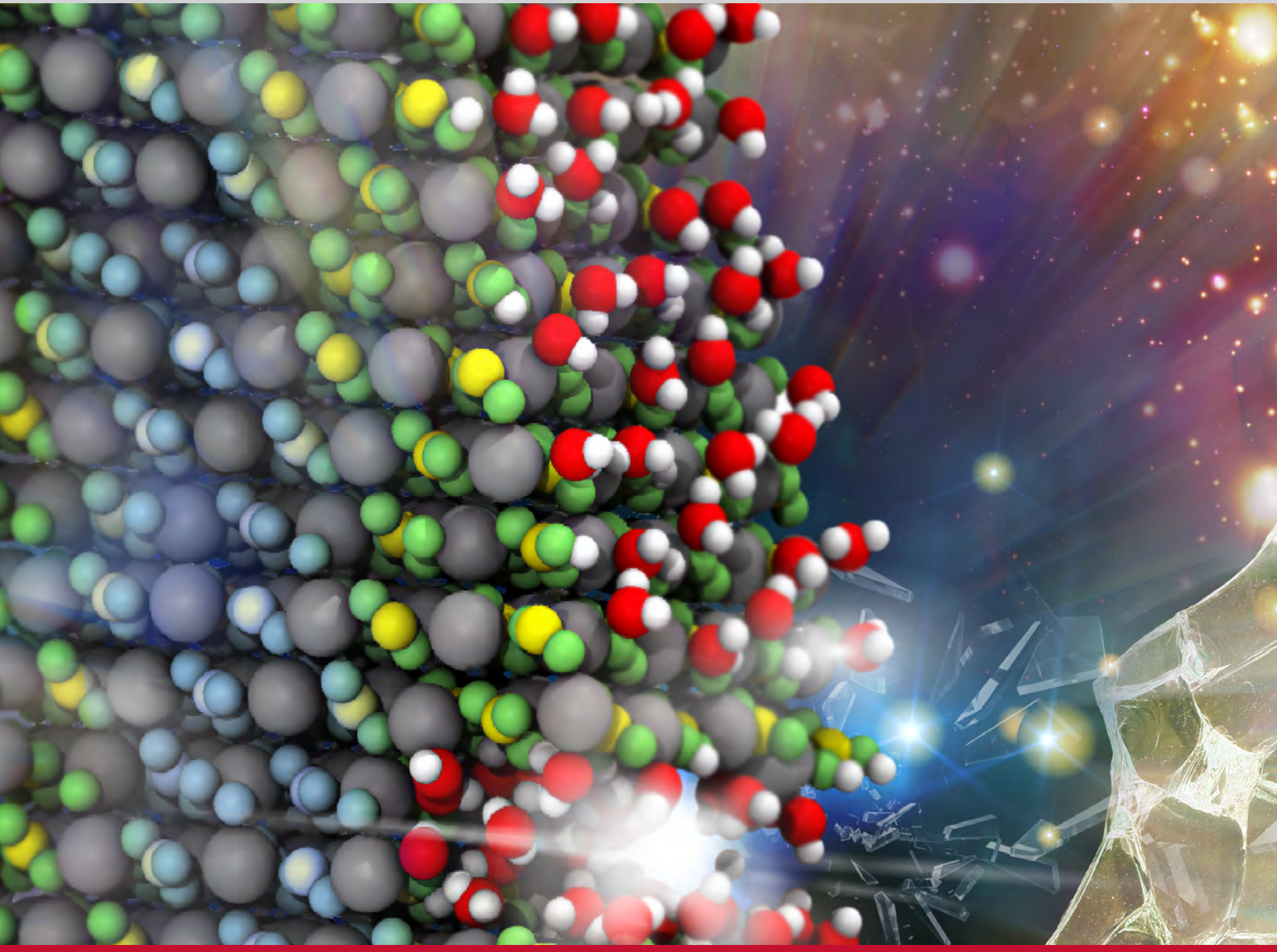
Department of
MECHANICAL ENGINEERING
THE UNIVERSITY OF UTAH

newsletter



FOSTERING INNOVATION

2024

Chair's Message

Dear Friends of Mechanical Engineering,

The past year has been one of amazing change and interesting dichotomies. We finished our first year in the Steve and Lynda Jacobson Pavilion and have truly enjoyed the space. We had our largest freshman class ever (almost double 5 years ago) with more than 400 students, but also graduated the smallest class in 6 years (seemingly a residual effect of the COVID pandemic). With this smaller class graduated and so many new students the past few years, we now have more students than ever. We have brought on several new faculty with exciting research areas and started new programs in several areas to help with all of this growth.

This year we have added three new degree programs at the graduate level: MS and PhD in Robotics, MS in Systems Engineering, and an MS in Engineering Management. The Systems Engineering and Engineering Management programs can be completed completely online, for those students unable to take classes on campus. We already have dozens of students signed up for these programs and will have our first Robotics graduate this Fall with nearly two dozen students switching to the new program. We are also working on an MS degree in Aerospace that would start in the Fall of 2025. Nearly 20% of our undergraduate students express a preference for aerospace, so there is plenty of interest!

The faculty has continued to grow. We added six new faculty this past year and have 4 new faculty coming this year, all in the robotics, systems, and engineering management programs, plus some faculty in advanced manufacturing and biomaterials. These new faculty will have a big impact on the courses we can offer and how many sections, hopefully making our classes more accessible to a wide range of students.

We had a fantastic year with our senior design teams. We had nearly 20 projects that were industry sponsored and heard uniformly great comments from our sponsors, some of which are highlighted in this newsletter. We get to help our Olympic Team work towards the gold in Paris this summer! What fun it is to work with our USA climbing team.

Overall, we are having more impact than ever. More students in the program (including nearly 8% of all incoming freshman), more ongoing research, more programs in high demand areas, and students winning more competitions. We are grateful for your support and hope you will enjoy learning more about our adventures this past year. We are looking forward to an even better year coming up!

Best regards,
BRUCE K. GALE, Ph.D.
Professor and Chair

Simulation of Fracture in Calcite with Water

About the Cover:
The image highlights fracture modeling of a calcite system under environmental conditions using molecular dynamic simulations.

Photo courtesy of Dr. Pania Newell. Learn more at http://newell.mech.utah.edu

Highlighted Grants

Over 40 new projects awarded, more than $4.8 million in funding since last September!

Edoardo Battaglia – NIH, 6 mos, "CSTAR Collaborative Mentorship Program"

Marc Calaf – NSF, 3 yrs, "Centering Indigenous Knowledge and Values in the Development of Integrated Agroecological Renewable Energy Systems through Convergent Research"
NSF, 2 yrs, "EAGER:Generalizing MOST-based surface layer parameterizations for turbulence resolving ESMs"

Jiyoung Chang – U of U, 1 yr, "Thermally-Induced Modulation Of Porosity And Mechanical Strength In Electrospun Polymer Membranes"

Brittany Coats – US Department of Justice, 3 yrs, "Mechanics Of Retinal Hemorrhage In Abusive Head Trauma"
NSF, 1 yr, "Conference: 2024 Summer Biomechanics, Bioengineering, And Biotransport Conference (SB3C)"

Mike Czabaj – Air Force Research Lab, 3 yrs, "Investigation Of Fracture In Thin-Ply-Hybrid Composites Using A Novel X-Ray CT In-Situ Experiment And BSAM"
Office of Naval Research, 9 mos, "Characterization Of Am Components For The USNA"

Tianli Feng – NSF, 5 yrs, "CAREER: Prediction And Understanding Of Thermal Transport Across Successive Interfaces"
DOE, 1 yr, "Building envelope air leakage detection and quantification by a novel transient IR imaging method"

Bruce Gale – DHHS, 1 yr, "SBIR Phase I: Point-of-Care Assay for Type 1 Diabetes Diagnosis and Prognostication"
DHHS, 1 yr, "SBIR Phase I: Point-of-Care Multiplexed Immunosuppressant Monitoring"
Psycheceutical Bioscience Inc, 2 yrs, "Brain surgery drug delivery"
U of U, 1 yr, "AMI - AMI - Automated Microfluidic Instrument Ascender"

Jake Hochhalter – Hill Engineering, 6 mos, "Standard testing for measurement of fatigue crack growth near cold-worked bolt holes"
US Air Force, 3 mos, "Method Development To Correct Inaccuracies In Stress Intensity Factor Models And Improve Reliability Estimates"
DOE Sandia, 1 yr, "Genetic programming with symbolic regression for continuum damage models"
DOE Sandia, 1 yr, "Genetic programming with symbolic regression for analytical stress intensity factor solutions"

Ken Monson – NIH, 2 yrs, "Tissue Softening In Traumatic Brain Injury"

Pania Newell – NSF, 3 yrs, "CLIMA/Collaborative Research: Enhancing Soil-Based Infrastructure Resilience to Climate Change: Harnessing the Potential of Fractured Soil by Adding Polymers"
DOE, 1 yr, "Advanced Multi-Physics Machine Learning for Subsurface Energy Systems Across Scales"

Alex Novoselov – UT State Legislature, 6 mos, "Hybrid Rocket Modeling"

Shuaihang Pan – Medtronic Inc, 3 mos, "ZN Alloy Design And Characterization"

Erika Pliner – Job Site Safety Institute, 1 yr, "Effectiveness Of Level Tools And Instruction On Optimal Ladder Setup"

Yongzhi Qu – DOC, 1 yr, "A Neural Differential Machine Learning Framework With Nonlinear Physics For In-Situ Modeling Of Dynamic Systems"

Sameer Rao – United Minerals, 1 yr, "Supercritical Extraction of Bio-Mineral Complexes"

Shad Roundy – NSF, 3 yrs, "U.S.-Ireland R&D Partnership: Highly Efficient Magnetoelectric Nano-antenna Arrays with Wide Operational Bandwidth"

Rob Stoll – USDA, 1 yr, "Predicting smoke exposure in vineyards"
USDA, 1 yr, "Model Based Evaluation of Grape Vineyard Exposure to Wildfire Smoke"

Pai Wang – NSF, 5 yrs, "CAREER: New Polarizations of Elastic Waves in Architected Materials"
DOE Sandia, 1 yr, "Metamaterial-Enhanced Roton-Like Zero-Group-Velocity Ultrasound For High-Quality Through-Wall Transmission"

Haohan Zhang– NIH, 3 yrs, "A gaze-controlled neck exoskeleton for dropped head syndrome"
ALS Association, 1 yr, "Seed: A Neck Exoskeleton for ALS Head Drop"

Building Technology to Train Olympic Athletes

Top ranked speed climbers may only be hundredths of a second apart in finish times. As the U.S. Olympic Training Team looks for ways to take their best speed climbers from their current high world ranking to podium positions in Paris this summer and LA in 2028, new technology could be the key to improving training. With the proposed U.S. Olympic Climbing training facility to be built in Salt Lake City, Utah and the 2034 Olympics slated to be in Utah, the University of Utah and its students are a great fit for building that technology.

Advisor Stephen Mascaro (third from left) discusses the project with team members

This opportunity began when Andrew Gill, the Capstone Coordinator for the Department of Mechanical Engineering, began a conversation Behan Abtahi from the United States Olympic Training Team about the Capstone program in the ME department at the U. Abtahi had previous experience working with the New Zealand Olympic team and their partnerships with capstone programs locally. Based on the success, Abtahi worked with Gill to bring the University of Utah Capstone program into the U.S. Olympic Committee Partner Alliance.

"I am excited for students to work on these projects," said Gill. "Not only are they interesting real world engineering challenges, but they also generate a lot of excitement for the students because they will be used by top caliber Olympic athletes in training."

Preliminary analysis from the USOPC Sport Performance Team determined that start mechanics, not reaction times, had the most impact on climb times, making it the focus for training improvements. With that knowledge in hand, the Capstone team was tasked with creating instrumentation to track multiaxial force data for the lower seven holds on two speed climbing walls. The device also needed to be interior to the wall and non-invasive in design to avoid interfering with training.

The team of students: Daisy Quach, Tren Hirschi, Lingbai Ren, Clarissa Seebohm, Gannon Brady, and Julian Torres worked with their advisor Dr. Stephen Mascaro to develop two different methods of collecting the necessary data. First, an Instrumented bolt, which uses four strain gauges on a machined 3/8" bolt. The strain gauge wires are routed through the hollow center of the bolt and a behind the wall a pin connector allows the strain gauges to be easily connected to an amplification/data collection circuit. The recorded strains are then calibrated into three-axis force data. The behind-the-wall design uses a commercial force transducer to collect the data. An internal plate is set within the hand hold and used to connect to another plate mounted to the transducer.

Both systems showed success as proof-of-concept. The data collected from the behind-the-wall system is nearly accurate enough to be used in training. However, this version is complex to install and not applicable to commercial gyms. The instrumented bolt offers a more deployable package; however, the calibration methods aren't consistent enough yet for training purposes.

"Going forward, we would like to refine these ideas into a final design that meets the Olympic Committees accuracy targets," said Gill. "The current plan is for a new group of students to carry on the project starting in Fall 2024. Their focus will be analyzing the contributing factors to the accuracy issues such as wall friction and load sharing between attachment points, as well as looking for other solutions that could reduce the force measurement inaccuracies."

In addition to finishing this project, the ME Capstone program will continue looking for other opportunities to collaborate with the U.S. Olympic Committee Partner Alliance. The Capstone program regularly partners senior undergraduate mechanical engineering students with industry projects and helps bring them to life.

You can find out more about the ME Capstone program on our website: mech.utah.edu/capstone/.

ME Team Wins Radiance Bowl

Students Trevor Whitaker (PhD) and Branden Webb (MS) along with advisor Dr. Sameer Rao won the $25,000 grand prize at this year's Radiance Technologies Innovation Bowl. Radiance Technologies sponsors this yearly academic competition between schools and conferences where groups compete for a single Grand Prize by developing innovative approaches to current research and development topics.

Whitaker and Webb receiving the grand prize

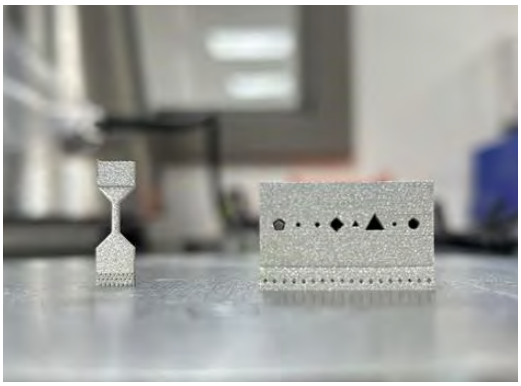
This year's topics focused on Micro-Electronic Packaging. The three areas of interest were: novel hardware architectures for AI/ML systems enabled by advanced heterogeneous packing, methods for fast thermal evaluations of 2.5 / 3D packaging assemblies to enable parametric testing of prototype configurations, and thermal solutions to enable tighter integration of chiplets in advanced packages.

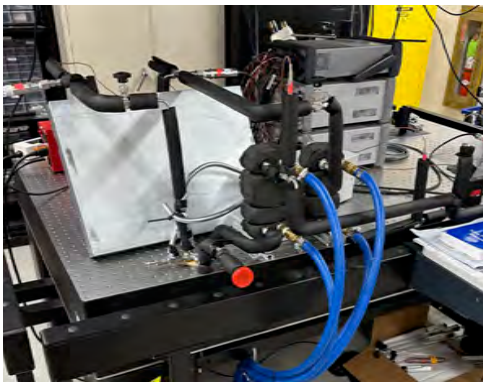
Whitaker and Webb chose to focus on the topic "Thermal solutions to enable tighter integration of chiplets in advanced packages." They proposed the use of indirect cooling with supercritical carbon dioxide (sCO2) as a replacement for traditional coolants like water or FC-72. Experiments were conducted in an additively manufactured stainless steel microchannel cold plate. Heating was applied to the bottom surface of the cold plate to mimic realistic electronics applications, and the experimental performance of sCO2 was compared with results from numerical simulations of water and FC-72 using a pumped-cooling figure of merit.

"We found that sCO2 performs much better than anything that is currently in use," said Webb. "Up to 70x better than using water. It's also safer than other coolants, both for the environment and for the chips themselves."

In spring, the team was chosen as one of three finalists and spent the semester further developing their idea. In early April, Whitaker and Webb flew to Hunstville, AL for the finals to present their design and cooling approach to Radiance. The panel of judges selected Whitaker and Webb as the winners of the award.

"Winning this award was personally very impactful," said Whitaker. "I am passionate about the research we conduct in the Rao Lab and this recognition helps reassure me that we are making meaningful contributions to our field. It is nice to take a small step back and see that our work is appreciated."


3D printed test coupon showing different channel geometries


Experimental test loop

Zhang Receives NIH Trailblazer Award

University of Utah mechanical engineering assistant professor Haohan Zhang and Kahlert School of Computing assistant professor Daniel Brown have received a National Institutes of Health (NIH) Trailblazer Award in a multi-PI proposal. This 3-year project will develop a new neck brace for patients with dropped head syndrome that use gaze tracking to help restore head-neck mobility. The Trailblazer Awards program is a prestigious opportunity for new and early-stage faculty to pursue research programs that "integrate engineering and the physical sciences with the life and/or biomedical sciences."

Assistant Professor Haohan Zhang

Dropped head syndrome is a condition most commonly associated with neuromuscular disorders where a patent's head droops forward onto their chest. One of the typical treatments is the prescription of neck braces, but many patients don't use them because they are static, uncomfortable, and ineffective. As a result, patients leave their condition untreated which worsens their ability to breathe, swallow, speak, and perform other daily tasks.

"Our long-term goal is to treat dropped head syndrome by restoring head-neck motions through a personalized, powered neck exoskeleton technology," said Zhang. "We are working towards determining general models to predict head-neck movements in different gaze conditions (e.g. smooth pursuit, saccade) and a personalization strategy for a gaze-controlled neck exoskeleton."

The award will help support multiple PhD students as they develop the predictive models for head movements conditioned on user's gaze as well as the user-in-the-loop gaze controller for the powered neck exoskeleton. This will lead to an easy-to-use control that follows the users natural head-eye behavior, combined with an ongoing human-in-the-loop personalization strategy.

Assistant Professor Daniel Brown

"The proposed research is significant because it is expected to provide strong scientific justification for continued development of the gaze-controlled neck exoskeleton and future clinical trials that are aimed at bring the technology to patents' homes," said Zhang. "Ultimately, this knowledge has the potential of offering new opportunities for better treatment for dropped head syndrome."

You can learn more about Zhang's research through the Utah Wearable Robotics Lab website: uwrl.mech.utah.edu/. You can learn more about Brown's research through his website: users.cs.utah.edu/~dsbrown/. Both are members of the University of Utah Robotics Center: https://robotics.coe.utah.edu/.

New Master's in Engineering Management at the U

Beginning this fall, the University of Utah will begin offering a Master's in Engineering Management. This new degree will be available for both online students as well as in-person. Students will gain skills in leadership and management, as well as learning to identify inefficiencies and improve decision making. This program is a great fit for any engineer interested in leadership and management roles.

"Engineers tend to be great employees and it's natural to promote them into leadership and managerial roles," said Todd Easton, Director of Engineering Management Programs at the U. "Some engineers obtain an MBA to help gain the skills for these roles, however, our program is more technical. The Master's in Engineering Management provides students an opportunity to learn leadership and managements skills, while also gaining additional technical engineering skills."

In addition to going through the program in a standard in-person format, the degree is also available online. This provides students the opportunity to take one or two courses a semester and finish the program in two or three years while continuing to work in their current roles. This allows students to take advantage of the tuition reimbursement programs offered at many engineering companies.

All students in the program will take core classes that will give them a range of skills including leadership, management, project management, product development, production efficiency, financial analysis, and optimization or statistical analysis. Beyond these core skills, students will take four courses of electives to help them specialize and gain additional tools for their specific goals. This provides students with the flexibility to get the most out of their educational experience and create a master's degree that is unique to their situation, career, and goals.

"Pursuing a degree in Engineering Management can open a whole new career with interesting new problems and opportunities," said Easton. "This is great for engineers who have spent a few years or even decades in a role and are ready for new challenges." More information on program requirements and how to get started is available on the Systems, Industrial, and Management Engineering website: systems.utah.edu.

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The First Robotics Degree Program in the Intermountain West

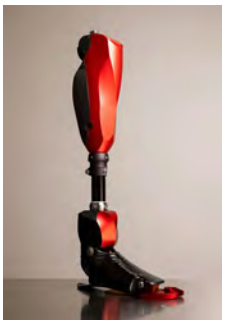
Beginning this fall, new graduate and undergraduate programs are available at the University of Utah in Robotics. The graduate programs include both MS and PhD degrees, along with a Graduate Certificate that can be completed as a non-matriculated or degree seeking student. Undergraduate students will be able to pursue a Robotics Minor or a Robotics Certificate.

These new programs will be focused on the interdisciplinary development of hardware, software, and algorithms to service the needs of companies developing the next generation of intelligent machines. The new programs have been made possible in part due to funding from the Utah System of Higher Education as part of the Emerging Technology Initiative, with support from campus (Kahlert School of Computing, Department of Mechanical Engineering, and Department of Electrical & Computer Engineering) and core industry collaborators (Sarcos Robotics, Kairos Autonomi, Motion Control, and Cricut). These groups are working together to develop curriculum and build a world class program.

"The new Robotics programs at the U are a big step in keeping the University of Utah at the leading edge of Robotics education, fueling our growing local Robotics industry, and inspiring the next generation of Roboticists," said Steve Mascaro, Director of Robotics Studies. "Our faculty and students are incredibly excited that this moment has finally arrived."

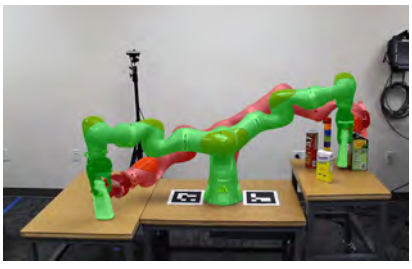
With the first robotics certificates and grad degree programs in the intermountain west, U Robotics will continue efforts to attract top talent to Utah and provide employers with a stream of talented Roboticists to support their emerging industries. Additionally, it builds on existing STEM efforts led by the Robotics faculty to support the Utah FIRST (For Inspiration and Recognition of Science and Technology) Robotics Competition aimed at attracting high school students into STEM careers. The competition brings in over 1500 students from across the country and world every year. The new Robotics programs at the U will further catalyze the U's growth in engineering and computer science degrees to support Utah's technology sector.

Students interested in the new Robotics programs can find more information on the website: https://robotics.coe.utah.edu/.



The Utah Bionic Leg, developed by Associate Professor Tommaso Lenzi, named to TIME's list of best inventions of 2023

Assistant Professor Jacob A. George was named Innovator of the Year for his work with the "LUKE Arm", a neuroprosthesis controlled by thought and endowed with a sense of touch.



Artificial Intelligence-based multi-object manipulation from the LL4MA lab directed by Associate Professor Tucker Hermans