TEAM BUILDING

ROBOTS LEARN TO WORK TOGETHER
Todays engineering students are often referred to as the "Maker Generation." They are accustomed to applying their knowledge to hands-on projects even while still in high school, let alone when they enter college as freshmen. But the knowledge they now need and in the workplace is rapidly expanding beyond the scope of any single engineering major. As we move into the world of interconnected products, we have an obligation to give our students the tools to pursue innovation. Mechanical engineering students, for example, are delving into computer engineering, and vice versa. We responded to this by creating a suite of interdisciplinary concentrations accessible to all students. Today, fully half of our graduates add a minor or concentration—including Technology Innovation, Nanotechnology and Energy Technologies, among others—to their foundational degree. And while that number continues to grow, we are working on ways to ensure that every student has exposure to the skills engineers will need in the coming years.

For one, we want all freshmen to have the experience of making something, either in the Singh Imagineering Lab or in EPIC. By doing so, they will see how the challenging foundational coursework they are taking applies to actually engineering something. They will also get an initial look at how multiple engineering fields are integrated into the process of designing and making a product. Programming and software are used in virtually all modern product design and manufacturing and are becoming increasingly relevant in our interconnected world. It quickly became apparent that students were engaging multiple disciplines as they pursue innovation. Mechanical engineering students, for example, are delving into computer engineering, and vice versa. We responded to this by creating a suite of interdisciplinary concentrations accessible to all students. Today, fully half of our graduates add a minor or concentration—including Technology Innovation, Nanotechnology and Energy Technologies, among others—to their foundational degree. And while that number continues to grow, we are working on ways to ensure that every student has exposure to the skills engineers will need in the coming years.

For one, we want all freshmen to have the experience of making something, either in the Singh Imagineering Lab or in EPIC. By doing so, they will see how the challenging foundational coursework they are taking applies to actually engineering something. They will also get an initial look at how multiple engineering fields are integrated into the process of designing and making a product. Programming and software are used in virtually all modern product design and manufacturing and are becoming increasingly relevant in our interconnected world; not to mention increasingly popular among our students. We require that all freshmen take a foundational course in programming and are modifying our curriculum to attract 75–100 percent of them to take more advanced programming courses later on. Data science and analytics are rapidly emerging to drive virtually all future innovation in any field imaginable, from medicine to manufacturing to retail to organizational and urban function. Divining meaning from large data sets applies to all engineering fields and we are finalizing a transformation of our undergraduate curriculum to insure all students, regardless of major, take a course that provides some data science foundation, inclusive of statistics for large data sets and machine learning.

In addition to these requirements, we plan to offer an array of more advanced electives in areas like smart and connected systems, engineering data science and analytics, and robotics and automated systems. All will engage multiple disciplines and we believe they will be very popular. Adding these to our existing minors and concentrations will ensure that our students are prepared for the new economy, where virtually every new product interacts with the digital world in some way. Several engineering schools have also begun to offer these kinds of courses and experiences, but, from what I have seen, most have done so at the individual department levels rather than as a broad foundational course necessary for any engineering major. By this time next year, we will have fully designed and approved a more holistic and unique approach that opens all of these areas up to all undergraduates and will transform how we educate engineers to give them the depth they will need to innovate in the digital economy.

Today, fully half of our graduates add a minor or concentration—including Technology Innovation, Nanotechnology and Energy Technologies, among others—to their foundational degree.

Evaluating the Maker Generation for the Digital Economy
BY DEAN KENNETH R. LUTCHEN

PHOTOGRAPH BY KALMAN ZABARSKY
PHOTOGRAPH BY MICHAEL D. SPENCER

By DEAN KENNETH R. LUTCHEN

PHOTOGRAPH BY KALMAN ZABARSKY
PHOTOGRAPH BY MICHAEL D. SPENCER
According to Professor Christopher Chen (BME, MSE), founding director of the center, the purpose of the center is to build a new community, not just of Boston University researchers, but of the biological design community. The center is dedicated to fostering a dynamic interdisciplinary environment where researchers from academia and industry can collaborate on research projects related to biological design.

The kickoff symposium, titled “Engineering the Future,” featured an array of speakers from academia and industry who gave presentations on biological science and technology, as well as on their work collaborating with other scientists. The symposium also included an array of poster presentations and a panel discussion on the future of biological design.

The kickoff symposium highlighted the multidisciplinary approach of the center, which focuses on the development of new technologies and applications in biological design. The center is expected to be a catalyst for new collaborations and partnerships, and to provide a platform for researchers to share their findings and ideas.

According to Professor Chen, the center will be a hub for researchers from across the University to connect and collaborate on research projects related to biological design. The center will also provide a venue for researchers to present their work and to connect with other scientists from around the world.

The kickoff symposium was an exciting event that showcased the potential of the center to bring together researchers from different fields and to foster new collaborations and partnerships. The center is expected to have a significant impact on the field of biological design, and to provide a platform for researchers to share their findings and ideas.
The excellence of our faculty and their research continues to gain increasing recognition among our peers,” Dean Kenneth R. Lutchen said. “This recognition is helping to fuel a virtuous cycle that attracts high-quality graduate students, who, in turn, help propel the College to new heights.” At 52th among 120 graduate programs—a top-10 ranking—the College’s subjective assessment score—the nation’s engineering deans climbed, as did its assessments of both heavily weighted factors in U.S. News & World Report’s ranking methodology of engineering schools. Among private engineering schools, the College ranks 11th nationally.

Other graduate programs significantly gained in this year’s rankings. The Computer and Electrical Engineering programs recorded their highest-ever assessment scores and rankings—both placed 36th in their large categories—which represented jumps of six and seven places, respectively, over last year. The Mechanical Engineering program also notched a substantial advance—a six-place jump in a field of 170 programs. The relatively new Materials Science & Engineering program also recorded its highest assessment score and rank since it started getting rated seven years ago with an 18-place jump into the 42nd spot. When comparing private universities only, every one of the College’s programs is in the top 20—Michael Seidel.

The excellence of our faculty and their research continues to gain increasing recognition among our peers,” Dean Kenneth R. Lutchen said. “This recognition is helping to fuel a virtuous cycle that attracts high-quality graduate students, who, in turn, help propel the College to new heights.” At 52th among 120 graduate programs—a top-10 ranking—the College’s subjective assessment score—the nation’s engineering deans climbed, as did its assessments of both heavily weighted factors in U.S. News & World Report’s ranking methodology of engineering schools. Among private engineering schools, the College ranks 11th nationally.

Other graduate programs significantly gained in this year’s rankings. The Computer and Electrical Engineering programs recorded their highest-ever assessment scores and rankings—both placed 36th in their large categories—which represented jumps of six and seven places, respectively, over last year. The Mechanical Engineering program also notched a substantial advance—a six-place jump in a field of 170 programs. The relatively new Materials Science & Engineering program also recorded its highest assessment score and rank since it started getting rated seven years ago with an 18-place jump into the 42nd spot. When comparing private universities only, every one of the College’s programs is in the top 20—Michael Seidel.

The excellence of our faculty and their research continues to gain increasing recognition among our peers,” Dean Kenneth R. Lutchen said. “This recognition is helping to fuel a virtuous cycle that attracts high-quality graduate students, who, in turn, help propel the College to new heights.” At 52th among 120 graduate programs—a top-10 ranking—the College’s subjective assessment score—the nation’s engineering deans climbed, as did its assessments of both heavily weighted factors in U.S. News & World Report’s ranking methodology of engineering schools. Among private engineering schools, the College ranks 11th nationally.

Other graduate programs significantly gained in this year’s rankings. The Computer and Electrical Engineering programs recorded their highest-ever assessment scores and rankings—both placed 36th in their large categories—which represented jumps of six and seven places, respectively, over last year. The Mechanical Engineering program also notched a substantial advance—a six-place jump in a field of 170 programs. The relatively new Materials Science & Engineering program also recorded its highest assessment score and rank since it started getting rated seven years ago with an 18-place jump into the 42nd spot. When comparing private universities only, every one of the College’s programs is in the top 20—Michael Seidel.
College Creates New Precision Diagnostics Center

The road to commercializing medical technology is usually long, requiring the work of basic scientists, clinical researchers, engineers and eventually industry partners, with one group passing along knowledge to the next until a marketable version of the technology is finally realized. But what if the work of these groups could be combined, with each working toward a common goal simultaneously? Team science has the potential to make the process more efficient and bring medical innovations to the patient faster.

Professor Catherine Klapperich (BME, ME, MSE) hopes that this new Precision Diagnostics Center (PDC) she directs will do just that. She saw the potential that BU’s diverse research portfolio offers and established the new interdisciplinary initiative that will capitalize on the synergy among faculty researchers to invent new medical diagnostic tools.

The PDC focuses on the success, momentum and infrastructure of the NIH Center for Future Technologies in Cancer Care (CFTCC), which Klapperich also directs at BU and which will now fall under the umbrella of the new center. The PDC’s mission will expand to include cancer and innovations that leverage point-of-care technologies to enable precision medicine across a wider swath of diseases. Researchers from the College of Engineering in collaboration with the BU schools of Medicine, Dental Medicine and Public Health will collaborate in the new center.

“This center comprises faculty across many departments of the University who are working on new ways to measure and use patient data. We want to take the power of that data and put it into applications that can be patient-facing either during an office visit or at home,” says Klapperich. “After working on building the CFTCC for five years, a common refrain was ‘Can we do this for other health-care areas?’ We see the PDC as being one way to bring the engineering innovations we have developed in point-of-care diagnostics to the clinic earlier in the design process. Patient and provider input and acceptance are essential to the success of these technologies.”

Point-of-care diagnostics allow clinicians, pharmacists and even patients themselves to conduct sophisticated molecular tests—like rapid strep throat tests, home pregnancy tests or blood-glucose monitoring in diabetes patients—in clinics and at home. The PDC aims to apply these innovations across a variety of areas using a three-pronged approach: developing new reagents and tests to make advanced patient monitoring possible; designing and creating the algorithms and devices that would house these technologies; and partnering with industry and government to translate innovations into the marketplace.

“The center will play to BU’s unique strengths as a research university, including capabilities in infectious disease, expertise in addressing healthcare disparities in underserved communities and our Photonics Center. We’re excited to access those resources and expertise to make a global impact where it’s most needed,” she says.

Next steps for the PDC include hosting networking and professional development opportunities for faculty, students, post-docs and residents—such as workshops, seminars and symposia—to attract new members and continue building community. The other founding core faculty members of the PDC include: Professor Edward Damiano (BME), Professor Muhammad Zaman (BME, MSE), Professor Thomas Bifano (ME, MSE), Professor Mark Grinstaff (BME, Chemistry), Professor Thomas Little (ECE, SE), Professor Ioannis Paschalidis (ECE, BME, SE), Associate Professor James Galagan (BME, Microbiology), Assistant Professor Allison Dennis (BME, MSE) and Professor Avrum Sira (MED, SE) —SARA CODY

Neurophotonics Center Aims to Advance Understanding of the Brain

The other founding core faculty members of the Neurophotonics Center and an ENG professor comes to BU from Mass General Hospital.

In order to improve our understanding of the organ’s healthy functioning and offer new pathways to understand how strokes, migraines, Alzheimer’s disease and other neurologic ailments affect it, Boas, the center’s founding director, is recruiting faculty from throughout the College of Engineering and across Boston University to pool expertise and further accelerate neurophotonics technologies.

“There are tremendous advantages to biomedical and photonics engineers working with neuroscientists,” Boas says. “Neuroscientists have questions and problems that engineers want to solve. Those solutions advance the field and lead to new questions and new solutions. Boston University has a wealth of expertise in photonics, biomedical engineering and neuroscience that is excellent fuel for this virtuous cycle.”

Many of the center’s efforts will utilize multi-photon microscopy, a method that even 25 years after its advent is still accelerating in terms of its technological advances and impact in the neurosciences. In addition, the center will be developing and applying novel approaches to measuring human brain function with light.

Human-functional brain imaging has been done for several years using fMRI scans, which produce sharp images of brain blood oxygenation and flow, key to seeing which areas of the organ are being stimulated at a given time. But fMRI scans require the subject to lay perfectly still in a confining machine for an extended period, not a natural state and a difficult procedure to use with infants, small children and others. They are also expensive. Instead, Boas uses functional near-infrared spectroscopy, which penetrates through the scalp and skull as much as a centimeter into the brain, where it detects blood oxygenation, ultimately enabling the imaging of brain function. Images aren’t as crisp as fMRI scans, but the wearable device allows the subject to move around naturally, engage socially and perform any number of activities while blood flow and oxygenation changes in the brain are observed in real time at a far lower cost. Furthering this research is expected to be one of the Neurophotonics Center’s initial projects.

The Neurophotonics Center is expected to draw on the efforts of doctoral students through the new $2.5 million National Science Foundation Research Traineeship grant for neurophotonics, which awarded its first fellowships in summer 2017.

An array of faculty from the College of Arts & Sciences, Sargent College and the School of Medicine will join College of Engineering faculty in the center.—MICHAEL SEILE

New 3D Metals Printer Keeps EPIC on Cutting Edge of Product Design & Manufacture

GE DONATION GIVES STUDENTS, RESEARCHERS AN EDGE

More and more products—from consumer electronics to hearing aids—are commonly made using 3D printing, and nearly every engineering school has 3D printers on which students can work. But virtually all of them print some form of plastic. With the addition of a metal-printing machine donated recently by General Electric (GE), the College of Engineering and the Engineering Product Innovation Center (EPIC) will remain on the cutting edge of education and research in this rapidly evolving field.

GE considered applications from 250 colleges and universities around the world before selecting just eight to receive a metals 3D printer. Boston University is the only engineering school in the Boston area to receive one.

As the range of materials used in 3D printing—or additive manufacturing, as it’s known in industry—expands from plastics to metals, the commercial possibilities are endless. It is only a matter of time before engineers and the practicing professional will like GE, the College’s new Product Design & Manufacture master’s degree program will particularly benefit from the addition of a metals printer, one of only about two dozen or so to be housed in engineering schools nationally.

“This will ensure that our new degree program is working with state-of-the-art tools in a rapidly evolving field,” Fine says, adding that the machine will be integrated into the College’s first graduate course in additive manufacturing.

“Adding metals to 3D printing changes the whole paradigm in design and manufacturing,” he says. “The design rules are different. You are designing products differently.” He notes that GE has begun 3D printing jet engine fuel nozzles. The nozzles used to be manufactured by assembling approximately 40 individual parts, but 3D printing reduces the part count to one.

The addition of metals to additive manufacturing also poses challenges for materials researchers, engineers and manufacturers. Among them are University of Massachusetts Amherst researchers Soumendra Basu and Uday Pal (both ME, MSE) who were involved in the effort to acquire the new machine.

“In additive manufacturing, the properties of metals can be different from what materials scientists are accustomed to. Also, the range of metals that can be 3D printed now is so small, there is interest in developing new materials.”

The donation marks a further deepening of the relationship between EPIC’s Industrial Advisory Board and EPIC. The company has been on EPIC’s Industrial Advisory Board since EPIC’s inception.

“They understand what we are trying to do and they’ve given us an understanding of their needs, which includes hiring more students who understand additive manufacturing and digital design. It’s a win-win,” Fine says. —MICHAEL SEILE
3D-Printing Patch Helps Guide Growing Blood Vessels

NOVEL METHOD PROVIDES POTENTIAL TREATMENT FOR ISCHEMIA

Surgery can correct the problem in large vessels, but treat problems of other approaches. Their research of new vessels while avoiding some of the cardiothoracic surgery at Stanford University—leg ischemia, and Joseph Woo, MD, the head of developing a method using 3D-printed patches with pre-organized structure reflected new branches that sprout form a disorganized network. That is what Chen observed. "The pre-organized architecture of the patch helped to guide the formation of new blood vessels that seemed able to deliver sufficient blood to the downstream tissue. While it wasn't a full recovery, we observed functional recovery of function in the ischemic tissue." Chen notes that while the results of this project are promising, this approach is still in early stages. Going forward, his team will continue working on the scalability of the patches, while experimenting with different architectures to see if there is a structure that works even better than what they have tried so far.

"This project has been long in the making, and our clinical collaborators have been indispensable to the success of the project," says Ozaki. "As bioengineers, we were focused on how to actually build the patch itself, while the clinical perspective was critical to the design process. We look forward to continuing our partnerships as we move forward."—SARA CODY

Dean Lutchen Visits Fifth-Grade Class to Inspire Students

Dean Kenneth Lutchen took a hands-on approach when he made a presentation to a fifth-grade class at the Joseph R. Dawe, IV Elementary School in Stoughton, MA. He made the trip before—his daughter is the fifth-grade teacher there. He spent his visit showing the students how engineers invent new technologies that improve society and walked them through the invention process—from idea to patents to commercialization—that brings technologies into use, hopefully inspiring some of them to think about their future careers.

"The feedback from the surgeon about the ease of use was quickly incorporated in the design, which had several iterations. Because we could run through the iterations quickly, it made this a successful experiment," says White. "It's a simple thing, but it fulfilled a need for the patients. We were able to both stimulate and record neural activity successfully," says Lissandrello. "Ultimately, the nanoclips is a tool which addresses many challenges associated with interfacing with small-diameter nerves in the peripheral nervous system, and we hope it will enable others to conduct studies which would not have been previously possible." According to White, while this technique may not lend itself to mass produce large batches of these tools, the fast turnaround time between design, production and implementation makes it a great option for conducting science experiments, because they happen on a much smaller scale. White will continue to work with Gardner's research group to speed up the printing process so it could become scalable for manufacturing. She also intends to extend the nanoclip design to include optical sensing, where optical fibers are incorporated into the sensor for use in areas such as optogenetics.

"The feedback from the surgeon about the ease of use was quickly incorporated in the design, which had several iterations. Because we could run through the iterations quickly, it made this a successful experiment," says White. "It's a simple thing, but it fulfilled a need to move the science forward, and I look forward to more opportunities to collaborate with other faculty researchers in the future."—SARA CODY

Nanoscale 3D Printing Enables Bioelectric Medicine Research

When Professor Alice White (ME, MSE, Physics, Biomedical Engineering, BME) came to BU in 2013 as chair of Mechanical Engineering, she was keen to encourage the sort of cross-disciplinary research she had experienced as chief scientist at the storied Bell Labs. For her own research, she set up a powerful 3D-printing tool with nanoscale resolution—at the time, one of only three labs in the country with this tool. In addition to her personal projects, she helped to attract collaborators whose research could be advanced using this capability. An early realization of this hope came when, at the invitation of BU President Robert A. Brown, she gave a presentation to visitors from Singapore about her laboratory’s ability to design and print on such a small scale. Afterward, she was approached by Professor Timothy Gardner (Biology, BME) who had also presented, about his research challenge in measuring neural activity in songbirds. Their collaboration blossomed quickly. The fruit of their partnership, a nanoclip just twice the width of a human hair is the focus of the cover story in the June issue of the Journal of Neural Engineering.

Gardner’s research team was working on experiments to stimulate and measure electrical activity in tiny nerves in zebra finches, but they found the attachment they used was too big and stiff for the delicate nerve, causing damage that led to inaccurate measurements. "Professor Gardner mentioned how the current technology for attaching to the peripheral nerve in a zebra finch was cumbersome and caused damage and scarring," White says. "We had a conversation in the morning about that challenge, came up with a solution, designed it that afternoon, printed it overnight and, the next morning, had the first version in Professor Gardner’s hands." "The nerve interface devices that are required to advance this emerging field must be very small but also must be very secure. The challenge is to attach a nerve to a device securely and then allow the nerve to pass through and lock the device inside," says Gardner. "The feedback from the surgeon about the ease of use was quickly incorporated in the design, which had several iterations. Because we could run through the iterations quickly, it made this a successful experiment," says White. "It’s a simple thing, but it fulfilled a need to move the science forward, and I look forward to more opportunities to collaborate with other faculty researchers in the future."—SARA CODY

PHOTO PROVIDED BY DEAN LUTCHEN
STRENGTH IN NUMBERS

ROBOTS LEARN TO WORK TOGETHER

BY SARA CODY

Agriculture, Automotive, Medicine, Biotechnology. Name an industry, and Professor Calin Belta (ME, SE, ECE) can tell you how the field of robotics will impact it—if it hasn’t already. Robots are going to significantly aid in allaying some of society’s greatest problems and stressors in a variety of ways, from performing automated tasks, to helping with housework to preventing dangerous situations. As they grow smarter, robots will also become more autonomous.

Many of the largest, resource-rich companies in the country—including Google, Amazon and Uber—are now investing in creating autonomous robots. Since it doesn’t make sense for an academic institution to compete with these deeply resourced companies financially, BU researchers are taking a number of unique approaches to advance the field, namely, improving the systems to make them work better. →
Flying and ground-based autonomous vehicles of many types are being developed and tested in the Robotics Lab (left). Professor Christos Cassandras (ECE, SE) and research team members from a collaborative grant awarded by the Energy Department’s Advanced Research Projects Agency-Energy NEXTCAR program display the vehicle they will turn into an autonomous smart car (right).

“The idea is to create heterogeneous robots both in the air and the ground that can go into an unknown or hostile environment,” he says. “Instead of sending in people to survey an area, you can send in a robot to identify enemies, collect and interpret data, and move around this unknown environment so they don’t collide into things.”

Belts and his team plan to use robots to build a map, identify areas of interest and locate survivors. They want the robot to not only be able to gather important data about disaster zones, but also demonstrate self-awareness in terms of knowing when it has to return to recharge. In addition to disaster relief and military applications, the technology could be used agriculturally to survey crops.

“My group brings in this kind of rigorous thinking that people use from computer science so we can use these platforms in dynamical systems and robotics to come up with smarter ways to control them,” Belts explains. “We do this by bringing together two fields; one is machine learning and the other is formal methods, which is highly theoretical and seeks to prove the correctness of systems by developing mathematical algorithms to ensure what you make does what it’s supposed to do.”

The College of Engineering supports interdisciplinary research with resources like the Belts-directed Robotics Lab, located behind the Engineering Product Innovation Center (EPIC). His research group, the Hybrid and Networked Systems (HyNeSyS) lab, focuses on making robots smarter and able to perform tasks autonomously. Improving upon machine learning—the mechanism that allows robots to become smarter as researchers track their progress—offers valuable insight that in turn helps to answer other questions.

Compared to developing an algorithm that predicts outcomes nearly, machine learning is messy because it does the exact opposite. Machine learning happens through trial and error, through which the robot learns from the data that is immediately available to it without any background or context. However, the process provides important insight into how neural connections are made as the machine learns, which can improve systems going forward. Belts seek to improve this process by cleaning up the process of machine learning and making it more rigorous, or, as the industry refers to it, explainable.

“Understanding the ‘how’ of an idea working is crucial to improving it and making it smarter,” Belts says. “It’s one thing if an image algorithm that classifies between cats and dogs makes a mistake, and another thing entirely if a safety-critical system fails. Imagine a space application where lives depend on it working the way it’s supposed to do.”

Funded by the Department of Defense, one of Belts’s projects concentrates on persistent surveillance, where teams of robots are sent out to survey an area. Belts uses motion capture technology and floor projections in the Robotics Lab to run disaster relief scenarios, where the goal is to send a robot into a disaster zone and have it find its way through collapsed buildings and debris.

The driest period in California history began in 2011 with a drought that lasted until April of 2017. Prolonged, rainless periods resulted in vast expanses of forest land becoming kindling for fires, as the Los Angeles Times reported that firefighters were battling “larger and more aggressive wildfires as drought conditions continued.” Unless caught quickly, in many cases the fires would grow so large and unwieldy by the time help arrived that they could not be contained. Fire does not discriminate in its path of destruction, and countless wildlife and human homes alike were destroyed.

The College of Engineering supports interdisciplinary research with resources like the Belts-directed Robotics Lab, located behind the Engineering Product Innovation Center (EPIC). His research group, the Hybrid and Networked Systems (HyNeSyS) lab, focuses on making robots smarter and able to perform tasks autonomously. Improving upon machine learning—the mechanism that allows robots to become smarter as researchers track their progress—offers valuable insight that in turn helps to answer other questions.

Compared to developing an algorithm that predicts outcomes nearly, machine learning is messy because it does the exact opposite. Machine learning happens through trial and error, through which the robot learns from the data that is immediately available to it without any background or context. However, the process provides important insight into how neural connections are made as the machine learns, which can improve systems going forward. Belts seek to improve this process by cleaning up the process of machine learning and making it more rigorous, or, as the industry refers to it, explainable.

“Understanding the ‘how’ of an idea working is crucial to improving it and making it smarter,” Belts says. “It’s one thing if an image algorithm that classifies between cats and dogs makes a mistake, and another thing entirely if a safety-critical system fails. Imagine a space application where lives depend on it working the way it’s supposed to do.”

Funded by the Department of Defense, one of Belts’s projects concentrates on persistent surveillance, where teams of robots are sent out to survey an area. Belts uses motion capture technology and floor projections in the Robotics Lab to run disaster relief scenarios, where the goal is to send a robot into a disaster zone and have it find its way through collapsed buildings and debris.

Belts uses motion capture technology and floor projections in the Robotics Lab to run disaster relief scenarios, where the goal is to send a robot into a disaster zone and have it find its way through collapsed buildings and debris...
His name is Baxter and today he’s learning to make toast. Three feet tall and featuring red robotic arms and an animated face, the humanoid robot stands in front of the toaster in the experimental arena of the Robotics Laboratory, where he will teach himself through trial and error—how to pick up a slice of bread, insert it into a toaster, turn the toaster on and remove the toast once it’s done. This seemingly simple task is performed by the 300 pound, $20,000 robot from Rethink Robotics to demonstrate the process of machine learning.

“Baxter demonstrates machine learning with the toast experiment because he is going into an environment where he knows nothing about making toast, and after a long process of trying and failing, he learns how to do it,” explains Robotics Lab Director Professor Cain Betta (ME, SE, ECE). “He is just one of many robots in the lab, and we are making him smarter by having him interact with his environment. It’s one of many ways we work with robots in here.”

Assistant Professor Roberto Tron’s research in computer vision—a mathematical field that aims to enable computers to interpret and understand real-world images—also puts Baxter to work. Baxter allows Tron, who works in the Robotics Laboratory located behind the Engineering Product Innovation Center (EPIC), to research ways of making manufacturing and industrial processes more efficient using computer vision.

“Right now, there’s a change occurring in industrial robotics,” Tron says. “In the eighties, there was a big development wave in industrial processes more efficient using computer vision. Assistant Professor Roberto Tron’s research in computer vision—a mathematical field that aims to enable computers to interpret and understand real-world images—also puts Baxter to work. Baxter allows Tron, who works in the Robotics Laboratory located behind the Engineering Product Innovation Center (EPIC), to research ways of making manufacturing and industrial processes more efficient using computer vision. “Right now, there’s a change occurring in industrial robotics,” Tron says. “In the eighties, there was a big development wave in industrial processes more efficient using computer vision. Assistant Professor Roberto Tron’s research in computer vision—a mathematical field that aims to enable computers to interpret and understand real-world images—also puts Baxter to work. Baxter allows Tron, who works in the Robotics Laboratory located behind the Engineering Product Innovation Center (EPIC), to research ways of making manufacturing and industrial processes more efficient using computer vision. “Right now, there’s a change occurring in industrial robotics,” Tron says. “In the eighties, there was a big development wave in industrial processes more efficient using computer vision. Assistant Professor Roberto Tron’s research in computer vision—a mathematical field that aims to enable computers to interpret and understand real-world images—also puts Baxter to work. Baxter allows Tron, who works in the Robotics Laboratory located behind the Engineering Product Innovation Center (EPIC), to research ways of making manufacturing and industrial processes more efficient using computer vision. “Right now, there’s a change occurring in industrial robotics,” Tron says. “In the eighties, there was a big development wave in industrial processes more efficient using computer vision. Assistant Professor Roberto Tron’s research in computer vision—a mathematical field that aims to enable computers to interpret and understand real-world images—also puts Baxter to work. Baxter allows Tron, who works in the Robotics Laboratory located behind the Engineering Product Innovation Center (EPIC), to research ways of making manufacturing and industrial processes more efficient using computer vision. “Right now, there’s a change occurring in industrial robotics,” Tron says. “In the eighties, there was a big development wave in industrial processes more efficient using computer vision. Assistant Professor Roberto Tron’s research in computer vision—a mathematical field that aims to enable computers to interpret and understand real-world images—also puts Baxter to work. Baxter allows Tron, who works in the Robotics Laboratory located behind the Engineering Product Innovation Center (EPIC), to research ways of making manufacturing and industrial processes more efficient using computer vision. “Right now, there’s a change occurring in industrial robotics,” Tron says. “In the eighties, there was a big development wave in industrial processes more efficient using computer vision. Assistant Professor Roberto Tron’s research in computer vision—a mathematical field that aims to enable computers to interpret and understand real-world images—also puts Baxter to work. Baxter allows Tron, who works in the Robotics Laboratory located behind the Engineering Product Innovation Center (EPIC), to research ways of making manufacturing and industrial processes more efficient using computer vision. “Right now, there’s a change occurring in industrial robotics,” Tron says. “In the eighties, there was a big development wave in...
WEARABLE WINDOWS INTO BREAST CANCER

DARREN ROBLYER IS DEVELOPING TECHNOLOGY TO HELP DOCTORS CHOOSE THE BEST THERAPIES

BY ELIZABETH DOUGHERTY

When Assistant Professor Darren Roblyer (BME) set up his Biomedical Optical Technologies Lab (BOTLab) at BU after arriving in 2012, he immediately started cold-calling doctors. He told them about a device he’d made, a new way of imaging tumors that could help cancer patients. It’s worth your time, he told them.

His device uses diffuse optical spectroscopic imaging (DOSI) and Roblyer helped develop the technology while a postdoctoral fellow at the University of California, Irvine. The technology sends near-infrared light into tissue and measures what is reflected back, allowing doctors to peer several centimeters under the skin into breast cancer tumors and see their response to chemotherapy. Read-outs are instantaneous, and preliminary studies offer hope that the technology may someday provide doctors with information that currently eludes them—an immediate alert when drugs aren’t working.

“It’s a window into the tumor. You can actually see what’s going on biologically without taking a biopsy,” says Professor Catherine Klapperich (BME, ME, MSE), associate dean for research and technology development.

Breast cancer is typically diagnosed with a biopsy after an abnormal mammogram; doctors rarely do additional imaging or biopsies to track progress. Rather, they prescribe a treatment plan, and for the most part, stick with it. The plan varies depending on the genetic makeup of the tumor, the tissue structure and the size. For some women, particularly those with large tumors that would be difficult to remove without taking the entire breast, doctors prescribe the medicine to shrink the tumor first.

The medicine typically includes chemotherapy, which has a range of debilitating side effects. But most women respond extremely well to this therapy—five years later, 75 to 90 percent are cancer-free, according to Naomi Ko, a School of Medicine assistant professor of hematology and medical oncology and a breast oncologist at Boston Medical Center (BMC).

It’s the remaining 10 to 25 percent Roblyer hopes his device will help. These women don’t respond to the chemotherapy and spend months suffering its side effects without any benefit. Currently, says Ko, the best tool she has to determine if a patient is responding is to feel the tumor with her fingers and get a rough measure of its size using a ruler. “What you don’t want is the tumor to grow, meaning the chemo is not working,” she says. “That happens. I’ve had to send a patient emergently to the operating room for surgery.”

If clinical tests over the coming years confirm his early results, Roblyer hopes his device will provide doctors with better information more quickly, so they can change a patient’s treatment plan and avoid wasted time and emergency surgeries. “We’d like to prevent patients from undergoing months of ineffective treatment,” he says. “The idea is to use optical feedback to personalize and improve treatment for each patient.”

At UC-Irvine, Roblyer and his colleagues used DOSI to measure several dozen breast cancer patients, all of them treated with chemotherapy to shrink tumors prior to surgery. Roblyer analyzed the data, looking for signals that might be connected with a good outcome—and he found one. In women whose tumors responded to chemotherapy, the DOSI images revealed a flare, a data spike that occurred early in treatment. The flare appeared within 24 hours of infusion with chemotherapy and represented an influx of oxygenated red blood cells into the tumor.

It isn’t clear yet exactly how the flare contributes to tumor shrinkage. When Roblyer came to BU, his priority was to start larger studies to validate his findings about the flare. He had reduced the size of the DOSI equipment needed to take measurements and wanted to get his new technology into a clinical trial. Earlier versions of the back end of the device, the part that produces the laser light, were the size of a refrigerator, but his current versions can be carried like a briefcase. “It gives us access to patients in new places, like the infusion suite at a cancer center,” he says.

His phone calls and emails to BMC oncologists led him to Ko, who agreed to run a clinical trial with him to test his technology. At this point, the tests involve collecting data from patients as they undergo chemotherapy prior to surgery. Roblyer and Ko will analyze that data to determine if his earlier findings hold up in a larger group of women. If so, it will add to the evidence that the device could help doctors improve care for patients who don’t respond to chemo.

The probe used in the study with Ko is handheld and about the size of a brick. “To get a full set of measures requires a few hours with the patient, and for this reason, it has been hard to convince patients to sign up. “A lot of these patients are already anxious about their treatment plan and for this reason, it has been hard to convince patients to sign up. “A lot of these patients are already anxious about their...”

BREAST CANCER IS TYPICALLY DIAGNOSED WITH A BIOPSY AFTER AN ABNORMAL MAMMOGRAM; DOCTORS RARELY DO ADDITIONAL IMAGING OR BIOPSIES TO TRACK PROGRESS.
optical devices and testing them in the lab. Photo (ENG’19) and Syeda Tabassum (ENG’18), is Fei Teng (ENG’18) (from left), Kavon Karrobi

A team of graduate students in the BOTLab, time. Photo by Jackie Ricciardi
cancer patient’s response to chemotherapy over
sensors that can noninvasively monitor a breast
cancer and how it responds to chemo,” Ko says. “I don’t know what
doors it will open, but there’s great potential to learn.”

Until now, cancer researchers could see only snapshots of tumors
from mammograms or examine tumor tissue after it’s removed
from the body. “With this device, we can see a living tumor reacting to
the medicine being infused,” says Klapperich. “The technology
is opening up the potential to answer new biological questions that
couldn’t have been answered before.”

The ability to see dynamic changes is one thing. But to under-
stand how that biological process might be linked to the shrinking of
tumors requires more extensive digging, the kind of digging that isn’t
possible to do in human patients.

So Roblyer also studies mouse models of breast cancer using the
BOTLab’s imaging technologies. To launch this effort, fifth-year
graduate student Syeda Tabassum (ENG’18), who works in the lab,
confirmed that it was possible to use a form of imaging called spatial
frequency domain imaging, or SFDI, to image breast tumors in
mice. SFDI uses near-infrared light and measures oxygen satu-
r ation, water and fat content. SFDI also allows imaging of the tumors
at multiple depths, so it is possible to create, for example, a map of
oxygen saturation across the entire tumor.

In new studies, graduate student Kavon Karrobi (ENG’19) is
using SFDI in combination with another form of imaging, called
multiphoton microscopy (MPM), which creates images of much
higher resolution. Using MPM, Karrobi can image a cross section
of the tumor and get a detailed look at the blood vessels, tumor cells and
structure of the tissue. It’s a bit like taking a slice of the tumor and
inspecting it under a microscope, but without touching the tumor.

Combining these tools, Roblyer’s team can image the tumor
throughout a course of treatment and see how it changes. The work
is just beginning, but one observation so far is that tumors don’t
change uniformly in response to treatment. “There are pockets
within a tumor and we’re trying to understand how they relate to
growth or resistance to therapy,” Karrobi says.

But she does ask, and she is grateful when they agree. “We do it
because we believe that this will further our understanding of breast
cancer and how it responds to chemo,” Ko says. “I don’t know what
doors it will open, but there’s great potential to learn.”

Until now, cancer researchers could see only snapshots of tumors
from mammograms or examine tumor tissue after it’s removed
from the body. “With this device, we can see a living tumor reacting to
the medicine being infused,” says Klapperich. “The technology
is opening up the potential to answer new biological questions that
couldn’t have been answered before.”

The ability to see dynamic changes is one thing. But to under-
stand how that biological process might be linked to the shrinking of
tumors requires more extensive digging, the kind of digging that isn’t
possible to do in human patients.

So Roblyer also studies mouse models of breast cancer using the
BOTLab’s imaging technologies. To launch this effort, fifth-year
graduate student Syeda Tabassum (ENG’18), who works in the lab,
confirmed that it was possible to use a form of imaging called spatial
frequency domain imaging, or SFDI, to image breast tumors in
mice. SFDI uses near-infrared light and measures oxygen satu-
r ation, water and fat content. SFDI also allows imaging of the tumors
at multiple depths, so it is possible to create, for example, a map of
oxygen saturation across the entire tumor.

In new studies, graduate student Kavon Karrobi (ENG’19) is
using SFDI in combination with another form of imaging, called
multiphoton microscopy (MPM), which creates images of much
higher resolution. Using MPM, Karrobi can image a cross section
of the tumor and get a detailed look at the blood vessels, tumor cells and
structure of the tissue. It’s a bit like taking a slice of the tumor and
inspecting it under a microscope, but without touching the tumor.

Combining these tools, Roblyer’s team can image the tumor
throughout a course of treatment and see how it changes. The work
is just beginning, but one observation so far is that tumors don’t
change uniformly in response to treatment. “There are pockets
within a tumor and we’re trying to understand how they relate to
growth or resistance to therapy,” Karrobi says.

Such heterogeneity within a tumor is common and well known,
but Roblyer’s tools are allowing his team to visualize them in a
completely new way. For instance, Karrobi plans to overlay detailed
images of tumor vasculature onto maps of oxygenation. “One
provides context for the other and could give us an idea of what is
happening inside,” he says. “We’re still very much in the exploration
phase.”

This research is helping Roblyer’s team learn more about how
tumors behave and also what the signals they see with the imaging
tools they are testing mean. The more Roblyer understands about
the cellular and molecular processes his device detects, the more
valuable those signals become. “We’re interested in what’s going on
in a tumor over time,” he says. “We can image things other people
can’t, so we’re learning a lot. It could go in many different directions.”

Meanwhile, Roblyer’s lab continues to advance the DOSI
technology. Last year, they created the first wearable DOSI device,
improving upon the brick-sized probe. The wearable device is flat,
star-shaped and flexible so it can conform to the shape of the breast
and be worn during a chemotherapy infusion, making it more conve-
nient for patients.

To shrink the technology, however, Roblyer had to alter its
function. His older probe collects absolute measures, but the new
one detects only relative changes. It’s a bit like having a heart rate
monitor that shows how much faster the heart beats during exercise
but cannot tell the starting or maximum heart rate.

Roblyer is also improving speed and resolution. For instance, he
recently completed a second wearable device that has many more
light sources and sensors, allowing it to probe more deeply and take
a series of images at different depths throughout the tumor tissue,
potentially revealing pockets of response or nonresponse to therapy
in a patient’s tumor.

He and his team of two postdoctoral fellows and seven graduate
students have managed to create these new designs in less than two
years. The seed money to create the first wearable probe came from
the BU Center for Future Technologies in Cancer Care, directed by
Klapperich. Roblyer also received a grant to support collaboration
with the Fraunhofer Center for Manufacturing Innovation at BU,
which helped create the flexible circuit board and skin-safe material
in the wearable device. In addition, he has received funding from the
American Cancer Society as well as a $4 million, five-year grant from
the US Department of Defense Breast Cancer Research Program.

He wants to take those newer devices to the clinic. He’s already at
work on his next version: a wearable design that has many more
light sources and sensors, allowing it to probe more deeply and take
a series of images at different depths throughout the tumor tissue,
potentially revealing pockets of response or nonresponse to therapy
in a patient’s tumor.

He and his team of two postdoctoral fellows and seven graduate
students have managed to create these new designs in less than two
years. The seed money to create the first wearable probe came from
the BU Center for Future Technologies in Cancer Care, directed by
Klapperich. Roblyer also received a grant to support collaboration
with the Fraunhofer Center for Manufacturing Innovation at BU,
which helped create the flexible circuit board and skin-safe material
in the wearable device. In addition, he has received funding from the
American Cancer Society as well as a $4 million, five-year grant from
the US Department of Defense Breast Cancer Research Program.

He wants to take those newer devices to the clinic. He’s already at
work on his next version: a wearable design that can collect absolute
measures of oxygenated blood, fat and lipids. All of his efforts must
move forward in parallel, with his team learning from studies of
patients and laboratory animals and adjusting their technology each
step of the way.

“The most important thing,” says Roblyer, “is to figure out if this
is the right technology and if it will help people.”

Biomedical engineer Darren Roblyer set up his Biomedical Optical Technologies Lab with the goal of making new devices that not only shine
light on cancer biology, but also help improve treatment for patients. Photo by Janice Checchio

A team of graduate students in the BOTLab, time. Photo by Jackie Ricciardi

Darren Roblyer’s wearable sensors conform to
the breast and use an array of LEDs and optical
sensors that can noninvasively monitor a breast
cancer patient’s response to chemotherapy over
time. Photo by Jackie Ricciardi

THE MORE ROBLYER UNDERSTANDS ABOUT THE CELLULAR AND MOLECULAR PROCESSES HIS DEVICE DETECTS, THE MORE VALUABLE THOSE SIGNALS BECOME.
THE LIGHT STUFF

ALUMNA’S START-UP AIMS TO IMPROVE HEALTH THROUGH LIGHTING

BY SARA CODY

The invention of the lightbulb paved the way for humans to conquer the darkness, effectively severing dependence on the sun to produce working hours. Recent advances in materials research are now providing new ways to render light that are healthier, more satisfying and more energy efficient. Jessica Morrison (PhD’16) aspires to change how people use light with her new start-up company, Helux Lighting, by using these materials advances to tailor light color, intensity and direction to meet personal needs. “Light is something we take for granted and generally ignore because it seems like a fixed resource instead of something we can shape to live around,” says Morrison. “What I want to do with the company is move forward with state-of-the-art light technology that will allow for more personalized environments by directing it where it is needed.” Adding directional controls to a light source would provide users with the option to redesign workspaces to align with their personal preferences, inherently improving productivity and reducing energy consumption with targeted task lighting.

Morrison first learned about microelectromechanical systems (MEMS) working as a PhD student under Professor David Bishop (ECE, MSE). As a postdoctoral researcher in Professor Thomas Little’s (ECE, BS) laboratory and as part of the NSF Engineering Research Center for Lighting Enabled Systems & Applications (LESA), she integrated MEMS with advanced light sources. Her company, Helux Lighting, has created an innovative system using next-generation light sources, including LEDs and laser diodes, and a deformable mirror, a device that uses microscopic actuators to change the mirror’s shape. She applied this technology to lighting by creating a device that electronically adjusts light position, brightness and illumination with the goal of creating healthy, energy-efficient environments.

“Dr. Morrison has been at the center of efforts to enable the directional control of lighting using MEMS within LESA and is the lead inventor of this enabling technology,” says Little. “Her technology involves a variable focus, lotus-shaped mirror that can tilt, tip, focus and ‘piston.’ Those degrees of freedom can be computer controlled and thus allow integration into low-cost steerable lighting devices.”

Today’s typical office building is filled with rows of cubicles illuminated by fluorescent light, computer screens glaring. With Morrison’s technology, she envisions a work environment that incorporates task lights that disperse light where it’s needed automatically. This could decrease the cost for consumers, save energy, increase consumer well-being and productivity and alleviate light pollution that is harmful to plants and animals in the environment.

“Currently people are willing to put on a coat when they are cold but wouldn’t necessarily be willing to shell out extra money for a special light, even though it could improve their health or their environment, because they aren’t aware of the significant role that it plays,” she says. “Ultimately, we want to shift the conversation to get people thinking about the overall impact of light and provide options to improve their consumption of it.”

It wasn’t until she attended the Advanced Research Projects Agency-Energy Innovation Student Summit, a career opportunities and professional development summit, that Morrison realized commercialization would be the best path to get her technology out into society, and there were resources that would help her do that. “After completing my PhD, I was looking for alternatives to a career in academia, and after talking to a few people at this event, it was suggested to me that I keep going because I had something that could really help people’s lives,” she says. “I was hesitant at first, because I never imagined myself starting a company, but once that seed of an idea was planted, it grew and now I can’t wait to dive in.”

Last spring, Morrison headed to Lawrence Berkeley National Laboratory to join Cyclotron Road, a highly selective incubator program focused on hard science innovation. The two-year fellowship, located in the heart of Silicon Valley, provides financial and logistical resources—like laboratory and office space, staff scientists and program mentors—for new technology companies, as well as opportunities to attend industry conferences and other networking events.

“The Cyclotron Road program is such an incredible program that is such a perfect resource for me, at first I wondered if it was too good to be true,” she says. “But their goal is to invest in technologies that are in the gap between blue-sky research and the ones that are shovel-ready.” Helux is based on research foundations that will need effort and expertise to shape into products; this expertise will be available through specialized resources offered at Cyclotron Road. I am very excited to get started.” Jessica Helux Lighting is still in the research application phase, which means Morrison will continue to refine the technology in the Cyclotron Road program to make it more efficient as she learns the business side of running a company. Initially, she plans on focusing on the architectural and artistic lighting industry to gather information about market needs, which will shape her approach in terms of research and development.

HER COMPANY, HELUX LIGHTING, HAS CREATED AN INNOVATIVE SYSTEM USING NEXT-GENERATION LIGHT SOURCES, INCLUDING LEDs AND LASER DIODES, AND A DEFORMABLE MIRROR, A DEVICE THAT USES MICROSCOPIC ACTUATORS TO CHANGE THE MIRROR’S SHAPE.
For centuries, windows have remained largely functionally unchanged. But a BU alum saw the opportunity to improve something we see and use every day and formed his company, View, with the goal of reengineering the window to make it smarter.

“We have this everyday object, the window, that was completely under-optimized and we’ve just been living with problems like heat and glare while missing out on highly desirable things like natural light and a beautiful view,” View CEO Rao Mulpuri (’92, ’96) says. “Light is required to live a healthy, happy and productive life. We aren’t using windows well and because of it, we are also losing a lot of energy. It was a compelling idea for us to build a business around redesigning the window from the ground up.”

Natural light is important to health and wellness, and a well-placed window can go a long way in improving the environment both at home and at work. Blinds and shades can help manage the discomfort caused by the glare of direct sunlight, but we use them at the expense of the natural light and views that add to our well-being. View has completely reengineered the window by being the first company to commercialize large-scale, dynamic glass. The company uses semiconductors and software that automatically eliminates glare while letting in natural light and allowing access to views—it’s like putting sunglasses on buildings. Windows with View Dynamic Glass also lower building energy consumption by about 20 percent, and adjust themselves automatically (though users can also control them from a smart phone app).

“People spend 90 percent of their time indoors, so first and foremost we want to help create better, healthier, more productive spaces for those who live and work inside buildings,” Mulpuri notes. “Our goal wasn’t so much to create this beautiful piece of technology, glass, sensors or software; it was to use these as a mechanism to create delightful human environments.”

From an early age growing up in India, Mulpuri knew he wanted to be in the business world. Inspired by his father’s steel fabrication business—which he built from the ground up as a mechanical engineer—Mulpuri became an engineer with the expectation that he would eventually take it over. But after he decided to pursue his master’s degree at Boston University in the manufacturing engineering program, these plans changed.

During his time at BU, Mulpuri worked closely with Professor Vinod Sarin (ME, MSE) who had come to academia from industry and was using his real-world experience to do a lot of applied work in his laboratory. Mulpuri decided to stay at BU to complete his PhD where he continued to work with Sarin as well as Professor Soumendra Basu (ME, MSE) and Associate Professor Michael Gevelber (ME, MSE, SE), who advised him on his graduate thesis. In a twist of fate, Mulpuri even met View’s current Chief Technology Officer, Robert Rozbicki (’92, ’99), a teaching assistant at the time; they’ve now worked together for more than 27 years.

“I never thought I would pursue a PhD because I never considered myself a traditional academic—I’m not a lab guy, I’m a business man. But I came to BU for my master’s degree and stayed for my PhD—and I’m so glad I did,” Mulpuri reflects. “While nanomaterials and materials science is a fascinating field and you become sort of an expert while solving original problems, what I really learned at BU is how to learn, which prepared me well for my career.”

After graduating from BU, Mulpuri worked for 12 years at Novellus, a semiconductor equipment company. Beginning as a technologist and working his way up to an executive role, he eventually moved his family to Japan to oversee operations. As the company grew, so did he.

“The semiconductor industry taught me how to do rapid development and use technology to quickly advance outcomes in a disciplined fashion, which allows you to sort through and address technical challenges that ultimately lead to success,” he explains. “That approach created a natural segue to look at other areas in the world that were untapped opportunities so we could fundamentally change for the better something that people take for granted every day. And that is what led me to View.”

Not only has View changed the functionality of glass, but also the form. Multiple nano-scale layers of metal oxide form the electrochromic ceramic coating on the inside of a window, and when a small electric voltage is applied, the ions move between the layers, causing the tint that is automatically controlled by software that connects to sensors located in the building. So far, this technology has been implemented in more than 350 buildings in North America, including commercial offices, healthcare facilities, universities, airports, hotels, government buildings and multi-family residential complexes (while View has not tackled single-family homes yet, that is certainly on the horizon as the company continues to expand).

Mulpuri says that building the company—from the technology to the business plan—from the ground up and scaling it to mainstream has been the most rewarding part of his career. “As a business leader, at the end of the day you have to deliver results, and as an engineer you apply what you have learned to something that is real and useful and benefits society,” he says. “When you feel every day back, I am a family business guy at heart and that is the mindset that has governed the way I built this company.”

He remains actively involved in the BU community as a member of Dean Kenneth Latchen’s Advisory Board and received the Distinguished Alumnus Award in 2012.

**A ROOM WITH A VIEW**

ENG ALUM SHAKES UP THE COMMON WINDOW

RAO MULPURI (’92, ’96) CREATES BETTER, HEALTHIER SPACES

BY SARA CODY

View CEO Rao Mulpuri (’92, ’96) says his company’s dynamic glass can lower a building’s energy consumption by about 20 percent and can be controlled from an app.

**VIEW BY THE NUMBERS**

- **MORE THAN 500 PATENTS FILED**
- **MORE THAN 500 BUILDINGS ACROSS NORTH AMERICA, EUROPE, MIDDLE EAST, AND INDIA, WITH 350 ALREADY COMPLETED AND ANOTHER 300 IN PROGRESS**
- **MORE THAN 20 MILLION SQUARE FEET OF REAL ESTATE USING VIEW DYNAMIC GLASS**
- **20,000 BUILDING OCCUPANTS ENJOY THE BENEFITS OF DYNAMIC GLASS EVERY DAY**

**VIEW DYNAMIC GLASS USING SMART TECHNOLOGY TO IMPROVE SPACES FOR THOSE WHO LIVE AND WORK INSIDE BUILDINGS.**

**NumbeR 23**
Getting Power to the People

CARAMANIS AWARDED SLOAN FOUNDATION GRANT TO IMPROVE ELECTRICITY DISTRIBUTION NETWORKS

While the use of clean, renewable energy is rising nationally, its growth is being restrained by an imbalance between the consumption and generation of power. Wind and solar power are available and cheap, but their availability varies widely depending on location, season and time of day. Fossil fuel–generated power is available anytime but is expensive and carbon-intensive. Utility companies average out the cost difference and charge consumers accordingly, leaving little economic incentive for consumers to adapt to cost differences and increase the use of renewable sources.

Professor Michael Caramanis (ME, SE) is working to change that by developing algorithms that will enable consumers to choose when and how they use electricity. Recognizing the potential of this approach, the Alfred P. Sloan Foundation has awarded Caramanis a $420,000 grant to pursue it.

“In a distribution network today, you pay an average price whether you consume in the morning or at night, on a hot or cold day, and regardless of the location of the grid that you are connected to,” says Caramanis. “This practice results in an electric power system that operates very inefficiently and provides perverse incentives for inefficient investments by all parties involved.

He is developing algorithms that take a number of generation and usage factors into account and derive dynamic prices. Smartphone apps that incorporate these algorithms could enable users to take advantage of the emerging Internet of Things and pursue their preferences at the lowest cost or highest benefit.

“Knowing how electricity prices will change over time, and in particular their locational granularity, will be very important information to consumers,” Caramanis adds. “For example, in midday, prices are high in commercial areas but low in residential areas where everyone is away at work; the opposite trend is true in the evening. We want to empower consumers by giving them information and financial incentives to do the right thing.

Consumers might, for instance, specify when they expect to plug in electric vehicles to charging outlets and when they expect to depart. The consumer’s smartphone would then monitor the cost of electricity as it flows from the power grid to the distribution network, reducing their costs and allowing them to pass along savings to consumers. It would also facilitate more efficient use of solar and wind power, much of which is underutilized in the current system. Taken together, Caramanis believes his proposed dynamic price discovery and sharing market will contribute to lower energy costs and increased adoption of clean, renewable energy sources.

Caramanis and his research group have already conducted computer simulations that demonstrate the potential for significant benefits of optimal spatiotemporal electric pricing. The Sloan Foundation grant will facilitate pilot studies using actual networks to evaluate the impact of spatiotemporal pricing, and Caramanis expects the results to boost confidence in the technology. A wide range of utilities, including National Grid, have expressed strong interest in participating.

“Building confidence is the key prerequisite to establishing a new market. Although we have already simulated benefits in computer studies, demonstrating bilateral benefits for utilities companies and consumers in actual pilot studies can provide invaluable momentum,” says Caramanis. “The Sloan Foundation grant will allow us to verify these results by key participating stakeholders, including distribution companies, practitioners, regulators and consumer advocates. Should applicability and societal benefits be documented, barriers to the adoption of efficient distribution markets will have been significantly overcome.” —SARA CODY
Duan Receives NSF CAREER Award

RESEARCH AND OUTREACH WILL FOCUS ON CARBON NANOFUIDICS

Assistant Professor Chuanhua Duan (ME, MSE) netted a prestigious National Science Foundation (NSF) Faculty Early Career Development (CAREER) award in recognition of his outstanding research and teaching capabilities. He will receive more than half a million dollars over the next five years to pursue high-impact projects that combine research and educational objectives.

Duan’s research will focus on developing an understanding of the fundamental mechanisms that affect the flow of water and ions through nanoscale graphene conduits.

“This exciting project is at the intersection of fluid mechanics, nanotechnology and materials science,” says Professor Alice White (ME, MSE), chair of the department. “It will inform the design of novel nanoporous membranes with impact on some of the world’s largest challenges.”

Graphene, a flexible sheet of pure carbon one atom thick, is a material that allows surprising ease for passage for liquids and ions with high selectivity. Graphene sheets can be stacked horizontally to form channels, called graphene nanochannels, or rolled into carbon nanotubes. These structures could potentially be used for water desalination, improving the efficiency of batteries and fuel cells, lab-on-a-chip technologies and other biomedical applications. However, when researchers have tried to repeat experiments, large discrepancies in the data attributed to variables such as curvature, ion density and membrane structure have resulted.

To address this challenge, Duan will use his NSF CAREER award to study water and ion transport in single graphene nanochannels and single carbon nanotubes with different sizes, surface properties and substrate materials. He will also perform molecular dynamics simulations to elucidate underlying mechanisms revealed by his experimental studies.

This combined experimental-computational approach, he expects to achieve a complete understanding of mass transport in carbon nanofluidic conduits.

“My lab has developed a novel technique, inspired by capillary flow, to accurately measure water and ion transport in a single carbon conduit,” says Duan. “To fully understand the effect that each variable has on the process and resolve discrepancies in previously reported results, this level of accuracy is key.”

In addition to the research component of his CAREER project, Duan will fulfill the educational objectives by creating a module to teach carbon nanofluidics to K-12 students. Image provided by Chuanhua Duan

New Sensors for Smart Lighting

Imagine a student sitting in a secluded corner of a college library, writing a last-minute paper. Just as she reaches the final paragraph summarizing her argument, the lights go out, prompting her to get up and wave her arms around. In an energy-efficient room, these lights may be controlled by motion sensors that turn them on only when they detect that someone is moving. However, if everyone is quietly working, the lights can’t register their presence—which doesn’t always serve the students well.

Now, a team from the Lighting Enabled Systems & Applications Engineering Research Center (LESA ERC)—a collaboration including Boston University, the University of New Mexico, Thomas Jefferson University, and Rensselaer Polytechnic Institute (RPI) faculty and graduate students—is tackling the issue. Funded primarily by the National Science Foundation, the center researches and designs smart lighting: lights, sensors, and controls that can adapt to better support human productivity, energy efficiency and wellness. The team was awarded a US patent titled “Sensory Lighting System and Method for Characterizing an Illumination Space” for a system of LED lights and sensors that can detect the location and poses of occupants in a room without using cameras. (While occupancy sensing is not a new idea, it is novel to interpret the reflected light in a room using low-cost sensors built into the lights, without using cameras.)

“The lights in a space are strategically located,” says Professor Thomas Little (CECE, SE), associate director of the LESA ERC, referring to his office overhead lights. “They’re in a good position in these indoor environments to interact with us.” Rather than completely overhauling lighting design, Little wants to make what’s already there smarter. He and his colleagues have been working on a system of responsive LED lights called luminaires, which they have designed to be energy efficient, increase productivity and improve health by responding to the needs of people in the room. Sensors embedded in the luminaires, called “time-of-flight” sensors, can detect people and objects and change lighting intensity, turn lights on and off and even adjust color. For example, the system could change the balance of red and blue light to mimic sunlight in a room without windows, rather than relying on fluorescent bulbs.

The sensors measure location by emitting a brief pulse of light and timing how long it takes that light to reach the people and objects in the room, a process that is also used in some types of radar or sonar. By combining time-of-flight data from multiple sensors throughout a room, it is possible to differentiate between people, pets and furniture, and to classify actions such as sitting, standing, or writing on a whiteboard. For example, a speaker at the front of a classroom could use arm movements to change the lighting settings in the room or to advance the pages of a PowerPoint presentation.

Researchers also hope that the luminaires can positively affect human health. According to the Mayo Clinic, certain types of depression, such as seasonal affective disorder and circadian rhythm disorders, can improve with exposure to different levels of light.

LESA ERC’s patented lighting system can potentially change the landscape of smart lighting, and the researchers are also exploring commercialization opportunities. Right now, most people rely on passive sensors that don’t respond to human needs. “If I sit at my desk and don’t move, after 15 minutes the lights go out. All the offices are like that,” Little says. But it’s good to know that in the near future, a “smart building” with responsive luminaires could turn on the lights for us, set themselves up for our school or work purposes, and maybe even make us healthier while they do it. —CAITLIN BIRD
All eyes were on the Class of 2017 as 364 graduates moved forward in their new careers.

ENG Alum Bob Hines Is a NASA Astronaut Candidate

Hines (ENG’97) survived a selection process where the odds against making it were, well, astronomical: a record 18,300 people applied for the astronaut slots. The Air Force combat veteran and lieutenant colonel in the Air Force Reserve has been a research pilot at the Johnson Space Center in Houston for five years.

Hines’ possible assignments range from the International Space Station to commercial spacecraft to journeying into deep space as part of NASA’s Orion project, which has an ultimate goal of reaching Mars. “We are going to be thrilled to do whatever mission they put in front of us,” says Hines, adding that his generation of space explorers is surfing an expanding wave of opportunity. When he started working at NASA five years ago, the agency’s mission “was probably at the bottom of the bathtub,” as the space shuttle program ended. “The parking lots were pretty empty.” But with the range of upcoming missions, he says, “The space world is our oyster right now.”

Hines’ course of study as an aspiring astronaut will combine a trekkie’s wildest dreams with rigorous intellectual requirements. “Spacewalks are the hardest thing, physically and mentally,” NASA said in announcing its new class, so candidates must demonstrate their prowess in a giant pool that simulates weightlessness, training in spacesuits to master life support systems, handle emergencies and make space station repairs.

“Spacewalks are the hardest thing, physically and mentally,” NASA said in announcing its new class, so candidates must demonstrate their prowess in a giant pool that simulates weightlessness, training in spacesuits to master life support systems, handle emergencies and make space station repairs.

Learning the International Space Station’s advanced technological systems, including its robotic arm, as well as Russian (along with English, one of the station’s two international languages) are also part of the regimen. Before he graduated, Hines had done independent research with Associate Professor Sheryl Grace (ME), who wrote him a recommendation for the Air Force. For his part, he credits BU, and particularly Grace, with teaching him the “foundation of engineering and engineering discipline” undergirding his career.

Born in North Carolina and raised in Pennsylvania, the 42-year-old Hines majored in aerospace engineering at ENG and earned a master’s degree from the US Air Force Test Pilot School. He also holds a master’s in aerospace engineering from the University of Alabama.
Commissioned in 1999 by the Air Force Officer Training School, he has served 18 years on active duty or in the reserves. In those capacities he recalls, he would be gratified to be in radio communication with US soldiers after dropping a bomb and hear the background noise of enemy fire suddenly stop. During the execution of deposed Iraq leader Saddam Hussein in 2006, he flew combat patrol over Baghdad, “a pretty bizarre thing,” he says, for a man who first heard of Saddam as a high school sophomore during the first Gulf War in 1991. Hines has numerous military and military honors, including two Air Medals for meritorious achievement during aerial flight and Iraq and Afghanistan Campaign Medals. He and his wife, Kelii, have three children. The astronaut candidates—seven men and five women—reported in August to begin two years of training. When they graduate, they will join an astronaut corps that currently stands at 44 and a tradition dating back to the first US astronauts 58 years ago.—RICH BARLOW
A cardiologist, Binoy K. Singh, MD, (BME’89) fills many roles—provider, educator, communicator and manager among them. Whether he is educating patients about care, managing his team or trying to diagnose a problem, Singh utilizes the skills he learned and honed during his undergraduate years, liked the fact that he joined the Engineering College of Boston University. “It’s an honor to work with Dean Lutchen, who is educating patients about care, managing his team and positively impact the educational experience of students,” he says.

“Now, as he serves as associate chief of the Department of Engineering at Boston University, Singh provides support and guidance to help develop strategic priorities and improve the curriculum for undergraduates and graduates.”

In 2011, Singh made a gift to the College that established the Binoy K. Singh Imagining Laboratory, known colloquially as the Tinker Lab, in 2017. Singh’s gift to the Engineering College of Boston University is the perfect place to pursue his interests in the engineering curriculum to develop his skills and implement and utilize technology and process to address them. His experience at BU has made every other life endeavor easier.”

Singh, who spent much of his childhood in the middle of the country, liked the fact that when it came time to choose a college, Boston University offered a diverse, metropolitan setting and a strong biomedical engineering degree program to develop his skills and interests in math and science, and Boston was the perfect place to pursue his interests in the sciences, medicine, culture and arts. During his undergraduate years, Singh participated in an internship with Haemonetics in Braintree, MA. “The opportunity to work on quality control of transfusion systems and to learn how the important operations in hospital operating rooms was incredibly rewarding. I developed a deep appreciation for teamwork, discipline and responsibility. The experience was one of many while at BU that served to set the foundation of my career,” he says.

Another highlight of Singh’s BU experience was the BME Senior Design Project, when he had the privilege to work with Professor H. Steven Callburn (BME) and his team on a large biomedical engineering research project. Singh’s project focused on the effects of different variables—such as sound frequency, source position and space distance—on sound perception. “To work with a professional team contributing to understanding and advancing the field of auditory research and technology was priceless. The entire experience was the ultimate culmination of a challenging and rewarding undergraduate curriculum,” he says. Now, as he serves as associate chief of cardiology at Northwell Health-Lenox Hill Hospital in New York, Singh’s relationship with the College has evolved into a deeper connection over the years. Singh continues as a dean’s leadership Advisor at the College of Engineering and the Boston University College of Engineering to innovatively support, and positively impact, the educational experience of our next generation of Societal Engineers,” he says. —SARA CODY
“As an engineer, your main job is to be a problem solver, so you have to be able to apply your skills outside of that and you have to be able to apply it wherever you can.”

Summer Mundon (ME’17)
My research focuses on trying to understand how objects change shape. Studying how skin wrinkles, roots writhe in soil and leaves curl as they grow enables us to design new materials. These topics are connected by geometry and mechanics, and they all rely on structural instability. Not long ago, a structure losing stability led to failure and disaster; instability makes rigid materials useless, so engineers had to design around it. Now, the resilience of soft materials has enabled engineers to rethink the role of stability in the design of new materials. In the Mechanics of Slender Structures (MOSS) laboratory, I study the instabilities of thin structures in order to aid in the design of wearable electronics, smart needles, soft robots and ultra-lightweight mechanisms. My research is interdisciplinary, bringing together ideas from physics, mechanics, mathematics, biology and materials science. BU’s culture of collaborative research makes an ideal environment for my work. I often find myself pursuing a research question out of curiosity, only to realize its potential applications much later. I love that the College of Engineering encourages the freedom to pursue curiosity-driven research.