GEORGIA INSTITUTE OF TECHNOLOGY

INDUSTRIAL & SYSTEMS ENGINEERING

The H. Milton Stewart School of ISyE Alumni Magazine

Fall 2016

ISyE: Connected

Thank you for picking up the annual issue of the Stewart School of Industrial & Systems Engineering's (ISyE) alumni magazine. Here you can read about the School and some of its programs, research, projects, and outreach activities. You will also learn about some of our outstanding faculty, students, and alumni. I think you will find — as I do — that ISyE is creative, innovative, and has a strong interdisciplinary approach to problem solving.

At ISyE, we strive to create a better world by applying engineering principles to complex problems in order to find solutions. In order to compete in this globally connected world, we also seek to enhance and expand our collaborations with industry, government, and community partners.

We do this through a balance of two main branches of research: theoretical and application-driven. In the context of theoretical — or foundational — research, we work to enhance and expand the development and growth of ISyE by discovering breakthrough ideas, models, and solution approaches. In the context of application-driven research or projects, we apply the power of existing methodologies to new and real-world problems and problem domains of societal and global concern. A symbiotic relationship exists between these two research arms, and both of them are very important. For instance, the relevant problem-solving capabilities that we can provide a company today are often made possible by fundamental research that preceded them. Without advances in fundamental research, we limit ourselves in what we can contribute in practice.

At ISyE, we teach our students engineering principles, but just as importantly, we motivate deeper learning by teaching them how to think. We also encourage our students to expand their horizons through study abroad, co-op/internship programs, problem-based learning, and entrepreneurship, as well as participating in research projects.

ISyE is who we are today because of our connections — to our students, our faculty, and our alumni — who constitute a powerhouse of engaged, purpose-filled talent. And because of our research and project partners, our various disciplines, friends of the School, and the world at large. There are a variety of ways to partner with us to help advance our faculty, students, and program. I encourage you to stay in touch and help us continue to be the best School of its kind in the nation.

Keep that Yellow Jacket spirit alive!

Edwin

H. Edwin Romeijn, Ph.D.
H. Milton and Carolyn J. Stewart School Chair and Professor
H. Milton Stewart School of Industrial & Systems Engineering

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22

Feature Story

22

Bill & Penny George on Philanthropy, Leadership, & Health Care

9

39

47

ISyE News & Additional Features

2 ISyE by the Numbers

4 Senior Design: Project-based Solutions for Real-world Problems

6 Senior Design Team Instrumental in Successful Georgia Tech Library Move to New LSC

8 LEAP: Increasing Youth Participation in Trade and Logistics Careers

9 New Environmental Leadership Summer Program for High School Students

Mission Possible: High School Students Learn What It Takes to Be Industrial Engineers

10 Machine-learning Research at ISyE Brings a Powerful Approach to Solving Problems and Making Decisions

19 Three ISyE Researchers Receive 2016 Golden Goose Award for the Honey Bee Algorithm

20 Meet ISyE's Newest Advisory Board Members

27 Pinar Keskinocak, William W. George Chair and Professor, Focuses on Health & Humanitarian Systems

28 Development of Workforce Allocation Optimization Tool Traces Path through ISyE

32 Research Briefs

38 Redefining Success as an Avenue of Personal Growth

39 Kimbrough's Unique Vantage Point

40 Alumni Spotlight: Tracy Hawkins and Safe Drinking Water for Tanzania

43 Edward H. Kaplan, ISyE 2016 Distinguished Scholarship Lecturer, on Adventures in Policy Modeling

45 ISyE Dedicates Studio in Honor of Cecil G. Johnson

47 The Classes of 1951 and 2016: 86-year-old Graduate Prepares for Commencement

48 Reflections: Studying Abroad and Defining Success

ON THE COVER: *Standing — Pinar Keskinocak, William W. George Chair and Professor, and Monica Villareal (Ph.D. IE 15) former George Fellow. Seated — Bill (BSIE 64, Honorary Ph.D. 08) and Penny George and Sheereen Brown (BSIE 12, MSHS 14) former George Fellow. Illustration by Michele Melcher*

ISyE by the numbers

ISyE is the No. 1 program of its kind, as ranked by *U.S. News & World Report.*

26 Number of consecutive years the ISyE graduate program has been ranked No. 1

22 Number of consecutive years the ISyE undergraduate program has been ranked No. 1

Degrees Offered:

1 B.S. in IE degree

- With 5 concentrations in:
  - Economic and Financial Systems
  - General Industrial Engineering
  - Operations Research
  - Quality and Statistics
  - Supply Chain Engineering

9 Master's degrees

- Master of Science in Analytics
- Master of Science in Health Systems
- Master of Science in Industrial Engineering
- Master of Science in Operations Research
- Master of Science in Quantitative and Computational Finance
- Master of Science in Statistics
- Master of Science in Computational Science and Engineering
- Master of Science in Supply Chain Engineering
- Master of Science in International Logistics

5 Doctorate degrees

- Industrial Engineering with concentrations in:
  - Supply Chain Engineering
  - Statistics
  - Economic Decision Analysis
  - System Informatics and Control
- Operations Research
- Algorithms, Combinatorics, and Optimization
- Computational Science Engineering
- Bioinformatics

Fall 2016:

Enrollment

1,553	295	156
Undergraduates*	Masters	Doctoral

Enrollment of Women

46%	39%	26%
B.S.	M.S.	Ph.D.

**includes co-op and study abroad students*

AY 2015-2016

ISyE Degrees Awarded

393
B.S. degrees

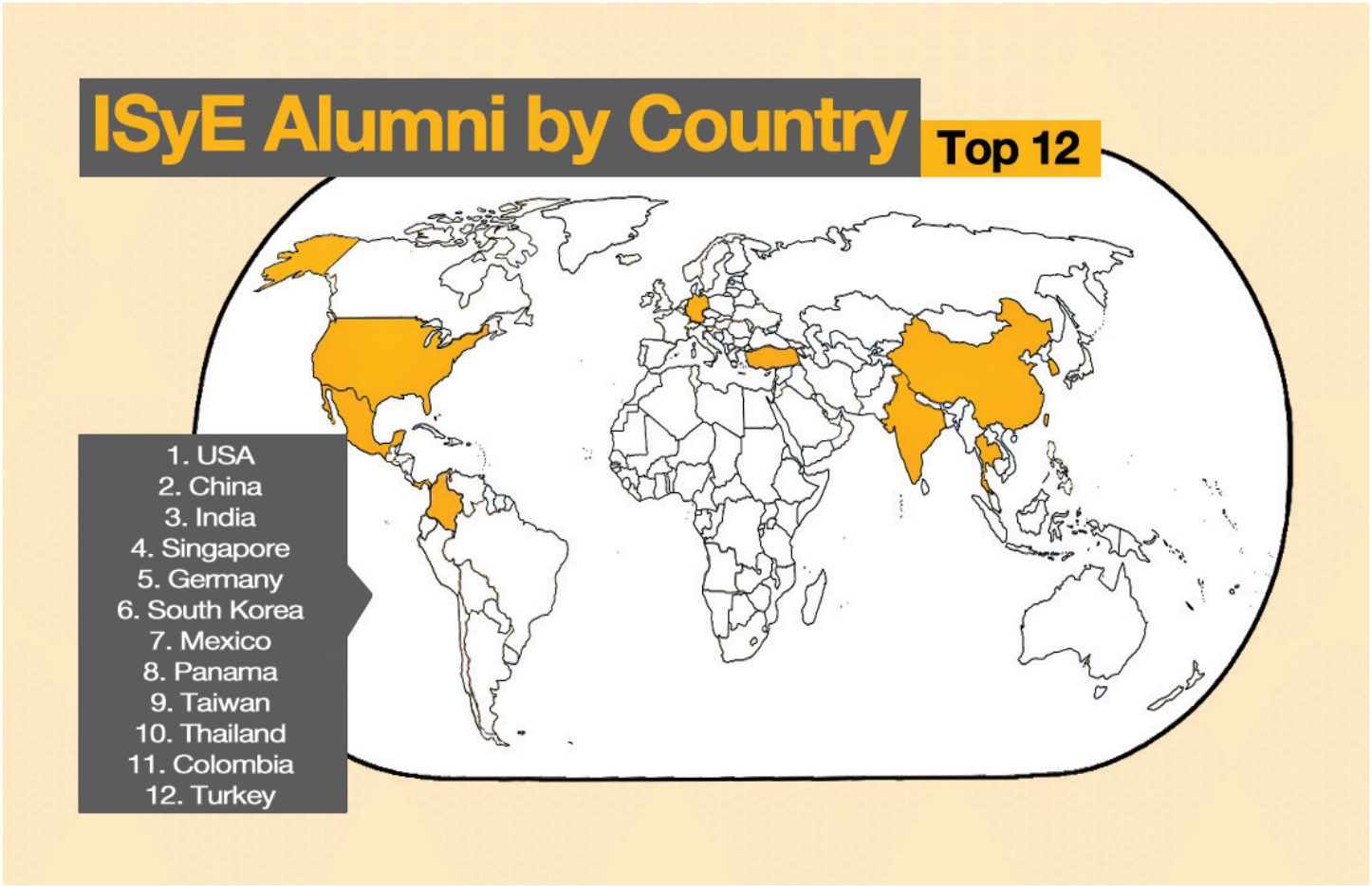
166
M.S. degrees

19
Ph.D. degrees

Of the 393 B.S. IE degree recipients in 2015-2016

- **61%** graduated with honors.
- **27.5%** graduated with a co-op designation on diploma.
- **39.7%** participated in study abroad.*
- **13.8%** participated in undergraduate research.*
- **12.7%** plan to go to graduate school.*
- **95.4%** entered industry careers upon graduation or had job offers two months prior to graduation.*
- **$68,000** median starting salary with a B.S. IE.*

**self-reported*



Senior Design: Project-based Solutions for Real-world Problems

Twenty-eight Senior Design teams completed real-world Capstone projects for the spring 2016 semester. The 28 teams presented their projects at the spring 2016 Capstone Expo on April 26, 2016. Out of this group, three teams — Interface, reFUEL, and UPS Air Opt — were chosen as finalists to compete in the Best of Senior Design on May 4. Team Interface was selected as the first-place winner. During the 2016 Capstone Expo, a panel of alumni judges chose Senior Design team Second Self as the ISyE winner.

First Place: Developing a Sales and Operations Planning System for Interface, Inc.

The Interface team developed a sales and operations planning system for Interface, Inc., the world's largest modular carpet tile manufacturer. The software-based system takes in sales history for demand forecasting and production planning. With customizable inputs, the system generates potential production scenarios to run through a simulator of the entire production process. This allows Interface to analyze results, compare trade-offs, and make continuous improvements. With the team's recommendations, the system predicted production savings of $2.2 million for the first quarter of 2016.

Interface implemented the project by the end of the third quarter in 2016, which will build the foundation of a sales and operations planning team, which Interface did not have prior to the Senior Design project.

"The Interface team is proud to have worked with the ISyE Senior Design team. Their work to develop a sales and operations planning system gives us the ability to quickly evaluate various production and inventory strategies given a certain demand scenario. This system gives us the scenario-planning tool we need to continuously adapt our strategy to changes in the marketplace," said Chris Turk, Senior Vice President for Manufacturing and Operations at Interface.

Jingyu Zhu, Yaodong Jia, Kattelie Thys, Antong Su, Ziyu (Tino) Zhang, Alexandria Schmid, Lisa Liu, and advisor Alexander Shapiro

Finalist: Recognizing Fraud Using Ensemble of Learners for Fleetcor

Team ReFUEL developed a random forest classification model using machine learning to detect and prevent fraud for Fleetcor. The company is a leading independent global provider of specialized payment products and services including fleet cards, food cards, corporate lodging discount cards, and other specialized payment services for businesses throughout the world. Fleetcor, which is liable for all fraudulent transactions on their cards, can use this model to save upwards of $5 million in fraud payouts each year.

"The Senior Design team from Georgia Tech was a pleasure to work with," said Justin Els, Risk Manager for Fleetcor Technologies. "The talented and highly motivated team produced an elegant fraud detection model that surpassed our expectations. This model provided invaluable insight into new fraud trends occurring throughout the country."

Advisor Sebastian Pokutta, Haidan Zhou, Julia Wayne, Mary Elizabeth Herndon, Haeun (Ashley) Park, Saharsh Chordia, Andree Curran, Matthew Faenza, and Kyung Kim

Finalist: Embedding Consolidation into Routing Decisions for UPS Air

Team UPS Air enabled UPS International Air Freight to take full advantage of package consolidation for international shipments by redesigning their routing decision process. This was accomplished through the development of an optimization-based tool that effectively combines dense and volumetric cargo on flights.

UPS has already begun to implement the project by using the optimization tool in the UPS International Air Freight business unit. After the tool has been fully vetted using sample data, the optimization tool will be implemented as a stable analytical tool that complements the business unit's existing toolkit of evaluation software/methods, according to Jack McPherson, Network Planning Services Manager of UPS Corporate Transportation.

"I cannot speak highly enough of the Senior Design team that supported this project. As an ISyE alumnus, I am very proud of how the team members represented our institution and the ISyE program," said McPherson. "The team was able to quickly comprehend a very complex problem and provide an implementable solution through a robust mathematical model and optimization tool deliverable."

Peter Alcock, James Alcock, Cristian Barron, Nicole Gottret Murillo, Abubaker Abubaker, Emily Dong, Eduardo Prieto, Sebastian Salazar, and advisor Paul Griffin

Judges' Award: Enabling Scalable Growth for Second Self

The Second Self team worked with local microbrewery Second Self — founded by Jason Santamaria (MSMGT 06) and Chris Doyle (BSMGT 07 and MBA 11), two Georgia Tech alumni — to implement a project that will enable the brewery's scalable growth from a local to a regional brewery.

Second Self is in their third year of production and has reached a crucial period of growth and development. They must be able to keep production up with increasing demand. The goal of the project was to find and eliminate inefficiencies in Second Self's current production schedule, facility layout, and inventory systems, while providing Second Self with a comprehensive growth plan in order to reach regional brewery status, thus staying competitive in the Southeastern craft beer market.

"We both really enjoyed working with the team. We gave them access to all parts of the business, and they came up with many suggestions for us that we will be implementing in the next few months. We always enjoy working with Tech students and alumni because of their driven work ethic and ability to think outside the box," said Santamaria, Second Self beer architect.

Edwin Romeijn (ISyE School Chair), John Na, Brian Homans, Matthew Zerkus, Charlie Oliva, John Cho; bottom row (l-r): Yikyung Kim, Sue Pedapudi, and Gloria Lozano (not pictured: advisor Benoit Montreuil)

Senior Design Team Instrumental in Successful Georgia Tech Library Move to New LSC

Imagine being given the task of relocating over two million books and other research materials from a library to another building almost five miles away. And a time frame of just a few months in which to complete the project.

This is exactly the challenge that was being faced by the staff of Georgia Tech's library in the spring of 2016. Tech's Crosland Tower and Price Gilbert libraries were scheduled to be closed in December 2015 for renovation to make the libraries' physical space more user-friendly, rather than centered around housing the library's material collection. In the last 10 years, visits to the libraries have increased by 50 percent, while check-out of print materials has dropped 75 percent in the same time period. Ninety-five percent of the library's holdings were moved to the new EmTech Library Service Center (LSC).

The LSC is a high-density storage facility – there are about 40-50 similar high-density library storage facilities around the country – designed to permanently house Tech's library materials, along with most of Emory University's. The LSC is located on Emory's Briarcliff campus, where materials are stored on 32-foot-high shelves at a temperature of 55 degrees with 30 percent humidity to preserve the life of the collected materials for up to 250 years.

Because of scheduling issues, Tech needed to get its materials into the LSC in the span of a few months. This was the ingest process, part of which included what Kimberly Mull, Director of Security, Facilities, and Logistics for the Tech libraries, called "deduping" — removing duplicated book titles, journal runs, and other materials that Tech shared with Emory's library.

Ingestion also involved processing each individual piece of material, vacuuming it prior to storage, and giving everything a barcode so books and materials can be located by order pickers within the LSC.

Because the ingestion and set-up process of the LSC was essentially a warehousing project, Catherine Murray-Rust, Dean of Libraries & Vice Provost for Academic Effectiveness at Georgia Tech, knew that this was an area where industrial engineers could play a role. She thought the LSC ingestion process would make a good ISyE Senior Design project.

"If we had some IEs look at the process, then they could bring some warehousing strategies that the library community doesn't really understand very well and apply them," said Murray-Rust. "It seemed a really wonderful opportunity to give back to [the library community] from something on the other side of our lives, which is the engineering perspective."

So that's where the Senior Design team — Taylor Cormier, Sagar Govil, Ansley Hobbs, Jung Ha Lee, Trisha Long, Sinan Najm, and Andrea Norris (advised by Andrea Laliberte, Edenfield Executive in Residence and Professor of the Practice) — from ISyE stepped in.

"We were looking for a project we were excited about, and [we liked] the idea of having this project so close to campus and involved with Georgia Tech," said team member Trisha Long. "It's a really unique project, and we couldn't have picked a better one."

The team worked closely with Mull and Jay Forrest, a reference and subject librarian from Tech who was heavily involved with the ingestion process, on developing a plan to make the move from Tech go as smoothly as possible.

Initially, the team visited several other high-density storage sites, including at the University of Georgia and the research facility shared by Duke University, North Carolina State University, and the University of North Carolina-Chapel Hill. Then the team came back and looked at EmTech's LSC. These visits gave the Senior Design team information about the kinds of questions they needed to ask about EmTech's ingestion process, while considering such constraints such as budget, safety concerns, and how much equipment needed to be purchased for the move.

"Our main constraint was trying to reduce the budget as much as possible within the safety constraints, and [visits to the other high-density facilities] helped us picture how much equipment the library would want to keep [after the move]," explained Long. "We wouldn't want to buy lots of equipment and have it not be useful, so we tried to take into consideration what they would use – such as how many carts and how many vacuums would keep the collection alive for the next few years.

"After those trips, we were totally inspired. We were able to create a flow-process model that gave us two different ways to make decisions: Is it the fastest way and is it the cheapest way and go back and forth between the two models, and narrow down what our final recommendations were."

The team came up with several suggestions that positively impacted the ingestion process. One, said Forrest, involved the use of gravity conveyor belt rollers in the processing line: "Prior to using gravity rollers, we were probably processing 12,000 books per day per average for about a month. We identified a source for gravity rollers, brought them in, and implemented them. That helped us get to 15,500 books per day on average. So that one change improved our throughput quite a bit."

Perhaps most importantly, the team's flow-process model and long-term projections confirmed that the library could hire a moving company at several hundred thousand dollars below the projected budget. "We went from one vendor that was over our initial budget to one vendor that was quite a bit under our initial budget," explained Forrest. "This resulted in cost-savings to both Emory and Tech."

Now that Georgia Tech's library collection is safely moved and stored at the LSC, Mull praised the Senior Design team's role in the success of the move: "I think it was a good collaboration. We see students all the time in the library, but to actually work with them had a good result. We incorporated around 90 percent of the team's suggestions, and I would love to do another project with another Senior Design team. It left a really good imprint on the library."

When asked how it made her feel to hear about the positive results of her team's hard work, Long said, "From the beginning my team was excited to work with the school. The project let us learn so much about our library, and we walked away feeling even more connected to Tech." ▪

Senior Design by the Numbers

Just to give you an insight into what is being accomplished by some of ISyE's Senior Design teams, here is a summary of the potential impacts for particular sponsors from projects they hosted during the spring 2016 semester:

- **23%** reduction in product unit cost, $2.2 million/year.
- **45%** reduction in expedited shipping, $2.1 million/year.
- **130%** increase in profitability and **40%** increase in inventory turns.
- **$10-23 million/year** increase in profit from improved pricing.
- **$2.9 million/year** savings from centralizing an audit function.
- **$1 million/year** savings in outbound transportation.
- **$3.5 million/year** savings from improved freight consolidation.
- **48%** reduction in defects, $200K/year.
- **$2 million/year** savings in international shipping.
- **$5 million/year** reduction in fraud losses.

The group of 28 Senior Design teams has shown potential for more than $30 million/year in savings or increased profits.

In addition, teams have:

- Launched strategic initiative for a major 3PL.
- Developed strategic growth plan for craft brewer.
- Improved clinical trial planning in the Democratic Republic of Congo (DRC).
- Improved polio screening in the DRC.
- Avoided excess investment in CAT scan equipment for a hospital.
- Improved patient experience in a women's health care center.

LEAP: Increasing Youth Participation in Trade and Logistics Careers

Georgia Tech's Supply Chain & Logistics Institute (SCL) has launched a fast-track certification program designed for 16 to 24 year olds to learn about the world of supply chain and logistics and to help them become the talent employers are looking for in this field.

"We are pleased to be providing an opportunity to an audience who may not yet know about the numerous potential job opportunities and career paths in logistics and how to prepare to capitalize on these opportunities," said Tim Brown, SCL Managing Director.

The program is easy to access, self-paced, online, and students can begin at any time. Also, there is no minimum GPA requirement.

The Logistics Education and Pathways (LEAP) program includes four main areas of online instruction:

- Supply chain management principles.
- Warehousing operation.
- Transportation operations.
- Customer service operations.

Students will be able to learn at their own pace while progressing through the online program toward a certificate. In addition to the course content, students will receive career coaching, resume advice, and participate in industry career opportunities.

The LEAP program is currently tuition-free for residents of various counties and active-duty military members who will be moving to one of these counties. To learn more, visit **https://www.scl.gatech.edu/leap**.

"The LEAP program is an excellent way to introduce young people to the world of supply chains," said Scott Figura, former Coca-Cola Supply Chain Executive. "It will help develop a much-needed pipeline of talent to support new and existing operations. The participants will be prepared for a quick integration into the business operations by learning industry fundamentals and common language. LEAP can help to identify and develop the next generation of supply chain professionals and prepare them for solid job opportunities in our community."

The LEAP program was made possible by a generous grant from J. P. Morgan Chase & Co. ▪

Video: LEAP into a new future. Learn the knowledge needed to participate in the growing field of supply chain and logistics. **http://bit.ly/2aFni9f**

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New Environmental Leadership Summer Program for High School Students

Georgia Tech hosted the first-ever week-long Environmental Leadership summer program for high school students in July. Founded and led by ISyE's Valerie Thomas, Anderson Interface Professor of Natural Systems, the program featured a multidisciplinary approach to developing environmental leadership skills in young students.

Nineteen students participated this year, engaging in a variety of high-energy and fun activities. Highlights included:

- Building pizza box solar ovens (and baking s'mores in them).
- Implementing a waste audit of Georgia Tech's recycling efforts.
- Building and racing solar- and battery-powered cars.
- Playing resource allocation and international treaty negotiation games.

Students participated in discussions with young environmental leaders, as well as with ISyE's Ron Johnson. They also had the chance to tour energy and environmental research labs at Georgia Tech. This included the Tech Hydroponics Lab and a LEED (Leadership in Energy and Environmental Design) Certified building.

The program's counselors consisted of Georgia Tech undergraduates from electrical and computer engineering, public policy, and materials science and engineering. The camp was co-developed by Thomas' two children. Her daughter, Irina Bukharin, now a junior at Swarthmore College majoring in political science, developed the leadership component of the camp. Thomas' son, Alexander Bukharin, now a high school senior, helped develop the activities, tested the games, and proved the solar oven design.

Mission Possible: High School Students Learn What It Takes to Be Industrial Engineers

The fifth annual Mission Possible, ISyE's summer program for rising ninth through 12th graders, was held this past June, and was sponsored in part by Procter & Gamble. Coordinated by Dawn Strickland, Academic Advisor and Instructor, and Brandy Blake, Professional and Technical Communication Coordinator, 33 high school students were introduced to the field of industrial engineering through conversations with ISyE faculty, a guest speaker presentation by Caterpillar, a field trip to Coca-Cola's executive offices, and hands-on learning activities.

At the end of the week, students gave group presentations that focused on creative solutions to real-life industrial engineering problems.

"These were mini IE problems that gave the students a taste of what it is like to think like an industrial engineer," said Blake. "I was impressed with the variety of solutions these young students came up with to solve their project problem."

The students were given one of two problems to solve. The first involved a pedestrian flow problem in the lower East and Club Lounge areas of Tech's Bobby Dodd Stadium. They toured the stadium and the problem areas so they could more easily visualize possible solutions. The second problem concerned campus sustainability. Employees from Tech's sustainability office spoke to the campers about how campus recycling efficiency could be improved. The campers focused on improving recycling while taking cost into consideration.

"I thoroughly enjoyed working with these students and finding ways to open their minds to the exciting field of industrial engineering and how IEs approach solving problems," said Blake. "And I look forward to meeting a new group of students in 2017."

Machine-learning Research at ISyE Brings a Powerful Approach to Solving Problems & Making Decisions

by Gary Goettling

A child born today will probably ride to middle school in a driverless car or bus, guided safely along its route by machine-learning algorithms.

Machine learning is a branch of artificial intelligence in which computers are trained to learn from data so as to perform tasks on their own, whether detecting anomalies in a secure computer network, accurately predicting customer demand, or navigating an autonomous vehicle through traffic.

For Georgia Tech engineers, machine learning presents both opportunities and challenges — and the H. Milton Stewart School of Industrial & Systems Engineering (ISyE) is well positioned to take a leading role.

"The ISyE school at Georgia Tech has worked very hard over many years to establish an outstanding reputation for combining innovation with applications in engineering," said Sebastian Pokutta, David M. McKenney Family Associate Professor and Associate Director of Research for the Center for Machine Learning @ Georgia Tech (ML@GT). "This makes us a logical place for the development and deployment of machine learning — perhaps the hottest area of engineering today. We have the benefits of an established research infrastructure with a tradition of close collaboration among all Tech colleges and schools. This tradition extends to our numerous industry partnerships as well. Also, we have terrific, capable people. Our faculty, students, and staff enjoy solving complicated problems — and they're very good at it."

All analytical tools share a common purpose in that they extract meaningful information from large sets of data to inform decision making. What sets machine learning apart is its predictive accuracy. Unlike standard computation, where a computer follows explicit instructions from a human programmer to perform a defined task, machine-learning algorithms are trained to look for and remember certain patterns in data that are relevant to the performance of a specified task, which is expressed as a mathematical model. When provided new data — algorithms provide insights, outcomes, and "what-if" scenarios but they cannot create new data — the algorithms then act on their previously gained knowledge, their experience, to solve other problems or perform tasks by adjusting the model outcomes accordingly. For example: Show a thousand pictures of a dog to a machine-learning algorithm, and it will learn the characteristics of dogs and then be able to pick them out from a gallery of animal photos.

Machine learning is not new. It's the technology that powers search engines as well as recommendation systems used by Facebook, Amazon, Netflix, eHarmony, and thousands of other sites.

What's new is the rapidly increasing number and scope of applications for machine learning, boosted by the availability of tremendous amounts of data, cheap data storage, advances in high-performance computing, and the development of increasingly sophisticated machine-learning algorithms.

Applications run a diverse gamut from supply chains and logistics to computer vision and object recognition; from autonomous vehicles and natural language processing to health data analysis and manufacturing.

From an industrial engineer's perspective, machine learning is a powerful way to automate the optimization process in large, complex systems involving petabytes of data — a scale too large to be handled by traditional computation.

At ISyE, machine-learning techniques go hand-in-hand with the school's traditional research and education mission that emphasizes the development of methodologies to solve real-world problems.

"We're interested in developing and devising machine-learning and optimization methodologies to see how they interact with each other and whether they can be made to interact in a very integrated way," said Pokutta. "Then deploy these technologies or methods in real-world applications in a variety of different domains."

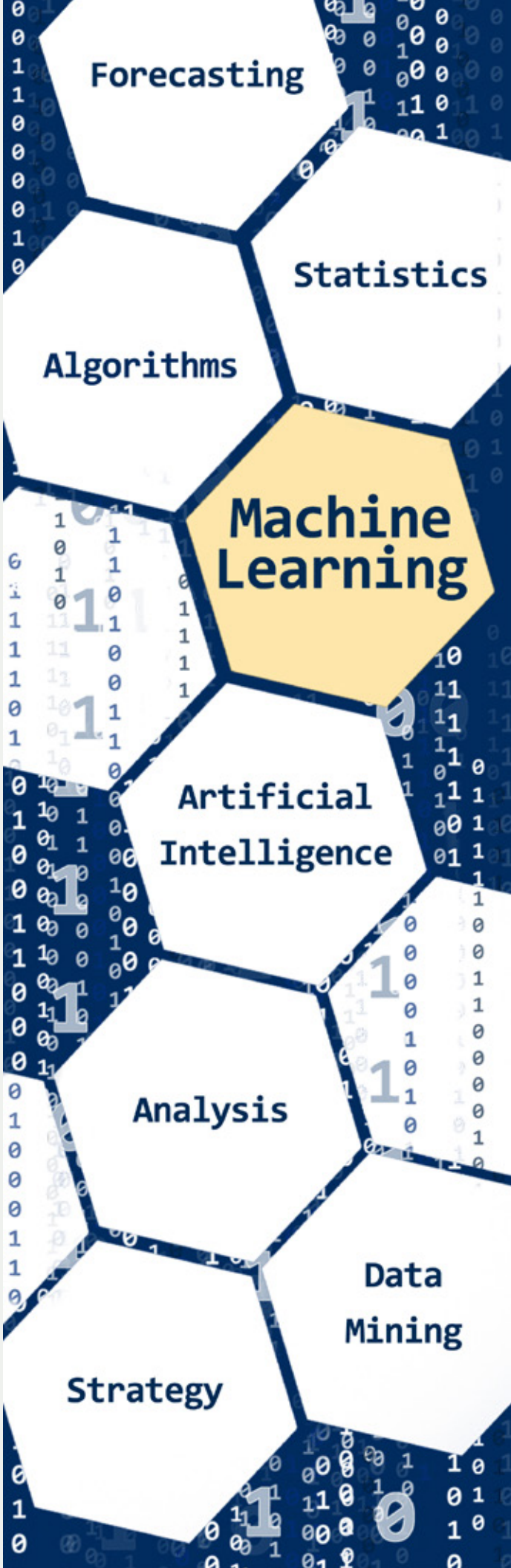
While machine learning is concerned with studying data to obtain new insights, "you still have to do something with those insights," he continued, "and that's where the optimization part comes into play because you have to make those insights actionable by turning them into decisions — that's when the connection between machine learning and optimization becomes apparent."

ISyE faculty are involved with machine learning in a number of key areas including:

Supply Chains and Logistics

When it comes to optimizing supply chains regarding production, supply, product deployment, distribution, and delivery, machine-learning research and development at ISyE are having a profound impact in two ways. One, they automate routine supply chain decisions, enhancing speed and efficiency. And two, machine-learning algorithms provide human decision makers with predictive analysis and guidance for the choices they make in response to changing circumstances. In effect, machine learning is making supply chains smarter, which dovetails with the emerging concept of the physical internet.

The physical internet takes some of the basic characteristics of the information internet — open access, standardization, interconnectedness, digitization, speed — and applies them to the operation of supply chains and logistics, said Benoit Montreuil, Coca-Cola Material Handling and Distribution Chair, Professor, and Director and founder of the Physical Internet Center.



"In this context," he continued, "we're taking advantage of the physical internet's digital aspect to hyperconnect all facets of a given business, and then using machine learning to understand the business more deeply. We have a project right now with an industry partner where we're using machine-learning techniques to model product availability through their autonomous dealer networks, their factory, and warehouses in order to help them make better decisions."

The ISyE school at Georgia Tech has worked very hard over many years to establish an outstanding reputation for combining innovation with applications in engineering. This makes us a logical place for the development and deployment of machine learning — perhaps the hottest area of engineering today. — Sebastian Pokutta

Montreuil anticipates that machine-learning algorithms will eventually automate a significant portion of product movement through the adoption of smart, standardized modular cargo containers — a key component of the physical internet. Fitted with sensors and two-way communication with the shipper through a wireless computer network, containers will learn how to operate in a dynamic environment and be largely self-directing, he said.

"You will communicate to the container that it has to be in Chicago in 18 hours, let's say, and it will work as autonomously as possible to get there, interacting with humans or more sophisticated logistics agents only as necessary, using machine learning as one of the reasoning mechanisms to make sure the modular container goes where it is supposed to go."

Machine-learning algorithms and techniques being developed by ISyE researchers Schneider National Chair in Transportation and Logistics Chelsea White, Coca-Cola Professor Alan Erera, H. Milton Stewart Associate Professor Mohit Singh, and Assistant Professor He Wang, also support supply chain forecasting models that more accurately predict the impact of demand variables, and thereby help decision makers optimize their supply chain operations. Common influences on demand include new product introductions, seasons and holidays, consumer preferences and trends, product promotions, weather, and material shortages.

The work will enable companies to better manage inventory levels, improve delivery times, enhance customer satisfaction, and ultimately save money. Machine-learning analysis also provides management with a dynamic view and a high level of visibility of the core processes and elements of their supply chain.

Algorithms work with historical data as well as data drawn from contemporary sources such as social media, where the first inkling of important consumer trends often appear. In a method called online learning, data becomes available in a sequential order, and decisions are made in real time. For example, when a company launches a new product, it can use online learning to track the sales data and adjust its pricing and inventory strategies for this product.

Machine learning also facilitates a rapid response to unexpected disruptions to the supply chain, such as a natural disaster in an area that's the source of a particular raw material, thereby enabling companies to seek alternatives.

"There's a lot of ground work still to be done in machine learning as it relates to supply chains and logistics," said Montreuil. "It's a very pioneering domain and a fantastic time for researchers."

Health Care

The U.S. health care system is awash in data: electronic health records; claims data; medical procedure results such as EKG readings, lab test findings, and genetic analysis; and health-monitoring information from wearable devices.

This wealth of data is fueling innovative analytics-based research for improving health care in three main areas: efficiency (cost), effectiveness (outcomes), and public health, particularly in terms of equity in the system and ensuring that the needs of vulnerable populations are addressed. In addition, data analytics can make it possible to tailor medical treatment to the needs and characteristics of individual patients, said Julie Swann, Harold R. and Mary Anne Nash Professor and Co-director of the Interdisciplinary Research Center for Health & Humanitarian Systems, adding that "we're still in the early stages of what is being called individualist or precision medicine.

"You have to have a large enough set of data so that you can start to draw conclusions from it," she continued. "These datasets may be deep, very detailed, and could also be wide in the sense that you're bringing together heterogeneous data types."

While data is becoming increasingly available, it takes a lot of resources and advanced methodologies to fully harness its power, according to Swann. Machine learning is one set of analytic techniques that's being used to turn data into information and knowledge for application at either the policy level or patient population level.

Algorithms create a mathematical model specific to a particular area of inquiry, such as patient care at a particular hospital, that imparts a big picture understanding of the system and how certain decisions or actions affect the system as a whole. More important, the algorithms can predict the consequences of one decision versus another regarding whatever metric is being studied.

"Data can drive decision making," she said. "For example, you can use data to inform what kinds of things insurance should be required to pay for or what interventions associated with a specific disease or illness are most effective at reducing the burden on the entire system."

Machine learning and analytics can reach down to the clinician level in exceptional detail to look at, say, continuous patient monitoring in an intensive care unit. Researchers can learn what kinds of medical situations qualify for monitoring and for how long, what medical actions were taken related to the monitoring, and if a personalized treatment approach would be possible, based on certain patient characteristics.

"The modeling of systems that have tens of thousands of constraints or variables can be used to evaluate access to health care too," said Nicoleta Serban, Coca-Cola Associate Professor with the ISyE Health Analytics research group. "For example, collecting health care utilization data involving millions of individuals for events such as hospitalizations can be used in estimating the cost savings of preventive care. Modeling to assess for the occurrence of severe health outcomes, applied to data for millions of individuals, can be used to characterize what impacts health care utilization behaviors. Distributed computing is used to improve the computational effort of such methods."

In one problem solving application of machine learning to health care, ISyE faculty are analyzing data from Geisinger, a hospital network in Pennsylvania, to help predict the risk for sepsis and septic shock in patients before they are admitted to the hospital. Sepsis and septic shock are the dominant causes of death in intensive care units in the U.S., accounting for up to three million cases yearly. The next step is to facilitate prevention measures by applying the analytical techniques developed by ISyE to real-time patient data at each of Geisinger's various locations.

While data is becoming increasingly available, it takes a lot of resources and advanced methodologies to fully harness its power. Machine learning is one set of analytic techniques that's being used to turn data into information and knowledge for application at either the policy level or patient population level. — Julie Swann

A machine-learning framework called DAMIP discovers gene signatures that can predict vaccine immunity and efficacy on an individual basis. Developed by Professor Eva Lee and her colleagues from Emory and the Centers for Disease Control and Prevention (CDC), the work marks an important advance in both developing new vaccines and better vaccines to fight emerging infections and improve monitoring for poor responses in people with weak immune systems.

DAMIP-implemented results for yellow fever demonstrated that a vaccine's ability to immunize a patient could be successfully predicted with greater than 90 percent accuracy within a week after vaccination. Results for flu vaccine demonstrated DAMIP's applicability to both live-attenuated and inactivated vaccines. Similar results in a malaria study enabled targeted delivery to individual patients.

Additional health care applications of machine learning by ISyE faculty include quantifying disparities in access to pediatric primary care, evaluating the impact of access to pediatric asthma care on severe health outcomes, projecting the

impact of Medicaid expansion in Georgia on access to adult primary care, and estimating the cost savings on preventive dental care for young children.

Swann emphasized that health care research at ISyE is collaborative. "Many of us are affiliated with other entities on campus such as the Center for Health & Humanitarian Systems and the Health Analytics group. We also draw upon the expertise of statisticians, computer scientists, optimization experts, systems engineering experts, and others in the area of advanced analytics, and machine learning is one part of that work toward improved health care decision making."

Energy

ISyE researchers at the Strategic Energy Institute (SEI) are helping the companies that produce and distribute electricity maintain their capital assets and provide uninterrupted service to their customers. These assets — transformers, turbines, generators — have been fitted with thousands of sensors that continuously stream performance data in real time to central monitoring centers scattered around the country. At the centers, data is analyzed for anomalies or abnormal behavior, which would trigger repair or maintenance actions to avoid a catastrophic system failure.

"You need really efficient analytical tools to analyze this data," said Nagi Gebraeel, Georgia Power Associate Professor and Associate Director of SEI, "and the underlying basis of these tools is machine learning."

Going a step further, machine-learning algorithms can predict the risk of asset failure over time. This knowledge allows utilities to optimize operations in terms of pricing, customer demand, and energy production, while maximizing their investment in multi-million-dollar assets, many of which are operating well beyond their design lifetime. For instance, data may show that derating the load on a particular generator by a specific amount would extend its life by a certain percentage.

The machine-learning algorithms developed for optimizing the power grid are applicable to any situation where abundant sensor data could accommodate trend analysis, such as for monitoring the performance of jet engines, locomotives, diesel generators on ships, or the engines of a truck fleet.

Interactive Optimization and Learning

At ISyE's Laboratory for Interactive Optimization and Learning (IOL), research takes place at the "intersection of optimization and machine learning," according to Pokutta.

Working across academic boundaries, IOL researchers have completed more than 20 projects so far in areas including logistics and supply chain management, manufacturing, predictive analytics, big data, digital services, energy, transportation, and medical and health care systems.

In addition, IOL is involved in a number of significant activities designed to advance basic science and drive innovation.

One project on the medical diagnosis side involves digital scanning technology that uses 3-D cameras and Kinect sensors to produce 3-D models of individuals for medical diagnoses. Machine-learning

and optimization techniques look for certain anomalies in the model scan data, and a report is generated.

At present, the technology could serve two potential applications. One is to screen pregnant women for cephalopelvic disproportion (CPD), a condition where the baby's head or body is too large to pass through the mother's pelvis. It is a preventable contributor to infant and maternal mortality in developing countries where neither ultrasound testing nor Cesarean delivery are available in rural areas. Women who are determined to be at high risk for CPD could then be referred to urban clinics for medically supervised labor or a Cesarean procedure.

Another potential diagnostic application of the ISyE invention is for the early detection of lymphedema, a severe, permanent swelling of an arm or leg that often follows surgery, chemotherapy, or radiation for breast cancer. Lymphedema is caused by a fluid buildup in lymph nodes damaged by the cancer treatment and afflicts an estimated four million people in the U.S.

The scanning technology could support a low-cost diagnostic device at home to detect the first signs of lymphedema by tracking patients' limb-fluid volumes over time. This early warning would give patients enough time to begin taking preventive measures that could thwart the onset of disease.

Manufacturing/Engineering Statistics

ISyE's System Informatics and Control (SIAC) group contributes to machine-learning capabilities by providing a new scientific base for the design, analysis, and control of complex manufacturing and service systems, anchored to the effective and seamless integration of physical and analytical models with empirical data-driven methodologies, according to Jianjun Shi, Carolyn J. Stewart Chair and Professor.

In practical terms, SIAC faculty develops quantitative models unified with data extraction and engineering knowledge integration capabilities, and then deploys these models in the analysis and control of complex manufacturing and service systems.

SIAC's research involves faculty with complementary backgrounds in manufacturing and service systems, quality and reliability engineering, diagnostics and prognostics, industrial statistics and data mining, and automation and control.

Shi's research centers on monitoring, diagnosis, and control of manufacturing systems. "I am working on multiple data fusion for abnormality detection in the semiconductor manufacturing process," said Shi, who studies the massive amounts of data continuously streamed from hundreds of sensors embedded into the manufacturing equipment. "The challenges are how to extract useful information from the data, learn the system's behavior, and improve its performance."

The analytical issues are complicated by sensing data's high dimensionality, variety, and velocity; and intricate spatial and temporal structures.

ISyE faculty solve these challenges by developing scaleable and agile machine-learning techniques that provide effective modeling and analysis of multi-sensor data streams, allowing researchers to extract essential information for manufacturing improvement.

In addition to real-time monitoring and fault diagnosis and control, machine learning facilitates online product inspection and can predict potential failures in the manufacturing process, thereby allowing time for planning corrective and preventive actions.

In related research, Assistant Professor Yao Xie focuses on detecting changes in massive data streams, which usually signal anomaly and novelty, as quickly as possible, and then analyzes them in real time.

She develops real-time change-point detection algorithms based on statistical and optimization theory for high-dimensional streaming data, which are usually dynamic in nature, corrupted, and carry incomplete data.

Xie has solved problems including seismic network data processing, social network event detection, environmental monitoring, and power network monitoring. She is currently working on accelerating the processing of the massive amount of sequential data generated from material science for the Materials Genome Initiative.

Professor Xiaoming Huo is developing fast algorithms to build predictive models from distributed inference, meaning the information is scattered among various locations and cannot be transported to a centralized database. The algorithms must be communication efficient, requiring only a minimal amount of communication between data locations.

A practical example is a company such as Walmart, which houses transactional data at its thousands of stores. Huo's algorithms would allow the retailer to utilize this distributed data to create predictive models for logistics purposes.

Another approach to utilizing distributed data may be termed "physics based and data-driven analytics," said Jeff Wu, Coca-Cola Chair in Engineering Statistics and Professor, and is a useful computational technique for some engineering and sciences applications. Here, data is derived from physics and then subjected to statistical data analysis.

Wu cited the example of designing the next generation of rockets for the U.S. Air Force. The physics, typically described or modeled by partial differential equations, must be understood first before a physical model can be built. The model is then refined by using a statistical analytic approach on large or small data.

Theory of Machine Learning and Optimization

Over the past decade or so, machine learning has become perhaps the most "intelligent customer'' of convex optimization, and the major outer driving force influencing the development of convex optimization, according to Arkadi Nemirovski, John Hunter Chair and Professor.

Numerous mathematical models arising in machine learning are of an optimization nature, which is why optimization algorithms form a significant part of the machine-learning toolbox, he pointed out. Typically, optimization problems of machine-learning origin are extremely large-scale. Their numerical processing requires the most advanced optimization techniques and is possible primarily when the problems are convex and well-structured.

Convexity as it pertains to mathematical optimization is a term denoting problems in which local information can be used to determine key global characteristics of a problem. This "local implying global" feature is also true of linear programming, the older, traditional programming technique that allows the computation of optimal decisions efficiently, assuming that the world is linear. Linear problems are also convex problems, with applications that include how to allocate time on a communications satellite among competing users, or for studying the relationship between traffic delay times and the number of cars on the road.

But not every problem is linear. Supply chain efficiency, for instance, is not a linear function of resources available. Convex optimization models provide a way of more accurately representing problems that account for real-world uncertainty.

Associate Professor Santanu Dey offered an example of the use of convex optimization in design of electrical power systems dispatch algorithms, a joint project with faculty colleague Assistant Professor Andy Sun and graduate student Burak Kocuk.

"Among other things, our results indicate that older generation algorithms that use a linear approximation of physical laws such as Ohm's law and Kirchhoff's current law produce

inferior performance in comparison to our new methods using the more powerful general convex optimization methods."

Convex problems form a "solvable case" in optimization, Nemirovski continued. "These are the problems for which high-accuracy approximations to optimal solutions can be found in an efficient fashion."

The close connection between optimization and machine learning goes beyond the fact that optimization forms the computational building blocks for the majority of machine-learning methods. Results from the optimization field have also been used to analyze data efficiency in machine learning. As an example, Assistant Professor Huan Xu works in the intersection between robust optimization (an optimization paradigm to address uncertainty) and machine learning. He has shown that some popular machine-learning algorithms are implicitly solving robust optimization formulations, and this robustness provides a unified tool that establishes favorable statistical properties of these algorithms. In effect, learning happens because uncertainty is carefully addressed.

Nemirovski, along with Professor Alexander Shapiro, Associate Professor George Lan, and Professor Anatoli Juditsky from Université Joseph Fourier, play a leading role in the design of efficient stochastic optimization methods, which are at the core of modern machine-learning approaches. These methods can make progress by only using limited information. In fact, they can often find solutions of acceptable quality without the need to observe the entire dataset. Consequently, they are the focus of much interest and research in computer science, industrial engineering, and other research communities interested in big data.

Many distributed, large-scale optimization problems involve translating large data sets into effective actions, which is a research interest of George Nemhauser, A. Russell Chandler III Chair and Institute Professor, and Shabbir Ahmed, Dean's Professor and Stewart Faculty Fellow. Ahmed illustrated with the example of coordinating the movement of autonomous vehicles in a network. The vehicles could be school buses or a fleet of delivery trucks that deliver loads from many sources to several destinations.

If each vehicle makes an independent decision as to which route it follows moving from A to B, some links within the network may become overly congested. Thus for smooth operation, the vehicles need to collect and learn from the traffic information in the network and adapt accordingly.

The information includes historical traffic data and real-time data from auxiliary sources such as road sensors and other autonomous vehicles on the road. This collective learning enables each vehicle to access a more accurate representation of the surrounding world.

The close connection between optimization and machine learning goes beyond the fact that optimization forms the computational building blocks for the majority of machine-learning methods. Results from the optimization field have also been used to analyze data efficiency in machine learning.

"This logistics problem can be set up as a decentralized stochastic routing problem for which some of the approaches that ISyE faculty are working on can be adapted," Ahmed noted.

Another example where machine learning would make decisions in an uncertain environment may be found in health care. Consider a cancer patient who receives a certain cancer-fighting drug every day. The problem is that doctors cannot know in advance the impact of any given drug on any given patient. If one is applying drug A, and the tumor is not growing but not shrinking either, should one switch to a different drug, with the hope that it might shrink the tumor? What is the optimal way to administer different drugs over time?

This particular optimization problem is known as the "multi-armed bandit" problem, referring to the choices facing someone playing several slot machines but who does not know the payoff of each arm in advance, and thus must decide which arms to play and when.

Similar trade-offs arise in many industries ranging from online advertising to logistics, in which one must decide how to allocate resources over time

between different alternatives whose benefits and costs are uncertain.

"Fundamental to such problems is the question of how to combine ideas from probability — due to the inherent uncertainty in the problem — with ideas from optimization since one wants to select between alternatives as intelligently as possible," said David Goldberg, A. Russell Chandler III Assistant Professor, whose study of probability and optimization are core to his expertise as well as to the entire field of operations research.

"One particular question I am studying is how to use ideas from probability theory to understand what an 'optimal' machine-learning algorithm will do when presented with trade-offs, how simpler heuristics compare to this optimal algorithm, and how to use these insights to design new algorithms and insights for machine learning."

Analytics

As the extraction of useful, actionable information from data, analytics undergirds everything at the ISyE school, which specializes in the development and application of cutting-edge analytics tools based on statistics, operations research, and optimization.

"We have a long history of being a world leader, way before 'analytics' became a buzzword," said Joel Sokol, Associate Professor and Director of the Master of Science in Analytics degree. "Machine learning is currently one of the hottest analytics tools being applied to analyze large and complex data sets, and ISyE has several specialists in both machine-learning theory and its application in a variety of industries."

One of Sokol's research interests is sports analytics, which uses machine learning and other computational techniques for predictive and optimization tasks.

While sports teams — particularly baseball — have long sought guidance from statistics, the availability of massive datasets covering virtually every conceivable metric offer a far better basis for optimal decision making.

Analytics techniques may be applied to sports management operations, game strategy, player performance and draft choice evaluation, and can even help a coach determine the optimal lineup for any given opponent.

Sokol devised a mathematical model for predicting the outcome of NCAA Division I basketball tournament games. With data input consisting only of which two teams played, who held home-court advantage, and the margin of victory, the model has consistently outperformed standard ranking systems.

Machine Learning @ Georgia Tech

Underscoring the growing importance of machine-learning research across campus, ML@GT was launched this past summer and named one of Georgia Tech's Interdisciplinary Research Centers. One of the focus areas of the center is to develop and study machine-learning processes and applications within or with close ties to the engineering disciplines. Pokutta, one of the Associate Directors of the Center, emphasizes that this is what makes the Tech center unique.

"While there are other machine-learning centers in the U.S., they are focused mainly on the interactions between statistics and computing," he noted. "The distinguishing feature of our Center is its incorporation of the engineering component."

In fact, the Center is an interdisciplinary effort involving all colleges and schools across campus. It is expected to serve as a nexus for collaborative machine-learning research as well as a one-stop resource for partnerships between Tech and industry.

"Machine learning will significantly impact the way we solve problems by making the process more dynamic and realistic," Pokutta says. "ISyE definitely has a strong stake in the machine-learning center and also has high interest in interacting with it and making it work." ▪

Three ISyE Researchers Receive 2016 Golden Goose Award for the Honey Bee Algorithm

John Bartholdi III, Craig Tovey, and John Vande Vate, all researchers who hail from ISyE, are part of an interdisciplinary team that has been designated as recipients of the 2016 Golden Goose Award.

The Golden Goose Award honors scientists whose federally funded work may have been considered silly, odd, or obscure when first conducted, but has resulted in significant benefits to society.

Along with Cornell University professor Thomas Seeley and data scientist Sunil Nakrani (who received his M.S. in computer science in 1998 from Tech and also completed post-doctoral work with Tovey), the team studied honey bee foraging behavior and the development of the Honey Bee Algorithm to allocate shared webservers to internet traffic. The original honey bee research, funded by the National Science Foundation (NSF) and Office of Naval Research, unexpectedly led to the algorithm that major web-hosting companies now use to streamline internet services and increase revenues in a global market worth more than $50 billion.

"The bees turned out to be even smarter than we thought," said Tovey. The team created a model for how the colonies' decentralized foraging system works, which Tovey and Nakrani adapted over a decade later to develop the Honey Bee Algorithm for allocating shared web hosting servers to variable internet traffic. Their algorithm beats the competition by up to 20 percent in revenue generation for the web hosts and ensures servers are serving the applications internet clients need, when they need them.

The team is being cited for their curiosity-driven research on how honey bee foragers are able to maximize nectar collection in ever-changing environments.

"The ISyE faculty members who were recently presented with the Golden Goose Award deserve this recognition for not only their research, but for their vision and commitment to connect science with societal needs," said Gary S. May, Dean of Georgia Tech's College of Engineering and Southern Company Chair. "It reaffirms the fact that engineers are creative problem solvers who have the ingenuity to develop solutions. The impact of the Honey Bee Algorithm will increase as internet use continues to climb worldwide."

Bartholdi, Tovey, and Vande Vate were inspired to study honey bee foraging after Vande Vate heard Seeley describing his own honey bee research on National Public Radio. "I wonder if the bees would do any better if they hired us as consultants?" Vande Vate mused to his colleagues after hearing the program. The tongue-in-cheek question led to a years-long examination of the honey bees' decentralized foraging patterns from a systems engineering perspective.

Today, major web-hosting companies are using Tovey and Nakrani's Honey Bee Algorithm and other similar biologically inspired methods to boost revenues and more efficiently allocate their servers. Every internet user benefits when servers are ready in the right place and in the shortest time.

"The internet is one of mankind's greatest accomplishments, and these scientists studied one of the smallest parts of nature to make it better," said Rep. Jim Cooper (D-TN), who had the original idea to create the Golden Goose Award. "Their ingenuity is the kind of talent that makes America's scientific and research community the best in the world." ▪

Meet ISyE's Newest Advisory Board Members

Stan Chia, Jeanene Fowler, Dan Shinedling, Jr., Moe Trebuchon, and Annie Walker joined the Stewart School of Industrial & Systems Engineering Advisory Board in the spring of 2016. These five alumni, and 15 other distinguished professional and community leaders, serve as a sounding board for the School Chair in an advisory capacity, as well as assist with the School's development goals. Each member brings extensive industry knowledge and unique expertise to this role and will serve a four-year term (2016–2020). Existing board member Jocelyn Stargel (BSIE 82, MSIE 86) was inducted as the Advisory Board's new chair. She will lead the board for a one-year term.

Stan Chia (BSIE 05) serves as Senior Vice President of Operations at Grubhub. His responsibilities include operations infrastructure, business development, sales, data operations, and general management of the local markets, as well as oversight of the Restaurants on the Run, DiningIn, and Delivered Dish businesses. With a passion for creating disruptive customer engagement, Chia is focused on delivering an unparalleled experience for Grubhub diners while bringing superior value to restaurant partners. Since joining in April 2015, he has helped grow Grubhub Delivery from five to nearly 50 markets. Prior to Grubhub, Chia held multiple senior leadership roles at Amazon, Cisco, and General Electric, running multibillion dollar P&Ls, as well as strategic supply chain organizations. While at Amazon, one of his accomplishments was the launch of the company's first toy pop-up store. His experience spans many industries, including retail e-commerce, high tech, and energy. Chia also holds an MBA from Emory University.

"I look at customer engagement and disruption as independently powerful but collectively unstoppable. Obsession with every facet of how customers interact with a product of service, combined with an unrelenting focus on delivering a superior experience, will allow for meaningful disruption to occur — and that is the heart of disruptive customer engagement."

Jeanene Fowler (BSIE 84) has over 20 years' experience in technology and business, with a variety of roles including Director of IT Application and Testing at MetLife, project manager/business analyst at various retail companies, small business owner, and over 10 years selling technology solutions for IBM. Fowler currently serves on the Georgia Tech Alumni Association Board of Trustees (2013-2016) and is the Greek Alumni Council Chair (2015-2016). She enjoys mentoring in the MentorJackets program, hosting for DinnerJackets, and volunteering at the Speed Networking and Capstone events. She also serves as Treasurer for the Alpha Gamma Delta House Association at Georgia Tech. She has participated in several international missions with the United Methodist Church, including trips to the Republic of Georgia and Jamaica, where she led the construction teams for a couple of years. Fowler also has an MBA from Kennesaw State University and has completed the Certified Financial Planning Program at Oglethorpe University. She is a Certified ScrumMaster, Certified Scrum Product Owner, and a member of Scrum Alliance.

"The most essential aspect of my ISyE background is systems thinking — input, process, output, and feedback for continuous improvement. I enjoy working with people to identify needs and goals, explore options to solve their problems, present recommendations, and implement solutions that exceed their expectations. Whether at IBM selling system solutions to businesses, my interior design business bringing function and beauty to residential clients, and now, helping people grow and protect their money, my ISyE background has served me well."

Dan Shinedling, Jr. (BSIE 92) possesses a keen entrepreneurial spirit and a passion for using computing to effectively automate business. Shinedling began his professional career as a developer and systems integration consultant. Looking to build something new, Shinedling co-founded KS2 Technologies, Inc. in 1995. Since that time, KS2 has become a leader in ERP, cloud, mobile, and infrastructure solutions with heavy emphasis on IBM and Oracle technologies. KS2 is a frequent recruiter and current employer of many Georgia Tech ISyEs. KS2's ISyEs are among its top performers and provide outstanding solutions for KS2's clients.

"I have always been drawn to difficult problems and opportunities that require complex and unorthodox solutions, and being an entrepreneur offers me the flexibility to approach these challenges in unique ways. We at KS2 Technologies, Inc. want to keep that entrepreneurial spirit alive, so we created the KS2 Entrepreneurship Award. The award is given to an ISyE student who has demonstrated entrepreneurship while pursuing a B.S. IE degree."

Moe Trebuchon (BSIE 86) possesses more than 25 years of supply chain, strategy, and operational consulting experience. He has served as a partner in the IBM Global Business Services and PwC Consulting practices. During Trebuchon's time with these firms, he has served multiple North America leadership roles including Retail Industry Leader, Business Analytics & Optimization Service Line Leader, and Supply Chain Service Line Leader. Throughout his career, Trebuchon's primary focus has been on helping clients achieve impactful business transformation via development of strategies, operational designs, leverage of information technology, and organizational change adoption. Having led a broad base of clients through complex technology-enabled change programs, Trebuchon is considered a subject matter leader in the application of demand forecasting, replenishment, WMS, TMS, order management, and omni-channel technology to the order fulfillment and delivery process. He has delivered numerous presentations at conferences and educational forums, addressing a broad array of topics spanning supply chain, enterprise transformation, business analytics, benefits realization, and change adoption.

"In my youth I measured success based on what I personally achieved. As I have aged and matured, I now measure success based on the impact that I am having on the lives, performance, and outcomes achieved by others. It has been a healthy evolution, and I often wonder if my definition will yet again morph in the years to come."

Annie Walker (BSIE 02) currently serves as Vice President of OTC Merchandising for Walmart U.S. She started her career with Walmart in 2002 as an industrial engineer. After spending two years with the Stores Engineering team, she supported the replenishment division in several capacities. Walker's latest role in replenishment was serving as Senior Director of Replenishment for the General Merchandise division. In 2012, Walker transitioned from Replenishment to Vice President for Merchandise Execution, responsible for developing and implementing strategies that support and drive the merchant strategy through to store execution. She is a graduate of the Walmart Leadership Academy program. Walker lives in Bentonville, AR, with her husband Jacob, son Ethan, daughter Ellen, and their two dogs. She enjoys running, swimming, reading, spending time with friends and family, and getting involved at her church.

"ISyEs make strong leaders because they are great problem solvers and strategic thinkers. These two competencies can be leveraged regardless of the career path chosen. The challenge I always give to any fellow engineer is ensuring that they incorporate the 'human' aspect to any process or decision that they make. Sometimes what motivates and inspires someone is far more important than what is most efficient."

From left: New Advisory Board members Moe Trebuchon, Stan Chia, Jeanene Fowler, Annie Walker, and Dan Shinedling, Jr.

Bill & Penny George

on *Philanthropy, Leadership, & Health Care*

Bill George (BSIE 64, Honorary Ph.D. 08), former CEO of Medtronic, is Senior Fellow at Harvard Business School specializing in developing authentic leaders. His wife, Dr. Penny George, is a leader in the national movement to transform medicine and health care through the principles and practices of integrative medicine. Together, they founded the George Family Foundation in 1994 to support programs they are passionate about and that transform lives by changing the systems affecting those lives for the better. Their foundation focuses on three primary areas: Penny's passion for integrative health and healing; Bill's passion for authentic leadership, and a shared passion for community.

"To see a need, a need that connects with something we understand and can bring resources to make it happen brings us pure joy," said Penny.

The Georges, who divide their time between Minneapolis, MN and Avon, CO, also support Georgia Tech at the Institute level through the William W. George International Study Abroad Scholarships, the George Family Foundation Women in Engineering Leadership Initiative in the College of Engineering, and several programs in the Stewart School of ISyE, including the George Family Fellowships, the William W. George Chair Endowment in Health Systems, and general program support for health systems.

What motivated you to start the George Family Foundation?

BILL: In 1994, I was with Medtronic, and I could see that our stock was going up and our future looked good. When Penny and I looked ahead at our income, we decided to set aside a significate amount to give back to society. We always believed in philanthropy, and creating the George Family Foundation enabled us to significantly increase our charitable giving well above what we were able to do before. However, it wasn't until 1998 that we went from what you would call checkbook philanthropy into a well-managed family foundation. That's when Penny took it over and put some focused leadership into it. At first, she hired an outside firm to support us. And then we moved to building our own foundation staff. We are really excited about the development and growth of this venture.

Bill, authentic leadership is currently your life's work and one focus of your foundation. Why have you chosen to devote so much of your attention to this issue?

BILL: When I completed my time at Medtronic, I took some time off to take a hard look at what it means to be a good leader. I felt that the world

was not being well-served by the current theories of leadership, and I wanted to look at the deeper side of leadership. During that examination, I realized we could empower many more leaders if we allowed and encouraged people to be themselves so that their leadership came from within.

This starts by examining your character, your values, your life stories, and especially your crucibles, which are the trials and tribulations you have faced. And that is the authentic you. In 2003, I wrote the book, *Authentic Leadership*. That led to new theories of leadership which were validated in 2007 with an in-depth leadership study we conducted at the Harvard Business School, the largest study ever done on leaders. I am very pleased with the progress that has been made in the last 13 years since I wrote *Authentic Leadership*.

What is one key area in the world of leadership that you hope will receive attention in the next two to five years?

BILL: I think it will be on how we gain self-awareness. The Oracle of Delphi told us four thousand years ago to "know thyself." But very little work has been done on how to do this. Our research at Harvard and my work shows that knowing yourself starts with your life story — especially the most difficult times you've had, because that is when you realize who the real you is. The key to emotional intelligence is self-awareness, which in turn can open up your capacity to be a good leader. Without a high level of emotional intelligence, one cannot become an authentic leader. But we have to learn how to do that.

There are wonderful opportunities for researchers to look at how we gain self-awareness. I've been working on this a lot, and I hope more scholars will start looking at how we become more self-aware. It is a life skill that can be developed.

What is one thing that we all could do to start becoming more self-aware?

BILL: I'll give you three things. First, deeply explore your own life story — especially your crucibles — in order to understand who you are and where you have come from. Beyond that, adopt a daily introspective practice. In our 24/7 world with smartphones, social media, and so much going on, we need to take at least 20 minutes every day to do some form of reflective practice. I've meditated for the last 41 years, but there are many other ways to have a reflective practice. It can be through prayer, keeping a journal, sitting in a quiet place and reflecting, or going for a long walk, to name a few. And finally, I would add the importance of getting honest feedback from people you trust so you can understand how you are interacting with other people and the impact you are having on them.

Most ISyE graduates end up in leadership positions of one kind or another. What advice can you offer them on how to become the best leaders they can aspire to be?

BILL: Find an environment that is nourishing, and then jump in and ask for leadership opportunities. Get into a leadership role as soon as possible. Don't wait for someone to tap you on the shoulder. Start leading where you are with your peers, and become that informal leader who makes things happen. Executives are always looking for people like that who show promise. And just as important, learn how to collaborate with your teammates because this is an essential skill in leadership.

I recently learned that you have both a 20-year-old and a 30-year-old mentor. Could you speak to having such young mentors, and to the importance of being a mentor as well as a mentee throughout life?

BILL: I believe in reverse mentoring. That means having mentors that are considerably younger than you are who can help you understand the younger generation/employees. My 30-year-old mentor helps me with all my social media. He also worked with me on my newest book, *Discover Your True North*. My 20-year-old mentor is a young man from Harvard. He and I have worked together for a little over a year, and I have learned a lot about millennials from him. I also have a couple dozen millennial mentees, but to have someone mentor me on digital media and to learn the hopes, dreams, and passions of millennials has given me a deeper understanding of this generation.

Penny, integrative health is one focus of the George Family Foundation. What is it about this area that captured your attention?

PENNY: I was diagnosed with breast cancer in 1996. It was through this personal experience that I became interested in different approaches to healing. At that time in medicine, the focus was on the disease and the body part. As I went through the process, I thought that seemed misguided. We come into a disease state, as with anything else, as a whole human being — connected in mind, body, and spirit. Not

to acknowledge that we can call on all those resources to heal seemed shortsighted to me. I realized I needed to do something. I'm a doctor's kid, and I'm accustomed to taking responsibility for myself. Something contributed to me getting cancer — it did not just come out of the blue. What could I do to prevent this from potentially coming back again? And if I couldn't prevent it, how could I make my life such that I could feel that this life was a good one, and the illness served me in some way?

Those were my personal objectives as I went through my own healing process which included assembling a team of healing professionals — what was referred to then as alternative approaches. Now it is referred to as integrative medicine. People don't want just traditional medicine or just the alternative approaches, they want the best of both. They want the integrative approach — something that would give you the chance to have optimal wellness and well-being.

My family was loaded with cancer, but no one had ever talked to me in my medical appointments about what could be done to prevent it because people did not believe you could. Now we know 80 percent of cancer is largely preventable; it is lifestyle related. That is the gist of how I became so passionate about integrative health care.

What is one key area of health care that you hope will receive attention in the next two to five years, and why?

PENNY: I would like to see health care institutions partner with individuals/patients wherever they are in their health journey and start focusing on the benefits of self-care, which is the true primary care. What we do for ourselves is just as important as what the health care system has to offer. Medicine certainly has something to offer, but the primary thing is what we are doing for ourselves to live optimally.

Is self-care the same as preventive care?

PENNY: In medicine, preventive care is getting the colonoscopy, mammogram, etc. It's more about looking for disease. My notion of self-care is all those things that an individual can do for themselves — eating well, exercising, reducing stress. For example, if someone has gastrointestinal issues, what if the first approach was to try an elimination diet as they waited to come in for their appointment to see if their diet was causing inflammation — instead of going in for an appointment and being prescribed pharmaceuticals without further investigation into why? As Greg Plotnikoff, one of my heroes in integrative medicine, said, "Fundamentals first, pharmaceuticals second." Don't go straight to a drug; figure out what is going on underneath first. We are too quick to jump to drugs. The worst case of this is the opioid epidemic in the country.

What word of advice can you offer to our students and young alumni who are heading into the world of health care?

PENNY: I would encourage them to consider researching integrative medicine and health and the challenges this poses for the current system. Our health care is moving in that direction already. We need to find optimal ways for a team-based approach that looks at the whole person to work in today's system. Also, consider researching how we introduce a shift in consciousness so the patient/individual steps up and starts practicing self-care.

As part of your philanthropic endeavors, you have funded an endowed chair position in the Stewart School of ISyE, as well as student fellowships. Why?

BILL: I think the next big frontier for ISyE lies in health care. By applying systems theory and application to the U.S. health care system, Georgia Tech can make breakthroughs in the health care delivery system and in improving patient outcomes more efficiently.

Pinar Keskinocak is the perfect leader to hold the William W. George Chair in Health Systems. She is a real star, and we are fortunate to have her at Georgia Tech and particularly in ISyE. She really knows how to take an operations research and management science approach and apply it to health and humanitarian systems. This is exactly what is needed in the area of health care, and we are so pleased to support her work. We have an enormous opportunity at Georgia Tech to do breakthrough work in the field of health. I hope other alumni will continue to support these kinds of activities so we can make Georgia Tech a global leader in the health systems approach.

PENNY: The student fellowships we support enable ISyE students to work on these difficult health care challenges with Pinar and her team. We are thrilled to be associated with that and putting some wind under their wings.

Sheereen Brown (BSIE 12, MSHS 14) and Monica Villarreal (Ph.D. IE 15) were both George Fellows. Villarreal helped develop a workforce allocation tool that enables developing countries to deploy

their health care workers in the most optimal manner. Brown is now working with the Task Force for Global Health to implement it in Tanzania and Zimbabwe. ***(See story on page 28.)*** **What is it like hearing about some of the students you have supported?**

BILL: They have done some amazing work. We need more health care workers in the developing world to come up with approaches to get and maintain health care workers in these areas.

Someone told me once that I get a vicarious pleasure from the accomplishment of others, and indeed I do. It is a great pleasure to hear what our graduates are doing and to read about this kind of work. It inspires me to work with more of them. But I hope it also inspires younger students to work on projects that can make a difference in the world as well.

You also have funded the William W. George Family International Study Abroad Scholarships at the Institute level. What motivated you to make this gift, and what do you think the impact is on the students who go abroad as a result of to your generosity?

BILL: Many Tech undergrads cannot afford to participate in study abroad programs, which would open their eyes to the world and broaden their education. That's why we created the William W. George International Study Abroad Scholarships to enable 50-plus Tech students to travel and study abroad each year. Meeting with them each year after they return and hearing their stories brings home just how transformative these experiences are in their lives.

If you had a crystal ball in which you could see the future, what problems do you think industrial engineers will be working on five to 10 years from now?

BILL: The future in solving any problem will be collaborative, bringing in people across disciplinary lines. We need to look at problems from a systems point of view. The great thinkers of the world will be systems thinkers. We are in great need of that systems mentality. Health care, in particular, is crying out for a systems approach. The Stewart School of ISyE is uniquely positioned to bring this capability of systems thinking into the health care arena. Health care is one of the most pressing challenges we have. ▪

Speed Round

What are you currently reading?

PENNY: *American Nations: A History of the Eleven Rival Regional Cultures of North America* by Colin Woodward.

BILL: *The Art of Authenticity: Tools to Become an Authentic Leader and Your Best Self* by Karissa Thacker.

What is one of the best meals you've ever had?

BILL: Enjoying a grilled leg of lamb, some vegetables, and wine with friends while sitting in our garden overlooking the lake and watching the full moon come up. This was the perfect evening and a perfect meal.

PENNY: I had a seafood stew the other night at Chimborazo, an Ecuadorian restaurant in Minneapolis, and it was just wonderful.

What is one of your favorite travel spots?

PENNY: Africa. I love going to Africa. The first time I traveled to Africa was 1967. I went with my parents on a photographic safari to Uganda and Kenya. Seeing the vast plain and the herd of animals was something that blew my mind.

BILL: I have many favorite travel spots. If I had to say one, I would say going to Colorado where we have a second home and go hiking in the mountains. The most challenging and rugged hike is Mount of the Holy Cross, which is just over 14,000 feet, and a very spiritual place for me.

What is your favorite leisure activity?

BILL: It would be a tie among skiing, hiking, and horseback riding.

PENNY: Horseback riding in wide open spaces.

Describe a perfect Sunday morning.

PENNY: Reading the New York Times and the Minneapolis Star Tribune with a latte, and then going to church.

BILL: A perfect Sunday morning would be going for a walk around the lake by our house, reading the New York Times, and then going to church for a nice service with beautiful music and spiritual uplift.

Pinar Keskinocak, William W. George Chair and Professor, Focuses on Health & Humanitarian Systems

Today's most pressing problems faced by humanity and our planet are complex, requiring a systems-level perspective. Pinar Keskinocak, ISyE's William W. George Chair and Professor, emphasizes the systems engineering perspective in her work focusing on health and humanitarian fields.

"Systems have multiple components, such as organisms, resources, information, and activities, with various interactions among those components and the environment in which they operate as well as other systems," said Keskinocak. "A narrow or myopic view, which focuses on one part of a system and ignores how that part interacts with the others, could not only lead to suboptimal solutions but also cause more harm than good in some cases."

Keskinocak is also the Co-director of Georgia Tech's Center for Health & Humanitarian Systems (CHHS) along with Julie Swann, Harold R. and Mary Anne Nash Professor. The Center, founded in 2007 by Keskinocak, Swann, and and Özlem Ergun, now a professor at Northeastern University, was elevated to an Interdisciplinary Research Center at Georgia Tech in 2015.

In 2014, the Center changed its name from the Center for Health & Humanitarian Logistics to the Center for Health & Humanitarian Systems to better reflect the Center's focus on systems.

"Humanitarian logistics is traditionally associated with procurement, transportation, and distribution operations for disaster relief or longer-term development activities," said Keskinocak. "In addition to our ongoing focus on logistics, we place a strong emphasis on incorporating systems transformation for complex, long-term challenges."

The Center has three primary areas of activity: education, outreach, and innovative solutions and research.

Keskinocak and team work with a variety of external organizations on addressing complex problems. They start by focusing on the symptoms, quantifying them to the extent possible, exploring possible root causes, developing potential solution approaches and estimating their impact under various scenarios, and then making recommendations.

"Our goal is to apply our expertise to help our partners improve the efficiency and effectiveness of their organizations, leading to a positive impact on people's lives," said Keskinocak.

Depending on the application, Keskinocak's work has led to different outcomes, such as hands-on decision support tools

"Our goal is to apply our expertise to help our partners improve the efficiency and effectiveness of their organizations, leading to a positive impact on people's lives."

or policy-level recommendations. For example, in her work on modeling infectious diseases, such as cholera or pandemic flu, the models and analysis lead to "recommendations on the most effective intervention strategies or the allocation of scarce resources such as vaccines," she said.

She also has worked with various hospital systems where multiple units interact with one another, for operational decisions such as staff scheduling or bed assignments.

At the individual — or patient — level, ISyE methods are used in medical decision making related to screening, diagnosis, or treatment. Examples include assessing the risk of infection in an organ transplant and the tradeoff of receiving a risky organ versus staying on the transplant list *(for more information on this project, see page 37)* and prenatal screening for Down syndrome.

The projects utilize different methods, e.g., a combination of optimization, simulation, and statistics, but they generally follow a system's approach focusing on the allocation of

continued on page 31

Development of Workforce Allocation Optimization Tool Traces Path through ISyE

In developing countries, health care workers (HCW) — doctors, nurses, pharmacists, and dentists — are as precious a commodity as gold. As Dr. Mark Rosenberg, former president and CEO of the Task Force for Global Health (TFGH) pointed out in a 2015 blog article, "In Mozambique [for example], where life expectancy is only 50 years, HCW shortages are particularly pronounced. Fewer than 1,500 doctors serve a population of 25.2 million."

To deal with the problem of HCW shortages, the TFGH, the Centers for Disease Control and Prevention (CDC), and the Mozambique Ministry of Health (MOH) joined forces. Involving a team from Georgia Tech in their efforts, they jointly developed a solution, called the Workforce Allocation Optimization Tool.

Currently, ISyE alumna Sheereen Brown (BSIE 12, MSHS 14) serves as a business analyst for the Public Health Informatics Institute (PHII), a program of TFGH. She works with a team leading the implementation of the tool in Mozambique, while also rolling it out in Tanzania and Zimbabwe. What makes the tool particularly special is that for the first time, HCW placement preferences are taken into account.

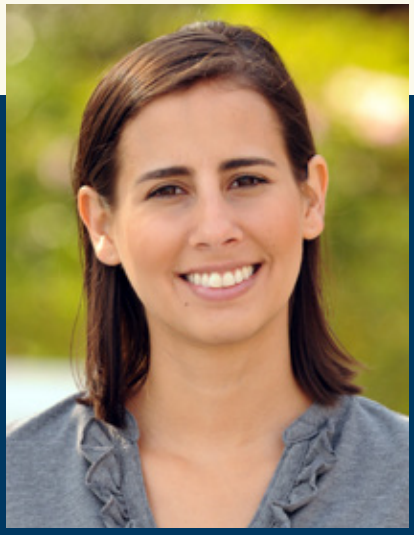
"Previously, in Mozambique, there was a very top-down approach to allocation, without any data to drive that process," said Brown. "There was no preference data from the HCWs — nobody got a say in where they went."

The problem with this approach is that once HCWs were placed somewhere, they would immediately apply for a transfer so they could go to a district of their choice.

In December 2015, Mozambique's MOH put the allocation tool in place to great success. By asking HCWs their top three preferences for placement within the country, over 75 percent of HCWs were satisfactorily placed in one of their top three preferences.

The tool's initial beginnings were in an ISyE special projects class led by Pinar Keskinocak, who holds ISyE's William W. George Chair. According to Keskinocak, developing the allocation tool was exactly the sort of problem tackled in ISyE. A conversation with Vivian Singletary (BSIE 95), an ISyE alumna who directs the PHII, led to giving two students in the special projects class the assignment of conceptualizing the allocation tool. Then-Tech undergraduate Emily Gooding (BSPFE 14) and master's student Colleen Hinojosa (MSSCE 14) developed a preliminary model of the workforce allocation optimization tool for their class project. The goal behind the allocation tool's creation was to address the question of how HCW demand could be met while improving the workers' sense of satisfaction in their geographical placement.

After the special projects class ended, ISyE Ph.D. student Monica Villareal (IE 15), who had prior experience developing other similar decision-support solutions,



Monica Villareal

In addition to their connection with the allocation tool, Monica Villareal and Sheereen Brown have something else in common: They were both recipients of a George Fellowship, given by the George Family Foundation, while ISyE students. *(You can read an interview with Bill and Penny George on leadership, philanthropy, and health care on page 22.)*

"I admire both Bill and Penny George for their holistic approach to health — an approach that's truly needed in this country. There are so-called silos — for example, mental health is siloed from physical health. The Georges understand the need to break down the barriers of these silos in order to improve our communities. I am very appreciative that a family with so much influence and resources focuses on this work," said Brown.

Villareal added, "The Georges are very committed to helping students improve the health care system. They are good humanitarians and work hard to improve the community around them. And they believe that at ISyE there are good minds and good ideas. I really enjoyed working on this project. Knowing that this tool was going to be implemented made me work harder and go the extra mile since I knew it was going to be used rather than just a nice project for a class or for a paper. Doing something that brings a benefit I can see motivates me."

worked with TFGH to further develop the tool. Villareal explained, "They needed a more robust tool." This included reprogramming the tool to meet specific requests on the part of the Mozambique MOH, as well as testing actual data and comparing results from the initial model to the HCW actual allocation. This measured the benefits of the model. In addition, Villareal ran different scenarios to test different model data input settings, such as giving increased weight for regions with higher HIV rates.

Once Villareal completed her Ph.D. work and joined the Denver Public School System as a Senior Analyst, further implementation of the allocation tool then passed to Brown.

After graduating with her master's degree in health systems, Brown was looking for a meaningful way to apply her IE skills and found the right environment at PHII. "In this role, I am at the intersection of people in public health; the processes and work that are done in public health; and the technology knowledge used to accomplish that work," she said.

"ISyE teaches you to be a process thinker and to understand the critical path for how important work is accomplished. My public health colleagues are brilliant: They're scientists, they're doctors, they're nurses, and they're thinking about tackling the health side. They're thinking about what combination of antibiotics someone with a particular disease should receive, or how many rounds of vaccine a child may still need.

"They're not necessarily thinking about how to improve their overall processes to make them more efficient, so they can do more for more people. That's where my team comes in."

The Excel-based allocation tool — specifically designed this way so developing countries don't have to spend a lot of money on expensive specialized software — tackles the HCW allocation problem from two sides: where the need is greatest and where workers want to be placed. Brown described the tool as "a way to solve the health care supply chain problem."

"The allocation tool uses one of ISyE's shining stars — optimization — to understand how to place this very scarce resource population [HCWs] around the country to serve the most people with the most need," said Brown.

"It looks at population distribution across the country, the health need burden of those different populations — whether there's a high HIV or malaria prevalence — and the demand that's precipitated by that population. And a critical key to its success is that it also takes into account the preferences of the HCWs that it's allocating.

"If it was just a matter of money, then these countries would hire a lot of HCWs and put them all over the country," said Brown. "But some of these nations have financial constraints, so the allocation tool helps to put nurses, doctors, midwives, and pharmacists in the places that will have the highest impact, and places where they'll also have a higher rate of satisfaction in that community."

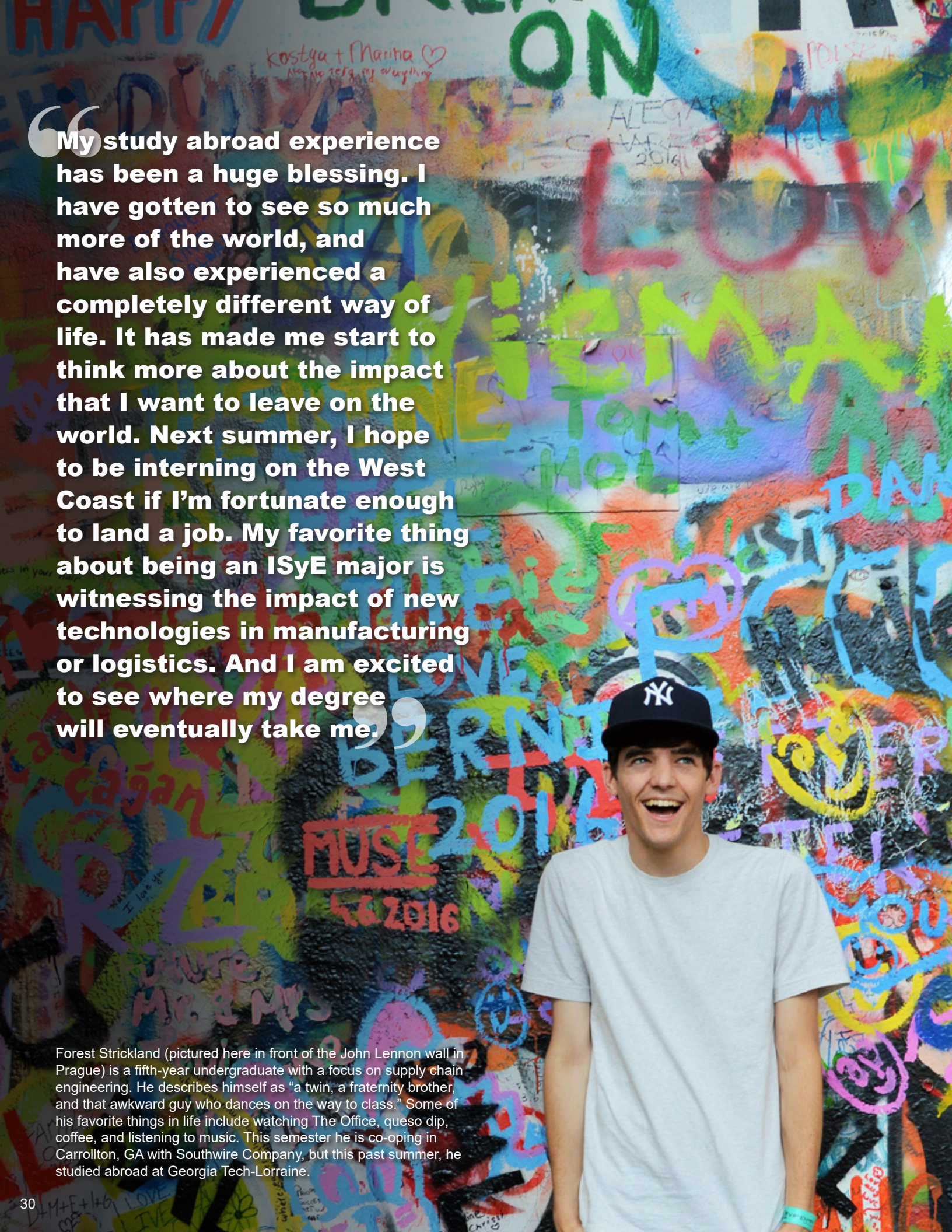
The next step is looking at the retention rate of the precious resource comprised of HCWs, based on use of the allocation tool. While official results are not in, the preliminary results look very promising. ▪

Brown emphasized that, like the Georges, the nature of her own work is very broad. Contrary to common conceptions, global health is not limited to developing countries abroad: "When people hear the phrase 'global health,' they may think about impoverished black and brown populations around the world. This view is often disconnected from the community health needs we have in the U.S.

"My domestic and international work with PHII and TFGH afford me opportunities to understand how the health needs of communities in this nation do not differ so greatly from communities around the world. Folks here in Atlanta want to live happy, healthy, and productive lives just like folks in Tanzania.

"I am grateful to the Georges for giving me the opportunity to pursue an education that has led to a career path that allows me to make this connection: to see global health in its full spectrum and not as siloed – not outside the U.S., but that global health is everyone around the world, and that includes our country, our community."

Sheereen Brown



“My study abroad experience has been a huge blessing. I have gotten to see so much more of the world, and have also experienced a completely different way of life. It has made me start to think more about the impact that I want to leave on the world. Next summer, I hope to be interning on the West Coast if I’m fortunate enough to land a job. My favorite thing about being an ISyE major is witnessing the impact of new technologies in manufacturing or logistics. And I am excited to see where my degree will eventually take me.”

Forest Strickland (pictured here in front of the John Lennon wall in Prague) is a fifth-year undergraduate with a focus on supply chain engineering. He describes himself as “a twin, a fraternity brother, and that awkward guy who dances on the way to class.” Some of his favorite things in life include watching The Office, queso dip, coffee, and listening to music. This semester he is co-oping in Carrollton, GA with Southwire Company, but this past summer, he studied abroad at Georgia Tech-Lorraine.

Keskinocak, continued from page 27

scarce resources for better outcomes, or decision support with the goal of improving health outcomes for individuals and populations.

In addition to lecture courses, Keskinocak regularly teaches project courses such as the undergraduate-level Senior Design, with an increasing number of projects being focused on health and humanitarian applications, and the master's level Health Systems Practice, where several successful projects such as the Workforce Allocation Optimization Tool have been initiated *(see article on page 28)*.

The CHHS team's educational offerings extend beyond the degree programs, and include a professional education certification in Health & Humanitarian Supply Chain Management. Participants in the program, who are active practitioners in health and humanitarian operations, come from all over the world — from non-governmental organizations, government, and industry.

"The knowledge sharing and conversations in these courses are extremely interesting and lively thanks to the experience and multiple perspectives of our participants," said Keskinocak.

The CHHS team hosts an annual international conference on Health & Humanitarian Logistics. The conference was founded because they saw a dire need for the often siloed worlds of health and humanitarian organizations to be in conversation with each other, especially since an increasing number of emergencies affect wide areas.

The conference rotates around the world. The 2015 conference was held in Johannesburg, South Africa. David Sarley, a senior program officer at the Bill and Melinda Gates Foundation commented that the conference "creates space for bigger conversations and dialogue."

The 2016 conference was held in Atlanta with over 200 participants from 27 different countries around the world who engaged in dialogue about challenges facing the global health and humanitarian sectors, and successful models of organizational collaboration and supply chain practices to strengthen health and humanitarian systems. Speakers and participants came from 115 different organizations across the private sector, non-governmental organizations, academia, and government. ▪

Ije Okafor is a fourth-year undergraduate with a concentration in economic and financial systems. Okafor, who studied abroad at Georgia Tech-Lorraine (GTL) this past spring, says, "I chose to study abroad because I wanted to immerse myself in a culture different from my own, while living in a beautiful and historical environment. I also wanted to gain some understanding of the French language and culture and yearned to interact with citizens of Metz as well as other international students."

In terms of using her IE degree, Okafor says, "If I could solve any of the world's problems, I would start with helping to boost the economy of a developing country. Specifically, I would want to help with financial risk management for that country's major corporations — measuring the risk of certain business transactions and exploring different ways to reduce that risk. Ideally, these practices would help that specific country's economic and financial success, which would positively affect how that country performs on a global scale. These practices could also potentially contribute to better business relations with the United States."

"During my time in France, I served as the secretary of GTL's Bureau Des Étudiants (The Students Board), and helped plan a day of service at Fort de Queuleu, an old WWII internment camp. Alongside 25 students, both American and French, I helped clean up old entryways and plant grass and flowers. This personal experience changed my previously narrow views about service, as I realized that service work and community engagement could be practiced on a global scale. As a global citizen, I can work toward the betterment of the greater community through active involvement in public service and volunteer work, whether domestically or internationally."

Mitigating the Risk of Food Supply Chain Terrorism

Because food delivery systems in the U.S. are so efficient, they are also potentially excellent bio-weapons delivery systems. Chip White, ISyE Schneider National Chair in Transportation and Logistics, and Alan Erera, ISyE Coca-Cola Professor, have teamed up to examine the relationship between the food supply chain and bioterrorism and how to mitigate the risk of a terrorist attack on the U.S. food supply chain.

"Because food supply chains are natural targets, one of the Department of Homeland Security's (DHS) key priority areas is food systems," said Erera. "Everyone eats. And the food delivery system is thought to be a compelling target for a terrorist attack that could lead to large numbers of sicknesses and fatalities, and could shatter people's confidence in the food supply."

Working with the DHS's Food Protection and Defense Institute (FPDI) at the University of Minnesota, White and Erera have developed a model for countering an intelligent adversary who seeks to use a food supply chain as a means of delivering a biological or chemical toxin to the public-at-large, potentially leading to widespread illness and death.

"As a terrorist weapon, the idea of [contamination in the food system] is obviously one that can be quite powerful," continued Erera. "You don't want to worry about your food.

"This is something important that's been on the minds of DHS for many years, and certainly since 9/11. Therefore, DHS prioritized food defense."

White and Erera's model is one of risk assessment and mitigation. It differs from what they call static models in that their model assumes the adversary — or would-be terrorist — is intelligent and adaptive.

"In our model, we have an adversary who is watching any defensive move to protect the food supply chain and is reacting and adapting accordingly," explained White. "Traditional measures of risk don't take such behavior into consideration."

The risk model that the pair has developed assumes that because the adversary is intelligent and adaptive, he will change attack strategies or defensive postures over time, while the supply chain owner is doing likewise — what White described as a "cat-and-mouse game."

The gaming aspect of the model involves both of the players — the adversaries and those who would thwart them — making the best decisions possible without knowing exactly what the other is doing. White and Erera apply an optimization framework to model how the players participate in the system over time and assess a related measure of risk.

It's almost like a chess match: How do you choose the best way to act based on what your opponent does? However, in this case, you only have incomplete or partial knowledge of what your opponent is doing — "incomplete observations," as White put it.

White and Erera have worked with FPDI for a decade and during that time have created different case studies to test their risk model. One such study involves feral swine and foot-and-mouth disease.

The wild swine, which could be infected with foot-and-mouth disease (intentionally or naturally), can then infect domestic herds — even when separated by fences — and a big outbreak of the illness could adversely affect the U.S. pork industry.

White said, "Feral herds have easy access to domestic herds and hence can serve as a way of infecting domestic herds with a variety of diseases, so there is quite a bit of concern about risks due to the intentional contamination of feral herds with foot-and-mouth disease."

White pointed out that the model "is a framework, so it morphs with the application. Cargo theft is another application." But even in this application, food security is still a concern: The product stolen most often is food. He continued, "Food can be stolen, contaminated, and sold on the gray market."

White and Erera both emphasize that despite how it may sound, this risk assessment is not in any way simple. One of the innovations they've developed, according to Erera, "is embedding sequential stochastic optimization problems inside game theoretical decision models that have been around for a long time.

"Once optimal decision policies are determined, then you can think of it as a simulation," Erera said. "Both of these players are playing this game optimally over time: One is trying to maximize the impact of attacks on the system; the other is trying both to balance the risk of an attack with maintaining productivity of the food supply chain. We simulate how the two opponents behave assuming that they're going to behave near-optimally.

"And then we see how risky the system is under those settings, or decide whether the defender can take different actions, because they're going to try some mitigation strategies. How much does that reduce these measures of risk? That's basically how this model works." ▪

Mapping Geophysical Structures of the Earth

Yao Xie, ISyE Assistant Professor, has been applying her work in Big Data to a geophysical project funded by the National Science Foundation. The project entails mapping shallow earth structures in Yellowstone National Park, with possible further applications for the oil industry.

In the Yellowstone project, microphone sensors that look, according to Xie, like a big nail, are placed in the ground. The head of the "nail" — or the microphone — contains the sensor and the data storage card. The "tail" of the sensor contains the receiver, which records the sound waves coming out of the earth, to a depth of the top few kilometers.

On this four-year-long project, Xie is working with a geophysicist from the University of Utah and a professor from the University of Georgia who specializes in developing sensor networks for geophysical structures such as volcanoes. Xie's role is to "develop new efficient methods to process and analyze the collected large amount of data."

"I will take the data collected by the sensor network developed by my colleagues and analyze this data for the image [of the earth]," said Xie. "That way we can see how these underlying geophysical structures are evolving over time, and detect any interesting features."

Because the sensors obviously cannot see through the ground itself, what they record is called ambient noise. According to Xie, ambient noises are the noises or hum made by the earth. Essentially, the sensors listen to the ground and record the hums they hear.

"We will have hundreds and even thousands of sensors placed in the earth to listen at the same time," she said.

The Yellowstone sensor network has not yet been placed, as the team is still in the process of securing permission for the project from the National Park Service.

Xie is also developing the model for processing all the data. The data she is using comes from an oil company in Texas that has placed a sensor field for purposes of oil exploration. This sensor network is very similar to the one that will be used in Yellowstone.

Xie said that the oil company listens to the earth for about a month, and this generates five terabytes of data. In order to develop and improve the model for processing the data — her task for the first three years of the project — Xie said that she needs to "improve the algorithm and cross-validate results with my geophysicist colleague to develop efficient algorithms for a distributed sensor system, and produce high-fidelity images in-situ." In the final year of the project, the team will apply for a permit to place sensors in Yellowstone, deploy the system, and process data from the national park.

"This project has both a scientific flavor as well as algorithmic and theoretical challenges, because it involves Big Data — very high-dimensional data that is continuous over time — and we would like to work online in real-time fashion," said Xie. "So that fits with my research interests very well.

"At the same time, it will have a real impact on the scientific world. They do need this data analysis technique to analyze this large amount of data, to be able to detect changes in real time, with the need for an algorithm for processing the data." ▪

Exploring How to Bring Electricity to East Africa

The ready availability of electricity is something we take for granted here in the U.S., while many developing African countries do not have the infrastructure to bring electricity to the citizens of their rural regions.

In order to develop a model for such an infrastructure — one that brings electricity more equitably to rural parts of African countries — researchers from both ISyE and ExxonMobil are working together to create a 30-year model for potential electricity generation. They are focusing particularly on the east African countries of Rwanda, Burundi, Uganda, Tanzania, and the central African country the Democratic Republic of the Congo.

Such a problem is compounded, said Valerie Thomas, ISyE's Anderson Interface Professor of Natural Systems, because "on the one hand, there are many people without access to electricity and on the other hand, you have the governments and agencies and companies that would build this capacity but also are poor. It's not that there's no grid, but there's not much of one."

Thomas and ISyE research partner Dima Nazzal, Executive Director of Academic Administration and Student Experience, are confident this problem can be solved, however. "It's a very difficult problem," said Nazzal. "We are attempting to design a large-scale complex system that has conflicting performance objectives and significant levels of uncertainty when it comes to electricity generation and storage capacities, electricity demand data, and stakeholders utility, to name a few. But this type of project is perfectly aligned for industrial and systems engineering research. We model these types of systems and try to create robust cost-effective designs – deciding where to locate power plants, where to build the grid network, and how much demand to satisfy, while balancing limited financial and natural resources."

One possible solution is the hydroelectric resources available in east Africa and other parts of the continent. "There is the potential to build large dams," explained Thomas, "that could provide electricity reliably in high quantities at low cost, if the generation and transmission system could be built, and if the environmental and social impacts could be addressed. Or, smaller lower-impact hydro power could provide more local solutions."

Thomas and Nazzal are also considering the balance between fossil fuels such as natural gas or petroleum and more climate-friendly resources such as solar or hydro. ISyE Ph.D. student Amelia Musselman is working with Thomas and Nazzal to develop an optimization model on how to supply electricity to the greatest number of people. She said that right now, she has "the model formulation ready — or at least the first version — and I'm working on programming it and getting the data to solve it."

ExxonMobil is working in conjunction with the ISyE team to construct models that can evaluate many trade-offs in a systematic manner, by selecting appropriate optimization tools.

According to Thomas, the next step is testing and validating the model to verify that it works: "Then we will do some experiments to answer the big questions about tradeoffs between environmental impact and costs." ▪

ISyE Solves Big Data Energy Problems

Nagi Gebraeel, Georgia Power Associate Professor and Associate Director of the Strategic Energy Institute, is working on two projects that represent the spectrum of optimization and Big Data problems within the energy industry.

The first, funded by General Electric (GE), looks at sensor data from gas turbines that power electricity generators. The turbines are large and quite expensive to both manufacture and maintain, so they are equipped with thousands of sensors constantly measuring whether the turbines are functioning within normal operation parameters by monitoring temperatures, pressures, and vibrations from different sections of the turbines in a process known as condition monitoring. Immense amounts of data are sent to Atlanta, GA, where GE's monitoring and diagnostic center is located.

Gebraeel's research team and collaborators include Shabbir Ahmed, ISyE Dean's Professor and Stewart Faculty Fellow; Kamran Paynabar, ISyE Assistant Professor; Andy Sun, ISyE Assistant Professor; Edmond Chow, CSE Associate Professor and Director of the Intel Parallel Computing Center in the College of Computing; and Polo Chou, CSE Assistant Professor and Associate Director of the M.S. in Analytics program. In response to the Big Data problem, they are developing a new computational platform to provide detection and predictive analytics for the energy industry. This platform assesses the health and performance of equipment in real-time and monitors trends to determine such things as:

- When to order new spare parts so they don't linger in inventory, costing money and possibly becoming obsolete.
- Prescribing operational profiles that extend an asset's life without increasing risk of failure.

By integrating detection, prediction, and optimization capabilities, the new prototype platform could help power companies achieve significant savings. Indeed, a preliminary study shows a 40 to 45 percent reduction in maintenance costs alone.

In contrast to the Big Data problem of gas turbines with thousands of sensors is Gebraeel's project analyzing Big Data from wind farms. A wind farm may have hundreds of turbines, which in turn are equipped with relatively few sensors. Thus — unlike the gas turbines — if one or even several wind turbines stop working, it has relatively little impact on the wind farm's power production. Furthermore, maintaining wind turbines often requires sending out cranes, or ships in the case of off-shore wind farms, which can be very expensive. So, in contrast to the gas or steam turbines which need to be repaired as soon as one goes down, it's more cost-efficient to repair several wind turbines

Natural Gas-fired Turbine Electrical Power Plant

at one time. Thus, the optimization model for wind farm maintenance focuses more on opportunistic maintenance.

"They are similar in that the objective is the same, and the constraints are the same, but the dynamics of solving and optimizing them are distinctly different. The perspective on the tradeoffs between the cost of maintenance and operation are almost the reverse," said Gebraeel. "These two settings represent the wide spectrum of configurations within the energy network."

Although the gas turbines present a setting with a high number of sensors on a smaller number of units, while the wind turbines represent a large number of units with relatively few sensors, either way, you end up with a Big Data problem.

"ISyE is one of the few engineering disciplines at the intersection of engineering, statistical sciences, and operations research. For example, the analytic algorithms that we develop are all based on statistical methodologies; the optimization models are all based on operations research," explained Gebraeel. "We are lucky to have some of the best statistics and operations research faculty here in ISyE."

An important aspect of algorithms designed to deal with Big Data in the energy sector is making sure that they are scalable.

Having a scalable computing architecture means the algorithms can be scaled as well. "Sometimes we test the limits of the algorithms in the research that we do," said Gebraeel. His research team uses both actual data from GE as well as simulated data. "Then we go to the hypothetical cases: Let's blow the number of units and the number of sensors beyond what's available in today's industry to study the limits of the algorithms we have re-engineered. It helps us understand the scope of their application." ▪

Decoupling MRI Machine Error Rate to Measure Alzheimer's Progression

MRI machines are powerful tools used widely in conventional medicine, including tracking the progression of mild cognitive impairment (MCI) and early Alzheimer's disease (AD). However, the machines do not always produce error-free results. Additionally, the high cost of data acquisition on these machines prohibits enough data collection for analysis of these errors.

Kamran Paynabar, ISyE Assistant Professor, and Chitta Ranjan, an ISyE Ph.D. candidate in statistics, worked with collaborators at Harvard Medical School to determine the measurement error rate for MRI machines and its effects on patient diagnosis.

The team used data from the Alzheimer's Disease Neuroimaging Initiative database, which included information for 741 patients, most of whom were 70 years or older. This information is concerned with observations of patients' brains to assess for MCI and early AD over a period of up to four years. They were specifically interested in the decline of the hippocampal volume — a brain structure associated particularly with long-term memory.

Such longitudinal data reveals whether cognitive ability of patients "is getting worse over time or it is stable. There often exist some measurement errors associated with MRI systems, and we show that these errors, if not detected and decoupled, may mask a significant declining trend in the cognitive ability of Alzheimer's patients," Paynabar explained.

Paynabar, Ranjan, and their collaborators developed a new method to determine the MRI machine errors through what is called "repeatability analysis": The measurement for a patient is taken over time, and the collected data is put together. If a patient could undergo an MRI with the process repeated in short intervals (for example, every hour or so), it would be easy to determine the measurement error, because the procedure is repeated.

However, because of cost and patient safety considerations, MRIs are not administered more than once a month. The challenge for the team was how to determine the measurement errors without repeatability. In response, the team developed a statistical model, specifically a model based on mixed-effect regression integrated with a newly developed EM-variogram technique, to determine the measurement error and decouple it from the overall model error.

The statistical model — which was validated in the experimental testing phase of the study — when applied to MRI data created increased sensitivity, allowing for earlier diagnosis and treatment of cognitive disease. As per government studies, AD is the fifth major cause of death for senior citizens in the U.S. Early treatment of these patients will lead to longer and healthier lifetimes for thousands of people.

Further, Paynabar said, the statistical model has applications beyond Alzheimer's disease. It is not limited to MRIs but can be applied to "any longitudinal data studies with unrepeated measures." It can be used for patients with brain tumors and other types of cancers and can also be used in drug testing, quality inspection, and other health care applications where limited data is available due to various practical constraints. ▪

Improving Organ Transplant Availability by Evaluating the Risk of Infection Transmission

The demand and the average time on the waiting lists for organ transplants are growing, while the supply of organs remains comparatively limited.

According to UNOS, the United Network for Organ Sharing, currently more than 121,480 people across the United States are waiting for an organ, while 30,970 people received transplants in 2015. In the same year, 6,648 people died on the transplant waitlist, while 6,702 were removed from the list after waiting so long that they became too sick to undergo transplant surgery.

A possible resolution to this problem is to increase the availability of organs. In the past, organs with a small risk of infection were often not chosen for transplant. After several transmissions of infectious diseases that occurred through transplants where these infections (or the risk) were not detected ahead of time, use of many more organs were discouraged because of problems with understanding the risk.

A collaborative project between ISyE and the Centers for Disease Control and Prevention (CDC) addresses this issue of risk estimation and perception, with the goal of assessing the risk of infection in an organ donor, and evaluating the options of receiving an increased-risk donor (IRD) organ versus staying on the waitlist for a patient. Ultimately, the goals are to reduce deaths due to organ transplants transmitting infections, boost the availability of organs without infection for transplant, and reduce the number of patients who die while on the waiting list.

The collaboration started with a Senior Design project, initially focusing on infectious encephalitis in liver transplants.

Under the guidance of Pinar Keskinocak, ISyE's William W. George Chair, and CDC subject matter experts (SMEs), the fall 2014 Senior Design team — Nishi Anand, Dylan Buczek, Nicholas Buczek, Timothy Lin, Tanay Rajore, and Muriel Wacker — developed two prototype tools to help physicians and their patients calculate the risk of infectious encephalitis and evaluate the benefits and risks of accepting IRD livers for transplant.

The collaboration has now grown into a $1,104,000 budgeted research project and includes a three-year, $651,000 grant from the Carlos and Marguerite Mason Trust. Joel Sokol, ISyE Fouts Family Associate Professor and Director of Georgia Tech's interdisciplinary Master of Science in Analytics degree, is the principal investigator on the grant, along with co-investigators Keskinocak and a team of SMEs from the CDC. The ISyE/CDC team will enlarge the project's scope to other organs and other infectious diseases such as HIV, Hepatitis B and C, as well as pathogens that cause encephalitis. The ISyE investigators will also study the possibility of increased organ sharing among Georgia facilities, to improve the in-state transplant system.

In the next year or two, statistical analysis of probabilities for transmission of infections compared with survival rates for liver, heart, kidney, and lung transplants will be completed. This will be followed by a pilot study of the currently in-development decision support tools in Georgia transplant centers.

In addition to the grant from the Carlos and Marguerite Mason Trust, Georgia Tech will also provide funds toward the project's indirect costs, and the CDC has agreed to fund a percentage of in-kind work. ▪

Redefining Success as an Avenue of Personal Growth

by Suraj Sehgal, ISyE undergraduate

When we think of success, we often don't know how to define it, and when we do, that definition tends to never work in our favor. Rather than becoming a constructive benchmark or approach, success becomes an amorphous concept that always eludes us.

Why is this so? It's because our society has convinced us that success is equivalent to fame, friends, and fortune, which makes it easier to constantly feel inadequate — like everyone else is doing life better than you can.

We need to redefine what it means to succeed. The traditional measures of success — promotions, high pay, high grades — are not enough. Our lives are made up of so much more than what we tend to measure and account for in a typical cost-benefit analysis. Success in our life must be holistic. After all, our lives have multiple aspects.

I see holistic success as an attitude, one that can help us develop as a complete individual: academically, professionally, spiritually, socially, and all other parts of our life. It's a mindset that helps us to see our lives not as an endless competition that we're doomed to lose — where everyone is constantly smarter, more popular, and better than us — but rather as an opportunity to learn, make mistakes, and ultimately, grow.

Part of this holistic view of success as an avenue for personal growth has been understanding the importance of being a global citizen. Through the opportunities that Georgia Tech has provided me, I feel like I have truly been able to push my boundaries, go outside my comfort zone, and grow.

Tech has allowed me to change the world while in college and not have to wait until after I graduate. My extracurricular activities, for example, provide me with ways to take these diverse and interdisciplinary perspectives and apply them toward causes that can better the world.

With the Grand Challenges Living-Learning Community, my team, the Food Fighters, has been working since our freshman year to empower college students who are at risk of food insecurity to take action regarding their food situation. We've recently conducted an official study to better understand what food insecurity looks like on Tech's campus, using our ISyE skills to help us analyze our data.

With One Voice Atlanta, a student organization on campus that works to raise awareness about human trafficking, assist victims, and prevent such crimes from occurring in the future, I have had amazing opportunities to connect with other community members, like the International Human Trafficking Institute and SKAL International Atlanta, being given the chance to speak and participate at film screenings, social justice nights, and symposiums.

Ultimately, what drives me is inner growth and a need to bring love to people. Even though I struggle with having that growth-oriented mindset and attitude of holistic success all the time, what has truly helped me develop clarity and purpose in times of chaos has been the practice of heartfulness meditation. I started this meditation practice when I was 17 years old, however, I began to meditate much more regularly after I started college. For me, especially at a high-paced environment like Tech, meditation is a way of stepping back, reminding myself that I am alive, and taking a moment to invest in myself, by doing something that many students seem to have forgotten — to just be.

Heartfulness meditation is about bringing your attention to the heart, helping people connect with the very organ that literally keeps us alive and metaphorically brings us all together. By taking just a moment to bring myself within, I am often reminded of the importance of love and being connected with yourself. And what I've learned in the process is that when I choose to work on myself and try to grow as an individual, it creates a ripple that affects my environment and all those around me. As a result, I can begin to change the world — simply by changing myself. ▪

Kimbrough's Unique Vantage Point

by Jason Maderer

Shane Kimbrough (MSOR 98) is a big sports fan and enjoys taking pictures. That's one reason he packed his camera for a four-month journey that began in October. He's looking for the world's most famous golf courses and wants to snap some photos for social media.

"I don't think anyone has done that before," Kimbrough said before the trip.

Not from his vantage point.

Kimbrough is currently 220 miles above Earth — he's the commander of the International Space Station (ISS).

Kimbrough and two Russian cosmonauts lifted off from Kazakhstan on October 19 and will stay in orbit until the end of February 2017. Taking pictures isn't the reason he's there.

Kimbrough is scheduled to perform two spacewalks in January. He'll leave the confines of the space station to install equipment that will better prepare the ISS for future manned commercial space flights. The four-month mission also includes the welcoming of cargo spacecrafts that regularly deliver supplies, food, and experiments.

Kimbrough's team has also bid farewell to three crewmates, who were on the station when he arrived, and welcomed a new trio in November. Their primary objective is science and technology research.

"A lot of the experiments will be done on our bodies," Kimbrough said. "For instance, we're going to look at mini-exercise devices. In order to get to places like Mars, we'll need to develop really small things to put in capsules. I'm one of the first people to get to try them, so I'm looking forward to that."

Kimbrough grew up in Smyrna, GA, attending Georgia Tech football and basketball games. His plan was to play baseball at Tech, but life instead brought him to the United States Military Academy after President Ronald Reagan wrote an appointment letter on his behalf. He earned an aerospace engineering degree at West Point, then was commissioned as a second lieutenant in the U.S. Army. He later served in Operation Desert Storm and retired as a colonel. He came back to Atlanta in 1996 to begin work on his master's degree.

"It was nice to be home after moving around so much while in the military," Kimbrough said. "I always wanted to be an astronaut, but it's such a longshot to be chosen. When I look back on it, having a master's degree from Georgia Tech was a huge stepping stone."

He still speaks fondly of his days in ISyE. He enrolled in the months after the 1996 Olympics.

Astronaut Shane Kimbrough. PHOTO COURTESY NASA

"We had the benefit of some really neat facilities and brand-new things when I arrived," he remembered. "I'm really honored to be a part of [ISyE] because of its ranking as the No. 1 program in the country."

Kimbrough says the math, science, and engineering techniques he learned in college help him every day in his job. "The problem-solving skills are definitely applicable in space — things don't always go the way we plan up there," he said.

This is his second trip. He spent 16 days in orbit with space shuttle Endeavour in 2008 on a crew of seven astronauts. Three of them were Georgia Tech graduates: Kimbrough, Eric Boe (MSEE 97), and Sandy Magnus (Ph.D. MSE 96).

These days, when not doing science experiments in his new orbital home, Kimbrough spends some of his limited free time in the station's Cupola. It's a mini-module with a wall of windows that always overlooks Earth. It's where he takes many of his photos. In a way, it's actually better than a spacewalk.

"You get a great view and don't have to put on your spacesuit."

Golf courses aren't the only places on his picture list. He's also looking for Georgia Tech and other schools he attended. He admits he's not a professional photographer, but he's learning quickly. Kimbrough's new home moves at Mach 25, or 178,000 miles per hour, providing a swift but spectacular view of his other home below. ▪

Alumni Spotlight: Tracy Hawkins and Safe Drinking Water for Tanzania

In September 2015, the United Nations held a summit on sustainable development. At this convocation, world leaders adopted the 2030 Agenda for Sustainable Development, which includes a set of 17 sustainable development goals (SDGs). The SDGs include putting an end to poverty, addressing climate change, generating affordable and clean energy for all, and — No. 6 on the list — clean water and sanitation.

Clean water and sanitation for the developing country of Tanzania are particularly on the mind of ISyE alumna Tracy Hawkins (BSIE 85). Hawkins is the face of SAFE Water Now (SWN), a U.S.-based nonprofit organization providing expertise, services, and resources to solve the problem of unsafe drinking water in Tanzania, all on a completely volunteer basis. This includes her role as the executive director for the organization, in which she handles the business development of SWN — everything from operations and communications to fundraising. "I wear a lot of hats," she said.

The goals of SWN are to both raise awareness for the need for clean water and to raise funds for ceramic pot filters that can provide clean water for a Tanzanian family for up to five years at a total cost of $40. To accomplish this, Hawkins works alongside her partner, Mesiaki Yonas Kimirei (who prefers to go by "Kim").

Kim runs SWN's sister organization, Safe Water Ceramics of East Africa (SWCEA), from just outside Arusha, Tanzania's second-largest city. SWCEA's employees actually make the ceramic pot filters.

Hawkins described this pursuit of clean water for the people in East Africa as a deeply felt mission: "I got involved in this without really knowing exactly what I was getting into. I got really scared because the venture grew bigger than I anticipated, and it was more important than I realized.

"So I struggled with continuing to do this work or not, because it's very complicated. But I just had to keep doing it. It's a passion, it's a calling, and because it's so fundamental to all life, to all people, to children, to the most vulnerable. I feel like it overrides religion and politics and gender – you can't segregate our society when it comes to water."

The development of SWN and SWCEA has something of a winding history: Hawkins was visiting Tanzania in 2005, when she collaborated with local potters to develop handcrafted ceramic souvenirs to sell to tourists coming to the country. Hawkins was looking into fundraising possibilities for this venture when she came across the ceramic pot water filter promoted by Potters for Peace, another U.S.-based nonprofit that produces ceramic pot filters in Central America.

Remembering that she had to drink bottled water on her Tanzanian trip, Hawkins was struck with the idea that a similar endeavor could be started in that country. She took the idea to the group she was working with in Tanzania and

the rest, as they say, was history: "My current partner, Kim, said 'We have to do this.' And so we did, and we've been doing it now for 10 years."

On a family property near Arusha, close to the main road, SWCEA has built its ceramic factory. The factory produces both ceramic pot filters and traditional pots. Making and selling the pots has allowed the factory to be sustainable during the filter's development.

According to Kim, there are several challenges to producing the filters, which are made with clay, sawdust, and colloidal silver. Potential obstacles include a minimal consumer market for the filters — most are purchased through donations; the difficulty of filter delivery to customers throughout East Africa; flooding, which has damaged production machines and materials; and an unreliable source of electricity, which can cause production to lag.

Additionally, slow production is a problem. Right now, 500 filters are produced each month, and that's where Georgia Tech's Engineering for Social Innovation Center (ESI) comes in. ESI matches students with real-world projects for corporations and nonprofit agencies. All projects aim to improve the lives of the underprivileged domestic population or people at the bottom of the pyramid in the developing world.

Three separate ESI teams are working to make SAFE Water Now's process for creating the filters more efficient. One group is creating a test tube incubator that tests the water before and after it is filtered, by adding a bacterial agent and heating it to an exact temperature. A second group is building a drying tent for the filters that is made out of inexpensive, lightweight, readily available materials. To deal with the issue of inconsistent electricity, and to power the incubator and the drying tent, another team is developing a solar-powered generator. With these three innovations in place, which are all still in the prototyping phase, the outcome of these ESI projects will reduce bottlenecks in the process to produce filters at the current capacity of 500 units per month.

"This project was the biggest highlight of my college career. We all want to be able to help, but we don't always know how. ESI made taking my skills and applying them to something meaningful an amazing, effortless, and natural process," said Meriem Guehaiz (BSIE 16), member of the SAFE Water Now incubator team.

SWCEA has, fortunately, also found a unique solution to distributing the ceramic pot filters: via the safari circuit. Hawkins said, "A large safari company that works in Tanzania and other countries – Overseas Adventure Travel [OAT] – brings their tourists for a cultural safari to our factory. Afterward, the tourists journey to the most rural locations, where they are able to donate filters to rural people living without safe water. OAT tourists have the opportunity to actually participate in delivering safe water to the local people living on the Serengeti, Ngorongoro Crater, or along the Great Rift Valley — a life-changing experience for everyone."

In contrast to Kim's list of very specific and immediate challenges, Hawkins described the challenges — which are two-fold — of their joint venture a little differently.

First, there's an educational component to using the ceramic pot filters that must be bridged. Hawkins said this involves "helping [the users] understand that water is making them sick and what they can do to prevent getting sick. It means helping them achieve simple goals, such as handwashing and treating their water. Beyond that — once the people we're serving feel better and see progress — we can talk about things like sanitation and girls' menstrual needs. [But] water has to come first."

Second, there's a cultural component to figuring out how to scale up and enlarge SWN/SWCEA from a business perspective. Hawkins noted that the two organizations are working with a social enterprise incubator and accelerator called Anza that is helping her figure out how to overcome cultural challenges.

"For instance, we really need consumer micro-credit to go to scale," she explained. "Think about going to Sears and buying a refrigerator, where it's easy to get credit." It's not currently possible for people to buy the pot filters on a credit system like someone would be accustomed to in the U.S.

Above: Tracy Hawkins presents SWCEA's director, Kim, with the organization's first computer.

Further, Hawkins and Kim want the ceramic pot filter to become an aspirational product, something that appeals to the middle and upper classes in Tanzania, which will increase the filter's desirability.

"So as you can see," Hawkins added, "This is using every single bit of IE systems knowledge that I could possibly drum up. This whole project is a systems engineering project. It's different from a systems engineering project that you would find in an industrialized country.

"I would say the biggest difference is the need for flexibility — to not plan too far ahead. As a matter of fact, the risks are so high working in this environment, you have to be able to flow with whatever's going on."

Pinar Keskinocak, ISyE's William W. George Chair and Co-founder and Co-director of the Center for Health & Humanitarian Systems at Georgia Tech, is on SWN's advisory board. She has helped Hawkins with SWN's development and confirmed the benefits of Hawkins' IE background: "Tracy's career, first in the private sector, then in the nonprofit sector, is an excellent example of how versatile and impactful industrial engineers can be. Through social entrepreneurship, she established SWN, offering a local and sustainable solution for clean water to many families in Tanzania, as well as creating job opportunities for the people and improving their livelihood."

The time and attention Hawkins and Kim have devoted to SWN and SWCEA paid off at the 2015 Energy Globe Awards, given out for the best sustainability projects, when SWCEA won first place in the Water category. Kim and his wife attended the awards ceremony, held in Tehran, Iran.

When asked if she has an anecdote that exemplifies for her SWN/SWCEA's work, Hawkins said she has two.

The first concerns her partner Kim, who comes from an educated family that knew to boil their water. However, Kim said that until he was able to drink filtered water, he always had a stomachache. Now he never has a stomachache, and he never has to go to the doctor.

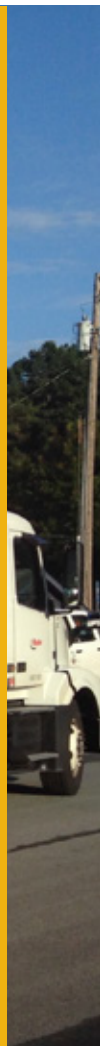
The second example is a mother who received a filter but told SWN/SWCEA that she used to filter her water through her dirty clothes to get rid of any sand or dirt in the water. She doesn't have to. "So this is what we're dealing with here," Hawkins said. "She has a real solution for treating her family's water." ▪

Hannah Chen, a third-year ISyE student, completed her second co-op this past summer at The Coca-Cola Company in the Environmental Health Safety Sustainability (EHSS) department. Chen spent a day riding in a Coke merchandise truck around Atlanta. From this experience she learned that the merchandisers need to balance efficiency and safety as they are physically lifting heavy weights all day. Seeing the industry from the merchandisers' perspective helped Chen with her co-op project.

"I united the EHSS department by streamlining their successful practices in creating an easy-to-use database. This database can be used by anyone in the office or facility to find over 5000 successful practices which include useful ways to save energy, resources, time, and money for the company, as well as preventing injuries in the facilities."

"By decreasing time to search a document by 67 percent, this database has been able to make an impact across the nation by streamlining production plant recycling, environmental compliance, and water efficiency programs."

Chen said that she has had a fantastic experience co-oping and is continuing to work at Coke part-time this fall while taking a full course load.



Edward H. Kaplan, ISyE 2016 Distinguished Scholarship Lecturer, on Adventures in Policy Modeling

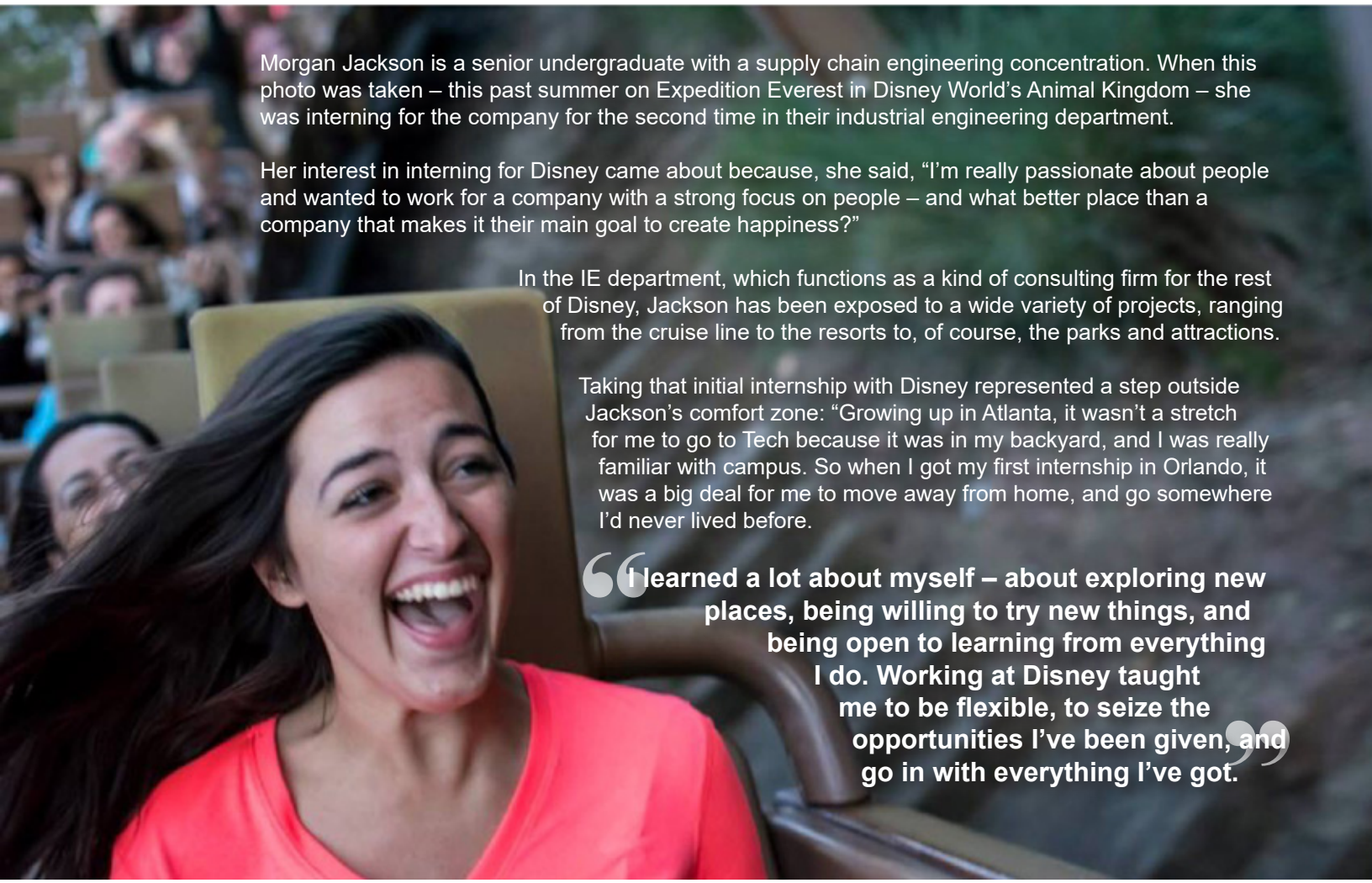
ISyE's Distinguished Lecture program promotes discussion on critical issues in our field by bring in leading scholars who engage and share their expertise with ISyE's faculty, students, and alumni.

In March, ISyE hosted Yale University's Edward H. Kaplan for its 2016 Distinguished Scholarship Lecture. Kaplan is the William N. and Marie A. Beach Professor of Operations Research, Professor of Public Health, and Professor of Engineering at Yale University, as well as president of INFORMS.

He discussed the application of operations research, statistics, and other quantitative methods to model policy problems. He recognized that analyses of all sorts often exhibit diminishing returns in insight to effort, and the hope is to capture key features of various policy issues with relatively simple "first-strike" models. Problem selection and formulation thus compete with the mathematics of solution methods in determining successful applications: Where do good problems come from? How can analysts tell if a particular issue is worth pursuing?

In addressing these questions, Kaplan reviewed some of his personal adventures in policy modeling selected from public housing, HIV/AIDS prevention, bioterror preparedness, suicide bombings and counterterrorism, in vitro fertilization, predicting presidential elections, and sports.

If you were unable to attend the ISyE Distinguished Lecture given by Dr. Edward H. Kaplan on "Adventures in Policy Modeling," the lecture is now available on video here: **http://b.gatech.edu/1qTYtgM**.



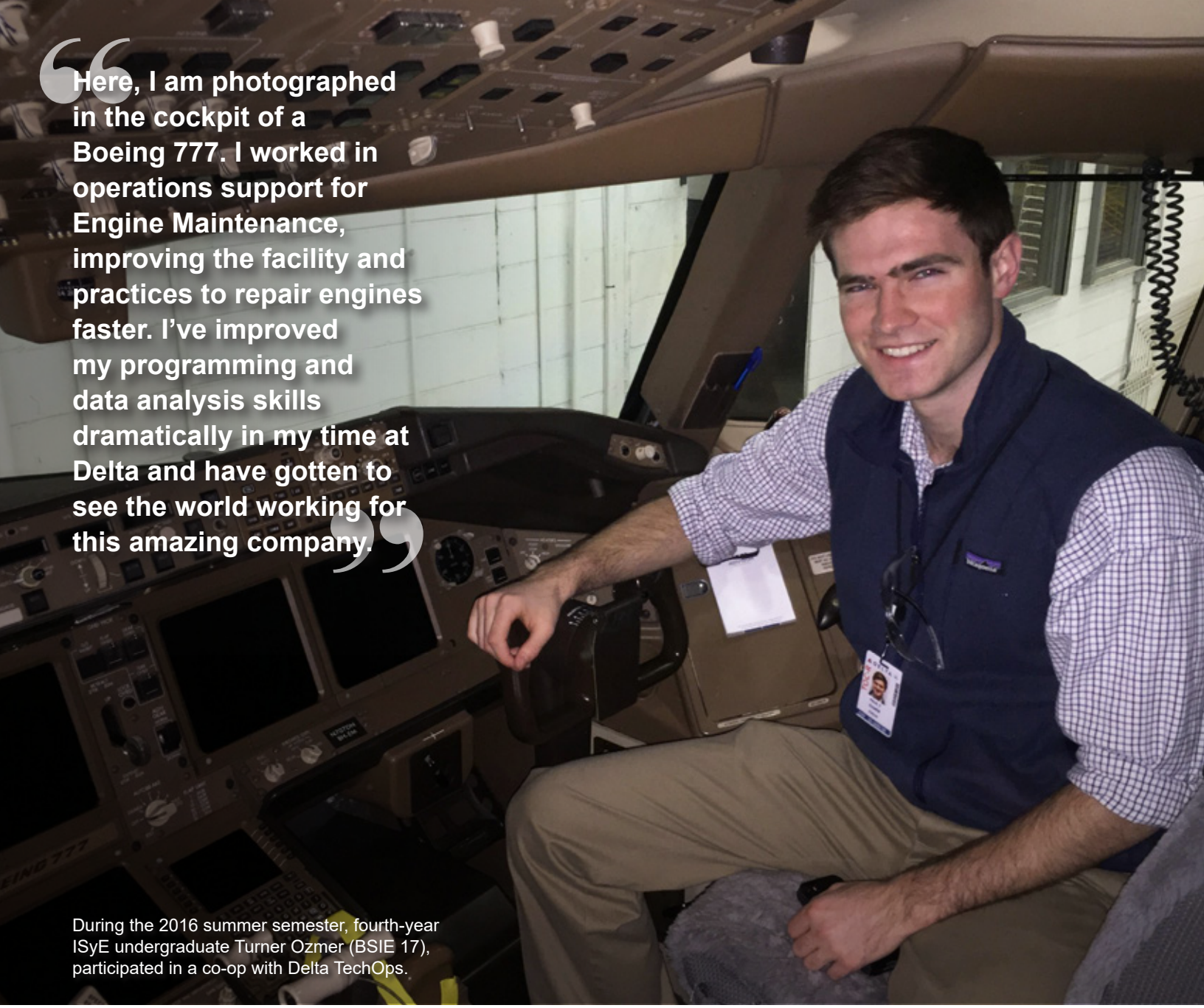
Morgan Jackson is a senior undergraduate with a supply chain engineering concentration. When this photo was taken – this past summer on Expedition Everest in Disney World's Animal Kingdom – she was interning for the company for the second time in their industrial engineering department.

Her interest in interning for Disney came about because, she said, "I'm really passionate about people and wanted to work for a company with a strong focus on people – and what better place than a company that makes it their main goal to create happiness?"

In the IE department, which functions as a kind of consulting firm for the rest of Disney, Jackson has been exposed to a wide variety of projects, ranging from the cruise line to the resorts to, of course, the parks and attractions.

Taking that initial internship with Disney represented a step outside Jackson's comfort zone: "Growing up in Atlanta, it wasn't a stretch for me to go to Tech because it was in my backyard, and I was really familiar with campus. So when I got my first internship in Orlando, it was a big deal for me to move away from home, and go somewhere I'd never lived before.

"I learned a lot about myself – about exploring new places, being willing to try new things, and being open to learning from everything I do. Working at Disney taught me to be flexible, to seize the opportunities I've been given, and go in with everything I've got."



During the 2016 summer semester, fourth-year ISyE undergraduate Turner Ozmer (BSIE 17), participated in a co-op with Delta TechOps.

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ISyE Dedicates Studio in Honor of Cecil G. Johnson

In April, the ISyE Studio was dedicated in honor of former faculty member Cecil G. Johnson. Johnson was a faculty member for 37 years and received both his bachelor's and master's degree from ISyE. Former Delta Airlines CEO and ISyE advisory board member emeritus Ron Allen (BSIE 64) provided the endowment for the naming of the studio in Johnson's honor.

Left to right: Ron Allen; Gray Johnson, Cecil Johnson's son; ISyE School Chair Edwin Romeijn; and Alan Johnson, Cecil Johnson's grandson and current ISyE student

Allen and Johnson had a long-standing relationship that began when Allen was an undergraduate at Georgia Tech. The initial relationship, Allen says, began with the first ISyE class he took, which was with Johnson.

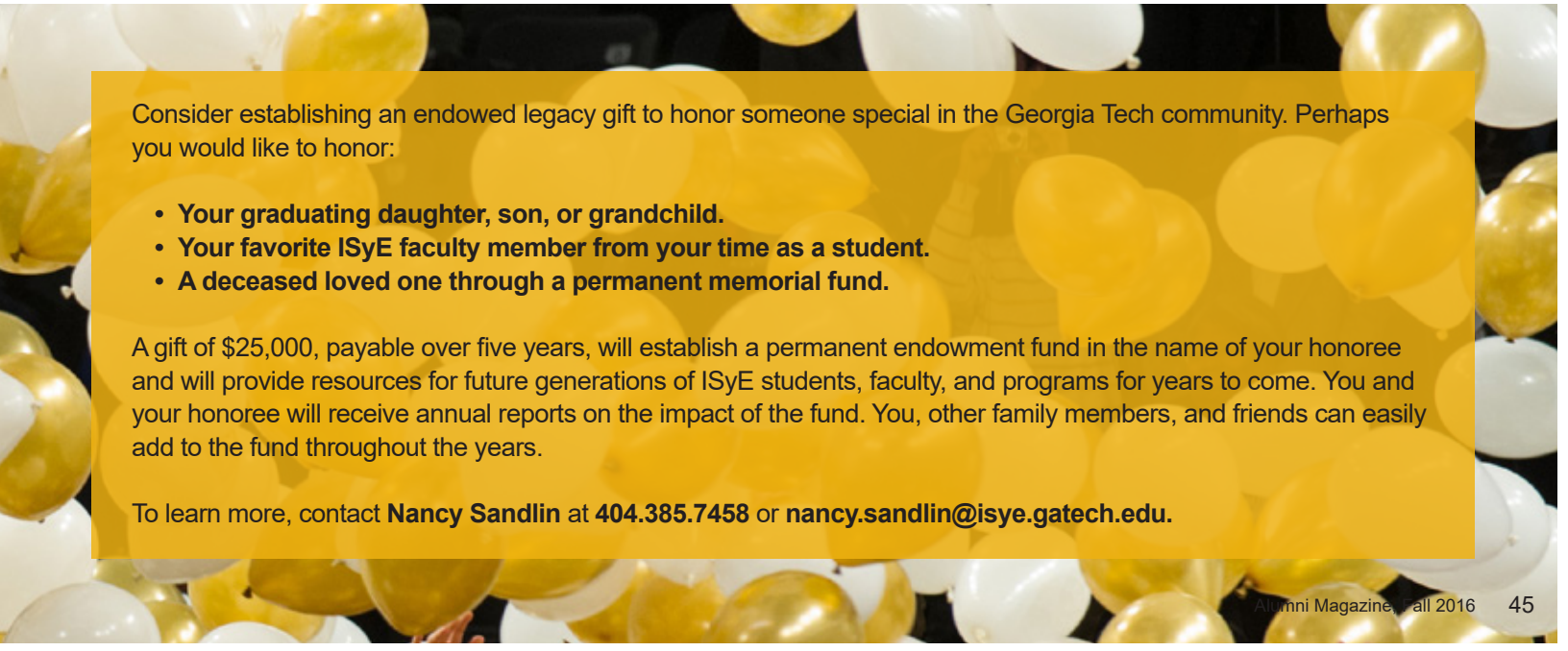
"Professor Johnson had such a reputation for being tough. And I was working about 20 hours a week and carrying a full load, so I had limitations on what I could do. I'm glad I didn't drop the class. What he taught us to do was think outside the box; [he] challenged us to do some nontraditional thinking in every aspect of the class."

Eventually Johnson helped Allen get his first job with Delta, a part-time role as a methods analyst in the methods department, while Allen was still a student. This led to a 34-year career with Delta for Allen, who served as Delta's CEO for 10 years until 1997.

The ISyE studio was established to provide students with a workspace to foster collaboration, encourage interaction, practice presentations, and gain tutorial assistance. Students have access to the latest technology to complete team projects, presentations, and videos.

"It's primarily focused on undergraduate students; it's an area where students can think out of the box, get out of the norm, and think in extraordinary ways, and that is what Cecil Johnson stood for. He taught people to be contrarians and not just take what you see in front of you as the norm, [but] to think about different ways of accomplishing different types of goals.

"You never forget someone like that," Allen added, "a mentor and friend." ▪



Consider establishing an endowed legacy gift to honor someone special in the Georgia Tech community. Perhaps you would like to honor:

- **Your graduating daughter, son, or grandchild.**
- **Your favorite ISyE faculty member from your time as a student.**
- **A deceased loved one through a permanent memorial fund.**

A gift of $25,000, payable over five years, will establish a permanent endowment fund in the name of your honoree and will provide resources for future generations of ISyE students, faculty, and programs for years to come. You and your honoree will receive annual reports on the impact of the fund. You, other family members, and friends can easily add to the fund throughout the years.

To learn more, contact **Nancy Sandlin** at **404.385.7458** or **nancy.sandlin@isye.gatech.edu.**

Lois Johnson, a third-year ISyE undergraduate, is from Oak Ridge, TN. This past summer, Johnson studied abroad at Georgia Tech-Lorraine (GTL) and spent time traveling around Europe.

She said that sometimes taking risks come with great reward, whether through bungee jumping in Stockhorn, Switzerland or deciding to come to Georgia Tech. “My decision to come to Tech, moving somewhere new from a small town to a big city, was a huge leap of faith. What I learned from that experience and other experiences I’ve had at Tech – such as my two internships [one with UPS and one with Equifax] – is that you only grow from taking those risks.

> **“So you need to put that fear aside, and if the experience doesn’t work out, you’ve learned something from the experience.”**

“Coming to GTL, I have wanted to experience so many new things and put myself outside my comfort zone – travel with new friends to new places. Planning things spontaneously – what trains I’m going to take or what I’m going to eat – rather than being super calculated. There’s a lot of fear in doing that that needs to be conquered. And you need to be okay with the fact that when you take those risks, there may be some failure, but you grow from that failure – and not just the success of those risks.”

She loves ISyE and the versatility of the major and serves as an ambassador for the program.

The Classes of 1951 and 2016: 86-year-old Graduate Prepares for Commencement

by Jason Maderer

In many ways, Leo Benatar was very similar to many of his fellow graduates at spring 2016 Commencement ceremonies. He followed up his bachelor's degree from Georgia Tech with a master's degree from the Institute. And it was a day he envisioned for years.

But in one way, he was very different from his peers: Benatar is 86 years old. "My kids joked that I'll have to update my resume now for my next job interview," said Benatar.

Benatar earned his Master of Science in Industrial Engineering degree, 59 years after he was ready to receive it.

Benatar graduated from Georgia Tech with his bachelor's degree in industrial engineering in 1951 during a ceremony on Grant Field. After a stint with the Navy, he returned to campus in 1954 and began working on his master's during night classes. Six months shy of graduation in 1957, while preparing for his thesis defense, his advisor left the Institute, and Georgia Tech couldn't find anyone knowledgeable enough about the topic to effectively hear the defense. Commencement came and went, and Benatar continued taking classes. A replacement wasn't found the next year either. Eventually, the Atlanta native decided to begin his career and leave campus without the degree.

A few years later, Georgia Tech dropped the thesis requirement, allowing master's students to graduate if they had taken enough courses. Benatar had, so he followed up with John White, the director of ISyE at the time, to ask about finally getting his degree. But White left shortly afterwards.

Benatar made some inquiries every so often during the last few decades, and wheels started to move in the right direction when he mentioned it last summer to Edwin Romeijn, the current chair of ISyE. In December, he received the word that he was officially a member of the Class of 2016.

"Psychologically, it's a tremendous feeling for me," Benatar said. "I'd done the work and gone to the classes but didn't get the fulfillment of the degree. I'm the type of person who wants to complete everything that I start. That's what I've done in business — it's what Tech taught me."

Among a long list of career accomplishments, Benatar served as the director, president, CEO, and chairman of the board of Engraph, Inc., a $500 million manufacturing company at the time of his retirement in 1996. He's a former chairman of The Federal Reserve (Sixth District, Atlanta). He's also the principal of Benatar & Associates and serves on the board of Aaron's, Inc.

"Georgia Tech was a great learning experience," he said. "It prepared me for business by forcing me to think through possibilities and work really hard to determine solutions. To be frank with you, I couldn't get into Georgia Tech today. The quality of the students that we're attracting is mindboggling."

Benatar and his wife, Louise, are members of The Hill Society (Georgia Tech's most prestigious giving society) and established the Leo and Louise Benatar Endowment for ISyE. The east entrance of McCamish Pavilion, the site of the spring ceremonies, is named after the couple. Seventeen members of his family and friends attended.

"Completing this gives me a tremendous sense of satisfaction," he said. "Far more than the worth of the degree. It was fun — it's not often that you're older than the president who gave you the degree." ▪

Reflections: Studying Abroad and Defining Success

By Julianne G. McCallum, ISyE undergraduate

This past spring, as a part of the Georgia Tech-Lorraine (GTL) study abroad program in Metz, France, I traveled to eight European countries in five months. The travel, while interesting, wasn't the most impactful part of my study abroad experience — rather, it was the friendships I made. Even when checking off bucket-list destinations, the experience always resonated more when I went with friends.

Meaningful, too, were the experiences that stretched my intellectual boundaries. Over the course of the semester, I studied and worked harder than I ever had before. I helped make an app with coding experience from CS 1301, wrote for the official GTL blog, and served as vice president for the Bureau des Étudiants (Resident Housing Association). My classmates and I even volunteered at a former holding camp in World War II, Fort Queuleu, where we repaired the historic iron gate and mingled with fellow volunteers from Metz.

As a result of this semester, I have become more confident in my presentation skills, reconsidered preconceived notions on politics, welfare, and the intricacies of financial markets, and changed my priorities. I've seen the beauty of people around me, as I saw complete strangers on trains help my friends out for no reason other than being kind.

When signing up for my semester abroad, I thought I'd find inspiration in grandiose buildings and seeing renowned works of art and architecture, but really, I found it in the people around me and in new experiences. And now that I am back in the States, my experience has afforded me the opportunity to reflect on what success means to me and the road ahead.

For me, success is rooted in happiness — being able to look back at my life and sigh contentedly. For some, happiness is etched in a fire-engine red Ferrari, but mine rests on one key pursuit: balance. I'm happiest — and most successful — when all the different aspects of my life reach an equilibrium point. So success is never a stagnant accomplishment, but rather evolves as life does.

This includes facets like personal health and well-being, relationships with people I love, achieving my goals and satisfaction in academics and career, volunteering in the community, and enjoying leisure. It's hard to live a life teetering toward imbalance: If I don't spend enough time with people I love, then I'm unhappy; if I don't spend enough time studying for that ISyE 3232 test, then I'll also be unhappy once T-Square loads the grades.

Balance in all pursuits is tricky to maintain because sometimes life gets in the way. As an ISyE student at Georgia Tech, the demands of classes can make balance even more difficult. The thought of achieving my academic goals — a degree from the most prestigious industrial engineering program in the country at a reputable Institute that I love — fuels my quest for a purposeful career.

Here at Tech, I am fortunate in many ways. Beyond exemplary academics, Georgia Tech tries to make the pursuit of balance realizable with events, clubs, and programs that create opportunities to expand horizons. The Institute of Industrial and System Engineers, the Society of Women Engineers, Energy Club, and French Club have all brought new perspectives, responsibilities, and experiences. And Georgia Tech's International Plan, a degree designation that encourages a global mindset in studies and careers, is the reason I had the opportunity to go abroad in the first place.

Georgia Tech is a place you come to be successful — not just in school, and not just in finding your perfect job, but in defining your terms of success and pursuing them. For me, that's the most valuable part of attending this Institute and studying industrial engineering: I'm pursuing the balance I need while at the same time earning a degree I'm passionate about, and that makes me very happy. ▪

Connect with the Stewart School of ISyE

Are you interested in collaborating with ISyE? The School welcomes your engagement and offers many ways to get involved: ISyE works closely with business and industry leaders as collaborators on a variety of research and projects as well as student enrichment activities. You can also connect with the School through sponsorships and philanthropy that brings the best education possible to our students and supports our faculty as they tackle research issues that improve the quality of life for all.

ISyE faculty, students, and alumni are creative, analytical, and engaged, and by working together, we can provide the best academic experience for our students.

Partnership Opportunities
isye.gatech.edu/about/partnerships

ISyE Core Research Areas
isye.gatech.edu/research

K-12 Outreach
isye.gatech.edu/about/partnerships/k-12-outreach

The people listed on this page are ready to help you tap into everything ISyE has to offer.

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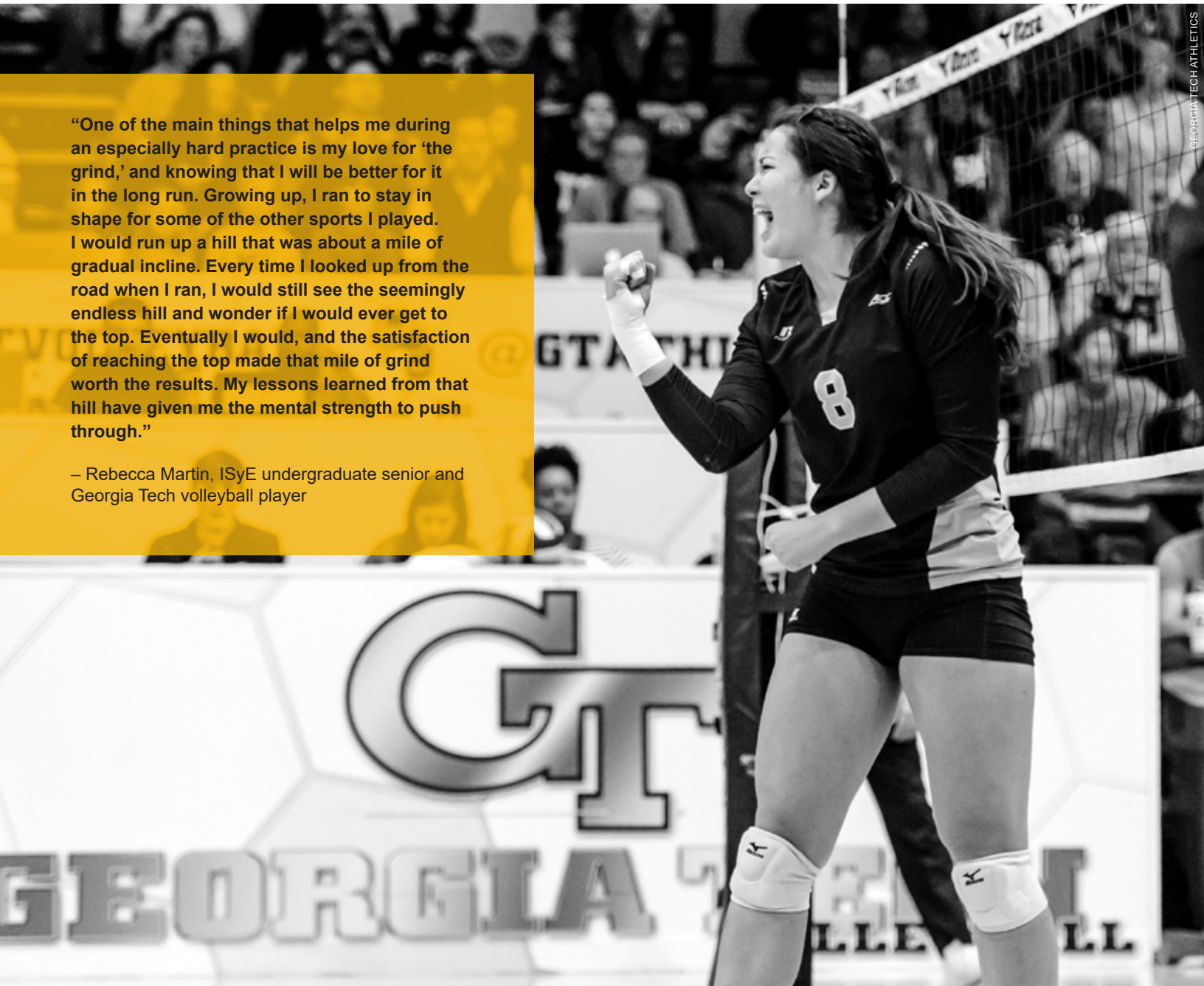

"One of the main things that helps me during an especially hard practice is my love for 'the grind,' and knowing that I will be better for it in the long run. Growing up, I ran to stay in shape for some of the other sports I played. I would run up a hill that was about a mile of gradual incline. Every time I looked up from the road when I ran, I would still see the seemingly endless hill and wonder if I would ever get to the top. Eventually I would, and the satisfaction of reaching the top made that mile of grind worth the results. My lessons learned from that hill have given me the mental strength to push through."

– Rebecca Martin, ISyE undergraduate senior and Georgia Tech volleyball player

GEORGIA TECH ATHLETICS