THE UNIVERSITY OF UTAH college of engineering

2019

RESEARCH REPORT

Dean, College of Engineering: RICHARD B. BROWN
Associate Dean for Research: KEVIN WHITTY
Excecutive Director, External Relations and Development: JOSH GRANT
Senior Advisor, Development: MARILYN DAVIES

Research Report Editor: VINCE HORIUCHI
Photography and Graphic Design: DAN HIXSON
Contributing Writer: MARILYN DAVIES

FROM THE DEAN

In 2004, when I arrived at the University of Utah as the newly appointed engineering dean, I didn't know that an economic "tsunami" was about to hit that would end up transforming not just the college, but the entire state as well. After years of being a net exporter of engineering talent and innovation, Utah was about to emerge as America's "Silicon Slopes" with one of the hottest tech economies in the nation. Leading Utah's flagship engineering program through this era has been at times both exhilarating and challenging. But an amazing partnership with visionary state and university leaders has made the journey more fulfilling than I could ever have imagined. And the best is yet to come!

States across the nation are asking why Utah would selectively invest more than $24 million, including an additional $5 million in the 2019 session, in ongoing dollars and $10.45 million in one-time funding in the state's eight university engineering and computer science programs. The answer is in the numbers. According to Cyberstates.org, technology jobs in Utah increased from 49,300 in 2004 to 143,000 in 2018, and since 2010, Utah has grown its base of net tech employment by 39%, giving it the fastest-growing tech sector of any state.

With the addition of 3,505 jobs in just one year, tech-related employment in Utah as a percentage of overall employment rose to 9.3% in 2018. Meanwhile, the average wage for tech jobs increased from $55,800 in 2004 to $74,827 in 2018. Plentiful jobs and rising salaries have contributed to a 30% increase in the state's population, which grew from 2.4M to 3.2M in just 15 years.

Located at the epicenter of so much change, the College of Engineering has been steadily increasing the output and quality of its graduates. In 2018, the college awarded 1,048 engineering and computer science degrees, compared with 562 in 2004. Engineering enrollment has also nearly doubled with a fall headcount of 5,530. We continue to generate nearly half of Utah's BS, MS and PhD engineering and computer science degrees, and the pipeline is full of well-qualified undergraduates. In addition to workforce development, the College of Engineering is fueling the economy with world class faculty research. Expenditures in 2018 topped $95 million, and invention disclosures by engineering faculty were 58, five times more per faculty than in any other college. More important than the numbers is the determination and creativity of our faculty as they address some of the world's most pressing technical, medical and environmental challenges.

While I could not have imagined everything that has happened, I am proud of the college, and proud of the role our faculty and students continue to play in fueling Utah's economy. If there is a tidal wave of economic dynamism, we helped to create it. I am extremely grateful to all of the board members, legislators, university administrators, industry leaders, alumni and friends who have contributed to our success. Now is not the time to slow down.

Richard B. Brown
Dean, College of Engineering

CONTENTS

MEETING UTAH'S WORKFORCE DEMANDS

When Jennifer and Mason graduate from the University of Utah in May 2020, they will be entering one of the nation's hottest tech job markets. Jennifer, a computer science major, aspires to a career in artificial intelligence development and using AI to eliminate problems that may not even yet exist. Mason is another computer science major who plans to become a senior data analyst while completing a master's degree. They are two of the more than 1,000 highly qualified engineering and computer science graduates the College of Engineering will add to the workforce next year.

What both may not know is that they are part of a coordinated, statewide effort to increase the annual output of engineering and computer science graduates among the eight colleges and universities in Utah's System of Higher Education (USHE). Since 2001, Utah legislators have invested $24 million in ongoing funds and $10.45 million in one-time funds to create a highly skilled workforce for America's "Silicon Slopes."

Utah's "Engineering Initiative" was the brain-child of then Gov. Michael Leavitt and came to life in the 2001 legislative session through SB61 Enhancements to the State Systems of Public and Higher Education, sponsored by state Sen. Lyle Hillyard. The initial goal was to double, then triple the output of highly qualified technical graduates. Since then, a succession of governors, legislators and industry leaders have kept the dream alive through additional rounds of targeted appropriations. ***The 2019 legislative session appropriated $5 million in additional funds to USHE's engineering and computer science programs, the largest single increment since the initiative began.***

Investments in Utah's engineering and computer science programs have resulted in a 139% increase in the annual output of degrees, translating into 3,283 graduates a year in these sought-after fields. While the growth is impressive, it's not enough to meet industry demand. According to the most recent data from Cyberstates.org, Utah's tech occupation job postings in 2018 reached 29,499, a 111% increase in postings over 2017, and total tech employment is 143,000, which represents 9.3% of all Utah employment.

In his April 1 address to the Utah Technology Innovation Summit in downtown Salt Lake City, Leavitt noted that Utah's tech industry now accounts for $1 for every $7 of GDP in the state. Despite the success of the Engineering Initiative in fueling such growth, workforce development remains the key factor in the state's continued economic success. Leavitt said, "The Engineering Initiative of 18 years ago is not enough for the next 18. It's time to double it again. Having workers of the 21st century has to be part of an economic vision."

THE LEADING EDGE

THE FINE PRINT

A team of University of Utah biomedical engineers led by assistant professor Robby Bowles have developed a method to 3-D-print cells to produce human tissue such as ligaments and tendons, a process that will greatly improve a patient's recovery. The 3-D-printing method, which took two years to research, involves taking stem cells from the patient's own body fat and printing them on a layer of hydrogel to form a tendon or ligament which would later grow in vitro in a culture before being implanted.

SENSING DANGER

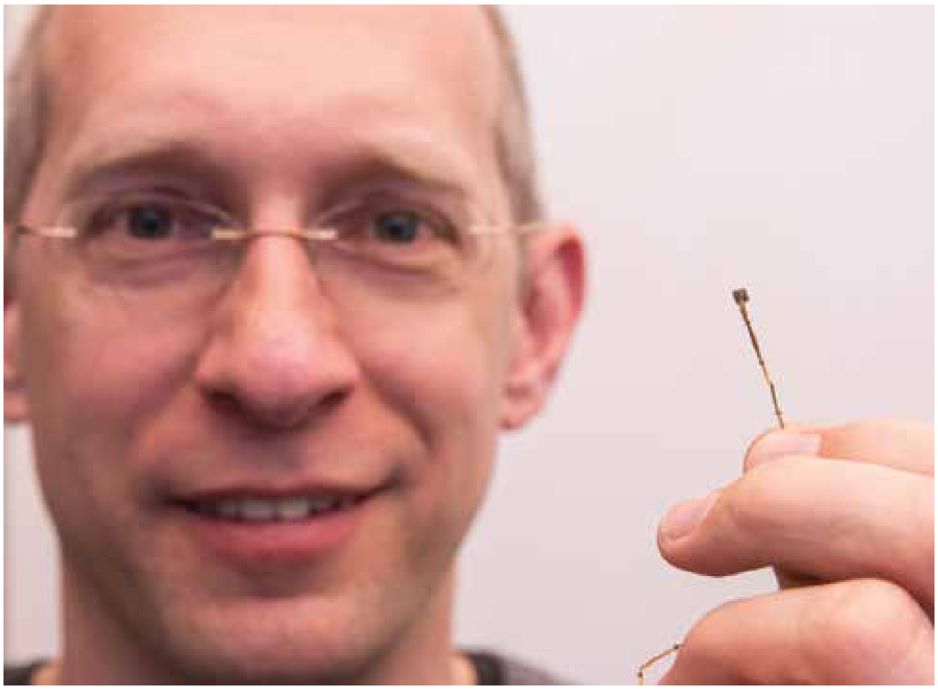
Electrical and computer engineering associate professor Hanseup Kim received a $2.2-million grant from the U.S. Department of Energy to design and build small low-power chemical sensors that can "smell" when a plant is being attacked by insects or overwhelmed by weeds. Corn stalks emit certain organic compounds when they are broken or damaged. When insects like grasshoppers begin to chomp on corn stalks, these compounds are discharged and can be picked up by the sensors. The research will benefit the production of corn, which has many uses.

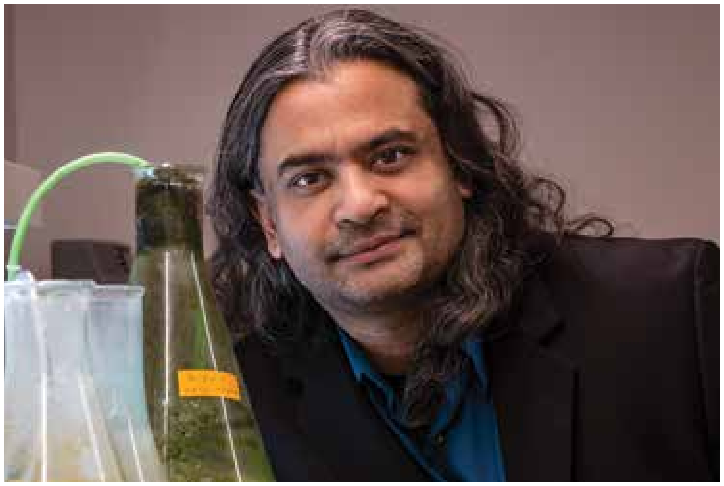
PICTURE THIS

Electrical and computer engineering associate professor Rajesh Menon has discovered a way to create a camera without conventional lenses. Instead, the camera could use a flat pane of glass or any see-through window as a lens. This technology could be used in obstacle-avoidance sensors for autonomous cars, in security cameras for homes in which windows act as lenses, or in augmented-reality goggles to reduce their bulk.

RESTORING HEARING LOSS

Electrical and computer engineering professor Florian Solzbacher is developing an implantable device for the deaf that is expected to produce much higher fidelity sound perception than can be achieved with traditional cochlear prostheses. In the proposed approach, a new version of the Utah Electrode Array, a brain-computer interface developed at the U, would be implanted directly in the patient's auditory nerve, as opposed to electrodes being placed in the cochlea.





ALGAE AS BIOFUEL

Chemical engineering assistant professor Swomitra Mohanty is part of a team that has developed a new kind of jet mixer that extracts the fatty lipids from algae more efficiently. Researchers have been interested in using algae as a biofuel. This mixer uses much less energy than an older extraction method, a key discovery that now puts this form of energy closer to becoming a viable, cost-effective alternative fuel. The new mixer is fast, too, extracting lipids in seconds.

THE AIR UP THERE

Chemical engineering assistant professor Kerry Kelly and associate professor (lecturer) Tony Butterfield are building a network of portable air quality sensors in Salt Lake County to give a more detailed picture of air quality in the area. The portable sensors, which are deployed at homes and schools, report the data to a central server. People can then see the air quality data throughout the county in near-real-time at **www.aqandu.org**. Kelly and Butterfield are also teaching students at local schools about the sensors by letting them build a version of the devices out of toy building blocks.

the miracle of Mucins

In developing new approaches to disease prevention and treatment, engineers and scientists these days are thinking smaller, much smaller. The answer to preventing or treating a host of diseases such as cancer, cystic fibrosis, sepsis and others, may one day be found through a deeper understanding of the chemical and mechanical properties at the boundaries of the human cell.

Our cells are constantly under attack from bacteria, viruses, chemicals and even mutations that cause cancer. Fortunately, we also have a protective layer in the form of mucins (the protein component of mucus) that effectively cover every wet surface in the body. Every time you blink, swallow, cough, digest, or go to the bathroom, your body is being lubricated by some form of mucin. Essential for hydration, nutrition, cell signaling and reproduction, mucins cover 200 times more body surface area than skin.

Researching these essential cell-surface structures is difficult because our cells make many different forms of mucins depending on the tissue they surround, whether they remain attached to the tissue or not, and whether the tissue is healthy or diseased. Human samples are difficult to obtain, and animal mucins vary greatly from ours.

Overcoming some of the obstacles in the study of mucins is University of Utah biomedical engineering assistant professor Jessica Kramer, whose efforts to model cell-surface tissues have already garnered national and international recognition. Since joining the faculty in 2017, Kramer has received The Dream Chemistry Award from the Czech and Polish Academy of Sciences, and most recently, a National Science Foundation Faculty Early Career Award.

The Dream Chemistry Award recognized Kramer's work developing chemical tools to study the mucins on cell surfaces. Mucins are glycoproteins, or proteins with sugars attached. These glycoproteins constitute the major component of the glycocalyx, a glycoprotein and glycolipid covering that surrounds the cell membrane. The 2018 NSF CAREER Award provided $500,000 to support her work in developing a cell-free method to make specific forms of mucins. The goal of these closely-related projects is to create authentic models of cell surfaces that will deepen scientists' understanding of nutrient absorption, fertility and immunity, and ultimately lead to new treatments for life-threatening diseases like cancer, and vascular and lung disease.

Kramer's lab is making fully synthetic human mucus to be used in defined and reproducible models of epithelial tissues. "We can't develop effective treatments without a better understanding of how and why mucins change," Kramer noted. "Mucins mediate the 'crosstalk' between our body and the external world." Her synthetic mucus will be 'tunable' and enable researchers to fit the model or treatment to the disease.

As in the study of mucins, Kramer's lab is also developing tools and methods for precision glycocalyx engineering that will enable systematic studies of the surface of cancerous and pre-cancerous cells. The glycocalyx is an array of glycoproteins, glycolipids and polysaccharides covering the surface of every cell. Cancer cells have a strikingly altered glycocalyx, but scientists don't know why. While the problems are challenging, Kramer finds herself inspired by their complexity. "We are the most advanced technology on the planet," she said. "As scientists, we are trying to learn from our own body's defenses how to prevent disease and infection."

A Salt Lake City native, Kramer began her career as a "pure chemist." After graduating from the University of Utah in chemistry, she worked for three years at Echelon Biosciences as a chemist where she became interested in glycolipids and glycoproteins. She became fascinated by the possibility of creating biological molecules that couldn't be made in any other way. Kramer completed a doctorate degree in organic chemistry from UCLA, followed by prestigious post-doc research at Berkeley and Stanford.

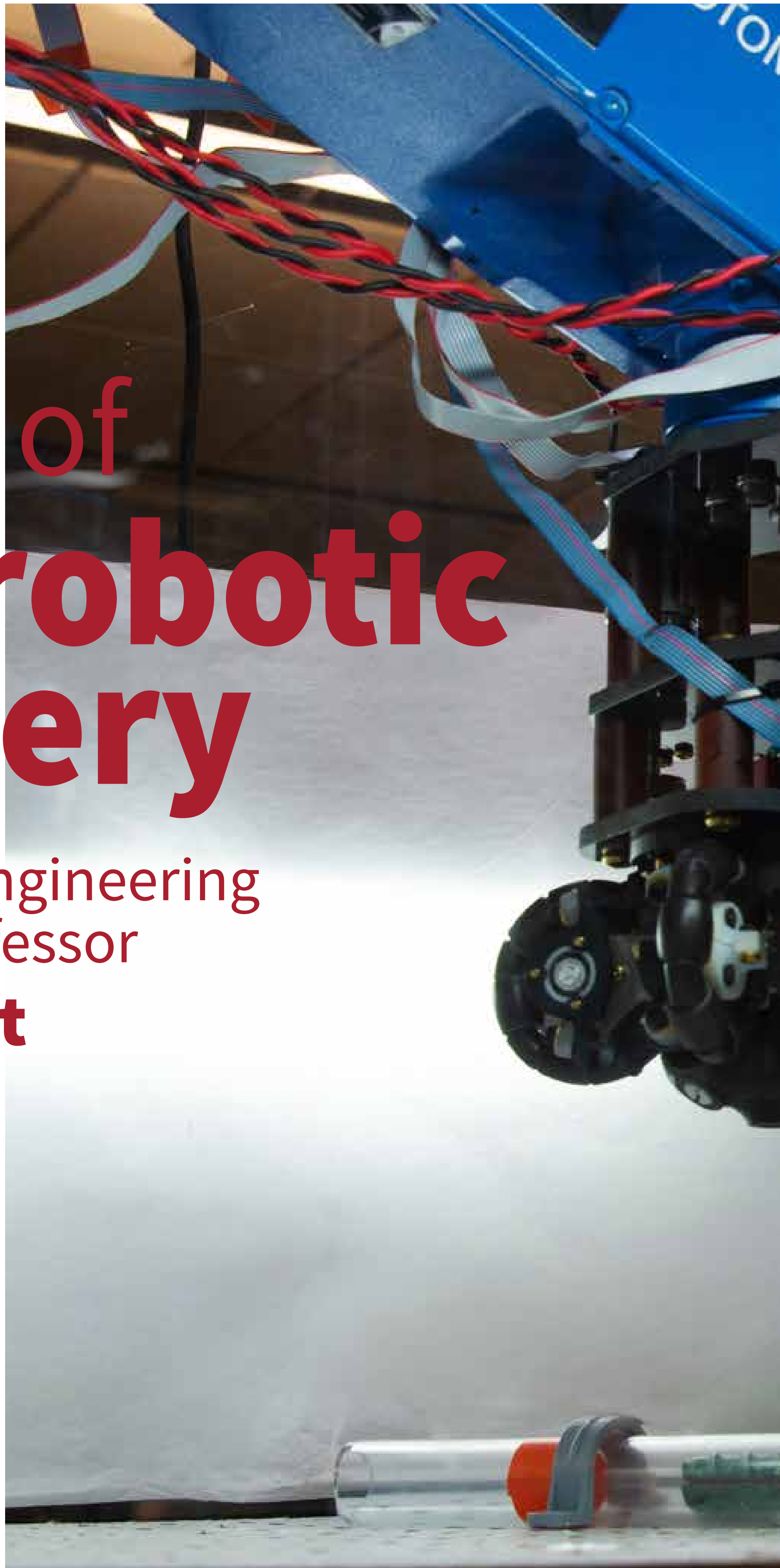
After considering offers from competing institutions, Kramer said, "I came back to Utah for the quality of the research and a top-quality lifestyle. It's important to minimize outside stress so you can focus on the important work at the university."

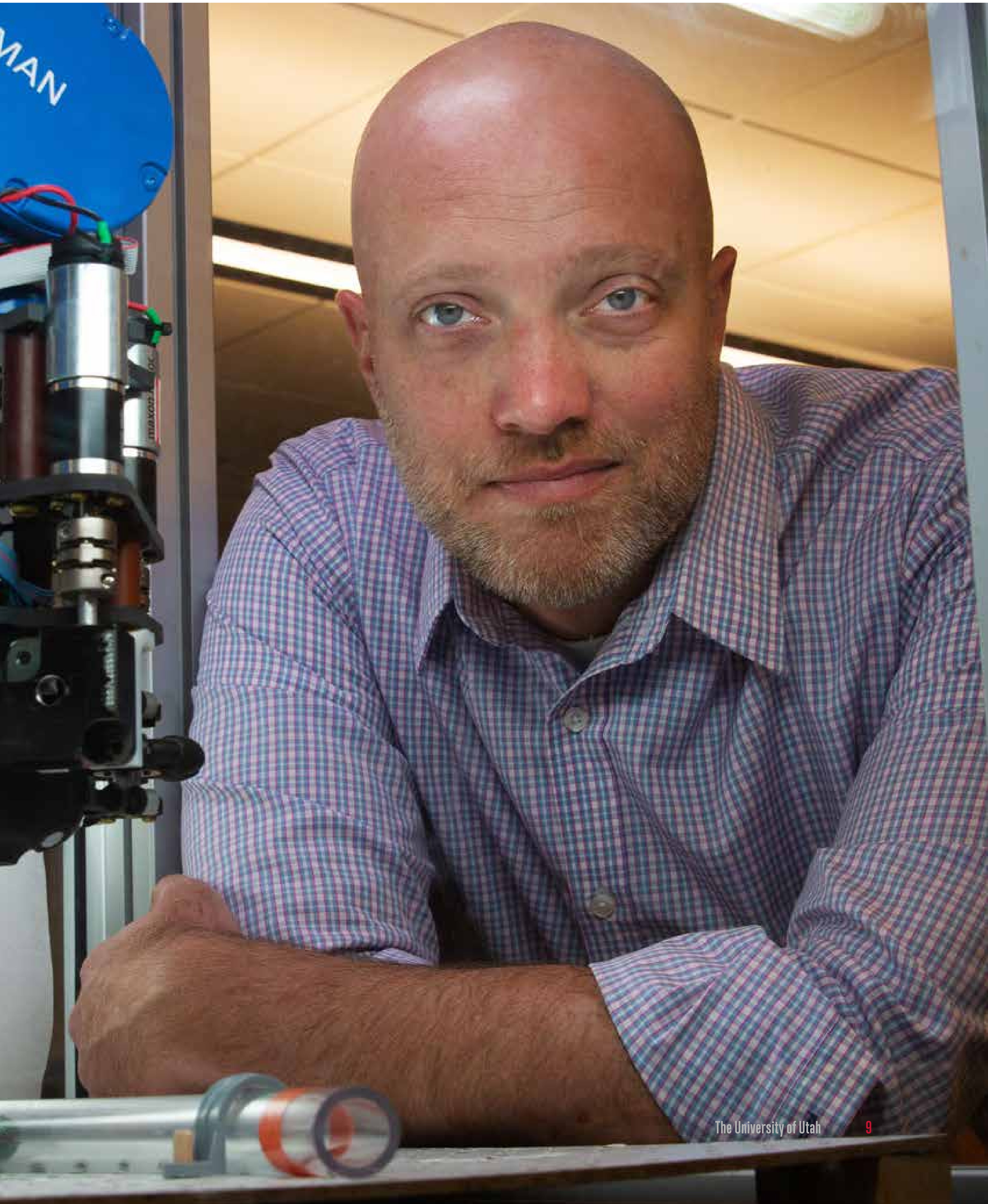
In addition to research, Kramer's responsibilities as a tenure-track faculty member include teaching, mentoring graduate students, publishing and service. She is grateful for the research opportunities she had as a U undergraduate and wants to provide the same quality experience for her students. Kramer's research currently involves five graduate students and two undergraduates.

She is one of the more than 100 outstanding professors who have joined the College of Engineering faculty since 2004, thanks to the funding provided by the Engineering Initiative.

future of Telerobotic Surgery

mechanical engineering associate professor **Jake Abbott**




MAN
maxon

Imagine a day in the future when you arrive at the hospital for your annual GI screening. You swallow a magnetic camera capsule, lie down comfortably and watch a movie while a robot named SAMM (Spherical Actuator Magnetic Manipulator) sweeps painlessly over your stomach and abdomen, gently driving the capsule forward through your GI tract to locate irregularities or potentially malignant tissue growth. No sedation, no invasive endoscope, and no recovery time required.

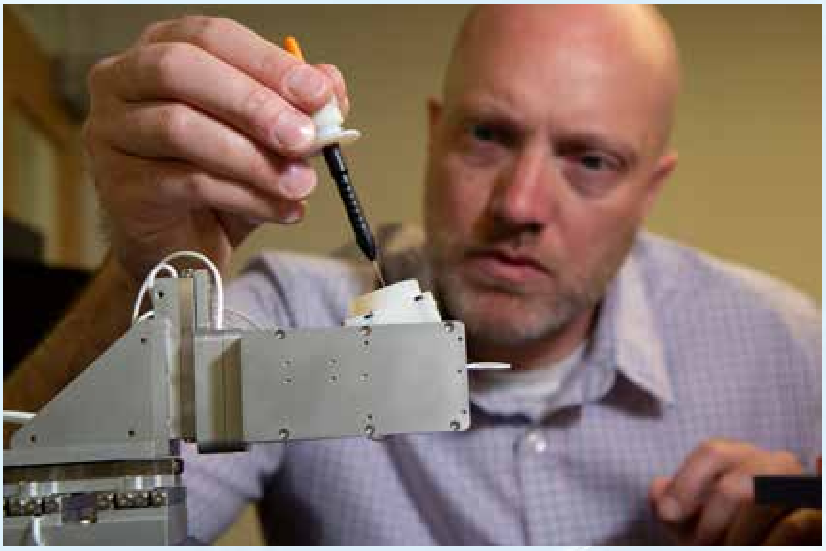
In his Telerobotics Lab, University of Utah mechanical engineering associate professor Jake Abbott and his team are engineering the solutions that will make this dream a reality. And they are betting that patient compliance will improve dramatically with a less-invasive method of detection. Despite the fact that colorectal cancer is the third leading cause of cancer death in the U.S., only 67% of individuals age 50 to 75 get regular colonoscopies.

Other capsule screening approaches are available but are used primarily in the small bowel and rely on the body's natural peristalsis to move and eliminate the device. Abbott's concept contains an internal magnet, a microprocessor and a wireless transmitter. A robotic system hovering over the body locates the magnetic capsule and drives it forward through the entire GI tract while sending real-time images to a computer screen. An important feature of Abbott's device is an external screw thread that enables the capsule to rotate continuously but gently through the complex folds and bends of intestinal tissue.

"Much of the prior research done on helical magnetic swimmers and screws has utilized electromagnetic coil arrangements for control, but these are difficult to scale up to the size of a human body. Also, electromagnetic coils generate heat, which is problematic for applications inside the human body," Abbott explained. "We have proven that it is possible to control such a device using a single permanent magnet moved and rotated dynamically through space."

While the lab is currently studying the gastrointestinal tract, the technology could eventually be adapted to other places in the body. It's one of several robotic systems in his Telerobotics Lab that focus on medical applications. Many of Abbott's systems involve miniature robots that are controlled and moved by magnetic fields.

"Microscale and mesoscale robots have the potential to revolutionize many aspects of medicine. I believe these untethered, wirelessly controlled and powered devices will make existing therapeutic and diagnostic procedures less invasive and will enable new procedures never before possible," said Abbott.



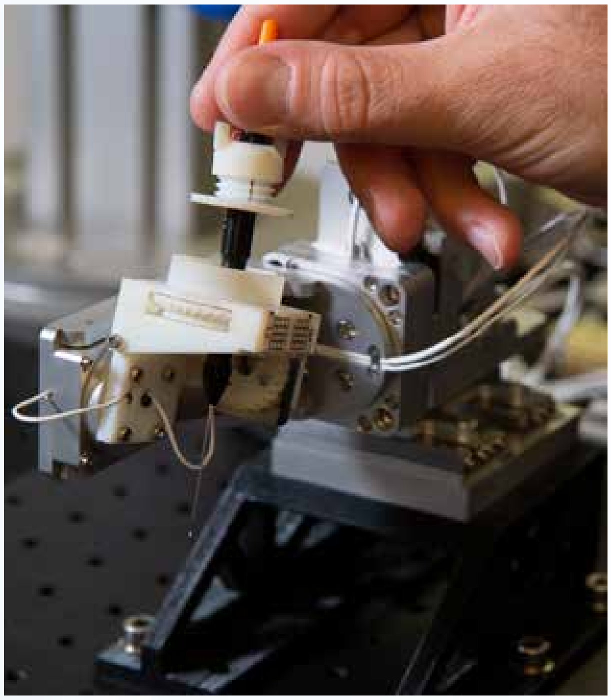
Abbott is also applying magnetic methods to improve the surgical insertion of cochlear implants, which are long, thin electrode arrays that stimulate nerves in the inner ear to provide hearing to a person who is deaf. In the vision of Abbott and his colleagues, a small magnet is attached to the tip of the device which is robotically inserted into the cochlea as it is magnetically guided into place.

"This is a novel, minimally invasive way to implant cochlear devices unlike anything that has ever existed," he said. "Current implantation procedures are traumatic and often result in the clinician accidentally puncturing a critical membrane in the cochlea, resulting in a loss of any residual hearing the patient might have. Our goal is to eliminate the risk of membrane puncture and to make the entire insertion less traumatic to the delicate cochlear structures.

Abbott is definite in his assertion that the robotic systems he creates are designed to assist clinicians, not replace them. This is the goal of his research in telerobotic retinal surgery, conducted with collaborators at Moran Eye Center, with the support of Intuitive Surgical Inc., and the National Eye Institute.

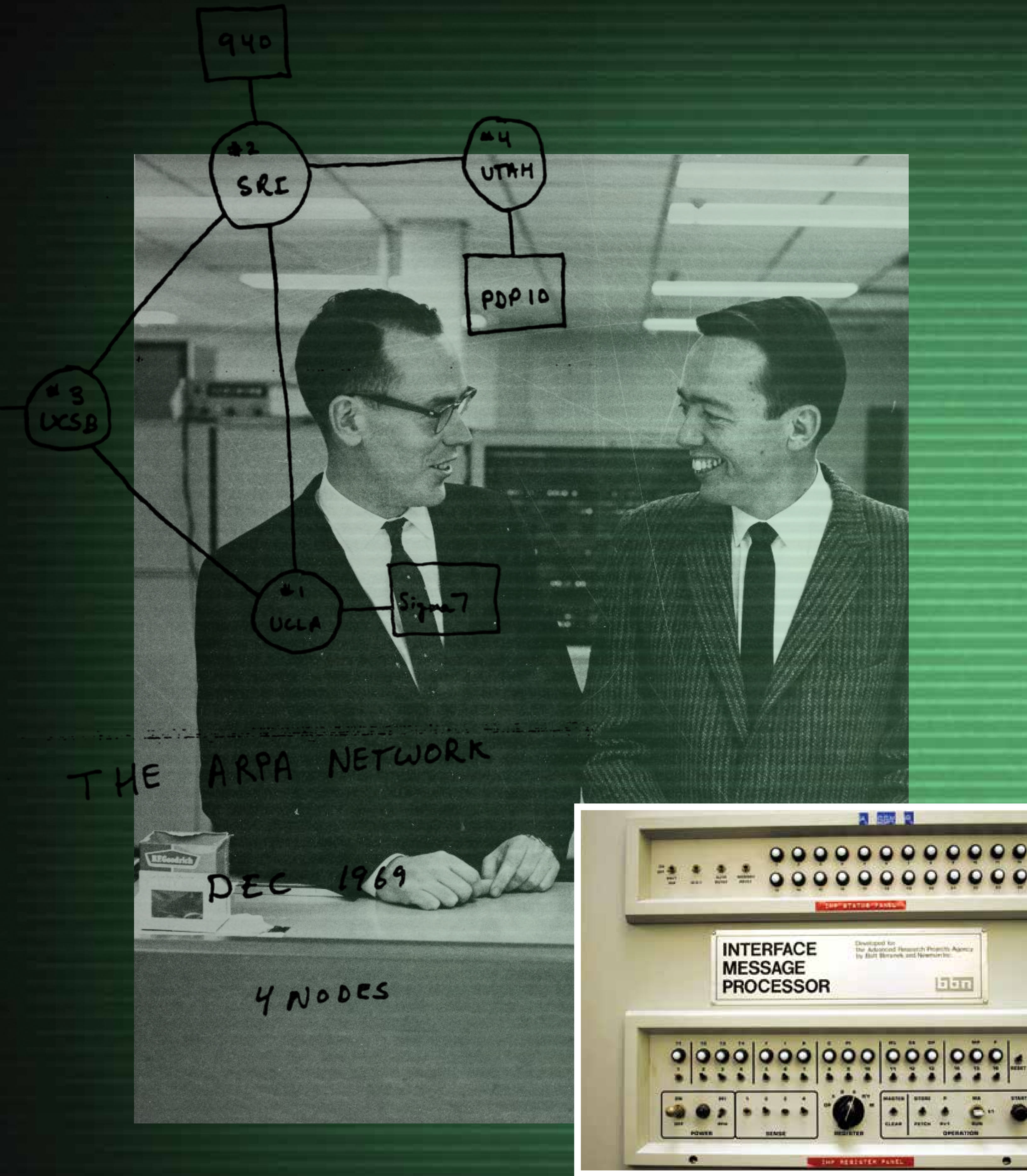
Forces experienced during retinal surgery are below the limit of human sensation and the surgeon must rely on visual feedback only. This puts the retina at great risk where surgical error of a few micrometers can result in the instrument exerting damaging force, causing loss of vision. In addition, many of the up-and-coming therapeutic protocols in ophthalmology, such as subretinal injection of stem cells and gene therapies, are beyond the limits of human ability. A surgeon's hand tremor combined with patient movement due to breathing and snoring limits the surgeon's ability to deliver the therapy to a precise location below the retina.

Abbott's team has developed a robotic manipulator that is more precise than all prior systems designed for robot-assisted eye surgery. At the same time, the system is small and light enough to be mounted on the patient's head using a helmet-like device that Abbott believes will help passively compensate for much of the error caused by patient movement due to breathing and snoring. The goal of the project is to incorporate existing disposable instruments, while delivering submicron precision at the retina. The current model of the robotic manipulator is



designed to facilitate a quick change of instruments and to enable the surgeon to easily and safely pull back the instrument when needed.

Abbott's passion for medical robotics was fueled as a graduate student at the U working on human-robot systems under U mechanical engineering professor Sandy Meek. After completing his master's degree, a move to Maryland for his wife's graduate studies led him to pursue a doctoral degree at Johns Hopkins where he studied with Dr. Allison Okamura, now at Stanford, one of the world's leading experts in haptics in robotics and medicine. That was followed by three years as a postdoctoral researcher at ETH Zurich in Switzerland working with Dr. Brad Nelson, a pioneer in microrobotics and the use of magnetics in robotics. Abbott joined the University of Utah in 2008 and is proud to call Utah his home.


940
#2
SRI
#4
UTAH
PDP 10
#3
UCSB
#1
UCLA
Sigma 7
THE ARPA NETWORK
DEC 1969
4 NODES
INTERFACE
MESSAGE
PROCESSOR
Developed for
the Advanced Research Projects Agency
by Bolt Beranek and Newman Inc.
bbn

Pioneers of the internet

In 1968, the nation's top computer scientists and members of the U.S. government gathered inside the Rustler Lodge atop the Alta Ski Resort in Salt Lake County, Utah. They were about to change the world.

"I was a graduate student at that time, and they invited me to come to this meeting," said Adobe co-founder John Warnock, who was attending the University of Utah in electrical engineering. "At that meeting, they approved the communication network that was going to connect all of the [university] centers together. And that was the ARPANET, which is now the internet."

A year later, four institutions — UCLA, the Stanford Research Institute, the University of California at Santa Barbara, and the University of Utah — became the first "nodes" to the ARPANET, the Advanced Research Projects Agency Network, and the precursor to what is now known as the internet.

On the 50th anniversary of what became one of the world's most significant technological developments, the internet is the foundation of all modern communications, from the web and email to social media platforms such as Facebook and Twitter.

In the 1960s, the Department of Defense's Advanced Research Projects Agency (ARPA) and its Information Processing Techniques Office (IPTO) were looking for a way to network computers together. IPTO director Robert Taylor and program manager Larry Roberts proceeded with a new idea of packet-switching as a means of transferring data from one computer to another. They set out looking for the top universities in the field to research it.

Taylor and Roberts funded David Evans (pictured on the right) and Ivan Sutherland (left) to help achieve their goals. Evans and Sutherland had been building the U's reputation in computer science research and had recruited excellent students such as Warnock and Steve Carr, who participated in the first Network Working Group meeting in 1968 and designed the initial Host-to-Host Communication Protocol for the ARPANET in 1970. The architecture for the ARPANET utilized an Interface Message Processor (pictured inset) at each of the four institutions.

On Oct. 29, 1969, UCLA student Charles Kline was supposed to send as the first ARPANET message, the word "login." The "l" and the "o" got through successfully before the computers crashed. It was a partial message, but they were the first letters transmitted long distance between networked computers.

The U was added as the fourth node in December 1969 using a DEC PDP-10 computer and the TENEX operating system. By 1981, there were 213 nodes connected to ARPANET. In 1990, ARPNET was retired, and most university computers migrated to a newer network. But those first four nodes will be remembered for being the launching point for a technological revolution.

As Taylor noted in a Salt Lake Tribune interview in 2017, "Of course we added many more nodes in 1970 and later, but the first four always stood as an important milestone in networking.

Getting Data Down to a Science

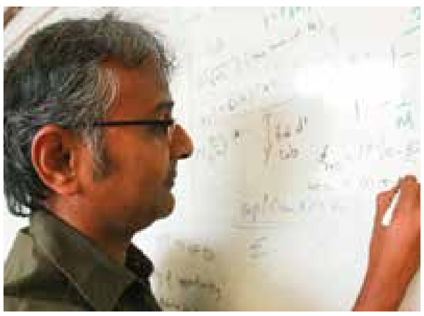
Data analysis is the backbone of services like Netflix, Facebook, Spotify and more. It's also become a critical aspect for nearly all research and an emerging science that touches on many aspects of life. The University of Utah's School of Computing is focused on innovative research and developing a robust curriculum in data science. See the aggressive steps we're taking to prepare students for this growing field.

Data science has become one of the hottest tools to aid researchers and businesses, whether it's to predict consumer habits, recommend which movie to watch or zero in on cancer causes.

The University of Utah's School of Computing is at the leading edge of research in this mushrooming field, and

has developed a series of comprehensive educational programs to prepare students to work in this high-demand field.

"Data science has become important because computer hardware has become so much more powerful," University of Utah School of Computing associate professor Jeff Phillips (pictured above) said. "We are able to capture a lot of data and store it cheaply and easily, and we're able to process that data for more complex predictions."



Gathering consumer data is the bread and butter for companies like Facebook, Google and Amazon, whose main source of revenue comes from advertising tailored to users' buying habits. Meanwhile, researchers in every discipline are relying more on data analysis for their work. As a result, a "data scientist," someone employed to analyze and interpret complex information for research or business, has become a much sought-after employee. The number of available data science jobs jumped 29% in just the last year and 344% since 2013, according to job recruiting site, Indeed.com. This rapid job growth has caused a serious shortage of data scientists.

Many of the School of Computing's faculty conduct leading research and/or instruct students involving data science. Phillips has taken the lead in organizing the wide-ranging data analytics academic programs and coordinating the broad data analytics research activities in the School.

Data Management and Analysis Track — This is the comprehensive track for masters and doctoral degrees in computing that cover data science. Basic areas of study are machine learning, data mining, visualization, databases, and algorithms.

Graduate Certificate in Big Data — For non-traditional students such as full-time employees looking to boost their education, this five-course graduate certificate program covers the same areas as the data management and analysis track but through online courses. The certificate is also perfect for students looking for a career change into the more lucrative field of data science.

Bachelor of Science in Data Science — This newly-approved degree launches this fall and is designed to give students the core data science fundamentals, techniques, and skills in an undergraduate degree. "The degree gives them the most critical material to start their career," Phillips said.

Utah Center for Data Science — Phillips and the School of Computing, together with the math department, are developing a university center in which students and faculty across campus can collaborate with computer scientists and statisticians on data-driven research. The purpose is to help researchers in other fields such as medicine, the humanities and social sciences to use data analysis more effectively.

On the research front, many School of Computing faculty members have been developing techniques for analyzing data faster and more efficiently, visualizing big data more effectively, and applying data science to the myriad disciplines where it can advance medical care, improve operational efficiencies, and accelerate scientific discoveries.

Professor Suresh Venkatasubramanian (pictured opposite, bottom), for example, is a pioneer in the rapidly-growing area of algorithmic fairness to ensure that automated decision-making systems produce unbiased decisions. His most recent project examines the ways in which social networks — which have become important sources of information and recommendations — can create patterns of inequality and how we might intervene in these networks to improve access to information for disadvantaged people.

He has also examined how algorithms used in job-search software or programs that calculate sentencing recommendations for criminals could possibly be biased in their outcomes and how they can be corrected.

School of Computing assistant professor Bei Wang (pictured opposite, middle) is collaborating with a team to develop novel statistical methods for combining imaging and behavioral data to understand how the properties of complex brain networks give rise to behavioral traits in autism and other neuropsychiatric disorders.

"A major barrier to creating effective treatments for autism is the lack of understanding of the specific brain mechanisms involved and how these are related to certain behavioral symptoms," she said.

Phillips is studying how to analyze massive amounts of data faster and more accurately. By allowing a small degree of approximation in the algorithms, one can deal with larger datasets and considerably increase the speed of analysis. He strives to optimize the balance between accuracy and speed in different applications. His approaches for handling very large datasets could be beneficial, for example, in examining disease outbreaks. "It allows us to interact with the data in more complex ways," he said.

Similarly, School of Computing professor Feifei Li has been conducting studies involving massive amounts of data from social media, such as tweets, by using geotags and other metadata. And associate professor Miriah Meyer has taken air pollution data streamed from air quality sensors around Salt Lake County to visualize the air condition in near-real-time.

Data science has become a new frontier for computing in both academia and industry. The College of Engineering is committed to staying at the forefront of this field and collaborating with researchers across campus to advance data science at the University of Utah.

"Data science is the ultimate connector on campus," Phillips said. "Just as calculus training is universal for any technical degree, data science will be fundamental to all research disciplines."

nuclear Fingerprints

It's a scary thought, but sometimes someone loses nuclear material. A sample of refined uranium or plutonium is discovered or unearthed somewhere in the world, raising a bevy of questions that need answers fast. Where did it come from? Who lost it? Was it stolen?

Fortunately, radioactive particles leave "fingerprints" that can answer some of those questions, and University of Utah civil and environmental engineering assistant professor Luther McDonald is working on ways to speed up the process of identifying the origins of mysterious nuclear material.

"That's the Holy Grail of nuclear forensics: Where did it come from? What is the route it took in being trafficked?" he said. "That can tell you the people who are responsible for moving it."

With funding from the U.S. Department of Homeland Security and the Department of Defense, McDonald and his team are developing a faster way of characterizing radioactive particles, particularly uranium, by examining their unique signatures. They synthesize uranium oxide by creating its chemical precursor, which is a paste, and then bake it in a furnace. The resulting ceramic-like material is then imaged with an electron microscope to determine the particles' size and shape. Another process they use to analyze a sample involves machine learning and algorithms developed for brain scans. The size and shape of the particles can help investigators determine which agency or company produced the material.

"It's like doing facial recognition, but on a uranium particle," McDonald said.

Another signature they examine is the oxygen isotopes attached to the particles. Oxygen is almost always found with uranium. The concentration of two stable oxygen isotopes — oxygen 16 and oxygen 18 — that accompany a radioactive particle, vary based on the latitude, longitude and altitude where the particles came from. McDonald said they can study the ratio of each isotope to help determine the material's place of origin.

A problem with these methods of analysis, however, is that variables such as humidity or impurities in the sample can change the results. Consequently, government labs that conduct nuclear forensics do not utilize them yet. McDonald and his team are studying how these variables change the outcome to more accurately predict the processing history and source of the nuclear material. He believes the morphology (the study of size and shape) of radioactive particles could become a valid tool for investigators in the next five to 10 years because the process is much faster than current methods.

"A full nuclear forensics investigation can take a week to a month," he said. "The goal with the morphology and oxygen isotopes is to make those measurements in a day."

McDonald's success in his research thus far has garnered a lot of attention and led to Forbes recognizing him as one of the "30 Under 30" science researchers to watch for in 2018.

"It was nice to have recognition from people who think that the science I do is cool," he said.

McDonald is a faculty member in the University of Utah's nuclear engineering program within the Department of Civil and Environmental Engineering. It offers master's and doctoral degrees in nuclear engineering as well as an undergraduate minor. With its unique facilities, the program provides education and research in nuclear processes, instrumentation and systems as well as the proper safeguards required for the protection of communities.

McDonald received his bachelor's degree in chemistry at the University of West Florida and a doctorate in environmental radiochemistry at Washington State University. He became interested in nuclear forensics because "I was just fascinated in the bottom row of the periodic table [which have the radioactive elements uranium and plutonium]," he said.

He also understood the importance of being accountable to all nuclear material for the safety and security of the world.

"If people know we can identify [culprits who try to steal nuclear material], then they are less likely to try and do it because they will know the consequences," he said. "That can act as a deterrent. We want people to have peaceful nuclear power."

NEW FACULTY

The University of Utah's College of Engineering is proud to hire some of the world's brightest and most inventive researchers and educators to its faculty. Adding 14 new faculty members this year is also a sign that the college's faculty continues to grow at a staggering rate to meet the demands of its rising student body.

GLENN SJODEN
PROFESSOR
CIVIL & ENVIRONMENTAL ENGINEERING

TSUNG-WEI HUANG
ASSISTANT PROFESSOR
ELECTRICAL & COMPUTER ENGINEERING

CUNXI YU
ASSISTANT PROFESSOR
ELECTRICAL & COMPUTER ENGINEERING

YI ZHOU
ASSISTANT PROFESSOR
ELECTRICAL & COMPUTER ENGINEERING

JUNGKYU KIM
ASSOCIATE PROFESSOR
MECHANICAL ENGINEERING

ROBERT PARKER
PROFESSOR
MECHANICAL ENGINEERING

PAI WANG
ASSISTANT PROFESSOR
MECHANICAL ENGINEERING

QINGYAO AI
ASSISTANT PROFESSOR
SCHOOL OF COMPUTING

MARINA KOGAN
ASSISTANT PROFESSOR
SCHOOL OF COMPUTING

ALAN KUNTZ
ASSISTANT PROFESSOR
SCHOOL OF COMPUTING

PAVEL PANCHEKHA
ASSISTANT PROFESSOR
SCHOOL OF COMPUTING

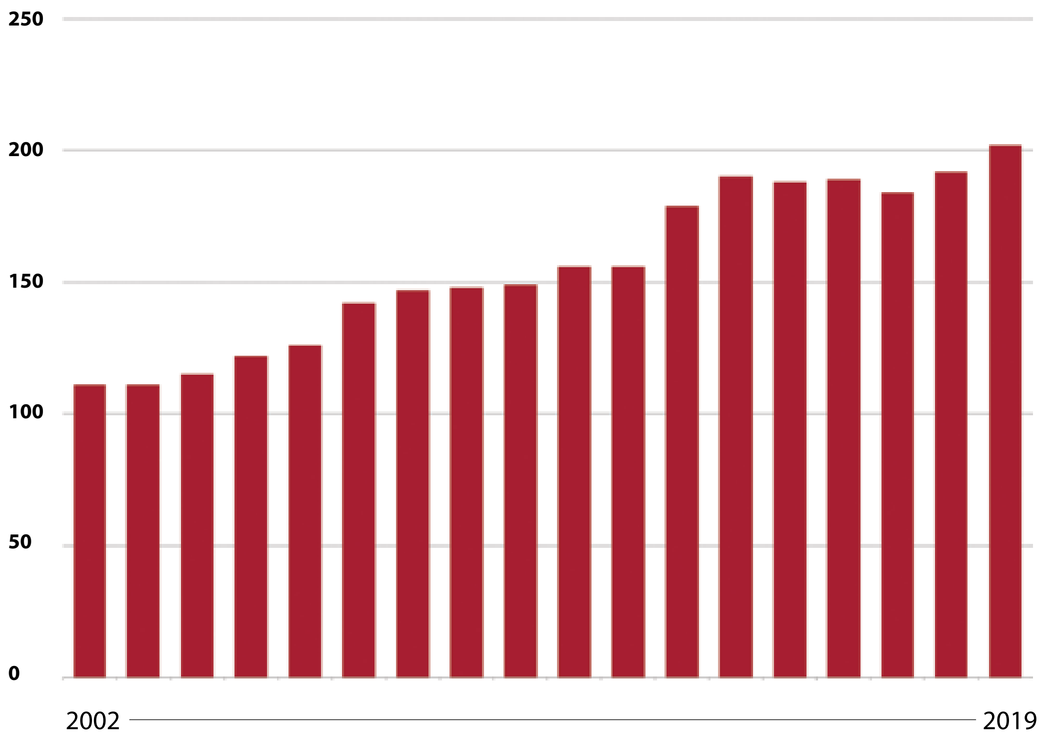
PONNUSWAMY SADAYAPPAN
PROFESSOR
SCHOOL OF COMPUTING

BLAIR SULLIVAN
ASSOCIATE PROFESSOR
SCHOOL OF COMPUTING

MU ZHANG
ASSISTANT PROFESSOR
SCHOOL OF COMPUTING

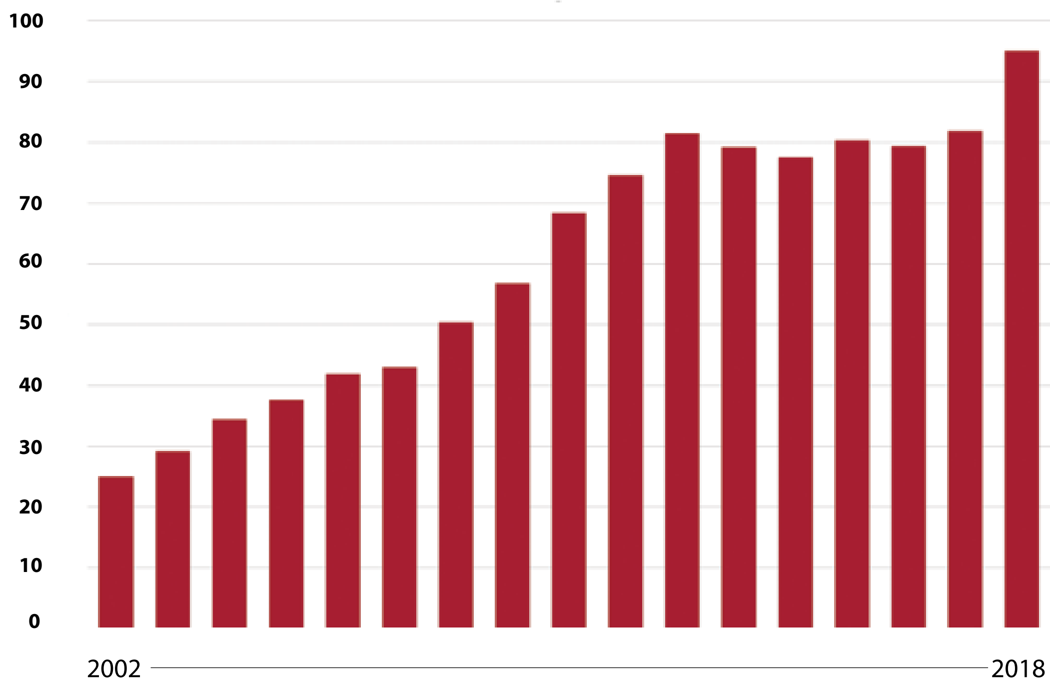
BY THE NUMBERS

TENURE TRACK FACULTY GROWTH



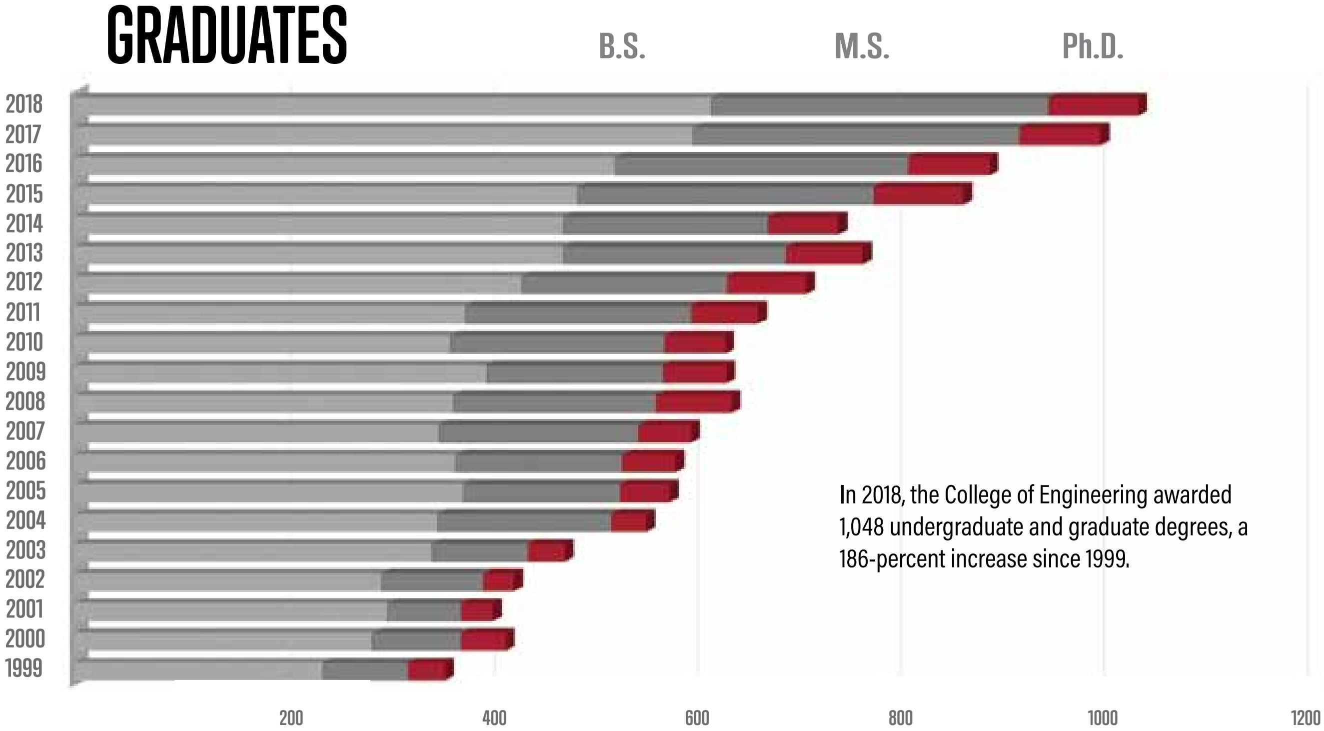
To meet the tremendous influx of students in the University of Utah's College of Engineering, we have been continually adding faculty who are world-class educators and researchers. This year, the college has 202 tenure-track faculty members, 82% more than in 2002.

ENGINEERING RESEARCH EXPENDITURES AT THE U



Our faculty and students are involved in cutting-edge research, from biomedical devices to robotics and computer software. Last year, the university's engineering-related research expenditures continued to skyrocket, reaching more than $95 million, a 280% increase from 2002, according to the *ASEE Databook*.

GRADUATES



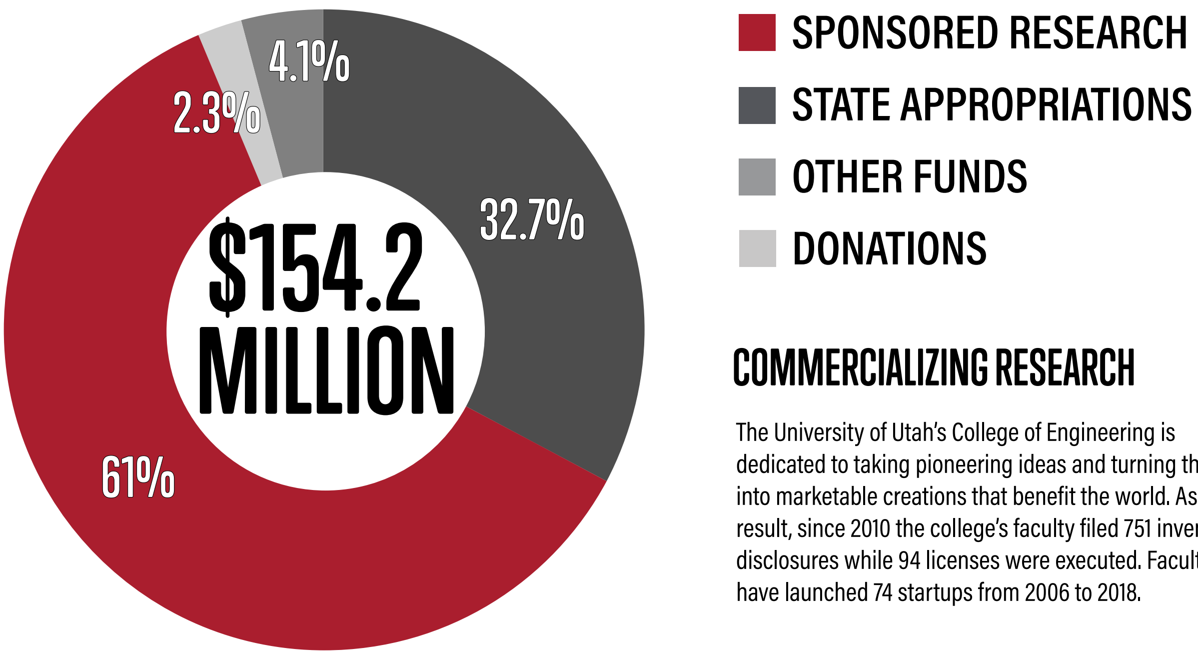
In 2018, the College of Engineering awarded 1,048 undergraduate and graduate degrees, a 186-percent increase since 1999.

RANKINGS

The University of Utah's College of Engineering is among the nation's most respected engineering institutions and is continually ranked favorably in a number of areas, according to the Profiles of Engineering & Engineering Technology by the American Society for Engineering Education.

- Research expenditures — #34 (out of 289 schools)
- Engineering doctoral degrees awarded — #39 (out of 219 schools)
- Doctoral enrollment — #36 (out of 207 schools)
- Tenured/tenure-track faculty members (#28 out of 320 schools)

ENGINEERING BUDGET 2017-2018

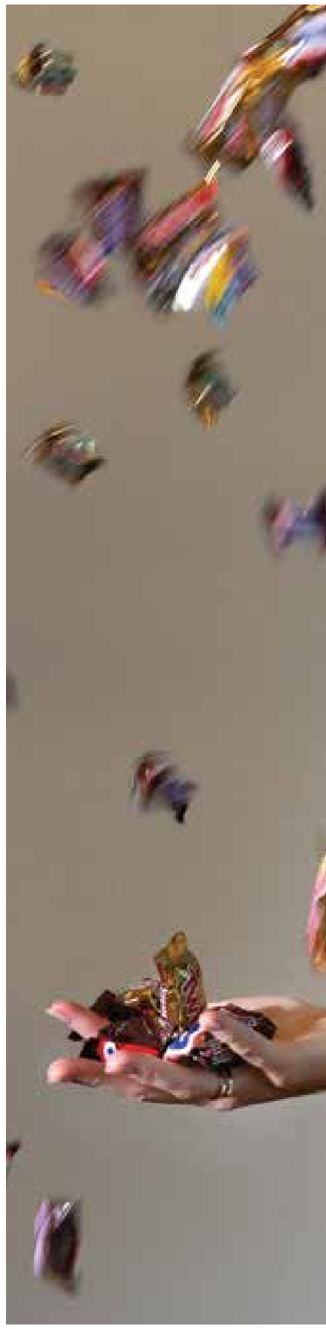


COMMERCIALIZING RESEARCH

The University of Utah's College of Engineering is dedicated to taking pioneering ideas and turning them into marketable creations that benefit the world. As a result, since 2010 the college's faculty filed 751 invention disclosures while 94 licenses were executed. Faculty have launched 74 startups from 2006 to 2018.

ALUMNA PROFILE

STACEY Espinosa



Stacey Espinosa graduated from the University of Utah's College of Engineering and landed a truly sweet job.

The 2009 chemical engineering graduate fulfilled a life-long dream of working with confectionary goodness. She is the R&D Senior Manager, Global Product Development for Gum and Mints for Mars Wrigley in Chicago, makers of some of the world's most beloved candies, from M&Ms to Snickers bars. She leads a team that is responsible for the development and delivery of product innovation for brands such as Extra gum, Life Savers, and Altoids mints.

"I love candy, and that is why I got into chemical engineering," she said. "I realized I could make a good living working on something I loved and that brings joy to a lot of people"

During her first day of class in Introduction to Chemical Engineering, professor Eric Eddings asked the students why they wanted to pursue that discipline. "I put my hand up and said, "I want to make candy,"' Espinosa remembered. "If you think about products you love and the experiences that you love, there is engineering behind it, and for me, that was candy."

While attending the U, she interned with Kellogg's helping develop a mixing system for the icing for Pop Tarts and optimizing packaging for breakfast cereal. After graduating, she landed her first fulltime job at Procter & Gamble in Cincinnati as an engineer and then senior engineer in their Bounty Paper Towel & Napkins business. Then in the summer of 2014, she and her husband moved to Chicago where she got a job at Mars Wrigley as a senior product developer in North America Gum and Mints.

Since then, Espinosa has risen rapidly in the company, first moving into a product development management role, then into her current position as R&D senior manager where she translates the science of making candy into a business strategy to grow the gum and mints division across the world.

"We have a lot of different functions at Mars Wrigley — product development, engineering, science — and we all work together to understand what's possible and what's scalable. That's one of the biggest challenges," she said about the importance of teamwork at the company. "The quality has to be there from beginning to end, and then you have to take that product innovation and make it possible for everybody to have it."

It takes tremendous teamwork to develop the company's innovative products, she said.

"R&D works with engineering, marketing, finance, supply chain, and consumer insights to understand global trends and what consumers want," she said. "We're responsible for ensuring we deliver consistent quality and a consistently delicious product experience to our consumers."

Espinosa said attending the University of Utah's College of Engineering was the foundation that launched her successful "Willy Wonka life."

"I not only learned the fundamentals of science and engineering, but I also learned about collaboration and working together, and that was such a big part of the program," she said. "Dr. Eddings and people like [former U chemical engineering professor] JoAnn Lighty and other professors there were always so supportive and curious about my passion, and they helped me find the different opportunities to be in engineering food."

ENAC

UNIVERSITY OF UTAH COLLEGE OF ENGINEERING ENGINEERING NATIONAL ADVISORY COUNCIL

John D. LaLonde - Chair
Chief Technology Officer
Abstrax Inc.

David C. Aldous
Chief Executive Officer
Rive Technology, Inc.

Bert L. Blaha
Co-Executive Officer
IM Flash

Don R. Brown
President
Partnet

Densen Cao
President and CEO
CAO Group, Inc.

Craig S. Carrel
President
Team 1 Plastics

Edwin Catmull
Retired - President
Walt Disney and
Pixar Animation Studios

Ronald H. Dunn
President
Dunn Associates, Inc.

Chris Durham
Executive VP, Acquistions &
Product Integration
Merit Medical Systems

Mark Fuller
Chairman and CEO
WET Design

Scott D. Gochnour
Chief R&D Officer
Civica Rx

Jeanette L. Haren
VP, Product Assessment &
Talent
PowerSchool

Kim P. Harris
Principal
Van Boerum &
Frank Associates, Inc.

Brett Helm
Chairman and CEO
DB Cybertech

Paul J. Hirst
Chairman and CEO
CRS Engineers

Jason E. Job
President and CEO
Job Industrial Services, Inc.

David S. Layton
President and CEO
The Layton Companies

Paul Mayfield
Director of Program
Management
Microsoft Corporation

Gretchen McClain
Principal
GWMcClain Advisory Services

Harold W. Milner
Chairman
VFC, Inc.

Ken Muir
Gen. Mgr & VP Analytics/IDOL,
Operations, Security & Stategy
- IM&G
Micro Focus

John R. Njord
Consultant
John R. Njord, LLC

Jonathan Oomrigar
Consultant

Susan D. Opp
Retired - Senior VP-Strategy
L3 Technologies –
Communication Systems West

Steven G. Parker
Vice President of Professional
Graphics
NVIDIA Corporation

David Pershing
President Emeritus
Distinguished Professor
U of U Department of
Chemical Engineering

Christopher H. Porter
Founder
Medical Genesis, Inc.

Jonathan W. Richards
Senior Counsel
Workman | Nydegger

Shane V. Robison
Senior Technology Advisor

Michael W. Soulier
Retired - Director Human Resources
E. I. Du Pont De Nemours & Co.

Jeff Spath
Head, Dept. of Petroleum Engineering
Texas A&M University

Gregory P. Starley
Managing Director
Star Portfolio Ventures, Inc.

Gerald B. Stringfellow
Distinguished Professor
U of U Dept. of Electrical &
Computer Engineering and Materials
Science & Engineering

Randal R. Sylvester
Chief Technologist
L3 Technologies –
Communication Systems West

Anne Taylor
Retired - Vice Chairman &
Managing Partner
Deloitte

J. Howard Van Boerum
President Emeritus
Van Boerum & Frank
Associates, Inc.

John A. Williams
Founder & General Manager
EPS, LLC

Jerry K. Young
Director Materials &
Manufacturing Technology
Boeing Company

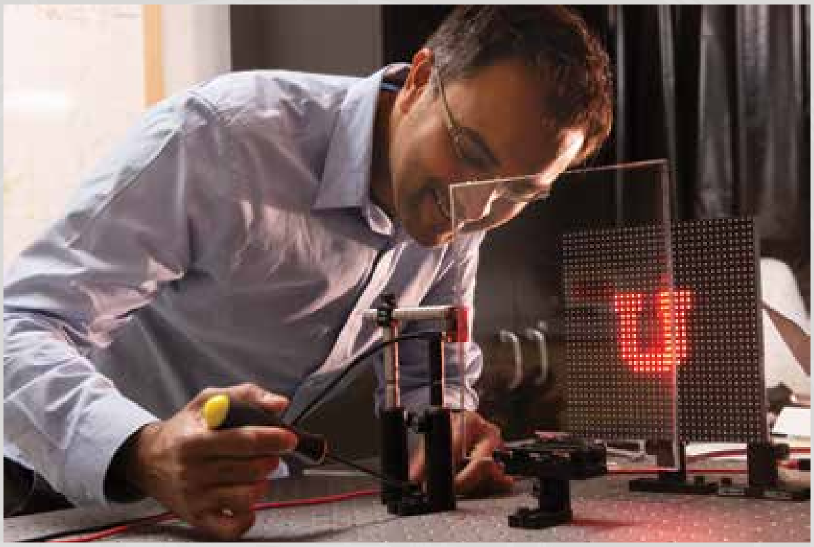
EX OFFICIO

Richard B. Brown
Dean
College of Engineering

Josh Grant
Executive Director of
Development
& External Relations
College of Engineering

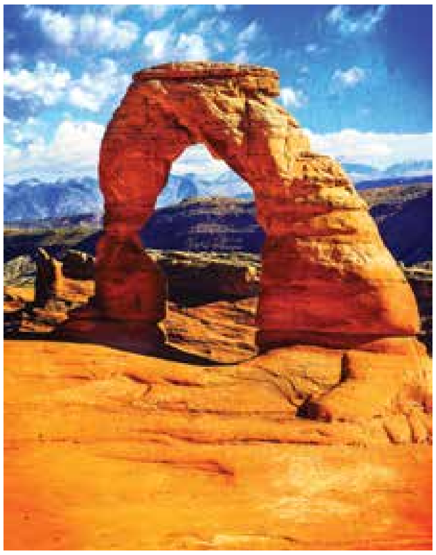
John C. Sutherland
Chair - Industry Advisory
Board
Assistant CIO
Brigham Young University

MULTIDISCIPLINARY RESEARCH CENTERS AND INSTITUTES



- Alliance for Computationally-guided Design of Energy Efficient Electronic Materials
- Biomedical Image and Data Analysis Center
- Carbon Capture Multidisciplinary Simulation Center
- Cardiovascular Research and Training Institute
- Center for Controlled Chemical Delivery
- Center for Engineering Innovation
- Center for Extreme Data Management Analysis and Visualization
- Center for Multi-Scale Fluid-Solid Interactions in Architected and Natural Materials
- Center for Neural Interfaces
- Center of Excellence for Biomedical Microfluidics
- Energy & Geoscience Institute
- Global Change & Sustainability Center
- Institute for Clean and Secure Energy
- Intel Parallel Computing Center for Data Analysis and Visualization
- Intermountain Industrial Assessment Center
- Manufacturing Extension Partnership
- Nano Institute
- NIH Center for Integrative Biomedical Computing
- NVIDIA CUDA Center of Excellence
- Scientific Computing and Imaging Institute
- U.S.-Pakistan Centers for Advanced Studies in Water
- University of Utah Robotics Center
- Utah Center for Interfacial Sciences
- Utah Center for NanoBioSensors
- Utah Center for Nanomedicine
- Utah Nanofab

LIFE IN UTAH



Utah has the fastest-growing tech economy in America. In the last 20 years, the state has gone from 1,500 tech companies to 6,700. The New Yorker already has called us "the next Silicon Valley." As a result, Utah's economy is booming and has one of the lowest unemployment rates in the country. Even better, all of this economic buzz is occuring amid some of the nation's most scenic landscapes and best outdoor recreational opportunities. That unique combination gets noticed. Here are some of the many accolades Utah and Salt Lake City have received recently.

UTAH

#1 State for Entrepreneurs — Amazon
#1 Economic Outlook Ranking — American Legislative Exchange Council
#1 State for Private Sector Job Growth — State Policy Report
#1 The Best Colleges for Skiers in the Mountain West (University of Utah) — Powder
#1 Best Mountain Towns in America (Park City) — Men's Journal
#2 Best Economy — U.S. News & World Report
#2 Best State for Business — Forbes
#2 Best State to Start a Business — WalletHub
#2 Best States for Winter Activities — GoAllOutdoors.com
#2 Happiest States in America — WalletHub
#2 Best Ski Destinations in the USA (Park City) — U.S. News & World Report
#3 Top State for Business — CNBC
#4 Best State in America — MarketWatch
#4 Best States — U.S. News & World Report

SALT LAKE CITY

#1 Best Cities to Start a Career — WalletHub
#1 10 Cities with Amazing Job Opportunities Right Now — CNBC
#1 25 Best Large Cities in America for Jobs — Trade Schools, Colleges & Universities
#3 Hippest Cities in America — MoveHub.com
#4 America's Best Cities for Young Professionals — Forbes
#9 Best Cities for Techies — Livability

COLLEGE OF ENGINEERING
OFFICE OF THE DEAN
72 S. Central Campus Drive
Salt Lake City, UT 84112-9200

Non-Profit Org
US Postage Paid
Salt Lake City, UT
Permit No.571

THE UNIVERSITY OF UTAH

Follow us:

@UtahCoE

facebook.com/UtahCOE

@UtahCoE

www.coe.utah.edu