

F O R W A R D »»»»»»»»» F E S T

RESOURCE GUIDE

November 2020

A YEAR OF
FORWARD
THINKING



A Y E A R O F
F O R W A R D
T H I N K I N G



»»»»»»»» What is A Year of Forward Thinking? »»»»»»»»

A Year of Forward Thinking spans the 2020–21 academic year and engages the entire Princeton University community — alumni, students, faculty, staff and friends — in a global conversation about pioneering solutions for today’s challenges.

forwardthinking.princeton.edu

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What Is Forward Fest?

Forward Fest is a monthly, online series of discussions with Princeton faculty, students, staff, alumni and other interested thinkers who will explore, engage and develop bold thinking for the future.

How to Use This Resource Guide

Binge as background reading to prepare for the Forward Fest discussions, follow along during the programming and use the information to fuel conversations with Princetonians and others about ideas that merit Thinking Forward together.

forwardthinking.princeton.edu/festival

FORWARD

THINKERS



Matthew Salganik

Professor of Sociology and
Director of the Center for
Information Technology Policy



Mona Singh

Professor of Computer Science
and the Lewis-Sigler Institute for
Integrative Genomics



Elad Hazan *06

Professor of Computer Science
and Co-founder and Director of
Google AI Princeton



Brad Smith '81

President of Microsoft

FRIDAY, NOVEMBER 20

8:00 PM – 9:15 PM EST

Thinking Forward Data Science and Artificial Intelligence

forwardthinking.princeton.edu/forwardthinkers

THINKING FORWARD: DATA SCIENCE AND ARTIFICIAL INTELLIGENCE

WITH THE DEVELOPMENT of sophisticated machine learning and advanced algorithms for analyzing massive troves of information, data science is transforming every academic discipline and exploring questions at the frontiers of knowledge, from decoding the human genome to perfecting the artificial intelligence that will soon drive our cars. Princeton University faculty are building the theoretical underpinnings of data science by integrating three strengths: the fundamental mathematics of machine learning; the interdisciplinary application of machine learning to solve a wide range of real-world problems; and deep examination of the societal implications of artificial intelligence, including issues such as bias, equity and privacy.

Computer science has become Princeton's most popular concentration, and the certificate from the Center for Statistics and Machine Learning (CSML) has grown to be the third most popular undergraduate program. Across Nassau Street, the Google AI Princeton lab is an innovative collaborative for machine learning research; and the Center for Information Technology Policy (CITP) is an interdisciplinary center dedicated to the study of how digital technologies impact society.

“It may take years before we settle down to the new possibilities, but I do not see why [machines] should not enter any one of the fields normally covered by the human intellect, and eventually compete on equal terms.”

— ALAN TURING *38

SPOTLIGHT: CSML

Founded in 2014, the [Center for Statistics and Machine Learning](#) is a growing hub for interdisciplinary data science education and research at Princeton. Approximately 200 undergraduates are currently enrolled in the certificate program, learning from faculty representing 15 different departments, from computer science to psychology to chemistry. CSML sponsors a series of Schmidt DataX workshops and mini-courses that teach students how to harness insights from advanced algorithmic data so it can be used to solve problems in a variety of fields.

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Matthew Salganik

Matthew Salganik is professor of sociology and director of Princeton University's Center for Information Technology Policy. He pioneered uses of data and digital technologies in social research, and authored the 2017 book, "Bit by Bit: Social Research in the Digital Age." His research examines how social media, smartphones and other digital devices can transform our understanding of human activity, while keenly pointing out the complex ethical challenges of collecting huge troves of personal information. "We can observe the behavior of millions of people without their consent or awareness, and we can enroll them in massive experiments, again without their consent or awareness," he said. "Researchers now have more power than ever before, and we need to develop approaches that help us ensure that we exercise this power in a responsible way."

MORE FORWARD THINKERS OF NOTE



Olga Troyanskaya, professor of computer science and the Lewis-Sigler Institute for Integrative Genomics — a computer scientist using big-data methods to predict mutations in the genome and develop [precision-medicine treatments](#) for autism, cancer and other diseases.



Ruha Benjamin, associate professor of African American studies — a sociologist who analyzes examples of "[discriminatory design](#)" to illustrate the relationship between machine bias and systemic racism.



» Companies like Google and Facebook have tons and tons of data, and they can make a lot of predictions about what you as an individual will do. »

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Mona Singh

Mona Singh is a computational biologist who leads a team of Princeton scientists in developing algorithms to decode genomes at the level of proteins, with a special interest in data-driven methods for predicting and characterizing protein sequences, functions, interactions and networks. “I had always been fascinated with the questions asked in biology and medicine but never enjoyed doing experimental lab work, so it was exciting to think about these questions computationally,” said Singh, professor of computer science and the Lewis-Sigler Institute for Integrative Genomics. She pioneered interdisciplinary courses in the field of bioinformatics, the method by which computers are used to synthesize vast quantities of raw biological data, and her recent work identifies genes and mutations that play a role in cancer development, an important first step to guiding new treatments.



MORE FORWARD THINKERS OF NOTE



Tom Griffiths, the Henry R. Luce Professor of Information Technology, Consciousness and Culture — an innovative psychologist who developed [algorithms for rational thought](#) that can teach humans to make better decisions.



Arvind Narayanan, associate professor of computer science — the leader of the [Princeton Web Transparency and Accountability Project](#) studies the impact of digital technologies on society, especially threats to privacy.

» The idea of cancer genomics is that you can uncover cell mutations that are relevant for cancer initiation or progression. »

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Elad Hazan *06

Elad Hazan is professor of computer science and the director and co-founder of the Google AI Princeton laboratory located on Palmer Square. A decade ago, Hazan co-invented AdaGrad, an algorithm to train deep neural networks that was widely adopted and influenced the machine learning community. Since joining the Princeton faculty in 2015, he's been working on accelerating machine learning and relating it to other fields of study, such as mathematical optimization and control. His students and team of computer scientists study the design and analysis of algorithms for basic problems in machine learning, optimization and control. In other words, they are developing more efficient methods so that artificial intelligence can learn quicker. Such advances are at the heart of future technologies, including autonomous vehicles, robotics and natural language processing.



MORE FORWARD THINKERS OF NOTE



Olga Russakovsky, assistant professor of computer science — the principal investigator of the [Visual AI Lab](#) aims to improve artificial intelligence systems' ability to reason with the visual world.



Jennifer Rexford '91, the Gordon Y.S. Wu Professor of Engineering, and chair of the computer science department — an engineer with an [expert understanding of the Internet](#)'s vulnerabilities, working to make it more secure, efficient and reliable.

» In the future, we will go beyond machine learning to more intelligent systems that can fully complement, enhance and surpass human performance in all fields. »

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2020 JACOBUS FELLOWS

Karan Singh

As a Ph.D. student at Princeton, Karan Singh works with Professor Elad Hazan '06 to improve feedback-driven interactive learning algorithms that are essential to cutting-edge technology. For his dissertation, Singh has combined elements from diverse fields of study: control theory, dynamical systems, harmonic analysis and theoretical computer science. In the process, he co-founded [a new sub-discipline called non-stochastic control](#), allowing for the development of more robust and efficient methods with significant ramifications for machine learning applications, especially in robotics. “It’s pretty rare that a student is able to create such an impact,” Hazan said.



Talmo Pereira

For his neuroscience Ph.D. dissertation, Talmo Pereira developed AI algorithms that track the body movements of animals in order to quantify body language. Ultimately, he thinks the technology will aid in the study of neuropsychiatric disorders in humans, but his research began with fruit flies. Pereira designed an algorithm called [LEAP, which tracks physical motion](#) and has quickly been adapted by labs all over the world. “The kind of data you get from this is incredible,” said Mala Murthy, professor of neuroscience and Pereira’s co-adviser. “There’s almost nothing like it.”



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COLLABORATIONS

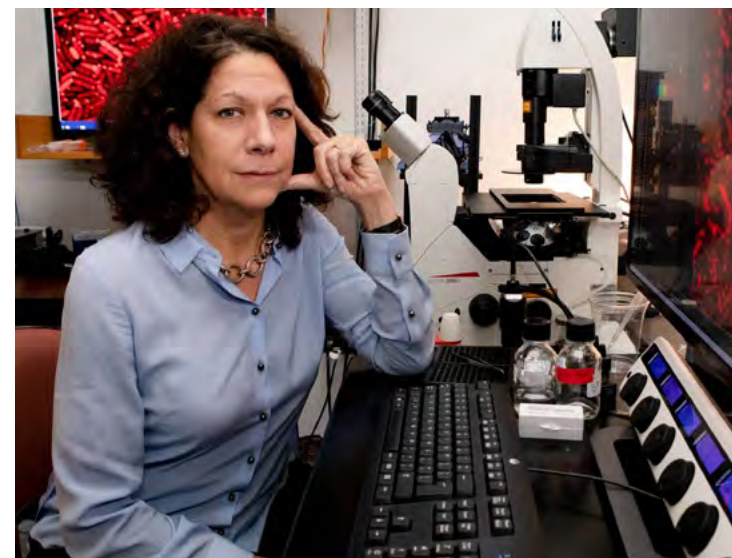
Google AI Princeton

The idea is simple, according to Eric Schmidt '76, the former chairman and CEO of Google: Give the smartest people access to the most powerful computers on the planet. That was the plan for the Google AI Princeton lab, which opened its doors on Palmer Square in 2019. Professor Elad Hazan '06 leads a team of computer science students who are dedicated to innovation and the advancement of faster, smarter machine learning. “Our vision for the lab is exactly that, to build upon these foundations,” Hazan said, referring to the work of Alan Turing '38, John von Neumann and John Nash '50. “As academics we try to think about theory for solving problems that are, many times, in the abstract, and it’s very helpful for us to be in touch with real-world problems.”



Microsoft

To better understand biofilms — the bacteria that cause lethal microbial infections — Princeton microbiologists partnered with [Microsoft's Station B](#) programming biology platform. Using advanced machine learning and Microsoft's cloud computing, [Bonnie Bassler](#), the Squibb Professor in Molecular Biology and chair of the Department of Molecular Biology, and [Ned Wingreen](#), the Howard A. Prior Professor in the Life Sciences and professor of molecular biology and the Lewis-Sigler Institute for Integrative Genomics, are able to study different strains of biofilms in incisive new ways to better understand how they form and how they can be disrupted. “This partnership can help us unlock answers that we hope someday may help save millions of people around the world,” said Microsoft president Brad Smith '81.



FORWARD THINKING ALUMNI



Photo: Andrea Kane

Brad Smith '81

president of Microsoft

After nearly three decades with Microsoft, Smith is recognized as “a de facto ambassador for the technology industry at large,” per The New York Times. He’s co-written two books about the future of technology: “The Future Computed: Artificial Intelligence and its Role in Society” and “Tools and Weapons: The Promise and the Peril of the Digital Age,” and called for a Hippocratic oath for artificial intelligence developers, asking, “What will it take to ensure AI will do no harm?”

Ellen Pao '91

co-founder and CEO of Project Include

A tech investor, advocate and former CEO of Reddit, Pao co-founded [Project Include](#) in 2016 to increase diversity and inclusion in the tech industry. The nonprofit uses data and advocacy to accelerate change in the white male-dominated culture of Silicon Valley. “There’s a lot of data out there today that talks about how [having diverse teams leads to better decisions](#),” she said. “There is a strong connection — proven connection — between doing better as a company and having racial and gender diversity in your organization.”



Blaise Agüera y Arcas '98 *04

vice president and Google fellow, Google

Agüera y Arcas became a tech celebrity due to his [captivating TED talks](#), which have been viewed millions of times. He worked at Microsoft for seven years as an engineer, strategist and team leader, then joined Google to become involved with its machine learning and computational neuroscience efforts. He now leads Cerebra, a Google team working on machine intelligence. “From the beginning, we modeled computers after our minds,” he said. “They give us both the ability to understand our own minds better and to extend them.”



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ALUMNI



Nicholas Johnson '20

graduate student, Massachusetts Institute of Technology

At Princeton, Johnson wrote a senior thesis that focused on a way to model a preventative health intervention designed to curb the prevalence of obesity in his native Canada. [Princeton's first Black valedictorian](#), Johnson earned his degree in operations research and financial engineering, along with certificates in statistics and machine learning, applied and computational mathematics, and applications of computing. Earlier this fall, he began his Ph.D. studies in operations research at the Massachusetts Institute of Technology, where he hopes to develop more theory to unify optimization and machine learning.

Alice Xue '20

software engineer, Facebook

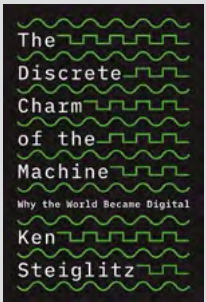
Before graduating and joining Facebook, Xue completed an award-winning thesis that combined her passion for the humanities with computer science. "[Can a Machine Originate Art? Creating Traditional Chinese Landscape Paintings Using Artificial Intelligence](#)" required algorithms that helped computers sketch and paint what appeared to be original East Asian art from the Princeton University Art Museum. "The paintings generated by my model were mistaken as human art 55% of the time," Xue said. "This research is significant because it introduces a model so 'intelligent' that it produces paintings good enough to pass as human-created."



RECOMMENDED READING



RACE AFTER TECHNOLOGY: ABOLITIONIST TOOLS FOR THE NEW JIM CODE, by **Ruha Benjamin** (2019): Benjamin, an associate professor of African American studies, sheds light on how technology is not neutral about race and offers tools to raise awareness of biases and how to correct them.



THE DISCRETE CHARM OF THE MACHINE: WHY THE WORLD BECAME DIGITAL, by **Ken Steiglitz** (2019): Steiglitz, the Eugene Higgins Professor of Computer Science, Emeritus, chronicles the evolution of information technology and where the digital future may lead.

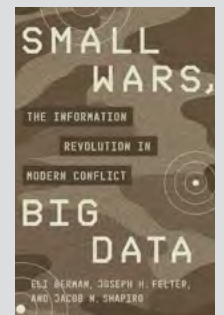
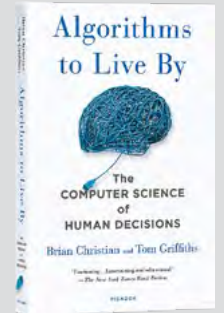


THE NEW DIGITAL AGE: TRANSFORMING NATIONS, BUSINESSES, AND OUR LIVES, by **Eric Schmidt '76 and Jared Cohen** (2014): Schmidt, the former chairman and CEO of Google, imagines a time very soon when everyone on Earth is online. What are the benefits of that level of connectivity? What are the dangers?

ALGORITHMS TO LIVE BY: THE COMPUTER SCIENCE OF HUMAN DECISIONS, by **Brian Christian and Tom Griffiths** (2016): Griffiths, the Henry R. Luce Professor of Information Technology, Consciousness and Culture, shares how some of computer science's most complex algorithms provide a simple template for making everyday human decisions.

BIT BY BIT: SOCIAL RESEARCH IN THE DIGITAL AGE, by **Matthew Salganik** (2017): Salganik, professor of sociology and the director of Princeton's Center for Information Technology Policy, examines how the digital revolution is transforming the way social scientists observe behavior, ask questions, run experiments and confront ethical dilemmas.

SMALL WARS, BIG DATA: THE INFORMATION REVOLUTION IN MODERN CONFLICT, by **Jacob N. Shapiro**, et al (2018): Shapiro, professor of politics and international affairs, and his colleagues explain how big data and the battle for information will tip the balance in future conflicts.



WATCH AND LISTEN



SHE ROARS PODCAST: Guest **Jennifer Rexford '91**: The chair of Princeton's computer science department explains the value of data science and why there is such hunger in the workforce for students who know how to harness it.



DATA SCIENCE AT PRINCETON: **Jennifer Rexford '91** describes the University's advances in data science and the potential impact on discovery and society.



NBC News

PRIVACY AND POWER: YOUR DIGITAL FINGERPRINT: **Arvind Narayanan**, associate professor of computer science, participated in this 2019 NBC News segment that examined the surveillance infrastructure that picks up — and monetizes — the digital crumbs from your every keystroke.



IS ARTIFICIAL INTELLIGENCE BIASED LIKE HUMANS ARE?: **Arvind Narayanan** and a team of Princeton researchers discuss their studies on how human biases seep into artificial intelligence.

COOKIES: TECH SECURITY AND PRIVACY PODCAST: A new series from the School of Engineering and Applied Science, Cookies episodes feature Princeton faculty discussing a variety of technology issues, from the peril and promise of artificial intelligence to the vulnerability of the Internet.



AI4ALL: Co-founder **Olga Russakovsky** and high school students **Dennis Kwarteng** and **Adithi Raghavan** discuss their motivations for participating in AI4ALL.



THE RISE OF ARTIFICIAL INTELLIGENCE: WHO WILL HAVE JOBS IN THE FUTURE?: A conversation with Microsoft president **Brad Smith '81**



THE FUTURE OF COLLABORATION AND INCLUSIVE INNOVATION: MICROSOFT + PRINCETON: **Brad Smith '81** frames the collaborative relationship between Princeton and Microsoft with a review from around the world on the nature of innovation in the 21st century.



HOW COMPUTERS ARE LEARNING TO BE CREATIVE: **Blaise Agüera y Arcas '98 *04's** 2016 TED talk examines the relationship between perception and creativity — and whether computers have the ability for both.



DISCUSSION

As you continue to think forward about data science and the future of artificial intelligence, brainstorm these questions in order to extend and deepen the conversation.

1. Are you an optimist or a pessimist about the future of data science and artificial intelligence? Why?
2. Is the notion of privacy obsolete in the modern world full of Internet of Things (IoT) devices, and how can people adjust their digital habits and activities to preserve anonymity? Can people use smartphones and still preserve their privacy?
3. How might your current job change in the next 10 years due to advances in artificial intelligence and robotics, and what type of education will be required to help the world's workforce adapt?
4. How do we ensure that (a) the machines and programs remain accountable to people and (b) that those who designed them also remain accountable? What needs to be done for people to trust artificial intelligence?
5. How could artificial intelligence and automation alleviate the growing global wealth gap rather than increasing it?

A YEAR OF FORWARD THINKING



Forward Fest is a monthly, online event series open to the public.

December's theme:

ARTS AND HUMANITIES

Thursday, December 17

What Are YOU Thinking Forward?

Share it now.

forward@princeton.edu

[#PrincetonForward](https://twitter.com/PrincetonForward)

For more information on future programming, visit

forwardthinking.princeton.edu/festival

forwardthinking.princeton.edu