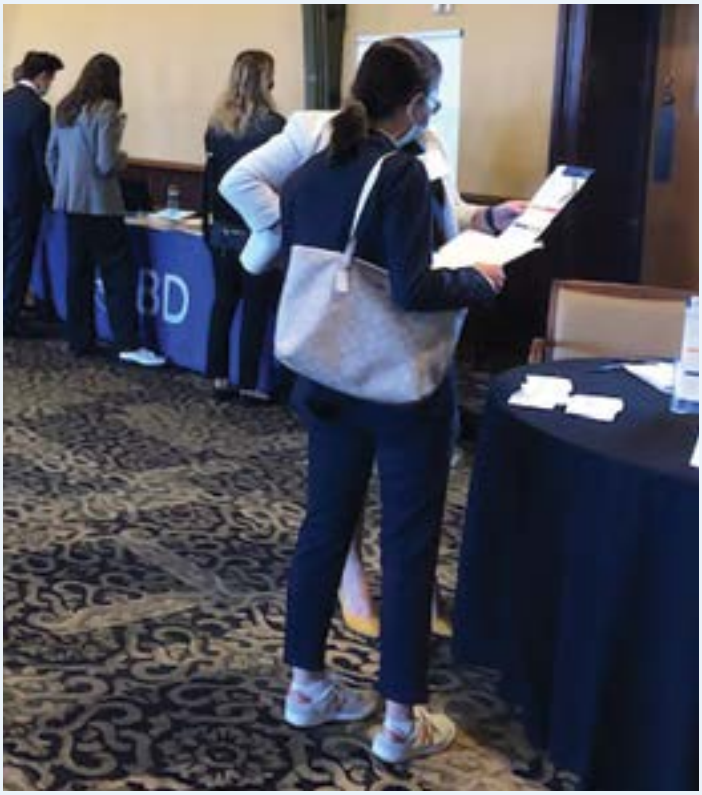
2021 Lehigh ISE Career Fair offered exciting employment opportunities to seniors and masters students

Held annually, this year's **Lehigh ISE Career Fair** convened on September 27, 5:00-8:00pm, at the Asa Packer Ballroom at the University Center. Populytics was the prime sponsor of the event.

Dressed in their best business casual clothing and practicing elevator pitches with their friends, more than 50 Lehigh University Industrial and Systems Engineering (ISE) seniors and master's students filed into this year's Populytics Lehigh ISE Career Fair with great anticipation. Welcoming each of them were many ISE alumni, representing their respective companies and organizations, sharing stories of internships that turned into professions and friendships that blossomed into successful startups. "I was surprised to see so many Lehigh ISE alumni represent their companies. It was great connecting with them!" said Parth Deven Ghandi '2023 ISE Master's student.

This year's Fair embodied a variety of participants from healthcare, software development, and consulting to versatile materials for endoprosthesis to fuel cells. What attracts companies to the Lehigh ISE engineer is that they apply critical decision-making and analytics to optimize complex processes, systems, networks, investments, and organizations that can be practiced in nearly all sectors of business.

As one of the initiatives of the **Lehigh ISE Industrial Liaison Program**, this year's Career Fair was the perfect opportunity for ISE engineers to network with alumni and in some cases, future employers.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NOVATION IS AT
HEART OF GORE.

FRANK E. CURTIS

DANIEL P. ROBINSON

Lehigh and Michigan join forces to design next generation optimization algorithms for data science applications

Advances in the design of algorithms for solving data science and large-scale, complex decision-making problems are paramount in modern-day scientific innovation. At the core of such algorithms is mathematical optimization, a particular strength of many of the faculty members in the Department of ISE at Lehigh. Lehigh ISE faculty members **Frank E. Curtis** and **Daniel P. Robinson**, in collaboration with Albert S. Berahas at the University of Michigan, have been awarded a three-year half-million dollar award from the **Office of Naval Research (ONR)** to design and analyze next-generation algorithms for solving problems aligned with the interests of ONR's Mathematics, Computer and Information Sciences (MCIS) Division.

For this project, the Lehigh and Michigan team will design, analyze, implement, and test algorithms designed to solve optimization problems involving stochastic objective functions and deterministic constraints. Despite recent advances in the context of solving unconstrained stochastic optimization problems—which includes the excitement around training deep neural networks (DNNs) for machine learning applications—relatively little has been accomplished in the constrained setting, despite the fact that constraints arise naturally in many applications of interest. Curtis, Robinson, and their faculty, postdoctoral, and student collaborators will leverage their expertise on stochastic nonlinear optimization to forge new classes of numerical methods for solving these cutting-edge problems.

Frank: "We're extremely excited to receive this support from ONR and look forward to this project, which we expect to lead to new algorithms and techniques that will inspire others in the community to tackle these very challenging and important types of problems."

TAMÁS TERLAKY

Lehigh ISE professor expands the optimization foundations of quantum computing

Among information engineers and scientists driving advances in theoretical computer science, control theory, statistics, quantum information sciences, and quantum computing in general, the topics of semidefinite and polynomial optimization (SDO and PO) attract great interest.

With support from the National Science Foundation Division of Computing and Communication Foundations, **Tamás Terlaky**, a professor of industrial and systems engineering at Lehigh University, is seeking to enhance the research community's understanding of this complexity while laying the groundwork for future advances in high performance and quantum computing methods.

"High performance computing has witnessed a steady advance in the efficiency of what are known as interior-point methods, or IPMs," says Terlaky. "But there are limits to their effectiveness, and known instances where even these highly effective IPMs fail to provide accurate solution. SDO methods, coupled with insights from real algebraic geometry lays the foundation to utilize the inherent power of quantum computing, and so have enormous potential to spark innovation in the quantum computing space."

The project, **On the Complexity of Semidefinite and Polynomial Optimization Through the Lens of Real Algebraic Geometry**, commenced October 2021, and aims to address several key questions on the complexity of SDO and PO through the lens of real algebraic geometry. The results of this project will deepen the understanding of the complexity in SDO and PO and have the potential to impact other disciplines, including quantum information sciences, where the emerging area of quantum IPMs with their unique advantages offer unprecedented intellectual challenges.

This is an interdisciplinary "NSF Collaborative Research" project, where Lehigh and Purdue researchers partner to tackle hard problems. The lead PI at the Department of Mathematics of Purdue University is Ali Mohammad-Nezhad joined by Co-PI Saugata Basu. Ali is a 2018 Ph.D. Lehigh ISE graduate.

DANIEL P. ROBINSON

FRANK E. CURTIS

Lehigh ISE team receives funding from the National Science Foundation

Lehigh ISE Professors, **Daniel P. Robinson** (PI) and **Professor Frank E. Curtis** (Co-PI) were awarded a three-year grant from the NSF Division of Mathematical Sciences to design, analyze, implement, and validate a new optimization framework that can manage more complex "sparsity" problems beyond the fundamental ones being used in practice.

Problems to minimize a function composed of a loss/data-fitting term and a regularizer have been of interest for decades throughout science and engineering. In particular, the past decade has witnessed an explosion of interest in problems involving sparsity-promoting regularizers such as the l1-norm, which are popular in compressed sensing, computer vision, machine learning, deep learning, and other areas. Moving past l1-norm regularization, researchers have realized the potential benefits of more complicated regularizers that promote structured sparsity, such as the group l1-norm and elastic net regularizers. Problems with such regularizers are significantly more difficult to solve. Therefore, the field demands new algorithms that are efficient and scalable, are applicable for problems with a wide range of structured sparsity-promoting regularizers, possess strong worst-case performance guarantees, and reliably offer accurate solution support estimates (i.e., predictions of the variables that are (non)zero at a minimizer).

During this project, algorithms will be designed to be broadly applicable, scalable, and efficient, and will be shown to possess strong convergence rate guarantees. The novelty of the proposed algorithms is that they will significantly build upon a "space decomposition with subspace acceleration" methodology recently developed by the PIs. This methodology, which the PIs have shown to yield state-of-the-art results for solving l1-norm regularized problems, adaptively decomposes the search space, then employs subspace steps based on proximal point and/or reduced-space Newton-type techniques.

Numerous science and engineering disciplines would benefit from scalable, efficient, and reliable algorithms for minimizing a loss function plus a term promoting structured sparsity. These include applications in computer vision (e.g., motion segmentation and face clustering), matrix completion, dimension reduction in multivariate regression, multi-task and label learning, and cost-driven prediction in healthcare, just to name a few. The PIs have strong expertise in the design, analysis, and implementation of algorithms for solving such problems, meaning that the project has a high probability of success.

Professor Robinson commented "Our team is excited because of the tremendously positive effect that our research will have in enabling smarter decisions in areas such as healthcare, medicine, and computer vision, to name a few."

2021 ISE Distinguished Alumni for Excellence in Industry Spencer C. Schantz Public Lecture

The ISE Department was honored to have David Burdakin, President JBT Aero Tech, give a **Distinguished Alumni for Excellence in Industry Spencer C. Schantz Public Lecture** titled **Great Businesses…How do they do it?** The lecture event was held Tuesday, October 21, 2021, in Iacocca Hall, Wood Dining Room from 4:30 to 5:30 p.m.

Dave was the recipient of the 2020 Distinguished Alumni Award. Because of the pandemic, the ISE Department was unable to hold the spring 2020 lecture and banquet. Fast forward to fall 2021, ISE was able to gather in person to honor our distinguished alumni, David Burdakin and enjoy his engaging and informative lecture.

Highlights from the lecture included companies such as Toyota, Danaher, and Illinois Tool Works (now "ITW") that went from humble beginnings to industry leaders. Burdakin shared key concepts and tools that can be applied to all organizations looking for growth. Following the lecture, alumni, faculty, and students enjoyed a cocktail reception and dinner also held in Iacocca Hall Wood Dining Room.

Dave Burdakin is Executive Vice President and President JBT AeroTech for John Bean Technologies Corporation (NYSE: JBT), a position he has held since early 2014. JBT AeroTech is America's leading provider of Airport Gate and Ground Support Equipment. Most known for its Jetway© brand passenger boarding bridges, JBT is also a leading global manufacturer of deicer trucks, cargo loaders and pushback tractors as well as provider of technical maintenance services at over 20 major airports.

JBT AeroTech is the third business where Dave has served as President, led a Lean Transformation and achieved record sales and profits. He had previously served as President of Paladin Brands and President of The HON Company, the largest operating company of HNI Corp. Before joining HNI, he held various roles at Illinois Tool Works, Bendix Industrial Group, and American Can Company. Dave also served on the Board of Directors of Wabash National Corporation (NYSE: WNC) for six years and was elected Lead Director in 2006. Dave holds an MBA from Stanford University Graduate School of Business and a BS degree in Industrial Engineering from Lehigh University. He and his wife Kim reside in Chicago. They have four adult children and one grandchild.

Lehigh ISE Spencer C. Schantz Distinguished Lecture Series

The lecture series is endowed in the name of the late Spencer C. Schantz, who graduated from Lehigh in 1955 with a B.S. in Industrial Engineering. Following progressive responsibilities with several electrical manufacturing companies, in 1969 he founded U.S. Controls Corporation and became its first CEO and President. The Spencer C. Schantz Distinguished Lecture Series was established by his wife, Jerelyn, as a valuable educational experience for faculty, students, and friends of Lehigh's Industrial and Systems Engineering department.

ISE Seminar Series

Lehigh ISE enjoyed an impressive lineup of guest speakers during the Fall 2021 Semester

2021

NOVEMBER 16, 2021
Kimia Ghobadi, Johns Hopkins University
"COVID-19 Hospital Capacity Management using Math Modeling"

NOVEMBER 9, 2021
INFORMS DISTINGUISHED SPEAKER: Dr. Jong-Shi Pang, University of Southern California
"Some Nonsmooth Function Classes and Their Optimization"

NOVEMBER 2, 2021
Nathan Kallus - Cornell Tech
"Smooth Contextual Bandits"

OCTOBER 19, 2021
Georg Stadler - NYU Courant Institute of Mathematical Sciences
"Optimal control of PDEs under uncertainty with joint chance constraints"

OCTOBER 12, 2021
Emily Tucker - Clemson University
"Reducing Drug Shortages by Improving Supply Chain Resiliency"

OCTOBER 5, 2021
Gabor Pataki - UNC Chapel Hill
"How do exponential size solutions arise in Semidefinite Programming?"

SEPTEMBER 28, 2021
John Wright - Columbia University
"Deep Networks and the Multiple Manifold Problem"

JENNIFER LAKEFIELD
CFP, B.S. IE '91

ISE welcomes Jennifer Lakefield as newest member of the ISE Advisory Council

Jennifer Lakefield graduated from Lehigh University in 1991 with a Bachelors in Industrial Engineering and currently holds the Certified Financial Planner™ certification.

Jennifer is semi-retired with over 30 years of experience at Investment Management organizations and financial services institutions. Her experience includes Portfolio Management, Traditional and Alternative Investments, Business Development, Sales & Marketing, Risk Management, problem solving, strategic planning, financial planning, and financial asset research.

Additionally, throughout her career, Jennifer has had a passion for volunteer work. Most recently she served as Chief Volunteer Officer and Chairperson of the Board of Directors of The Great Monmouth County YMCA. Throughout her term she helped lead the organization in hiring a new CEO, building out the management team and board committees, navigating a merger, a strategic planning initiative and helped strategize and pivot throughout the COVID-19 crisis. She continues to serve on both their Corporate and Foundation boards. She is also involved with The Nature Conservancy in both NJ and FL, as well as a variety of other charitable organizations.

Jennifer and her family – husband Bryan Briscoe and son Terence (TJ) – Lehigh, Civil Engineering, 23', split their time between Naples, FL and Colts Neck, NJ. Their daughter Mackenzie – UC Berkeley 21', lives in New Haven and works in Cognitive Science Research at Yale.

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