BERKELEY
IEOR
INDUSTRIAL ENGINEERING
& OPERATIONS RESEARCH

MACHINE LEARNING
FOR A CONNECTED WORLD

INSIDE

New machine learning courses and research
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Chair's Announcement

Dear alumni, faculty, students and friends of the department:

The IEOR department has had an incredible year as we continue to investigate pressing research questions and teach the next generation of engineers. This year we welcomed our first cohort of Management, Entrepreneurship and Technology (M.E.T.) students, expanded our master of engineering program, and added new courses in machine learning and innovation to help our students learn the latest skills. At the same time, our junior faculty are producing significant research that is paving the way for a promising future.

Our department now serves nearly 400 IEOR students, the largest student body on record, and nearly double the amount in 2010. We expect the growth trend to continue. In this issue of the IEOR alumni newsletter we will announce a new FinTech concentration for our growing one-year Masters of Engineering (MEng) program. New labs at the Sutardja Center for Entrepreneurship & Technology are also creating new IEOR classes in emerging technology areas such as data science, blockchain, and meat alternatives, and helping to educate students from all parts of campus.

We plan to continue our initiatives to make our student community diverse and inclusive and provide students with the best resources and network to build tomorrow's leaders. The department is helping to build community by continuing to support our graduate student group, and we've also created a new undergraduate communications team that you will learn about in this issue that we think will help foster a more tightly-knit Berkeley IEOR community. IEOR students are also leading groups outside of the department, such as the Society for Women Engineers. In this issue you will hear stories from students who attended the SWE annual conference.

The University of California, Berkeley is also celebrating its 150th anniversary this year. After 150 years of "fiat lux" (let there be light), Berkeley continues to shine as the #1 public university in the world. Founded in 1954 as a division of mechanical engineering, we became the Industrial Engineering department in 1956. With the rise of Operations Research, we became the IEOR department in 1966. We are proud that our department has been a significant part of UC Berkeley's history, and we look forward to the next 150 years of educating and leading research for a brighter future.

"We are proud that our department has been a significant part of UC Berkeley's history."

Go Bears!

Ken Goldberg

Chair and William S. Floyd Jr. Distinguished Chair of Engineering
UC Berkeley Department of Industrial Engineering & Operations Research

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Welcoming new and returning students

MANAGEMENT, ENTREPRENEURSHIP, & TECHNOLOGY (M.E.T.) INAUGURAL CLASS

In October, **the first cohort for the M.E.T. program** met at the Sutardja Center for Entrepreneruship & Technology to learn about resources at Berkeley for entrepreneurship students, including courses, study abroad opportunities, and **the new begin.berkeley.edu** web portal which is organizing entrepreneurship resources in one place to help students move more quickly through the innovation process.

Through the M.E.T. program, these students **will be the first in history to be eligible to receive both a degree in business and engineering** at UC Berkeley.

NEW IEOR PHD COHORT FOR 2017-2018

On August 21st, the IEOR department combined forces with the nuclear engineering department to **welcome new PhD students on the rooftop of Etcheverry Hall**. While it happened to be the same day as the **first total solar eclipse in twenty-six years in the U.S.**, a cloudy Berkeley day made viewing the eclipse all but impossible, but students still enjoyed the chance to meet.

IISE AND IEOR DEPARTMENT ORGANIZE SOCIAL TO WELCOME NEW IEOR STUDENTS

The IEOR department and Institute of Industrial & Systems Engineers (IISE) student group welcomed IEOR undergraduates back to school for the 2017/2018 year. Over 100 students showed up to receive free pizza and hear from department staff, Chair Ken Goldberg, and the new IISE student officers.

New IISE officers from left to right: **Chad Wakamiya**, Communications and Technology Chair; **Albert Loekman**, Treasurer; **Ebru Kasikaralar**, Vice President; **Stella Bao**, President; **Kaitlyn Li**, Corporate Chair; and **Emily Garcia**, Corporate Chair. (Not pictured: **Alyssa Hiraoka**, Social Chair.)

Building IEOR community

IEOR FALL PICNIC

In September, the **IEOR department sponsored its annual fall picnic**, a rare chance for faculty and students from all undergraduate and graduate programs to come together.

From right to left: Susheel Krishnamurthy, Wesley Jin, Stella Bao, Aditya Tyagi, Averell Wallach, Jerry Cortez, Rebecca Martin, and Camille Stuczynski

ALUMS REUNITE AT NOVEMBER REUNION

In November, over seventy alums met at Capgemini's Applied Innovation Exchange in San Francisco, for our annual alumni reunion. **The event featured lightning talks from Michelle Fisher (pictured left), Auren Hoffman, and IEOR chair and professor, Ken Goldberg**. Alums also had ample time to catch up while enjoying delicious food and drink.

The next alumni reunion will be in fall 2018. **Have an idea for an alumni event?** Please contact Keith McAleer at kmcaleer@berkeley.edu.

MARISSA MAYER VISITS IEOR NEWTON LECTURE SERIES COURSE

Former Google executive and Yahoo! CEO Marissa Mayer visited IEOR 195: A. Richard Newton Series, a course organized by the Sutardja Center for Entrepreneurship & Technology that brings distinguished innovators to Berkeley to tell their story to students.

Pictured right is IEOR Professor Phil Kaminsky interviewing Mayer for a special "Newton Chat" video. The video and a story about Mayer's visit can be found at scet.berkeley.edu/news.

Building IEOR Community

LUNCH & LEARN

IEOR PhD and MS students gather for their bi-weekly Lunch & Learn seminar where students share skills and practice presenting.

During Lunch & Learn this fall, students practiced their conference presentations, held a summer internship panel to share their experiences, a talk on the latest research in optimization, and how to use the Savio computing clusters on campus.

ALUM PRESENTS AT BADSS CONFERENCE

On November 11, **students organized the first-ever Bay Area Decision Sciences Summit (BADSS)**. The event featured a case competition between participating schools and a career panel.

The keynote speaker for the event was IEOR alum Nirmal Govind, who currently leads data science for streaming and algorithms at Netflix. Govind talked about how Netflix used data science to decide which television shows to produce, how to optimize how content is hosted on servers around the world, and how the Netflix app itself recommends movies and television shows to users.

BERKELEY STUDENTS TAKE HOME BADSS 1ST PLACE PRIZE

Students at the BADSS summit take home the first place prize for their geographical analysis of which zip codes would be best for sponsor Sunrun to direct future marketing.

Overall, four teams from Berkeley participated in the competition that also included students from San Francisco State University, Santa Clara University, and San Jose State University.

Read the whole story on page 18.

Master of Engineering Winter Spotlight

"DATA FUSION ANALYTICS TO PREDICT IN-HOSPITAL CARDIAC ARRESTS"

"We are working with UCSF to develop a classification model that will reduce false positive Premature Ventricular Contraction alarms. This model will be integrated into a "super alarm" patient monitoring tool that, by streamlining monitor data visualization and reducing false positive alarms, aims to reduce alarm fatigue for nurses in the UCSF Intensive Care Units and improve quality of care for patients."

From left to right: Alex Ackroyd, Segev Malool, Umesh Thillaivasan, Siddhant Issar, Yuntao Wang, and Adam Andrews.

AUTONOMOUS VEHICLES & PEDESTRIANS

"Our capstone project is aimed at modeling interactions between pedestrians and autonomous vehicles. Currently, we are capturing videos of human-driven vehicles interacting with pedestrians jaywalking and extracting trajectory data from these videos through Image Processing. The goal is to look for patterns that work in favor of safety and traffic management, then use those to teach an autonomous vehicle through machine learning to interact with jaywalkers. We're working under the guidance of Dr. Gabriel Gomes from the Mechanical Engineering department and Dr.Ching-Yao Chan from California Partners for Advanced Transportation Technology (PATH). We look forward to tackling any tough challenges to achieve our goal!"

From left to right: Mubarak Abdul Kader, Moyu Li, Dayi Wang, Salma Benslimane, Dan Xu (not pictured)

INTERNET OF THINGS (IOT) IN PRECISION AGRICULTURE

"This demo is a single smart plant system which can measure the air temperature and humidity as well as the soil moisture. The system will alert the user when the soil is too dry and the user can switch on the water pump wirelessly in their app.

"This is just the first stage. The ultimate aim of the project is to apply IoT to agriculture. The group hopes to make a fertilizing plan for oil palm trees planting by using IoT."

Making Machine Learning Fair

While machine learning (ML) continues to equip new engineers with powerful tools that are expected to touch most industries (see next page), IEOR researchers are working to ensure that these algorithms, which today are making innumerable decisions per second, are doing so in a way that is fair to everyone. Many applications for ML algorithms are innocuous, such as recommending a new song or movie for a user. But the stakes get higher when they are being used for critical life decisions such as who gets accepted for a loan or what medical treatments a patient should receive, which are situations where a large body of research has found existing racial and gender biases in the decisions made by people.

Currently, there are two main issues researchers are investigating with regard to fairness in machine learning. The first is the general lack of interpretability of many ML techniques. Working to figure out exactly why ML algorithms make the decisions that they do can be difficult, sometimes even for the engineer that designed the algorithm.

The second issue, which is the topic of a new paper titled "Spectral Algorithms for Computing Fair Support Vector Machines"[1] by PhD student Matt Olfat and assistant professor Anil Aswani, is ensuring that decisions produced by ML algorithms are not biased against protected classes (e.g., those defined by age, gender, race). If the data used to train ML algorithms is biased because of existing discrimination, then ML algorithms would encode those biases into the algorithm and perpetuate that discrimination through its decisions. Designing algorithms to reduce such biases is non-trivial because ML algorithms are able to learn combinations of other variables that identify protected classes (e.g., geographic location can serve as a proxy for race in segregated neighborhoods).

The first challenge for Olfat and Aswani was to identify how to translate different notions of "fairness" into mathematical constraints on the design of ML algorithms. The researchers considered both 'demographic parity', which means that decisions made by the algorithm will be the same for two individuals with similar characteristics but belonging to different protected classes, and 'equal opportunity', which means that the probability of positive decisions (e.g., approving a loan application) should be the same for two individuals with similar characteristics but belonging to different protected classes. The researchers translated these two notions of "fairness" into mathematical constraints with a popular ML technique known as a support vector machine (SVM).

The second challenge for Olfat and Aswani was to develop a computational approach for using data to train the resulting ML algorithm. This is a complex problem because "fairness" inherently leads to non-convex mathematical constraints, which are notoriously difficult for computation. The solution proposed by the researchers was based on the key insight that the non-convexity had a special mathematical structure that could be decomposed into "difference of convex" formulations using a spectral decomposition. In this way, the required computation was converted into an optimization problem for which good numerical techniques exist. Olfat and Aswani showed that the resulting computational approach was successfully able to improve the fairness of decisions generated by SVM.

Support for the research was provided by the Center for Long-term Cybersecurity at UC Berkeley. The center also contributed an additional $15,000 to support further research by Olfat and Aswani in this area. ▪

[1] M. Olfat and A. Aswani (2018), Spectral algorithms for computing fair support vector machines, In International Conference on Artificial Intelligence and Statistics (AISTATS). To appear.

PhD student Matt Olfat is working with assistant professor Anil Aswani to research methods to ensure that machine learning algorithms make decisions that do not discriminate against protected classes.

Assistant professor Paul Grigas (pictured third from left) with students taking his new machine learning course

New Machine Learning Course Equips Students with Latest Analytical Tools

A new course in the IEOR department is helping students gain skills in one of today's most applicable and exciting areas: machine learning (ML). *IEOR 142: Introduction to Machine Learning and Data Analytics*, taught by Professor Paul Grigas, is expected to grow rapidly as ML is revolutionizing artificial intelligence, retail, digital media, and virtually every other industry.

While many techniques commonly associated with ML have been around for quite some time, the field is currently enjoying a renaissance thanks to a perfect storm of easy access to data, fast computers with cheap storage, and the general value that these functions have for helping to solve engineering and business problems.

ML tools are algorithms that allow a statistical model to make predictions based on a smaller subset of data, typically called training data. As more data is fed into the system, the model "learns" from new data and builds a more accurate predictive model. One of the most common examples is a recommendation system, such as the ones companies like Netflix or Spotify use to recommend movies and music to their users. As a user consumes more music and movies, the recommendation system learns from the data to build a better model and make more accurate predictions about what to recommend to a user next.

The course surveyed both classical and cutting edge approaches in ML including linear and logistic regression, decision trees, boosting, random forests, natural language processing, and collaborative filtering. Students learned mainly through examples, such as how ML can be used to predict wine quality, loan defaults, customer churn, and parole recidivism.

Students also learned one of the most famous and useful machine learning techniques called 'random forests,' which was invented by the late Berkeley statistics professor Leo Breiman. The algorithm helps achieve a more reliable model by cleverly combining several models into one. The technique works best when models are different (i.e. uncorrelated) from each other.

The idea is very similar to what is commonly known as "wisdom of the crowd" or the tendency for collective opinions to be more accurate than individual ones. Grigas perfectly illustrated this concept by telling the story of Sir Francis Galton, who helped spark the idea with an observation he made at a county fair in 1907. Participants at the fair were encouraged to guess the weight of an ox that was on display. Galton noticed that while none of the individual guesses accurately predicted the weight of the ox, the average of all the guesses was amazingly close to the ox's true weight. Thus, the wisdom of the crowd principle was born.

Another useful and popular technique students learned was sentiment analysis using natural language processing (NLP). The idea behind NLP is to treat text as data, which can be difficult because language has a lot of ambiguity and subtlety, especially when rhetorical devices such as homonym, metaphor, and sarcasm are employed.

Grigas used Twitter to teach students to use this popular analysis tool. In order to create a model that predicts whether tweets are negative or positive, a training set must first be built where people code tweets as being positive or negative, on a scale of -2 to 2, for example. This training data can then be used to build a model to analyze large sets tweets to gain instant insight on how positively or negatively people are feeling about specific issues on Twitter.

After being prepared with a variety of ML techniques, students built teams and worked on projects of their choosing. The project topics included a wide range of application areas, representing the wide applicability of ML tools. Example student projects

included music recommendation systems, predicting demand for emergency services based on topographical features, forecasting academic performance based on environmental factors, and identifying muscles based on raw 3D data.

One group built a model to predict demand for bikesharing, which is becoming more popular in cities. Using data available online with Jersey City as a training set, students in the group found that about 80% of the demand could be explained by weather related factors, such as max temperature and wind speed, and built a model to predict where future demand may be highest.

Besides IEOR 142, the department also recently added the course *IEOR 135: Applied Data Science with Venture Applications* and updated the curriculum for *IEOR 165: Engineering Statistics, Quality Control, and Forecasting*. Additionally, UC Berkeley is building a new data sciences major that IEOR courses such as these will qualify for. ▪

Sutardja Center Opens New Labs to Help Students Work With Emerging Technologies

The Sutardja Center for Entrepreneurship & Technology (SCET) opened three new labs in the fall to help students understand and create new ventures in blockchain, data, and alternative meats.

SCET identified these three emerging technology areas as big opportunities for student entrepreneurs after conducting market research, consulting with advisors and investors, and

running experimental "challenge lab" courses to test student interest and startup potential.

The Data Lab will focus on bringing together the latest mathematical concepts, computer science tools, and industry problems together to help students learn the skills needed to create applications and solve business problems.

The goal of the Blockchain Lab will be to research how to solve some of the pressing issues preventing blockchain technology from becoming mainstream. These issues include creating mobile blockchain applications, scaling blockchain, the ability to create more efficient and broader smart contracts, and dealing with the policy and regulation issues around the new technology.

The Alternative Meat (or Alt.meat) lab will investigate how to create better meat alternatives. Meat is a $1 trillion industry in the United States alone, and consumers are increasingly moving toward vegetarian, vegan, and flexitarian diets due to concerns about health, climate, and animal welfare. Students in the lab will create alternative meat prototypes and work to understand how to create meat alternatives that are as delicious as meat while being affordable, healthy and non-detrimental to the environmet.

The Sutardja Center for Entrepreneruship & Technology was founded in 2005 and offered just one course at that time. SCET now offers fourteen IEOR courses with an innovative pedagogy that allows students to build and accelerate startups within their courses. ▪

IEOR offers new FinTech concentration to help meet demand in rapidly-changing finance industry

Starting in fall 2018, new IEOR master of engineering students will be able to pursue a concentration in FinTech, (short for financial technology), to equip them with technical skills in areas such as data analytics and machine learning to help meet the rapidly growing demand for these skills in financial and other technology companies.

FinTech is a broad term referring to new approaches to finance enabled by technological innovations such as high-frequency algorithmic trading, crypto-currencies, and micro-lending, that are rapidly changing the way we bank, trade, and manage our money.

In trading, the latest technological approaches are currently creating a shift from the traditional portfolio model where traders are primarily concerned with spreading out risk across diversified assets, to a model dominated by those who can best understand and react to data in real-time. These high-tech, data-driven companies are out-performing traditional models, resulting in high-demand for employees that can mine, analyze, and understand what data means in a larger context.

"One of most innovative aspects in finance right now is high-frequency trading," says IEOR Professor Xin Guo, who recently co-authored the book *Quantitative Trading: Algorithms, Analytics, Data, Models, Optimization.* "There is a technology war, and [traders] are working to get a millisecond ahead of their competitors. And if you are fighting on that kind of time scale, you are forced to be very innovative."

Professor Guo goes on to say that while students with business and traditional financial engineering skills are still necessary, many companies are struggling to recruit students with skills in data mining, machine learning, and the background needed to truly understand the large amounts of data that are being created every day in stocks and other markets. (Professor Guo has a server with over 10 terabytes of financial data that students are currently learning from.)

Another reason there is an extreme demand for students with high-tech skills in finance is that the same students are also being heavily recruited at other desirable companies such as tech giants Google, Amazon, and Facebook who also need students that can analyze, understand and make business decisions from large amounts of data. So, while students in the new FinTech concentration will have a special focus in finance, they will learn a wide range of tools that they can apply in almost any domain.

"The cool thing is that it's more tech than finance," says Professor Guo, reinforcing that the skills students will learn are fundamental, and can be broadly applied in many other industries that are currently changing due to technological innovation.

The new program received 110 applicants and will enroll 10-20 students for the 2018-2019 school year. Students will receive specialized FinTech training through their capstone and coursework. ∎

Alumni Profiles

KORY HEDMAN

Dr. Hedman received his PhD from Berkeley IEOR in 2010 and is currently assistant professor at Arizona State University. He recently won the 2017 Presidential Early Career Award for Scientists and Engineers (PECASE).

What was it like to receive the award? Were you able to visit the White House and meet the president?

It is an honor to receive this award from former President Barack H. Obama. PECASE award winners are usually invited to the White House to meet the president. That has not happened as of yet and my guess is that it will not happen with the new president.

What has been the most rewarding part of being a new professor? The most challenging part?

The most rewarding part about being a professor is being given a chance to have a meaningful impact in academia and industry. If you can secure funding, you are given the freedom to explore what you believe in and demonstrate its promise. The most challenging part is mentoring PhD students.

What was the most valuable part of your PhD experience at Berkeley?

There are two things I would like to mention. It was an honor to work with Dr. Oren; he gave me the opportunity to prove myself and I learned a lot from him. Second, as much pain as it caused, the PhD preliminary exam was a valuable experience. The preliminary exam forced me to challenge myself to a new extreme and what I took away from that experience is why I am successful today.

What do you miss most?

I have always enjoyed university environments and Berkeley was great: the people, the university, the city, the culture, everything. It was all a great experience.

SIRISHA VARIGONDA

Sirisha graduated with a bachelor of science degree from Berkeley IEOR in 2016. She currently is a logistics consultant at Arup, an engineering consulting firm headquartered in London.

What kind of work or projects do you do?

As logistics consultants, we work with design teams and assess operational requirements of built environment projects in order to provide process improvement and operational performance recommendations/metrics — this includes delivery and waste management strategies, urban logistics solutions, innovation in freight and goods movement, and back-of-house design for warehouses, universities, airports, corporate campuses, hospitals, and more.

What was the most influential, memorable, or useful IEOR class that you took?

Two of my favorite classes were 131 and 151. I enjoy simulation modeling and service design/analysis and have been lucky enough to employ some of the things I've learned in these classes at work. We regularly use statistics for delivery/waste forecasts and Simio occasionally for process/freight modeling ...I used Little's Law a couple of weeks ago, which was very exciting.

What is some advice that you would give to current IEOR students?

IEOR is an amazing interdisciplinary field that can affect really every industry, so don't be discouraged with the job hunting process — take advantage of our wide range of skill-sets to reach out and network across all engineering/tech/consulting fields. Also, definitely take advantage of our small class sizes to get to know everyone — a good chunk of us still stay in touch and are occasional part-time models for alumni newsletters.

RAJ JETALPURIA

Raj Jetalpuria is an IEOR alum who graduated in 2017. He now works as an Associate Consultant at Beghou Consulting, a management consulting firm specializing in the pharmaceutical industry. At Beghou Consulting, Raj has worked on data warehousing, sizing, and incentive compensation projects

What was the most influential, memorable, or useful IEOR class that you took?

My most useful class was IEOR 115 with Professor Goldberg. Learning how to create and manage a data warehouse and query has been very useful in my current role. The IEOR courses and engineering in general teach you how to think in an organized and strategic way which has impressed recruiters and led to success post-graduation.

What is some advice that you would give to current IEOR students, regarding school or careers?

Don't sell yourself short in your job search. Employers are looking for candidates that would be a good fit at their companies. Likewise, you should look for companies that would be a good fit for you. Spend more time recruiting for fewer companies, but make sure that the company you start your career at is one that you will enjoy working for.

What is your favorite memory from your time at Cal?

Game days and grabbing food on North Side with friends.

RENEE GU

Renee graduated with a master of engineering degree in IEOR in 2017. She currently works as an associate data scientist at Tesla Inc. where her main responsibilities are to support the Model 3 Battery Module manufacturing process, to analyze in-process data to identify optimization opportunities, and create reporting dashboards and visualization tools.

What is the most useful skill that you gained or learned from taking IEOR courses?

Things I learned from the MEng capstone project (Optimization of Surgical Clinical Pathway at UCSF Health) were really influential for my career. Fresh out of college, I lacked work experience before starting the IEOR MEng program at Cal. The opportunity to work with real-world clinic data helped me develop skills like project scope management, data acquisition, cleaning and integration, which all turned out to be very valuable when working in a manufacturing environment.

What is some advice that you would give to current IEOR students, regarding school or careers?

Don't rush to apply for "perfect jobs." Take the time to do job market research, customize your resume, learn something new, or just enjoy being a student at Cal.

What is your favorite memory from your time at Cal?

Exploring fun, quirky and trendy places in Berkeley and SF with friends.

Back row: Prof. Enver Yucesan, INSEAD, Prof. Schruben, Prof. Dashi Singham (NPS, and Berkeley PhD), Prof. David Goldsman (Georgia Tech). front row: Profs. Paul and Susan Sanchez (NPS, Cornell PhD), Prof. Theresa Roeder (SFSU, Berkeley PhD) and Prof. Vic Chen (Tsinghua U., Beijing and Berkeley PhD).

Prof. Schruben Honored with Lifetime Professional Achivement Award

IEOR Professor Lee W. Schruben recently received the Lifetime Professional Achievement Award (LPAA) by the Institute of Operations Research and the Management Sciences (INFORMS) Simulation Society, the highest honor given by the society. The award is given occasionally, at most once annually, to recognize major contributions to the field of simulation that are sustained over a professional career, with the critical consideration being the total impact of those contributions on computer simulation. Professor Schruben was honored for his discoveries in designs of simulation experiments, optimization of simulation system response, and foundations of simulation modeling.

To be chosen for this accolade, an individual's contribution must be related to research, practice, knowledge dissemination, software or hardware development, professional service, field status and/or visibility advancement. Professor Schruben, a UC Berkeley Chancellor's Professor and a Fellow of INFORMS, has made significant contributions in all of the areas listed by the INFORMS Simulation Society.

CONTRIBUTIONS TO RESEARCH

Schruben's research contribution in the field of computer simulation is apparent through his research publications about numerous fundamental advances in the field of simulation. He is one of the few researchers who

Prof. Schruben accepting the award with his wife, Donna

has received the I-Sim Outstanding publication Award multiple times.

CONTRIBUTIONS TO PRACTICE

Schruben was also involved in promoting and influencing the practice of simulation through his extensive collaboration with industry. He has been a consultant to over 20 government, private, and international organizations.

DISSEMINATION OF KNOWLEDGE

Beyond publications, books, and consulting, another great impact is his extensive teaching history at Cornell and at UC Berkeley. Schruben has had a long and consistent record of promoting the field of simulation and molding the future leaders in the field of simulation.

DEVELOPMENT OF SOFTWARE AND HARDWARE

Schruben developed a simulation software called SIGMA. SIGMA is used in universities worldwide and was recognized as one of EDUCOM's 101 Computing Education Success Stories.

SERVICE TO THE PROFESSION

Schruben has held various official positions for TIMS College on Simulation and Gaming, the precursor to I-Sim. He has served in editorial positions at important scientific journals.

ADVANCEMENT OF THE STATUS OR VISIBILITY OF THE FIELD

Schruben's rigorous early research papers established simulation as a field of scholarly academic research. He has been an international presence for decades and has promoted the field of simulation throughout the world.

Professor Schruben was selected for the 2017 Lifetime Professional Achievement Award by the Simulation Society for his excellence representing the field of simulation. His overwhelming accolades and presence in the field characterized him as an eminently worthy recipient of the LPAA.

The INFORMS Simulation Society is organized and operated to encourage the development and dissemination of knowledge in the area of simulation and to promote communication and interaction among individuals and organizations who share an interest in simulation. ▪

More IEOR awards

PROF. GRIGAS RECEIVES NSF CRII AWARD TO IMPROVE MACHINE LEARNING METHODS

IEOR professor Paul Grigas was recently awarded the National Science Foundation's Computer and Information Science and Engineering (CISE) Research Initiation Initiative (CRII) grant in the amount of $175,000 to investigate large-scale optimization methods and develop algorithms to improve scalability with large datasets.

PHD STUDENT SALAR FATTAHI CHOSEN AS FINALIST AT AMERICAN CONTROL CONFERENCE (ACC)

IEOR PhD student Salar Fattahi has been chosen as one of five finalists for the prestigious American Control Conference Best Student Paper Award for his paper titled "Closed-Form Solution and Sparsity Path for Inverse Covariance Estimation Problem."

PROF. RIGHTER WINS VALUETOOLS 2017 BEST PAPER AWARD

Professor Rhonda Righter, along with her collaborators Ivo Adan (Eindhoven University of Technology) and Gideon Weiss (The University of Haifa), have been award the Best Paper Award at the 11th EAI | VALUETOOLS International Conference on Performance Evaluation Methodologies and Tools.

ORMS ALUM WINS $100K DATA SCIENCE COMPETITION

Allen Tang (Operations Research & Management Science '16), along with three other Berkeley students, won a $100,000 prize in the Data Open championship, sponsored by the hedge fund Citadel.

Berkeley students Eric Munsing, Allen Tang, Soeren Kuenzel, and Jake Soloff win $100k Data Open prize

Berkeley IEOR Society for Women Engineers members Smita Balaji, Lucie Kresl, Waverly Runion, Emma Hsu, and Francesca Ledesma traveled to the SWE conference in Austin in October 2017

SWE Conference Reflection: Resilience in Success

by Lucie Kresl and Emma Hsu

This year, five students proudly represented the IEOR department at the Society of Women Engineers' (SWE) National Conference in Austin, TX. At the conference, students and professionals attended workshops, career fairs, and luncheons, where they learned skills to be empowered, strong female leaders in technology, and networked with company representatives and other engineering students from around from the country.

One of the workshops that we attended was called "SWE Storytellers: Boldly Inspiring Life's Choices." During the session, distinguished members of SWE shared their stories

as pioneering female engineers. Each woman shared stories of success and failure while emphasizing the importance of hard work, resilience, and support from peers.

Across all the stories shared, there was a common theme of resilience. These women all faced challenges and failures, but refused to give up or give in to society's expectations and pressures, each forging their own path to success. While these women were by far the minority in their college classes, it seemed like they found their real struggles — and later triumphs — while working in industry.

One of our favorite speakers, Mary Studlick, gave a speech entitled "How I Spent New Year's Eve with 50 Men

(on a Drilling Rig)." Mary told us about how she didn't look like your typical engineer when she first started working on the rig. Mary had long, braided pigtails and braces, while everyone else she worked with was a man at least twenty-five years her senior.

At first she had a hard time finding her place, but eventually, she found a way to relate to her coworkers — by telling jokes. Mary found that by always having a joke on hand, she was able to "boss" around these men with her humor.

In the end, Mary did share the essential steps to telling a good joke (a locked away SWE secret), but Mary's larger message to the next genera-

Members of the IEOR Communications Team at a meeting in October 2017

tion was to find a way to relate to the people you work with.

Another woman, Peggy Layne, presented a speech entitled "SWE Opens Doors." Up until now, we have both experienced immense opportunities that SWE has presented us on campus but not much further than that. As a professional member of SWE, Peggy found that as she got jobs in new cities, she found stability by joining SWE chapters in each new place. Eventually rising to be SWE President, Peggy said that without the support and encouragement of other SWE members, she would have never been able to reach such heights.

It was incredibly inspiring to hear from these women engineers, many of whom were one of the first women to graduate from their respective colleges with engineering degrees. Several times, members of the audi-

ence stood up and shared their own stories, some of them having connections with the speakers themselves. This truly showed the strong network of peers and support that these women were able to establish through SWE. ▪

IEOR Communications Team Helps Build Community

The IEOR department and students have started a new initiative to help build community with students, faculty, and alumni.

The IEOR Communications Team is composed of undergraduate students that meet bi-weekly to help the department with marketing, social media, events, and recruitment.

For 2017-2018, the president is Lucie Kresl, with social media committee leads Emma Hsu and Saba Abataki, marketing lead Nicky Lofgren, recruitment lead Smita Balaji, and events leads Ethan Kuo and Chad Wakamiya.

For spring 2018, the team will organize an undergraduate event, Cal Day, Big Give, and help the department work to recruit more diverse students from around the world.

The team started with just a handful of students in spring 2017, but slowly grew as students recruited their friends to join. In the inaugural meeting for spring 2018, more than twenty students attended and joined committees. ▪

BADSS summit organizers from left to right: Stella Bao, UC Berkeley; Theresa Roeder SFSU and Berkeley; Max Bush, SFSU; Hannah Lane, SFSU; Meggan Chu, San Jose State University; Tiffany Ta, Santa Clara University

BADDS Summit Helps Grow Bay Area Decision Sciences Community

Sometimes you can learn more by collaborating with others outside the classroom than you can learn inside of it.

That was what San Francisco State University (SFSU) College of Business dean, Linda Oubre, told students to kick off the first ever Bay Area Decision Sciences Summit (BADSS), an event organized by undergraduate students and faculty from the University of California at Berkeley, San Jose State University (SJSU), Santa Clara University (SCU), and SFSU.

The goal of the event was to help build the community of students and faculty working in decision sciences and related fields in the Bay Area. The summit featured a case competition, alumni panel, and keynote presentation from IEOR alum Nirmal Govind, head of the studio production & streaming data science group at Netflix.

In the case competition, students had the opportunity to form teams and use analytical tools to work on the problem of solar adoption. The competition was sponsored by Sunrun, a solar energy and panel company based in San Francisco. Sunrun provided students with data related to solar adoption and U.S. demographics, and challenged students to use the data to find the best opportunities for finding new customers.

From the data, students investigated many questions that may help Sunrun know where to go next for their next customer. Which states have the most sun and highest potential energy production? Do factors like age, dwelling type, and income matter? How do the incentives and laws of specific regions affect solar coverage?

The winning team was from Berkeley and made up of IEOR students Wesley Jin, Sumaanyu Maheshwari, Albert Loekman, and Tanay Gupta. In their analysis, the Berkeley students decided to investigate which factors were correlated with solar coverage

in each zip code, i.e. which features of a community have so far been associated with the most solar adoption? They found that the factors that mattered most are income, blue-collar percentage, median home value, median age, divorced percentage, and percent moved since 2000 (with the theory that new homeowners are more likely to invest in new solar panels).

"I'm so proud of the students for making this event happen, and especially of all participants in the case competition," said Theresa Roeder, SFSU professor, Berkeley IEOR lecturer, and advisor for the project. "It takes a lot to go through such a big dataset in so little time to find some results — and even more to stand up in front of a group to present and then put yourself through the grilling by the judges! Many thanks to Professor Yano and Professor Schruben for coming out and supporting our students. I'm looking forward to next year's event!"

After lunch, students had the opportunity to interact with data scientists and analysts to get their questions answered about what it is like to work in industry. What does a typical day look like? What kinds of skills are most important? How can I get my resume noticed? Panelists were alumni from SFSU and included Anthony Ratto, senior application support analyst at Sunrun, Stephen Ruane, data integration admin at Cisco Meraki, and Matthew Low, risk and business data analyst at the San Francisco Public Utilities Commission.

The day concluded with a keynote from Nirmal Govind (Berkeley IEOR M.S. '99), who currently leads data science for studio production and streaming at Netflix, a big job for a company that is now one of the

largest production studios in the world and is also responsible for one of every three bits transferred online today.

Govind went through some of the data problems at Netflix. What is the ideal catalog of movies and television shows that Netflix should keep on hand? How much is the content worth? How can Netflix predict demand for content in advance? The Data Science team at Netflix analyzes the entire process of producing content, including what should be sourced, which servers around the world should host which content, and how the Netflix app itself recom-

mends movies and television shows that you are most likely to want to watch.

One particularly impactful issue that Govind's team works on is the digital supply chain of producing original content through Netflix's studio. Given a simple show or movie idea (e.g. "Batman meets Stranger Things"), how can Netflix estimate the budget? Once a show is approved, how can the production supply chain of scripts, shoots, and schedules be optimized? For example, shooting some scenes out of order can mean big savings for movies and shows that film at multiple locations.

Besides the leadership from Professor Roeder and other faculty, the event would not have happened without the hard work of students at partic-

ipating schools, including Stella Bao from Berkeley, Hannah Lane and Max Bush from SFSU, Tiffany Ta from Santa Clara University, and Meggan Chu from San Jose State.

"I am so honored to help Professor Roeder's vision come to life, because this event was so fun and natural to our field of study. I hope this becomes a tradition among Bay Area universities where we continue to connect with like-focused students and apply our knowledge to highly interesting case studies. Thank you to all those who came and participated. I hope to see this event grow and that the trophy is 'personalized' for many

> **"I was very happy and excited to see students from different universities in Bay Area come together to connect, share, and learn from each other's experiences," - Stella Bao, *IISE president***

years to come! Congratulations!" said Hannah, who in addition to being the emcee for the event, created the first BADSS trophy and designed the logo.

"I was very happy and excited to see students from different universities in Bay Area come together to connect, share, and learn from each other's experiences," added Stella, president of the Berkeley chapter of the Institute of Industrial and Systems Engineers. "Special thanks to Hannah Lane, Prof. Roeder, and everyone in the committee organizing and staffing this event. Our hard work really paid off! Also, I am super proud of how our case competition teams came out. I would like to congratulate our case competition winners, you guys really deserves the golden trophy! Keep up the good work Bears!" ▪

Steve Blank Helps Sutardja Center Execs Innovate at 50x

The world is being Amazoned.

That is what startup legend Steve Blank argued at the Sutardja Center's innovation leadership executive program — an annual summit of executives from around the world who come to Berkeley to learn how to make their companies more innovative.

Things are quite different in the Amazon-age than they were in the 20th century, when executives at large companies had plenty of time to make decisions, according to Blank. Back then, companies mostly competed against companies similar to their own, and owned a large share of the market that they could hold on to with reliable business models. However, in the 21st, the startup movement has caused things to move much more quickly.

The psyche of disruption has changed the world. Blank calls this the "red queen problem," a reference to a quote by the red queen in Alice in Wonderland when she says "you will have to run twice as fast just to stay in place." Many executives at large companies can empathize.

Indeed, large companies today are at big risk of being disrupted by the nimble startup. Recent advances in technology have made the physical barriers to entry for new companies lower than ever before. And unlike in the 20th century, startups today are receiving huge investments from venture capitalists who hope that one startup in their entire portfolio might disrupt an entire industry and make them rich.

Because venture capitalists bet on their portfolio succeeding, and not on any single company, they can take huge risks that large companies cannot take. For example, venture capitalists are happy to bet on companies, like Uber and Airbnb, that have a chance to revolutionize an industry even if they might be breaking the law — a bet large companies cannot take.

Add this to the fact that startups have few policies and little bureaucracy to slow down decision-making, and it starts to seem like large companies may even be the underdog.

So, can large companies keep up with the nimble startup?

Blank suggests that large companies can keep up by becoming ambidextrous organizations, i.e. innovating and executing at the same time.

"That was nice theory in the 20th century," Blank said of the theory of ambidextrous organizations, "It is survival today."

While many executives give lip service to being innovative, Blank believes that companies need to create processes, institutions, roles, and metrics to actually innovate.

One approach is to create a separate innovation institution within a large company where entirely new inventions are created as opposed to the incremental improvements that might occur as part of the normal process of developing products. These small innovation organizations can be removed from company bureaucracy to act more like a startup and have different relationships with risk, failure, and more urgent approaches for developing new products.

Some companies already do innovation activities such as hackathons, research projects, university engagement, and some even have dedicated maker spaces where employees can be creative. But, for Blank, these innovation activities (which can sometimes degrade into "innovation theater") are not enough and may even be harmful as untested guesses can create "noise" for engineers and other implementers.

"In my world we turn pieces into a process," said Blank about the proper way to organize innovation activities.

Blank suggests that these activities can work really well when they are put into an innovation process where companies explore and test new ideas, incubate them, and then integrate them back into the rest of the company when and if the time is right.

To do this, Blank suggests companies use Alex Osterwalder's Business Model Canvas, a way to show an entire business model for a company or product in a single diagram. Filling out the canvas is not only a useful process for the innovator, but makes communicating the business ideas to others easier as well. Maybe most importantly, it also makes it clear

Steve shows Buzz Aldrin's expense report that he had to fill out after landing on the moon. Innovators should be isolated from bureaucracy as much as possible.

which parts of the business model are guesses, and need testing.

And it is testing these guesses, or hypotheses, that is vital to customer development, an approach that Blank is famous for pioneering. In the past, innovators tended to make assumptions about what their customers wanted. Innovators would then go on to create alpha and beta tests of their product, launch the product, and then watch as some products would succeed and some would fail because of false or correct assumptions.

Thanks to Blank and other pioneers in this field, modern entrepreneurship is focused more on discovering what customers truly want and need before wasting resources on building anything. Blank believes that entrepreneurs and innovators need to get outside of their building to talk to real customers as early in the develop-

ment process as possible.

He contends that the best way to develop products is by creating hypotheses about your products and then testing them, which usually involves talking to hundreds of real potential customers. And if you are innovating inside a company, talking to dozens more on the inside who will have a stake in the product you are developing. The earlier in the process that you can find out what customers and colleagues like and do not like, the fewer problems that will come up later.

If the process of creating hypotheses, testing them against empirical data, and using the results to support a theory sound familiar — it should. That's because it's the scientific method we all learned in middle school and that has also been around for the past 500 years.

Blank suggests entrepreneurs should use the scientific method when developing companies and products. By testing minimum viable products (MVPs), innovators can learn what customers actually want without having to guess.

For Blank, an MVP is the "smallest thing that will give you the most learning or feedback." So, rather than building an alpha version of your product, or barebones app without any features, an MVP may be as simple as drawing your app on a piece of paper, or creating a powerpoint slide that you can show to a potential customer to see if they like it.

"You have to get out of the building to understand the delta rate of change," Blank said to the executives who were doing just that by being at the program. ∎

Research Roundup

What are IEOR faculty and students working on? See featured research below.

PRICE OF ANARCHY

Tyler Maxey and Rhonda Righter

We all know that when individuals are left to their own devices, they will over-use shared resources, such as highways, wifi hubs, etc., than is socially optimal. That is, selfish customers join more, and their total customer utility is less, than would be the case if they cooperated to maximize their total utility for using the resources. This effect is often called the Price of Anarchy. Indeed, it is axiomatic that, in a fixed environment, collaborating customers (who are optimizing their overall utility) will do better than selfish customers, i.e., there is always a Price of Anarchy. Professor Righter, along with undergraduate student Tyler Maxey, and colleagues Hyun-soo Ahn of the University of Michigan and Hakjin Chung of the Korea Advanced Institute of Science and Technology (KAIST), have been exploring the question of whether there can be a Benefit of Anarchy in environments that react to the behavior of customers. They have shown, in a simple queueing system in which a profit-maximizing service provider decides on the capacity to provide knowing whether its customers will collaborate or not, that the service provider may be induced to provide higher capacity to selfish customers, and there can be a Benefit of Anarchy. When this occurs, it is a win-win-win situation, where the overall welfare of the customers and the service provider is larger, the customers' portion of the welfare is larger, and the service provider's welfare is larger, when customers are selfish rather than when they collaborate.

MANAGING WARRANTY INVENTORY FOR MULTI-GENERATIONAL HIGH-TECH PRODUCTS

Erik Bertelli and Candace Yano

High tech products such as smartphones or wearables are multi-generational in the sense that every year, a new version of the product is introduced, with some features that are shared with the previous year's model as well as added functionality. This setting poses unique problems for manufacturers in making operational decisions regarding production and warranty servicing of these products. For each generation, at some point, a decision must be made to stop producing that version of the product. However, this decision often comes before the items themselves are out of warranty. How should companies manage future warranty claims? Professor Candace Yano and PhD student Erik Bertelli are focused on optimal production and warranty decisions in settings where warranty fulfillment may involve provision of new replacements of the same model, repair using spare parts inventory, and rebates for upgrading to a newer generation of product. This research will enable the manufacturer not only to minimize the expected costs for satisfying warranty claims, but also to reduce electronic waste from unnecessary replacement items and spare parts.

PERSONALIZING EXERCISE ROUTINES USING ROGUE BANDITS

Yonatan Mintz, Anil Aswani, Philip Kaminsky, Elena Flowers, and Yoshimi Fukuoka

Many settings involve sequential decision-making where a set of actions can be chosen at each time step and each action provides a random reward with an unknown distribution. However, frequent selection of a specific action may reduce the expected reward for that action, while abstaining from choosing an action may cause its expected reward to increase. Such non-stationary phenomena are observed in many real world settings such as personalized healthcare and targeted advertising. In this project, we propose and analyze a new class of machine learning models called ROGUE (Reducing or Gaining Unknown Efficacy) bandits, which we show can capture these phenomena and we optimize these models with an algorithm that we call the ROGUE Upper Confidence Bound (ROGUE-UCB) algorithm. We validated our algorithm by conducting a numerical experiment using real world data from a healthcare intervention to increase physical activity. In this intervention, the goal is to optimize the selection of messages (e.g., confidence increasing vs. knowledge increasing) to send to each individual each day to increase physical activity. Our results show that ROGUE-UCB increases daily step counts by roughly 1,000 steps a day (about a half-mile more of walking) as compared to other algorithms.

OPTIMAL BIDDING AND ALLOCATION OF ONLINE ADVERTISEMENT OPPORTUNITIES

Alfonso Lobos, Paul Grigas, Zheng Wen, Kuang-chih Lee

Imagine that you have just enter CNN.com, where there is a space of 240x360 pixels in which you may be shown an advertisement. CNN sells that space by informing an ad-exchange that you -- a user in certain time and location, using a given device, etc. -- may be shown an ad. Then, companies called demand side platforms (DSPs), who manage the campaigns of many advertisers, submit bids to this ad-exchange in order to win the right to show one of their ads. The DSP that submits the highest bid wins the space and chooses which ad to show you among its different advertisers. This whole process occurs in hundreds of milliseconds and a DSP may participate in several billions of these auctions per day. This is a challenging real-time problem whereby the DSP seeks to optimize its bidding strategy and its plan for allocating the winning spaces among its advertisers, depending on their budgets and target audiences. We use tools from optimization, model predictive control, and machine learning to model this problem to derive a real-time policy that intelligently manages the tradeoff between maximizing the DSP profit and maintaining a proper budget spending for its advertisers.

ALUMNI REUNION

We look forward to the next alumni reunion in fall 2018! Thanks to those who attended in November. The department will continue to look for opportunities for alums to connect. Please contact Keith McAleer at kmcaleer@berkeley.edu if you have any ideas on how to continue to build our alumni network.
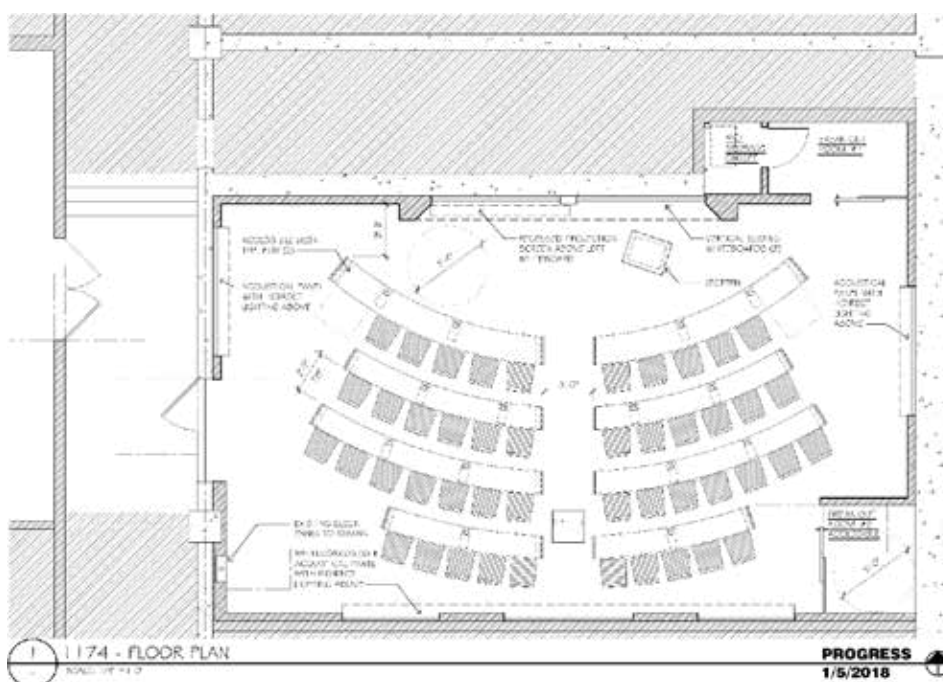Go Bears!

NEW CLASSROOM DESIGN

THANK YOU to the nearly fifty alums that have contributed so far toward renovating the IEOR basement classroom. The department now has a working design below. We are still hoping to receive more contributions to help us reach our goal!

STAY CONNECTED

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DONATE TO IEOR

Help us continue to deliver world-class research and academic programs. Right now we have opportunities to support graduate student fellowships and continue our renovations of Etcheverry Hall to create a better learning environment.

We sincerely appreciate your support!

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