Engineering and public policy play remarkably similar roles in the world. Both deploy deep knowledge – often bringing together multiple disciplines – to solve problems and provide groundwork for future progress. In essence, both are about getting things done for the benefit of society.

Along with these conceptual similarities comes a practical need for the fields of public policy and engineering to work together. Today, the concerns of policymakers – security, privacy, healthcare, the environment, economics – almost always involve a technological component. Conversely, many decisions by policymakers affect the direction and scale of research in science and engineering. Meaningful progress on any front demands a vigorous and fluent exchange of ideas between these fields.

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FORGET THE NEEDLE, CONSIDER THE HAYSTACK: UNCOVERING HIDDEN STRUCTURES IN MASSIVE DATA COLLECTIONS

Advances in computer storage have created collections of data so huge that researchers often have trouble uncovering critical patterns in connections among individual items, making it difficult for them to realize fully the power of computing as a research tool.

Computer scientists at Princeton University have developed a method that offers a solution to this data overload. Using a mathematical method that calculates the likelihood of a pattern repeating throughout a subset of data, the researchers have been able to dramatically reduce the time needed to find patterns in large collections of information such as social networks. The tool allows researchers to identify quickly the connections between seemingly disparate groups such as theoretical physicists who study intermolecular forces and astrophysicists researching black holes.

“The data we are interested in are graphs of networks like friends on Facebook or lists of academic citations,” said David Blei, an associate professor of computer science who, along with doctoral student Prem Gopalan, published an article on the research in the Sept. 3 Proceedings of the National Academy of Sciences.

“These are vast data sets and we want to apply sophisticated statistical models to them in order to understand various patterns. Finding patterns in the connections among points of data can be critical for many applications. For example, checking citations to scientific papers can provide insights to the development of new fields of study or show overlap between different academic disciplines. Links between patents can map out groups that indicate new technological developments. And analysis of social networks can provide information about communities and allow predictions of future interests.”

“Take the data from the world, from what you observe, and then untangle it,” Blei said. “What generated it? What are the hidden structures?”

Beyond the implications of the program itself for every American, the revelations were like a lightning bolt that illuminated the gap between the policy process and the complex reality of today’s digital technologies. Making good policy in any area requires some understanding of that field, but many policymakers are out of the loop when it comes to technology. Closing this gap is one of the most important challenges in technology policy.

The particular point I discussed at the committee hearing was the privacy implications of metadata surveillance by assuring the public that authorities are looking only at metadata, which perhaps seems anonymous. Although I did not take a stance on the cost-benefit calculation for the nation – it is indeed a difficult judgment – I wanted to make clear that metadata collection has a very real impact on Americans’ privacy.

When the U.S. Senate Judiciary Committee asked me to testify about the National Security Agency’s Internet surveillance program in October, I welcomed the opportunity.

Edward Felten is the Robert E. Kahn Professor of Computer Science and Public Affairs and directs Princeton’s Center for Information Technology Policy, a joint venture of the Woodrow Wilson School of Public and International Affairs and the School of Engineering and Applied Science.

BEAUTIFUL BRUSHSTROKES ARE DRAWN FROM DATA

A good painter uses simple strokes of a brush to bring texture, contrast and depth to a blank canvas. In comparison, computer programs often require painstaking effort to mimic a brief sweep of paint.

As a first step, a RealBrush user creates a few sample strokes using any desired medium, such as oil paint, nail polish or even toothpaste. The program uses the sample brushstrokes as baselines indicating fundamental characteristics of the strokes. RealBrush can use those samples to warp and blend the original strokes into any curves or forms the user desires.

“Our goal is to have it look like a photograph of a real stroke but to have it follow whatever path you happen to be drawing,” said Adam Finkelstein, a computer science professor and the senior researcher on the project.

A team of researchers including scientists at Princeton University has developed a program that allows graphic artists to quickly produce realistic brushstrokes on their computers.

The graphics program RealBrush, which was developed in collaboration with computer scientists at Princeton University, not only creates authentic brushstrokes in a wide variety of media, but it also allows users to warp and blend the strokes to achieve effects desired by the artist.

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In a later submission to the committee, I addressed a broader issue. A key complaint of the Foreign Intelligence Surveillance Court, which scotched the NSA, was that it had not received adequate technical information about the NSA's technology, causing the court to misjudge and approve certain NSA activities. I urged the Senate to take advantage of this nation's great technical expertise by giving technical experts a direct role in informing decisionmakers such as the court.

I became acutely aware of the scarcity of such expertise in Washington when I served as the first chief technologist at the Federal Trade Commission. Since returning to Princeton, I've been on a soapbox advocating for scientists and engineers to serve their country.

The engagement of so many of my engineering colleagues on matters of policy and the enthusiasm of our students bodes well. Their voices will illuminate hidden pitfalls and build bridges for decision makers who lack direct expertise in technology. Attacking the grand challenges of our society requires not only transformative technologies but also wise policy.

Continued from page 3

Research and teaching at that intersection is the primary goal of the Center for Information Technology Policy (CITP) but also is a growing focus across the engineering school. The Program in Technology and Society brings together CITP with the Andlinger Center for Energy Activities. I urged the Environment and the Keller Center to create special tracks of study for students interested in the broader implications of information technology or energy. The Keller Center also administers the Wang Fund for Engineering and Policy, which supports internships and other projects for engineering students.

OPENING WASHINGTON’S ‘BLACK BOX’

A group of eight undergraduates spent fall break in Washington, D.C., meeting with leaders in the field of technology policy – at the Federal Trade Commission, the State Department, advocacy groups, consulting and law firms, and the Washington Post. The trip was organized by Edward Felten, director of Princeton's Center for Information Technology Policy, and Janet Vertesi, assistant professor of sociology.

"Before going on this trip Washington was a black box in many ways," said Mario Alvarez, a senior majoring in computer science. The trip crystallized just how badly technologists are needed in policy-related organizations and how hard those with technology expertise are working to inform the policy process, Alvarez said.

The hosts, many Princeton alumni, also recounted for the students their own paths from school to working in Washington. “I think they got a better idea of what a career in technology policy could be," Felten said.

Steven Schutz

Participants in a fall break trip to Washington, D.C., included (from left): Maria Alvarez ’14, Erica Portnoy ’15, Steven Tran ’15, Bonnie Eisenman ’14, Assistant Professor Janet Vertesi, Professor Edward Felten, Anna Kornfeld Simpson ’14, Prerna Ramachandra ’14, Krysta Dummit ’15 and Stephanie Chair ’15. (Photo courtesy of Erica Portnoy)

FOCUSING DISCUSSION

Founded by Professor Edward Felten in 2002, the Freedom to Tinker blog (https://freedom-to-tinker.com) has been at the forefront of prominent debates on technology and society. Contributors – a roster of experts from many institutions – have exposed flaws and proposed alternatives in areas from digital copyright to voting machines. Now hosted by the Center for Information Technology Policy, the blog has focused recently on issues of privacy and online security.

Jennifer Rexford BSE ’91 is the Gordon Y.S. Wu Professor in Engineering at Princeton and a member of the Federal Communications Commission’s Open Internet Advisory Committee. She writes about Internet policy and network neutrality.

Revisiting the Potential Hazards of the Protect America Act

"In light of recent news about NSA wiretapping of U.S. Internet communications, folks may want to reconsider some background on the ‘wireless wiretapping’ provisions of the Protect America Act, and the potential security risks in wireless standards systems can introduce.” 08/08/13

Jennifer Rexford BSE ’91
You don’t need a scientist to tell you that Manhattan gets brutally hot in the summer. But it helps to have one if you intend to do something about it.

For the past year, Elie Bou-Zeid and his co-researchers at the Princeton Plasma Physics Laboratory and at Columbia University have been working with New York City officials to find ways to cool the city in the heat of the summer. The city has multiple interests in urban heating. For one, air conditioning use sends electricity demand skyrocketing in sweltering summer months, straining the electric grid and vastly increasing the city’s carbon emissions. The heat also poses a danger to some of New York’s most vulnerable residents.

“Heat waves are among the deadliest natural disasters, particularly in cities,” said Bou-Zeid, an assistant professor of civil and environmental engineering at Princeton. “Finding effective methods to mitigate their effects is not only an important environmental issue, it is also a public-health issue.”

The ultimate goal, Bou-Zeid said, “is to cool New York City by one degree.” In absolute terms, it might not seem like much. But even a small drop can have outsized effects. Research indicates that each degree of increased temperature in a heat wave increases mortality risk by 4.5 percent. Thomas Matte, an assistant commissioner of the city Health Department, said that lowering the temperature even slightly could mean the difference between life and death.

“There is a steeply rising relationship between ambient temperature and mortality,” he said. “Each additional degree of temperature increases the risk in a significant way across the population.”

Sweating summers in the city have been the subject of popular songs and movies, but they are also a scientific fact. In a recent study, Bou-Zeid and Dan Li, a doctoral student, found that environmental factors such as low evaporation and heat-retaining surfaces in urban areas markedly increase temperatures within cities. Bou-Zeid and Li published their results Sept. 14 in the Journal of Applied Meteorology and Climatology of the American Meteorological Society.

Cities already tend to be hotter than their surroundings, an effect that scientists term the urban heat island, and Bou-Zeid found that this difference is exacerbated during periods of high temperatures. Working mainly in Baltimore, the researchers found that the hot, still air of heat waves was less susceptible to cooling over city concrete than rural fields.

“The biggest single factor is the lack of vegetation,” Bou-Zeid said. “Less vegetation means less evaporation.”

Li likens a city’s parks and vegetation to a body’s sweat glands. Evaporation is a major way for cities to lose excess heat, which is why Central Park tends to feel cooler than the surrounding streets in the middle of August. (The reservoir plays much less of a role than the trees, Bou-Zeid says.) The second major contributing factor to city heat is that city building materials – brick, concrete, asphalt – tend to be good at trapping heat and bad at reflecting sunlight.

“Reflective roofs can also be very effective,” Li said. “But their mechanism is in reducing the heat stored in a city.”

In the past few years, New York has launched a major effort focused on buildings’ surface materials. The Cool Roofs program, which is in its fourth year, coats about 1 million square feet of roof space each year with white reflective paint.

Wendy Dessy, the program coordinator, said the goal is to lower temperatures inside the buildings in hot summer months. Bou-Zeid and Keith Rule, a senior project engineer at the Princeton Plasma Physics Laboratory, recently led a team of researchers who evaluated the effectiveness of reflective roof coatings. In experiments at the Plasma Physics Lab’s Plainsboro site, the researchers found that the white coatings now being used in New York effectively reduce building temperatures and electricity consumption for cooling.

For some structures, the drop can be dramatic, although the impact is much less for well-insulated roofs.

In the most recent project, Bou-Zeid, Rule and Stuart Gaffin, of Columbia University, plan to measure the effectiveness and durability of the roof coatings at selected sites in New York. As part of the project, the researchers will use special cameras to monitor coatings at buildings in various boroughs of New York City.

In the big picture, Bou-Zeid said, the reflective coatings can make a big difference not only for building residents, but also for people across the city. Based on previous simulation results for Baltimore, he estimated that dropping New York’s temperature by one degree Celsius and surface temperatures by about five degrees, “This is already a significant improvement and is worth doing since it is a relatively easy measure that can also reduce cooling-energy consumption. If you add more vegetation it will certainly improve the city’s microclimate even more, and the impact depends on the scale of addition of new vegetation.”

Two images of Noonan Plaza in the Bronx show the building’s roof before and after being painted white. (Photo courtesy of NYC Cool Roofs)
For decades, “trust but verify” has been the guiding principle of international arms control. A generation of diplomats and political leaders has worked to maintain the trust. Engineers and scientists, such as Alexander Glaser, have worked on the “verify.”

“How do you know that inside a box labeled ‘nuclear warhead’ is actually a warhead and not something else,” asked Glaser, an assistant professor in mechanical and aerospace engineering and at the Woodrow Wilson School. “How do you know if someone is cheating?”

Glaser, with Robert Goldston Ph.D. ’77, a professor of astrophysical sciences, and other colleagues at the Princeton Plasma Physics Laboratory and Microsoft Research, is developing a process to verify that nuclear weapons slatted for destruction are actual warheads, not fakes. The system would do so without ever measuring information that could reveal specifications of the warhead itself.

The project, funded by the nonprofit Global Zero and the U.S. State Department, involves the creation of a “zero-knowledge” proof. These proofs, invented by cryptographers in the 1990s, allow someone to demonstrate that a statement is true without revealing why it is true. To develop the system, which is based on a technique called “active neutron interrogation,” Glaser and his colleagues at the lab use an unclassified test item, made of concentric metal shells, that simulates a warhead for detection purposes.

Current arms-limitation treaties limit deployed warheads in the American and Russian arsenals, essentially by counting missile silos or submarines. In contrast, future agreements are likely to place limits on the total number of warheads, which will require inspections on thousands of warheads that are in storage.

“Where is that warhead project coming in,” Glaser said. “We can tell you what is inside the box without ever looking into it.” —JS

Assistant Professor Alex Glaser develops technology to verify the presence of nuclear warheads. Instead of testing his method on actual warheads, or even nuclear material, Glaser uses a test device made of concentric shells of tungsten, aluminum, graphite and steel. (Photo by Elie Shinarman)

Currently, the project is in the “verify” phase. The system, which is based on a technique called “active neutron interrogation,” allows the development of a new warhead verification system that could reveal specifications of the warhead itself.
TAKING THE LEAD IN TAKING THE WHEEL
by John Sullivan

Alain Kornhauser believes technology offers a solution to our dangerous relationship with driving.

Federal records show that 32,780 people died on the nation’s roads in 2012. Many fatalities involved driver error. Kornhauser Ph.D. ’71, an expert in solving transportation problems, says it is time to start taking the driver out of the equation.

“There are a lot of advantages to allowing automated systems to take over some, if not all, of the driving functions,” said Kornhauser, a professor of operations research and financial engineering at Princeton.

“It can save energy, reduce pollution, and it could save an enormous number of lives.”

Recently, Kornhauser has been working with New Jersey legislators to make the state more welcoming to automated vehicle technology. Proponents want to change regulations to ease its introduction and support companies that are developing the technology.

“We need to make sure that New Jersey is among the first states to pave the way for this new technology,” said Senator Tom Kean Jr., the Senate minority leader. Kean, who has introduced legislation to overhaul the state motor-vehicle rules, said Kornhauser’s “explore on this initiative is already proving to be an invaluable resource for state leaders.”

Kornhauser has spent decades helping state, local, and federal officials understand the empirical, data-driven science of transportation. Advances in pedagogy have to catch up with technology development and business hype.

Malcolm Wilson, a Princeton professor of civil and environmental engineering, is leading the team of students working on PAVE (Princeton Autonomous Vehicle Engineering), the extra-curricular team, which has competed in the national challenges sponsored by the Defense Advanced Research Project Agency (DARPA), is working to develop a car that can pass the New Jersey driver’s test.

One problem for auto makers is that state driving laws frequently lag behind the development of new technology. Sensible regulations that, for example, require a driver to be in full control of the vehicle might make it difficult for automation to move forward.

“We are going to require changes in the regulatory framework that controls and oversees the use and operations of the roads if these systems are going to appear and share the road with human drivers,” Kornhauser said.

“States are going to do this. And if states are doing it, then New Jersey should be leading the way.”

Professor Alain Kornhauser wants New Jersey to lead in developing automated systems that reduce accidents and improve efficiency. (Photo by Frank Wojciechowski)
Unfortunately, we can’t solve this problem entirely with power storage. And we can’t simply rely on gas or coal generators as backup.

Solar output can change in minutes...

Like it or not, we’ll always need to anticipate our electricity supply in advance.

...but mathematical models can help us make good decisions anyway!*

Nobody can predict the future...

...we’re going to have to prepare for uncertainty.

...but it takes half an hour to fire up gas turbines...

...and more efficient steam power takes eight hours.

We’re the renewables.

You can count on us, kid...

...except when you can’t!

*CASTLE Lab at Princeton, led by Professor Warren Powell BSE ’77, employs mathematical modeling to make better decisions under uncertainty. The lab currently is developing models to help integrate solar and wind energy onto the grid, structure decisions about when to turn on generators and how to deploy and manage energy storage options.