# utah ENGINEERING

## HIGH TECH HIGH TOUCH

THE UNIVERSITY OF UTAH • COLLEGE OF ENGINEERING NEWSLETTER

FALL 2019

# ENHANCING THE LUKE ARM

For Keven Walgamott, who lost his left hand and part of his arm in an electrical accident 17 years ago, delicately holding an egg or plucking grapes with a traditional prosthetic arm can be a near-impossible task.

But Walgamott was testing a prototype of a new high-tech prosthetic arm with fingers that not only move, they can move with his thoughts. And thanks to a biomedical engineering team at the University of Utah, he "felt" the egg well enough so his brain could tell the prosthetic hand not to squeeze too hard. He also could pull the grapes without squishing them into juicy pulp.

"It almost put me to tears," Walgamott says about using the "LUKE Arm," named after Luke Skywalker's robotic hand in "The Empire Strikes Back." "It was really amazing. I never thought I would be able to feel in that hand again."

The team led by University of Utah biomedical engineering associate professor Gregory Clark has developed technology for the LUKE Arm to mimic the way a human hand feels objects by sending the appropriate signals to the remaining arm nerves.

With this motorized, sensorized arm, an amputee can sense the touch of something soft or hard, understand better how to pick it up, and perform delicate tasks that would otherwise be impossible with a standard prosthetic with metal hooks or claws for hands.

The LUKE Arm itself has been in development for some 15 years by DEKA Research & Development Corp. It is made of mostly metal motors and parts with a clear silicone "skin" over the hand and powered by an external battery and wired to a computer.

But to make the arm's hand move and "feel," the Utah team has been developing a system that uses an invention by University of Utah biomedical engineering Emeritus Distinguished Professor Richard A. Normann called the Utah Slanted Electrode Array and now provided by Salt Lake City neurotechnology company Blackrock Microsystems (see sidebar). The Array is a bundle of 100 microelectrodes and wires that are implanted into the amputee's nerves in the forearm and connected to a computer outside the body. It interprets the digital electrical signals from the arm nerves, and the computer translates them to commands that tell the prosthetic hand how to move.

But the hand must learn how to "feel" the object in order to know how much pressure to exert because the wearer can't figure that out just by looking at it. The prosthetic arm has sensors in its hand that send signals to the nerves via the Array to mimic the feeling

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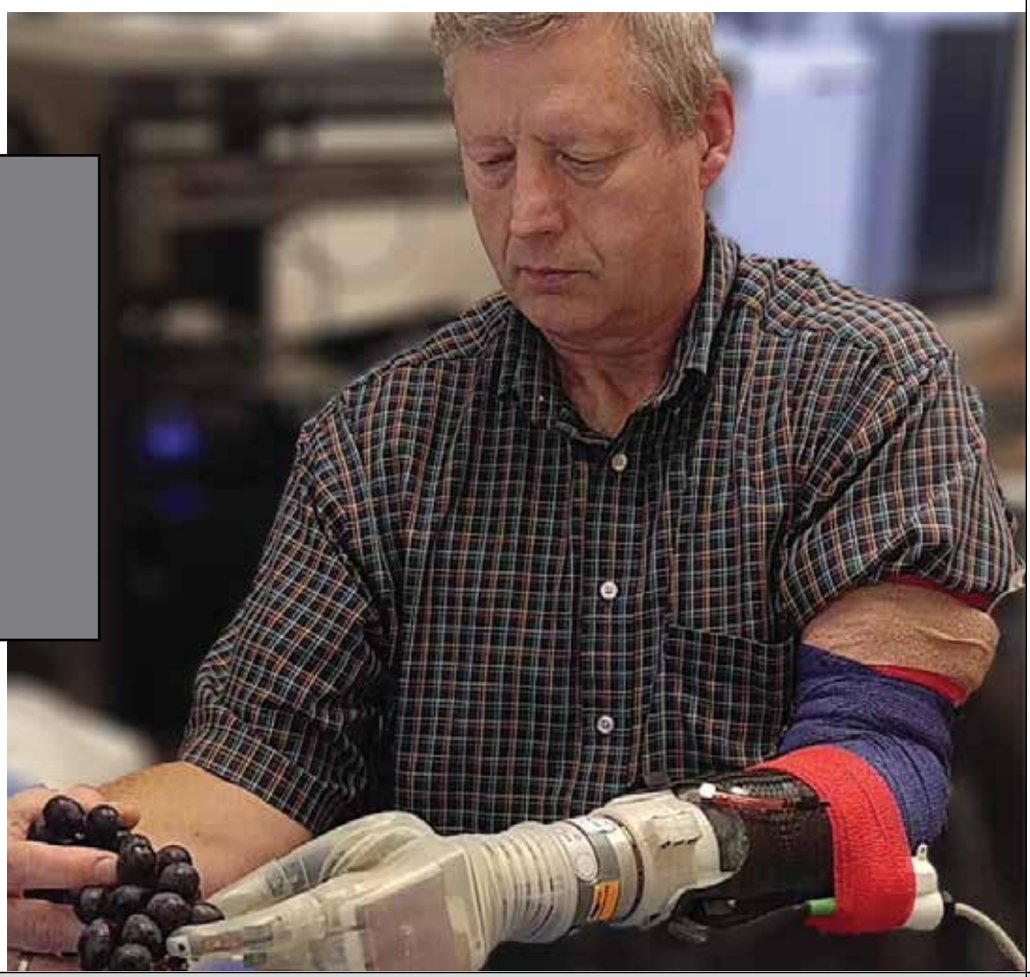
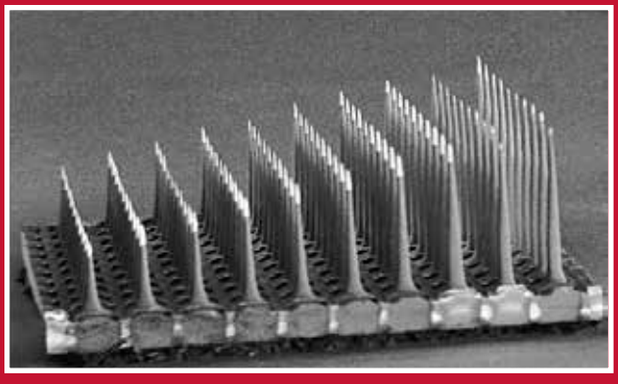


the hand gets upon grabbing something. Equally important is how those signals are sent. It involves understanding how the brain deals with transitions in information when it first touches something. Upon first contact of an object, a burst of impulses runs up the nerves to the brain and then tapers off. Recreating this was a big step.

To achieve that, graduate student Jacob George, a member of Clark's team, and collaborators from the University of Chicago used mathematical calculations along with recorded impulses from a primate's arm to model the sensory signal patterns normally sent up nerves from biological hands. That model was then implemented into the LUKE Arm system.

"We changed the way we are sending that information to the brain so that it matched the human body, and by matching the human body, we were able to see improved benefits," George said.

The overall team, which also involves researchers from the U's Health Sciences campus and the Cleveland Clinic, is already developing a version that is completely portable and connected wirelessly, giving the wearer complete freedom.



# THE KEY TO UNLOCKING BIOMEDICAL MIRACLES

*It's smaller than a copper penny, but the Utah Slanted Electrode Array (USEA) could be a marvel for a variety of people with disabilities.*

*The USEA is a tiny piece of silicon with 100 sharp microneedles that strut up about an eighth of an inch. The device can be implanted into the peripheral nerves, allowing it to communicate with hundreds of individual neurons.*

*The USEA is what allows the LUKE Arm, a motorized prosthetic arm being developed in part by biomedical engineering researchers at the University of Utah, to move with just the wearer's thoughts.*

*But the LUKE Arm is just one of many applications for this revolutionary piece of technology. Blackrock Microsystems, a Salt Lake City neurotechnology company, whose president and co-founder is University of Utah electrical and computer engineering chair and professor Florian Solzbacher, is further developing uses for the array. For example, Solzbacher himself is using a version to develop an implantable device for the deaf that is expected to produce much higher fidelity sound perception than can be achieved with traditional cochlear prostheses. Another version of the array is being used in research to help people see again who have been blinded by disease or trauma.*

*The Utah Slanted Electrode Array was developed by University of Utah biomedical engineering Emeritus Distinguished Professor Richard A. Normann, who began thinking about the concepts for the array in the 1980s after arriving at the U. Since then, the mission of the Utah Electrode Array has remained the same: Provide miraculous recovery never thought possible for victims of trauma or disease.*

# NSF CAREER AWARDS

*Four University of Utah College of Engineering faculty members were awarded the National Science Foundation's Faculty Early Career Development Program (CAREER) award in 2019. Here are this year's recipients:*

## Tucker Hermans

*School of Computing Assistant Professor*

Hermans develops algorithms to improve the control of multi-fingered robots. He uses computer models and machine learning to help robots predict the dimensions and other parameters of an object in order to learn how to effectively grab and use it. His team will develop software and computing procedures that work with a robot's cameras and tactile sensors to generate the data for optimizing the use an object.

## Michael Hoepfner

*Chemical Engineering Assistant Professor*

Hoepfner is developing simulations on how molecules behave in order to more accurately predict how they organize. He wants to find a better way to simulate those properties by using "neutron scattering" measurements to measure how molecules are organized in a solution. Hoepfner said he will be focusing his research on organic semiconductors, used in OLED televisions or in organic photovoltaics for more efficient solar panels.

## Owen Kingstedt

*Mechanical Engineering Assistant Professor*

Kingstedt studies how magnesium alloys heat up when they are deformed over just a few milliseconds. He hopes to better predict material performance during rapid events such as high-speed machining, ballistic impact or a vehicle crash. This research could benefit car manufacturers, for example, to help reduce vehicle weight, which would improve fuel efficiency.

## Jessica Kramer

*Bioemedical Engineering Assistant Professor*

Kramer will study how individual mucin proteins interact with salts, fats, other proteins and DNA to collectively form mucus. She will try to pinpoint the differences between mucus from different tissues and how bacteria, drugs, and nutrients interact with it. Eventually, she wants to create authentic models of human mucosal tissues to study nutrient absorption, fertilization, immunity and to develop new treatments for cystic fibrosis and cancer.

# New Material Sciences Engineering Department

Effective July 1, the University of Utah's departments of Materials Science and Engineering (MSE) and Metallurgical Engineering (MET E) merged into a single academic department administered jointly by the College of Engineering and College of Mines and Earth Sciences.

The motivation for this merger was to create one of the best departments of materials science and engineering in the country. The new academic unit, called the Department of Materials Science and Engineering, will have strengths in metals, ceramics, polymers, electrochemistry, nanotechnology, biocompatible materials, semiconductors, hydro-, electro- and pyrometallurgy, and mineral processing.

The combination of these departments doubles the faculty size to 22 tenture-track faculty with a combined $6.2 million in research expenditures for fiascal 2018-2019.

Metallurgical engineering professor and department chair, Michael Simpson, has become the chair of the new department. Professor Feng Liu stepped down as chair of the former MSE Department after serving for 7 ½ years.

"This merger is really the best possible path forward for the students and faculty of the two previous departments and the university," said Simpson. "Together, we can elevate the University of Utah's materials program to be one of the best in the country — attracting new investments from industry and government while also attracting the best and brightest students."

Students in the MSE department will enjoy all of the benefits of being members of both COE and CMES and have the opportunity to complete their degrees under current requirements.

# ALUMNA SPOTLIGHT
# JULIE KRAMER WHITE

University of Utah mechanical engineering alumna Julie Kramer White was only a teen-ager when she knew exactly what she wanted to do with her life.

"If you look at my senior yearbook picture, it says, 'I'm going to work for NASA,'" she remembered.

And just like the space shuttles and other spacecraft she would work on for the next 19 years, her journey to becoming NASA's Deputy Director of Engineering at the Johnson Space Center would be a straight trajectory upwards.

"There were not a lot of detours," she said. "It was just a process of continuously expanding my expertise. Then the opportunities presented themselves, and I was prepared and was able to capitalize on them. It ended up being a pretty direct route to that job."

Rewind to before her high school days, and White was more interested in animals than aeronautics — she wanted to be a veterinarian. But after realizing the "ick" factor involved in veterinary medicine, she changed her tune. She excelled in math and science, and thanks to a concerted outreach campaign in the 1970s to recruit more female students into STEM fields, she became interested in engineering. And with the rising popularity of NASA's space shuttle program, White realized, "I wanted to be an engineer to build spaceships at NASA."

Raised in a suburb of Indianapolis, White then attended Purdue University in West Lafayette, Indiana, where she received her bachelor's degree in Aeronautical and Astronautical Engineering. While earning her degree, she also started working for NASA in a co-op education position as a junior engineer.

After graduation, she began working at the Johnson Space Center in Houston and frequently traveled to Rockwell International's plant in Palmdale, Calif., to help build and maintain the space shuttle. It was there that she and the space agency realized how the shuttle would experience corrosion, fatigue and fractures similar to that of commercial aircraft. While taking classes at UCLA to learn more about structural fatigue, she met University of Utah mechanical engineering professor David W Hoeppner (now Professor Emeritus) and decided to attend the U to get a master's degree in mechanical engineering. She liked the strong collaboration at the U between mechanical engineering and the Department of Materials Science and Engineering.

"Dr. Hoeppner and the staff were really supportive," she said of her experience at the U. "I was thrilled to learn the academic background that would be so helpful to me in my job. It was definitely a win-win."

Then it was nothing but a straight shot up the levels of NASA, which included structural engineering, then vehicle systems engineering, which addressed problems that crossed over into mechanical, propulsion and vehicle control systems. White also led the group of

failure analysts who researched the cause of the fatal Columbia shuttle accident, which killed its seven crewmembers after re-entry into Earth's atmosphere in 2003.

In 2006, White became the chief engineer in charge of the Orion Multi-Purpose Crew Vehicle program, a U.S.-European co-venture to create a new manned spacecraft vehicle for the moon and beyond. That vehicle is scheduled to take a crew to the moon in as early as 2022. In 2017, White was moved into the management position of deputy director of engineering for the Johnson Space Center, which oversees the Orion program, the International Space Station, lunar exploration program and more.

Looking back at the arc of her career, starting with that prescient quote in her high school yearbook, White attributes her success to persistence, hard work and a bit of luck.

"It's a life lesson but especially true in aerospace: It takes a lot of commitment and dealing with setbacks," she said. "You have to have a lot of patience and persistence. Whether it's for your engineering degree or a job, you have to have the willingness to pursue them through the setbacks to focus on the goal. If you can do that, you will eventually get there."

# IN BRIEF

## WHITTY NAMED ASSOCIATE DEAN OF REASEARCH

The University of Utah's College of Engineering is pleased to announce that chemical engineering professor Kevin Whitty has been named the new associate dean for research. He replaced chemical engineering professor Eric Eddings, who had been the associate dean for seven years and is now the new chair of the U's chemical engineering department.

Whitty joined the University of Utah in 2001. He became associate professor in 2006 and was promoted to full professor in 2015. He has 25 years' experience in high temperature processing of fossil and renewable resources for production of power, heat, chemicals and fuels. His research focuses on advanced technologies for energy production with $CO_2$ capture including gasification, chemical looping and high pressure oxy-coal combustion.

He received a bachelor's degree from Oregon State University and master's and doctoral degrees from Åbo Akademi University in Finland, all in chemical engineering. He spent four years in industry managing research and directing pilot operations for energy technology development companies in Stockholm, Sweden.

He has received the Professional Achievement Award for Innovations in Green Process Engineering from the American Institute of Chemical Engineers and the University of Utah's Celebrate U Achievement Award in 2016.

"I am excited to be joining the Dean's office as associate dean for research," Whitty said. "The faculty and students in engineering are amazing and there is a lot of really interesting research taking place in all departments."

## EDDINGS APPOINTED NEW CHAIR

University of Utah chemical engineering professor Eric Eddings, who was formerly the College of Engineering associate dean for research, has replaced professor Milind Deo as the chair of the U's Department of Chemical Engineering.

Eddings earned bachelor's and doctoral degrees in chemical engineering from the U. He worked as a lead chemist at Unisys Corp, a senior engineer and vice president of business development for Reaction Engineering International, and is a partner with Amaron Energy in Salt Lake City.

He joined the U in 1998 as a research assistant professor, was hired as a tenure-line associate professor in 2001 and was promoted to professor in 2009. He is a member of the American Institute of Chemical Engineers, the American Society for Engineering Education and the Combustion Institute. His research area is in the utilization of fossil and renewable fuels, both for energy production and as a resource for the development of high-value products such as carbon fiber.

Eddings received the Outstanding Teaching Award from the U's College of Engineering, the Outstanding Instructor from the Department of Chemical Engineering, and the Kirkpatrick Chemical Engineering Honor Award.

"I look forward to building on the great momentum of previous chairs, to continue growth in faculty size, research productivity and student excellence," Eddings said.

Deo will return to teaching and his research on oil pipeline flow assurance, natural gas, hydrocarbon fuels and carbon dioxide capture.

# DEVRIES HONORED WITH ASEE LIFETIME AWARD

Kenneth Lawrence DeVries, the legendary University of Utah mechanical engineering Emeritus Distinguished Professor who was an award-winning and invaluable faculty member for more than 55 years, was awarded one of the American Society for Engineering Education's highest honors, the Lifetime Achievement Award, at the ASEE's Annual Conference & Exposition in June.

The award is given to only one educator nationwide each year "for sustained contributions to education in the fields of engineering and/or engineering technology. The contributions may be in teaching education, research, administration, educational programs, professional service or any combination thereof."

DeVries, who retired from the University of Utah last year, has led a remarkable engineering education career that underscores his dedication and leadership. He earned his bachelor's degree in mechanical engineering in 1959 and a doctorate in physics and mechanical engineering in 1962, both from the University of Utah. He joined the mechanical engineering faculty at the U that same year. Since then, he has served as department chair, president of the academic senate, associate dean for research, and acting dean of the college, to name just a few of his many positions.


He has received countless awards, including the University of Utah Presidential Teaching Award, Associated Students of the University of Utah Professor of the Year Award, the Utah Engineering Educator Award and the University of Utah Distinguished Teacher Award. In 2003, he received the Calvin S. and Jeneal N. Hatch Prize in Teaching, which is the university's highest award for teaching excellence. He also was honored with the Ralph Coates Roe Award from the American Society for Engineering Education and the Governor's Medal for Science and Technology.

# DISCOVER ENGINEERING DISPLAY


In an effort to reach out to more high school students and introduce them to the exciting opportunities in engineering, the University of Utah's College of Engineering has created the new Discover Engineering exhibit, a fun, interactive display that is traveling to Utah's high schools.

This multi-paneled display features 10 separate sections covering our seven engineering departments as well as Entertainment Arts & Engineering (EAE) and Construction Engineering. Each area has a video and an interactive display for hands-on learning, such as a video game designed by EAE students, a robotic arm that students can operate, an experiment highlighting how chemical reactions occur, and a bridge-design software program that demonstrates how bridges fail.

The college's Academic Affairs team plans to use the exhibit in a different Utah school each week during the academic year, including rural areas. It is designed to be set up in each school for two days with one or more representatives from the college attending to answer students' questions. "Our goal for the exhibit is to let students and high school teachers know about the important and exciting work that engineers and computer scientists do," said exhibit organizer Craig Clifford.

"We anticipate that this exhibit will lead to more schools teaching our High School Engineering course," he said.

*If you are interested in accompanying Discover Engineering as a representative from the College of Engineering, please contact Craig Clifford at craig.clifford@utah.edu.*

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# STUDENT LIFE
## ELDON PE'A

Engineering success may have come a little late for 36-year-old University of Utah graduate student Donald Eldon Pe'a, but he's living proof that hard work and a can-do spirit can lead to a rewarding payoff.

During his young adult life, Pe'a, who goes by Eldon, had no idea what he wanted to do for a career. Once he graduated from high school from his native country of Samoa, he served a church mission in Houston for The Church of Jesus Christ of Latter-day Saints. Upon returning home, Pe'a got married and started a family. For the next six to eight years, he worked odd jobs such as selling textbooks and loading and unloading planes at the airport.

That's when he decided to go to college. At first, he attended Utah State University in Logan, Utah, in engineering. "My wife made me realize my potential, and she convinced me that I could go into engineering."

But after the birth of their daughter and then twin sons 18 months later, Pe'a had to quit and move his family to Salt Lake City to work full time. He continued at different jobs while taking classes part time at Salt Lake Community College.

"But I hit a point where school was just taking too long, and I wanted to get it done faster," he said. "So I left my job and totally committed to school."

That's when Pe'a arrived at the University of Utah to study electrical engineering — and when he experienced a major setback. In the spring of 2015, Pe'a got seriously ill, developing an infection that resulted in emergency surgery and weeks in the hospital to recover. Consequently, his grades suffered. But with encouragement from U electrical and computer engineering professor Cynthia Furse, Pe'a was able to climb back up and is now on his way to earning a combined bachelor's/master's degree in 2020 where he's researching wireless power transfer for biomedical devices. He also made the dean's list the last three semesters and is now working a co-op at L3 Harris Technologies in Salt Lake City.

"My biggest motivation to succeed is my kids," he said about overcoming his adversity. "I wanted to show them that you can do anything despite the obstacles in front of you."