ME

VIRGINIA TECH DEPARTMENT OF
MECHANICAL ENGINEERING

2018 ANNUAL REPORT

COLLEGE OF ENGINEERING
MECHANICAL ENGINEERING
VIRGINIA TECH

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LETTER FROM THE DEPARTMENT HEAD

Welcome friends, alumni and all those who help support our Hokie engineers through their support, philanthropy, and time.

The 2018 annual report you hold now represents another year of growth for the Department of Mechanical Engineering at Virginia Tech. Our faculty has grown to include more than 65 full-time professors, and we are supported by 27 affiliate faculty members, adjunct professors, as well as many graduate teaching assistants. In all we serve more than 1,100 undergraduate and 300 graduate students, making us one of the largest departments on campus and one of the larger mechanical engineering departments in the country.

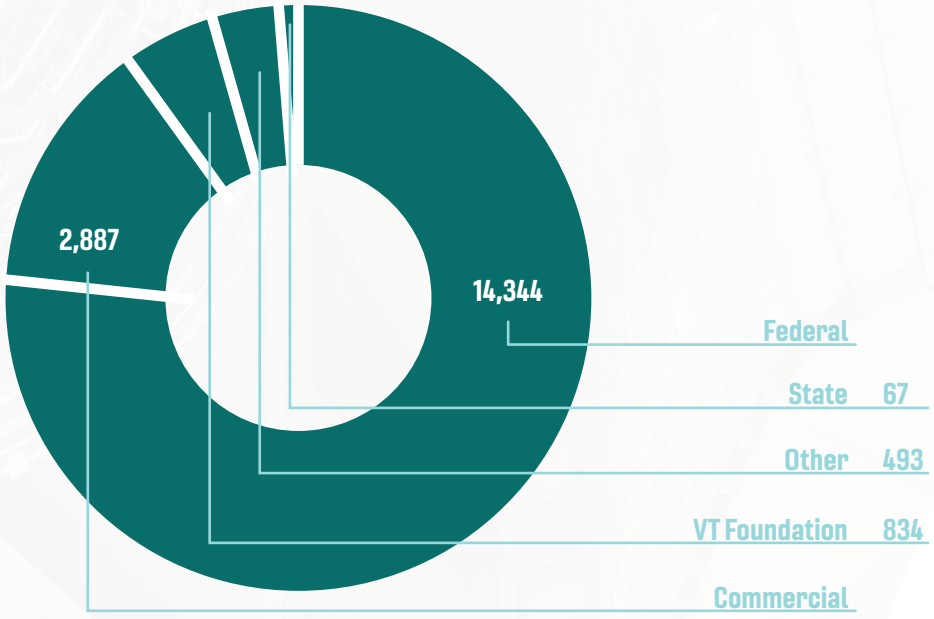
As we have for the last few years, we've included a list of our many supporters this year. I cannot overstate how important the support of alumni and friends of the department is for our continued success and growth. As a testament to the faith our alumni place in our department, the new Nicholas and Rebecca Des Champs Chair in Mechanical Engineering was established by the Des Champs family, extending Nick Des Champs legacy as a very successful engineer and entrepreneur. Nick was a member of our first doctoral ME class and the work of his family over the years in support of the department has been unwavering.

This year I am also pleased to announce that Professor Michael von Spakovsky has been named the Robert E. Hord Jr. Professor. Michael is one of or foremost researchers; an internationally-renown pioneer of thermodynamics, and an exceptional choice for the Hord Professorship.

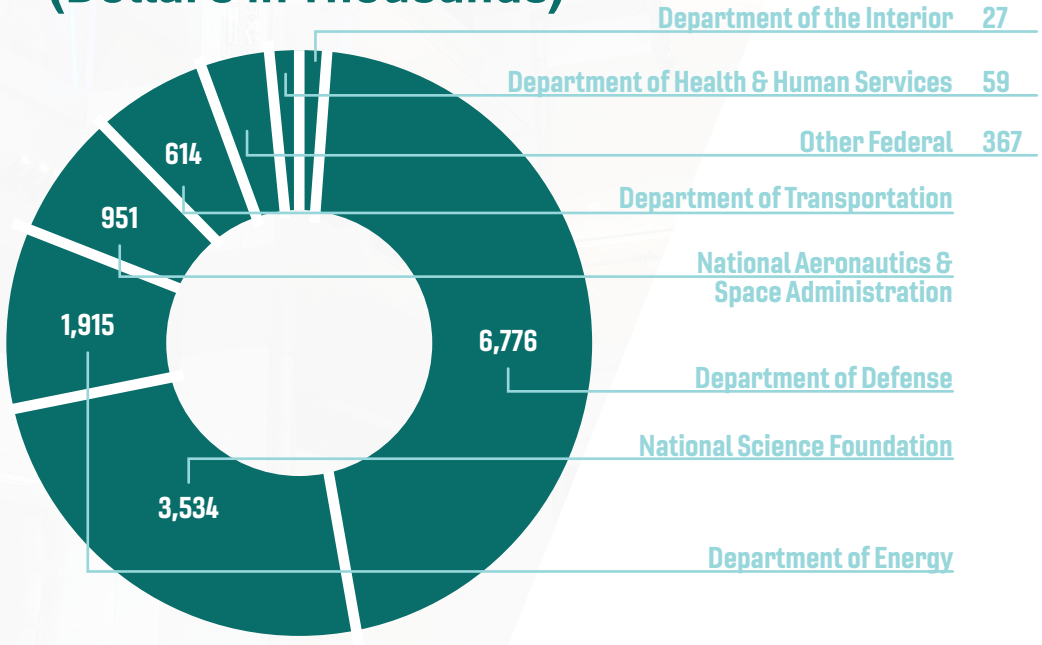
This year we also had the good fortune to add eight new faculty to our growing cadre of researchers. Five members join us as assistant professors: Oumar Barry from Central Michigan University; Kaveh Akbari Hamed from San Diego State University; Erik Komendera from NASA Langley; Juliana Duarte from the University of Wisconsin-Madison; and John Palmore Jr. from Cornell University. Also joining us is Assistant Professor of Practice Ry Long who has had industry experience with Bombardier Aerospace and Pratt & Whitney Canada, and comes to us from Central Michigan University. Two more colleagues will join us in the Spring Semester.

As we move into the 2018-2019 academic year, we are riding a wave of success. Academic success, funding success, hiring and diversity success, and above all, success in educating the nation's finest young mechanical engineers. I invite you to read about our progress in this annual report.

2018 ME Total Research Expenditures (Dollars in Thousands)



2017–2018 Federal Annual Research Expenditures (Dollars in Thousands)



63
Full Time Faculty

15
Named Faculty and Faculty Fellows

28
Affiliate Faculty

33
Laboratories

4
Centers

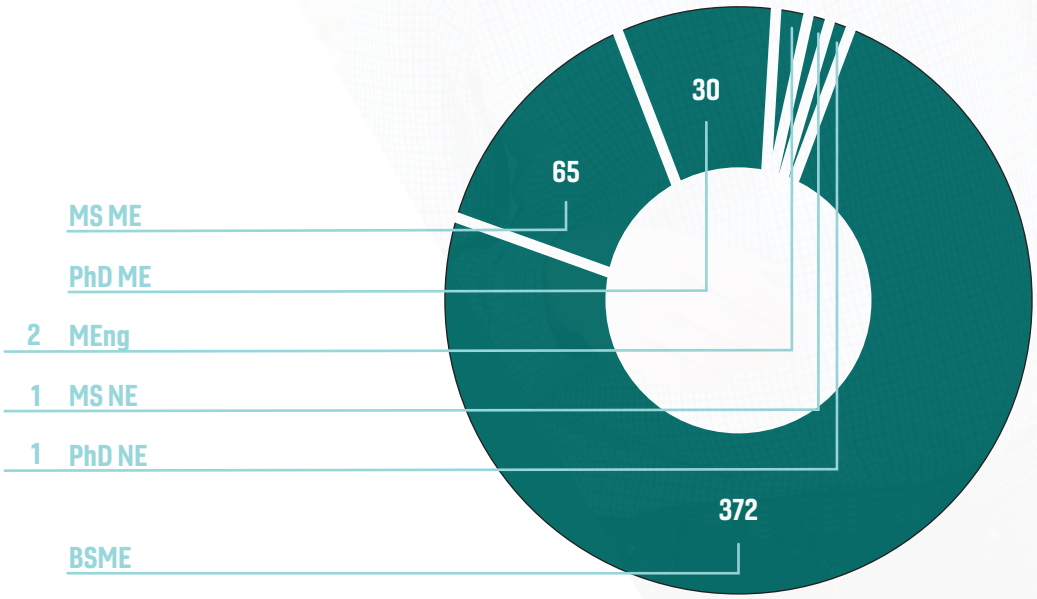
#15
Undergraduate Program
Rank Nationally

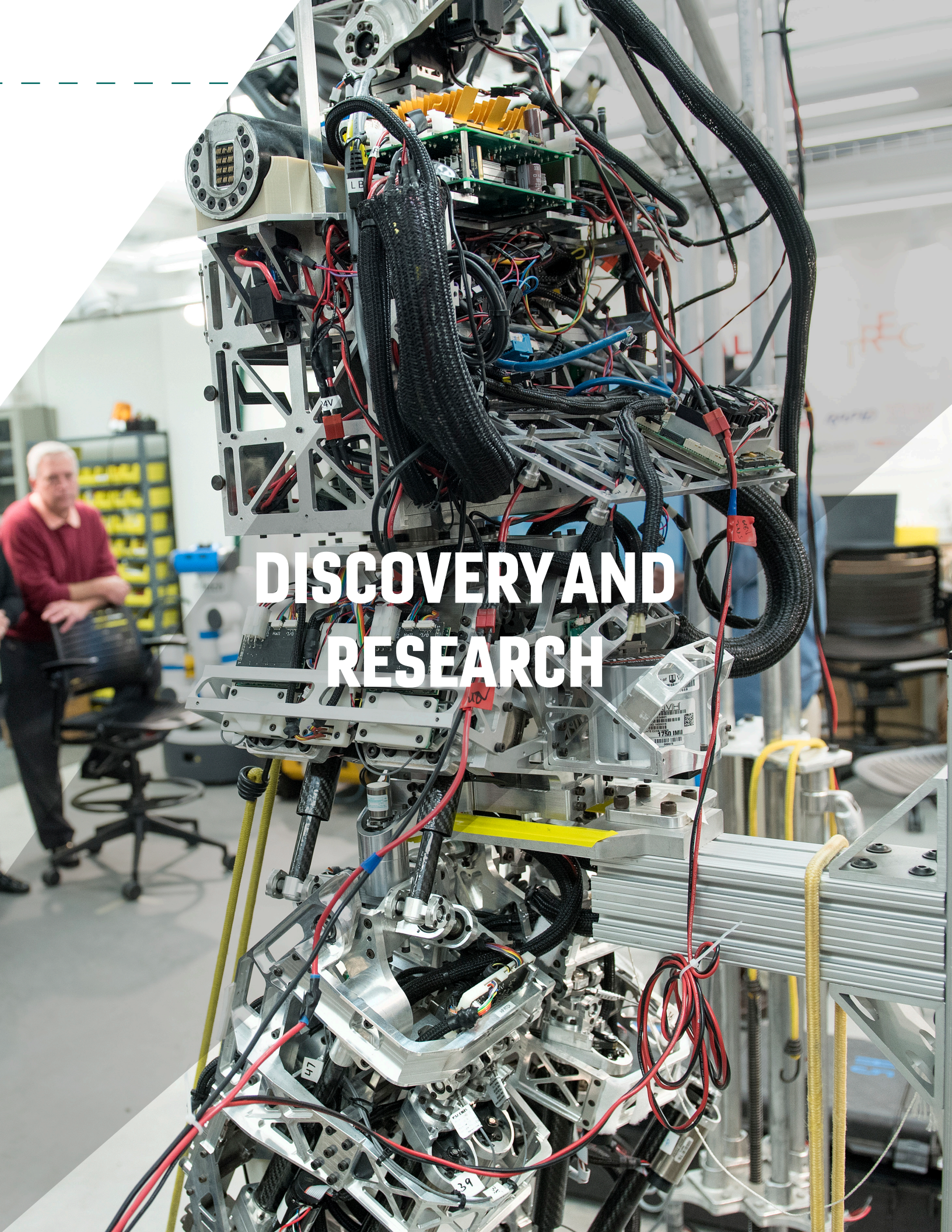
1,114
Undergraduate Students
Academic Year 2017–2018
(Sophomores–Seniors only)

#22
Graduate Program
Rank Nationally

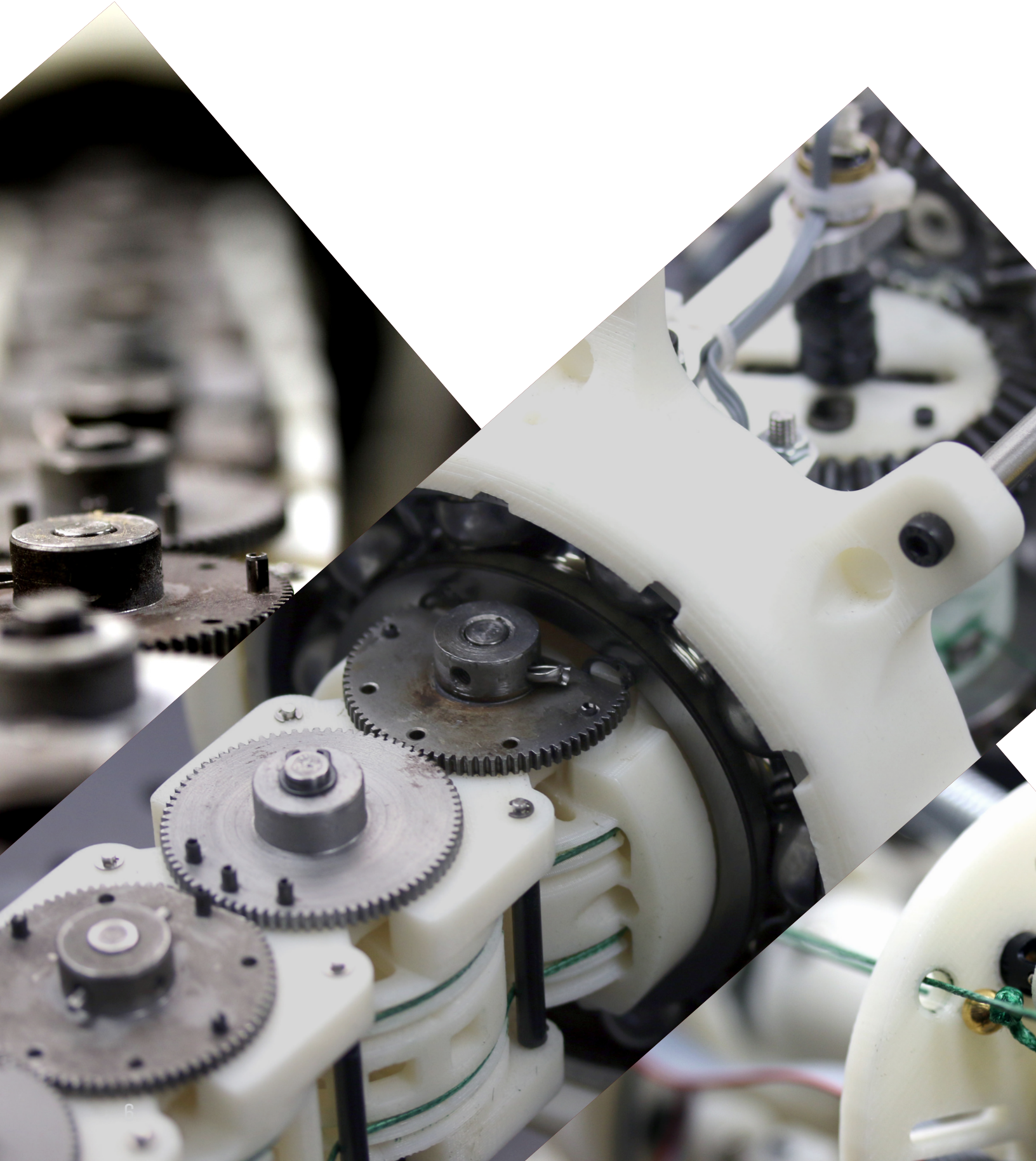
310
Graduate Students
Academic Year 2017–2018

Degrees Conferred 2017–2018



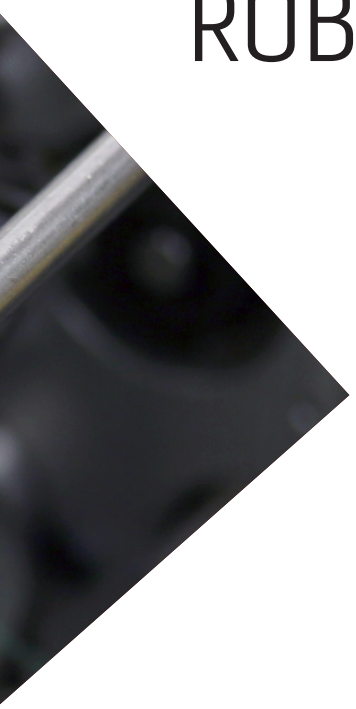


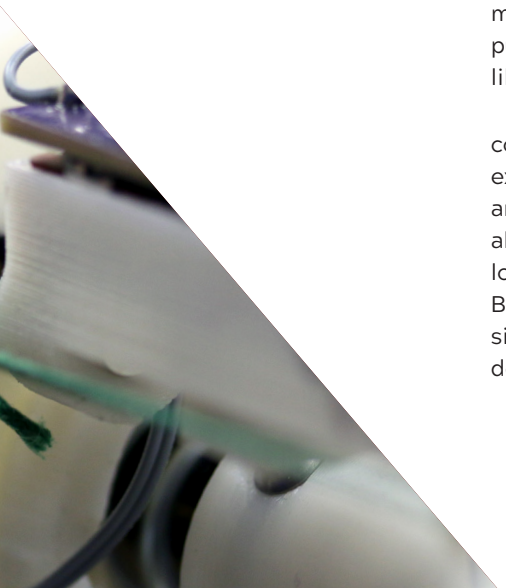
DISCOVERY AND RESEARCH



ROBOTIC TAILS:

HIGH-TECH TAILS MAY PROVIDE BIO-INSPIRED SOLUTION TO ROBOT STABILITY





In the Robotics and Mechatronics Lab of Pinhas Ben-Tzvi, associate professor of mechanical engineering, the tail has become a captivating solution for the problem of bipedal and quadrupedal robot stabilizing and maneuvering.

"If you've seen robotic quadrupeds, they are very big and very expensive, with articulated legs incorporating multiple degrees of freedom," said Ben-Tzvi. "The machines use the leg's multiple degrees of freedom to maneuver and stabilize so if they are pushed from the side, the legs adjust like a human to keep it from falling."

The problem is that with legs so complex, they are large and very expensive, requiring additional joints and motors, as well as complex control algorithms and increased computational load. With the addition of a robotic tail, Ben-Tzvi believes the legs can get much simpler, and the robot lighter, easier to design, and less expensive.

"We can make legs with a single degree of freedom, and one motor per leg that will allow the entire mechanism to run forward, but really fast," explained Ben-Tzvi. "The legs take care of the locomotion, and the tail takes care of stabilization and maneuvering. By decoupling the purposes, we can scale back the complicated legs to make the system much simpler, lighter, more agile, and less expensive."

The tail works by exerting forces and moments on the robot in six degrees of freedom: forces along the x, y, and z directions and moments about those directions. Ben-Tzvi and his students are mapping the forces and moments generated by the tail motion in an effort to provide stability and maneuvering. The tails are flexible, self-contained and made of the mechanisms that provide the structural backbone of the tail. Actuators and sensors in the tail joints measure position, velocity, and acceleration.

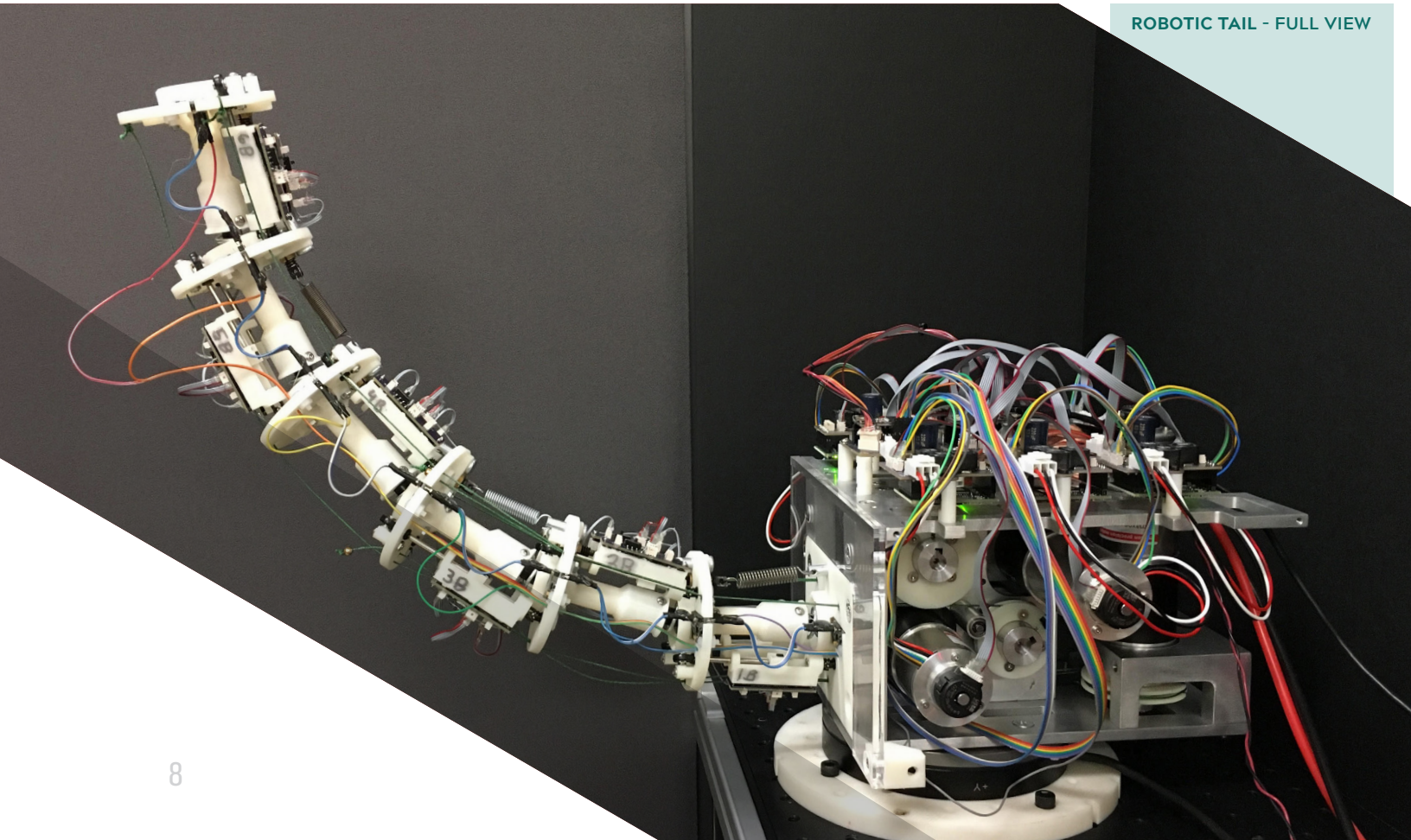
"We looked to nature to see how animals used their tails and how their tails are structured," said Ben-Tzvi. "What we saw was a continuous deformation and hyper-redundant structure, so we've been inspired by that, and the research we've done has been largely establishing the field of hyper-redundant robotic tails. We are pioneering - exploring the field and establishing it so that we have a baseline for coupled dynamic analysis of legged robots with tails onboard."

The tail needs to be robust and flexible, being able to perform a variety of functions to justify incorporating it into a complex, high-performance mechanism.

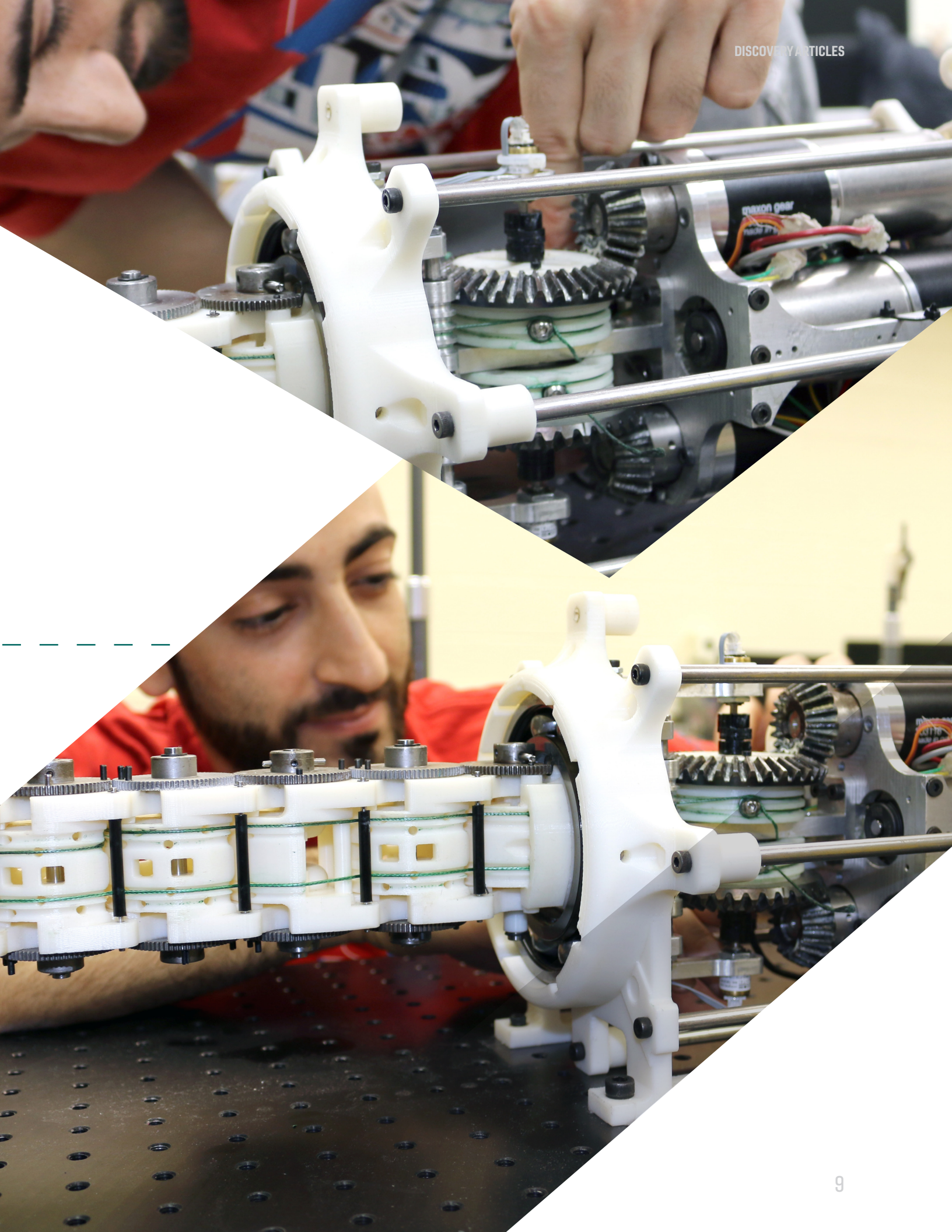
"The idea is that by generating different spatial motions of the tail, we can apply moments and forces around the base of the tail that will result in moments and forces applied to the robot, which will allow it to change direction or maintain stability.

After modeling and establishing the science behind the tails' potential, the team has come up with new mathematical modeling approaches that are widely applicable for flexible structures beyond tails. Because of their multiple mode shapes, the tails allow for a greater range of freedom than single degree of freedom instruments.

"WE ARE PIONEERING"



ROBOTIC TAIL - FULL VIEW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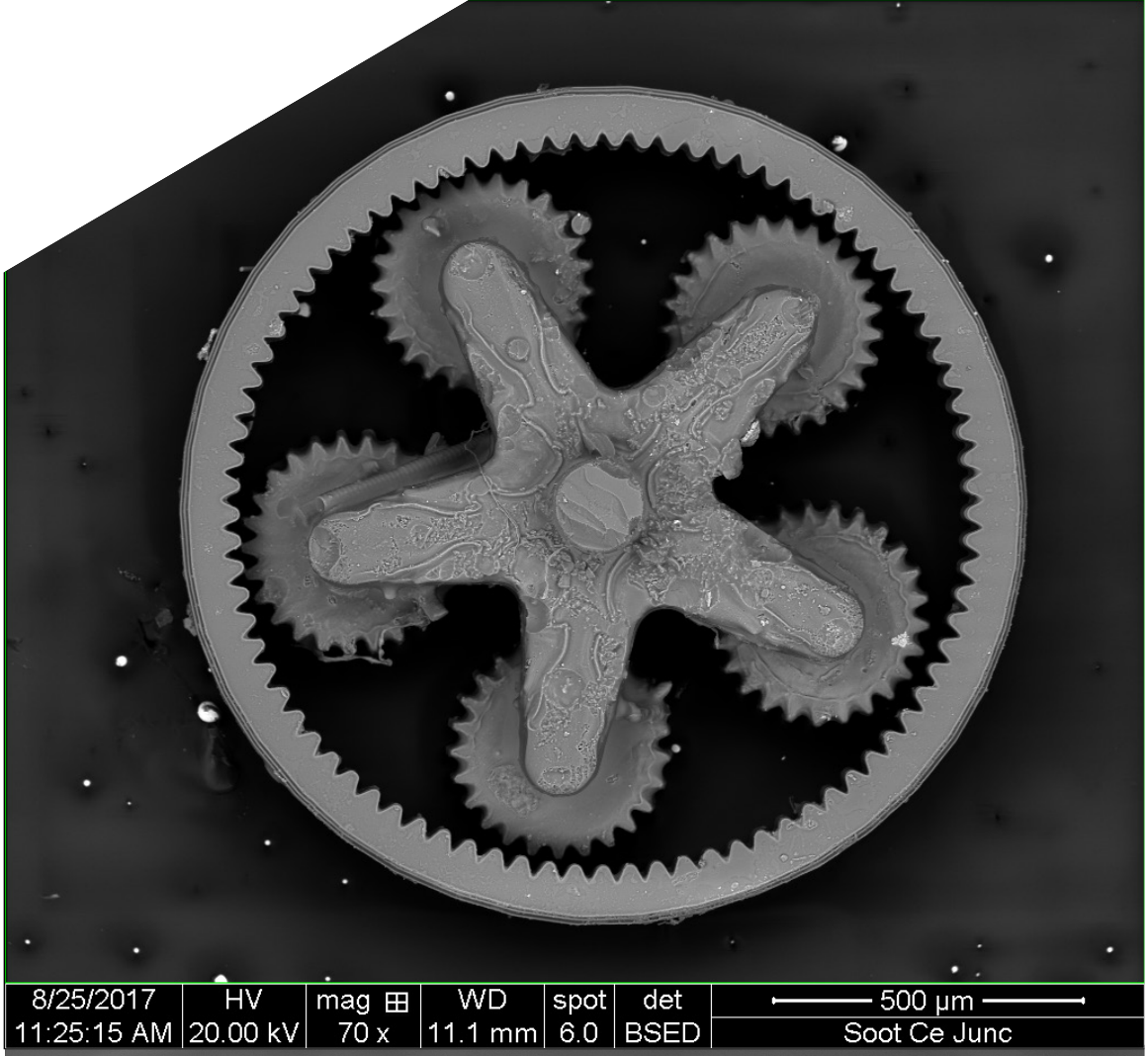
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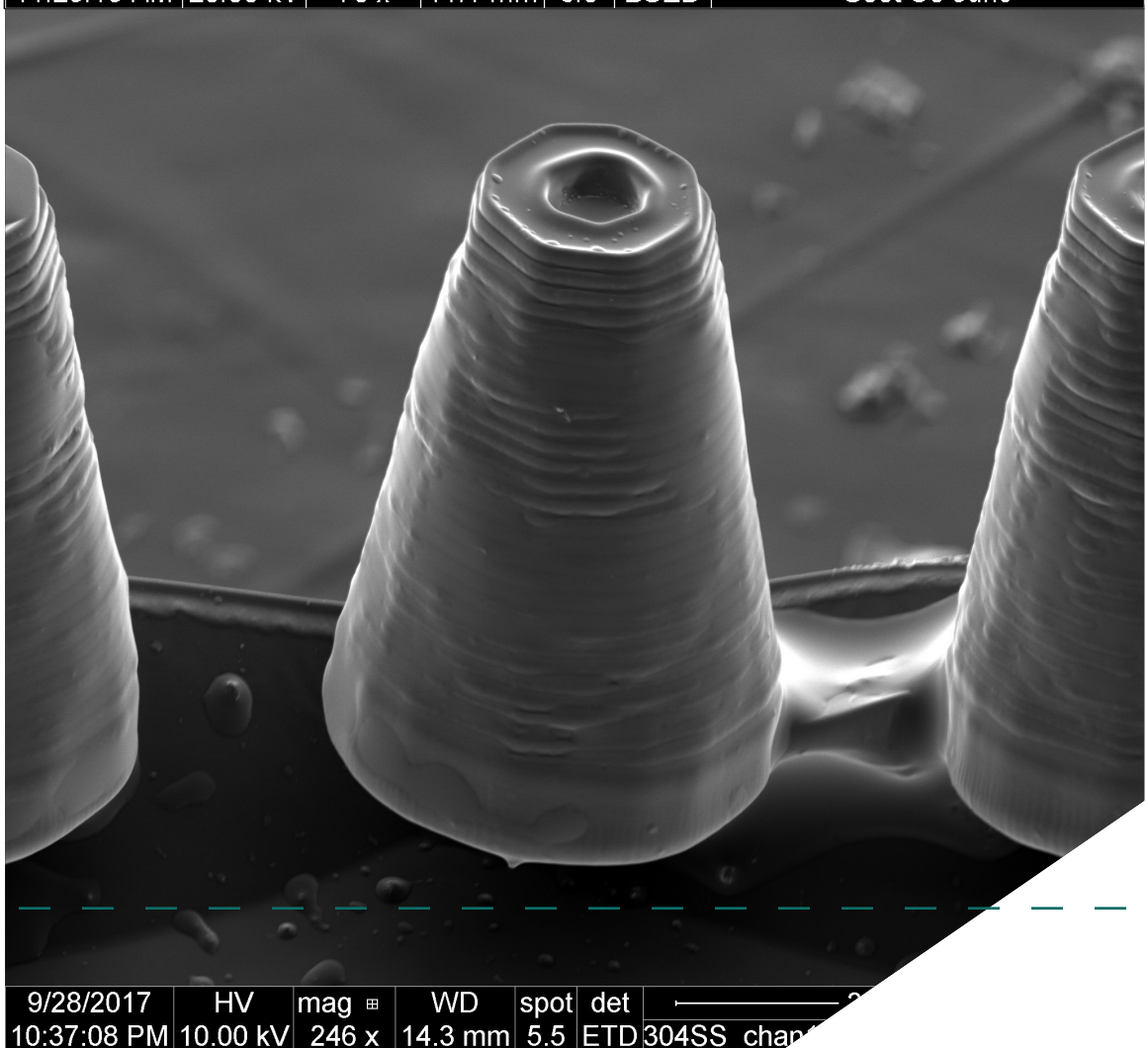
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NANO 3D PRINTING:

VIRGINIA TECH LEADS DRIVE TOWARD SCALABLE 3D PRINTING TECHNOLOGY

The National Science Foundation awarded $400,000 to Virginia Tech as part of an initiative to build the theoretical and experimental foundations of scalable, 3-D printing at the nano-level.

Rayne Zheng, assistant professor of mechanical engineering, will use the award for Additive Nano-Manufacturing of Resilient Materials to develop technologies to allow researchers to 3-D print at the nano-level and scale up their creations.

"Current commercially available additive manufacturing technology doesn't include a printer of the resolution and scalability needed to do work at the nanoscale level," Zheng said. "This grant program will support building the foundations needed to underpin scalable additive nano-manufacturing."

Zheng's research will look at how to create three-dimensional constructs with nanoscale features, with the goal of creating materials that are extremely strong mechanically and have exceptional thermal and electrical conductivity.

Using controlled precision optics and photosensitive materials, Zheng and his team will work toward developing and understanding the processes that produce scalable nano-architected materials that will be lightweight and capable of energy storage, among other applications.

"In our early work we've created 3-D nano-architected materials that are simultaneously strong and damage tolerant," Zheng said. "However, we realize there are challenges with current high-precision 3-D manufacturing technologies in scaling up nano patterns to sizes comparable to the size of the palm of a hand. With the support of the NSF, we hope to make a leap forward, gaining new knowledge on the underpinnings of high-resolution additive nano-manufacturing of scalable materials and components."

MALAWI DRONES:
VIRGINIA TECH UNMANNED AIRCRAFT SETS RECORDS IN MALAWI

$350 AIRCRAFT

DESIGNED WITH LOW RECOURCE ENVIRONMENTS IN MIND

Flights by a fully autonomous aircraft designed in mechanical engineering's Unmanned Systems Lab set several records in Malawi in 2017, including the longest cross-country unmanned aircraft flight, the first flight of an aircraft fabricated by Malawians, and the first delivery of a payload from a health clinic. The flights were part of tests conducted at the UNICEF drone testing corridor in Kasungu, Malawi.

Designed to carry small packages for medical supplies and diagnostics, the aircraft called EcoSoar, flew a 19 kilometer fully-autonomous mission from the Gogode Health Clinic to the Kasungu Airport carrying a simulated package of medical supplies.

More significant than the flight, was the fact the aircraft were built by a team of Malawian students from the Malawi University of Science and Technology (MUST) under the supervision of graduate students Zack Standridge in aerospace engineering and James Donnelly of mechanical engineering, and Kevin Kochersberger, an associate professor in mechanical engineering.

Thirteen Malawian students built five EcoSoar aircraft as part of a two-day fabrication workshop before the aircraft carried a simulated package of dried blood spot samples to the Kasungu Airport.

"EcoSoar was designed with low-resource environments in mind," said Kochersberger of the $350 aircraft made from such materials as foamcore poster board and 3-D printed parts. "I envision entrepreneurs in Malawi establishing businesses around the use of this aircraft - building, operating, and maintaining EcoSoar for both medical deliveries and environmental assessment activities."

In addition to a payload capacity of 130 grams (4.5 ounces), the aircraft can be fitted with an eight-megapixel camera to collect images of the ground environment, which can then be reconstructed for environmental monitoring.

The aircraft was launched from the Gogode Health Clinic and recovered at the Kasungu Airport about 15 minutes later.

The UNICEF drone testing corridor opened in July 2017 in partnership with the Malawian government to explore drone applications in emergency medical supply delivery, vaccine and sample delivery for diagnosis, and remote sensing for environmental assessment. It will remain open for one to two years.

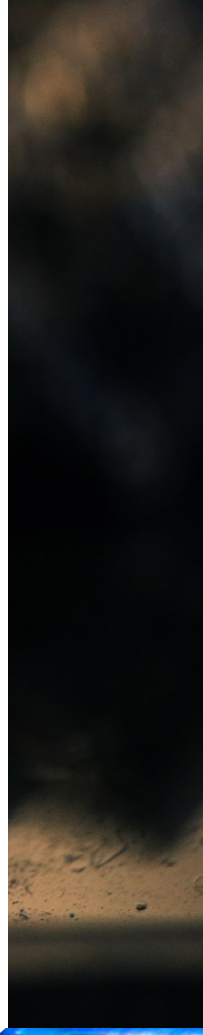
"It was truly inspiring to see a Malawi-manufactured drone built by students under Virginia Tech guidance," said Michael Scheibenreif, drone corridor lead with UNICEF, who took part in the training.

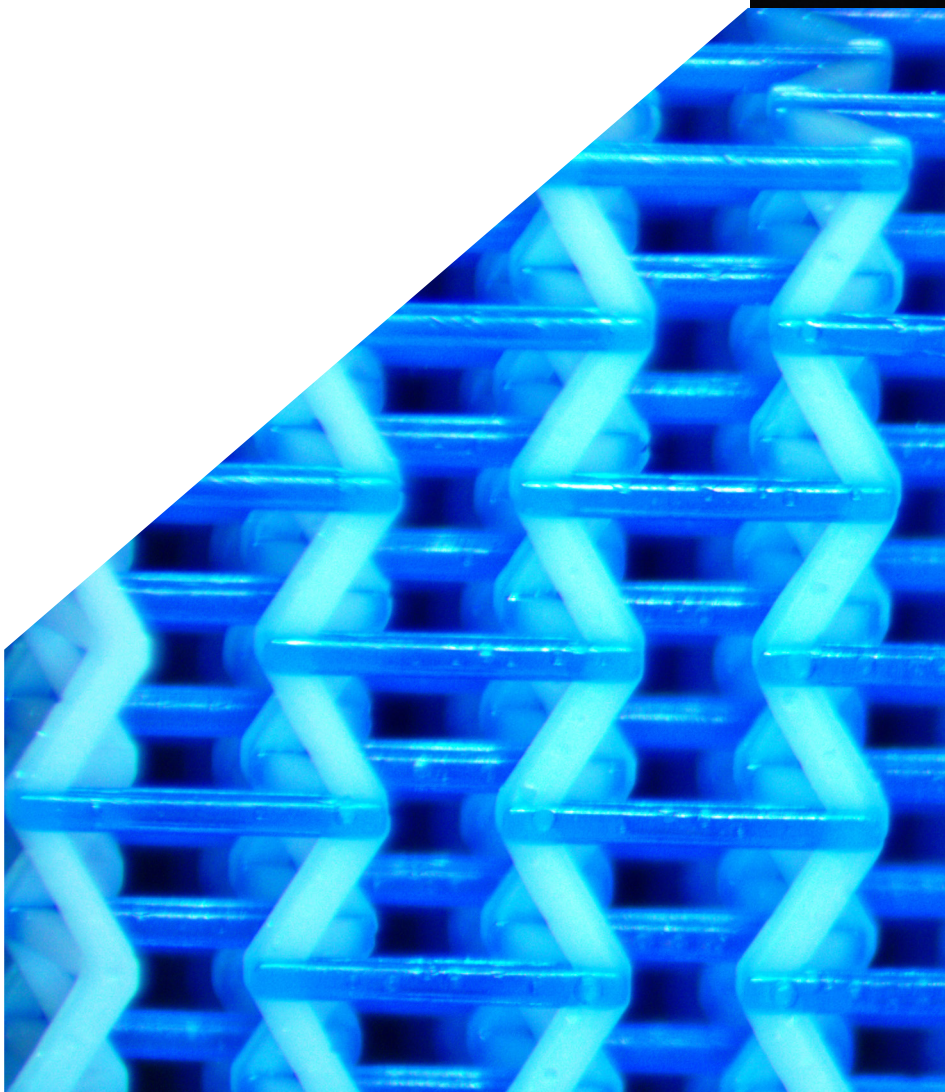
"This could have the potential to deliver medicine to remote and hard to access communities and is a great example of how important it is to build local capacity in the drone sector. If we can build an ecosystem of drone experts locally, we can ensure these solutions are sustainable and embedded within the communities they service," Scheibenreif said.

The UNICEF drone coordinator said that after witnessing the manufacture and flight of the EcoSoar, he sees great opportunity for drones to leapfrog over broken infrastructure to carry lifesaving materials to places where developed transportation networks do not exist.

MICRO SCALE 3D PRINTING:

NEW METHOD ALLOWS 3D PRINTING WITH PROGRAMMABLE STIFFNESS

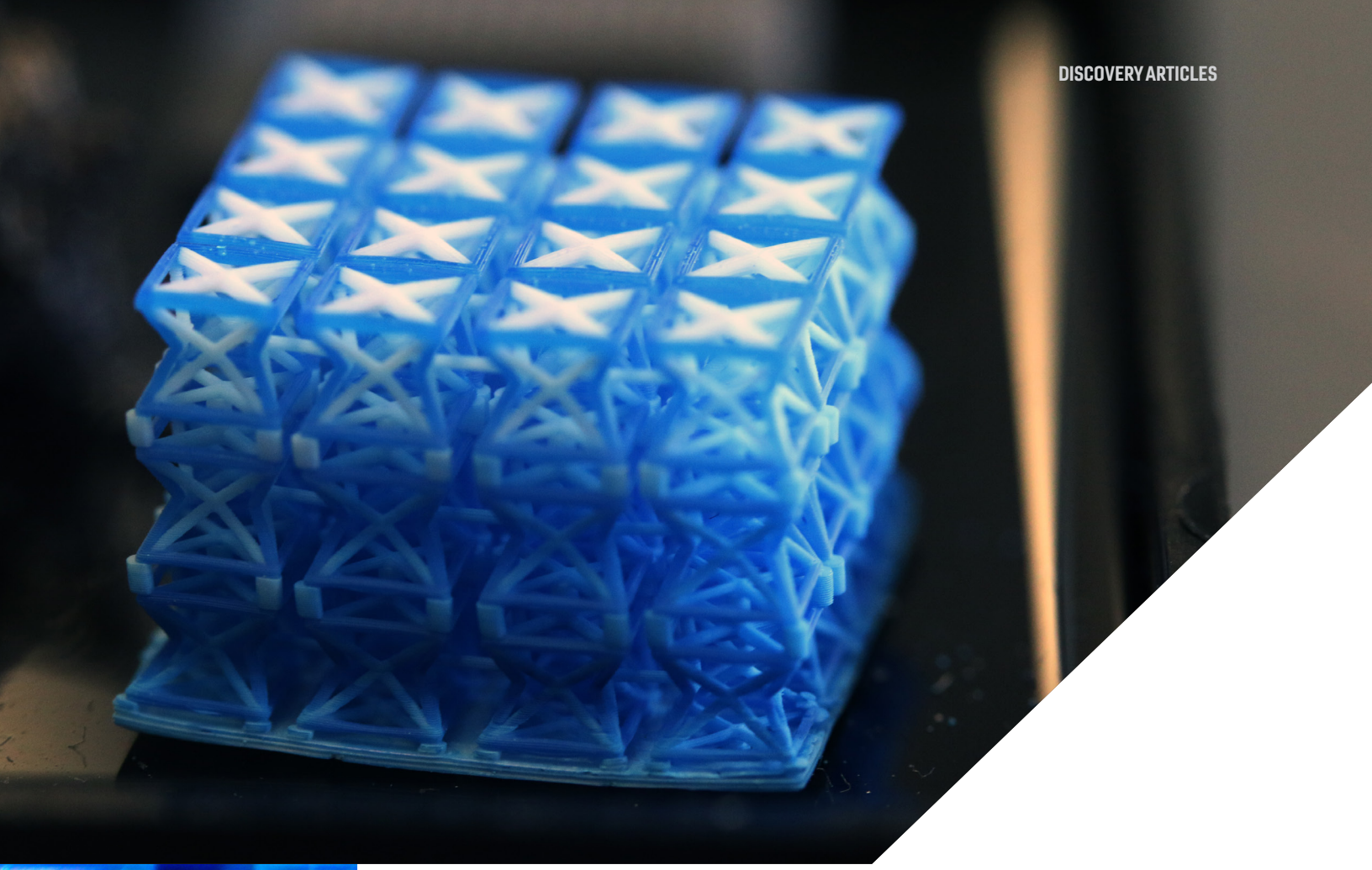


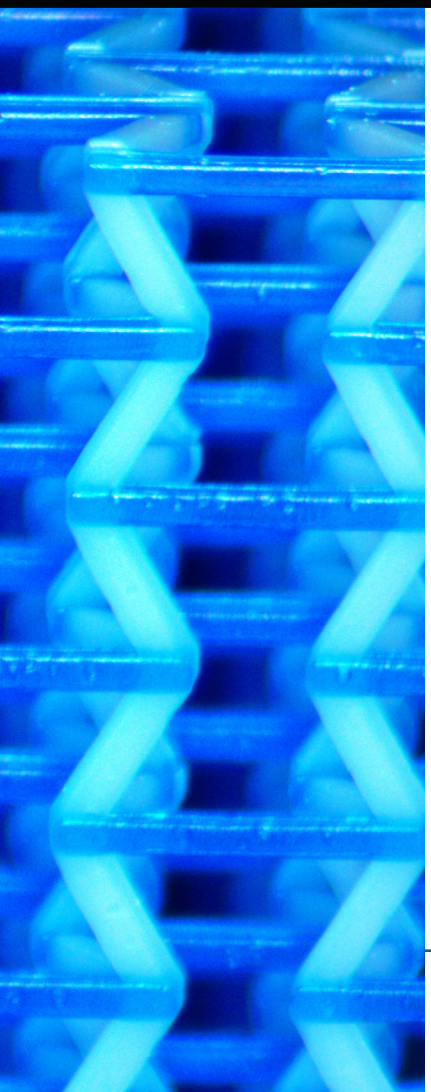


A new method of microscale 3D printing features in-situ resin mixing, delivery and exchange, and a robotic material cleansing system to allow switching between materials of different modulus, or flexibility, without cross contamination between properties.

The method, called multimaterial programmable additive manufacturing with integrated resin delivery, is featured in the journal Scientific Reports. The technology could be useful in various applications, including aircraft wing structures, protective coatings, energy absorption, actuation, flexible armor, artificial muscles, and microrobotics.

Xiaoyu “Rayne” Zheng, an assistant professor of mechanical engineering, and a member of the Macromolecules Innovation Institute, said the microscale manufacturing system can be up-scaled to the centimeter levels and above.





"We use this new technique to create materials with programmed stiffness," said Zheng. "Basically, you can program where the modulus is distributed in 3D. With this programming we can achieve morphing capability - to stretch and deform in different directions."

With normal material, stretching in one direction will cause the material to shrink in the opposite direction. The new patented process and design allows designers to create very specific modulus distributions within a build to allow for programmed morphing - where programmed expansion or shrinkage can occur throughout the material body.

"The technique is a robotic-based additive manufacturing, an integrated fluidic system that allows us to deliver different ink [resin] as feedstock," Zheng said. "The process is also self-cleaning so that there is no cross-contamination between inks."

Ideally, Zheng said, 3D-printing technology would like to be at a place where a functional device could be printed incorporating multiple materials without excessive construction, such as tooling, gluing, fitting, or welding.

"Achieving this goal requires us to put an array of different material properties into a single platform and connect them. The added degree of material design freedom allows us to achieve negative, positive-to-zero morphing strains without changing the 3D micro-architecture of a material," Zheng explained.

FRACTALS:
SYNTHESIZED COATINGS CREATE A HABITAT FOR ENERGY PRODUCING PHOTONS

The cost difference between fossil fuel and solar high capacity power plants can be measured in cents per unit of energy. A Virginia Tech mechanical engineer believes he's found a way to bridge that gap by catching the sun with fractals.

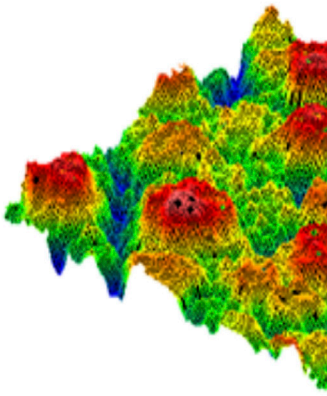
"Coal and natural gas electricity generation costs about 5 cents a kilowatt hour compared to about 10 cents for current solar thermal plants," said Professor Ranga Pitchumani, the George R. Goodson Professor of Mechanical Engineering. "With better receiver coatings, we can increase the operating temperatures and make up that nickel and get solar-powered electricity down to cost parity at 5 cents per kilowatt hour."

This savings can be made thanks to fractals, objects whose measure varies depending on the scale used for the measurement. They are multiscale, self-similar, hierarchical structures that are abundant in natural constructs such as coastlines, snowflakes or biological structures. This is unlike Euclidean objects such as a straight line, whose length is the same measured with a meter stick or a foot ruler. A meter stick measuring the coastline of Rhode Island will come up with a different answer than a one-inch stick which will better resolve the irregularities of the coastline. A one-millimeter stick will come up with an even different, and larger, number.

As Pitchumani, explains, "There are two ways to convert sun's energy into electricity. Solar cells using the photovoltaic effect work by discharging electrons, by virtue of impact by packets of energy in sunlight called photons; the electrons go through a circuit to provide electricity. The second way is by converting the energy of photons to heat." It is the latter that Pitchumani and his group in the Advanced Materials and Technologies Laboratory are focused on.

The problem Pitchumani and his graduate student Rahul Jain were confronted with was how to increase the amount of sun's energy a receiver can capture and convert to heat at higher temperatures.

Unlike rooftop photovoltaic solar cells, a solar thermal power plant requires acres of mirrors that aim the sun's reflection at a receiver which amasses the photons and turns them into heat. The energy is used to heat a fluid (water or molten salt) to generate steam to run a turbine, in the same way a fossil-fired plant would operate. The hotter the steam entering the turbine, the more efficiently the turbine can generate electricity. And



WITH BETTER RECEIVER COATING, COST DROPS TO

5 CENTS

PER KILOWAT HOUR WHEN USING FRACTAL SURFACES

higher efficiency translates to fewer cents per energy unit produced.

"You need to capture photons but when the receiver surface gets hot it re-emits the heat back out like a stove," Pitchumani said. "So, the challenge becomes creating a material to absorb the photons and minimize the heat energy lost to re-radiation. The holy grail would be no radiant heat lost."

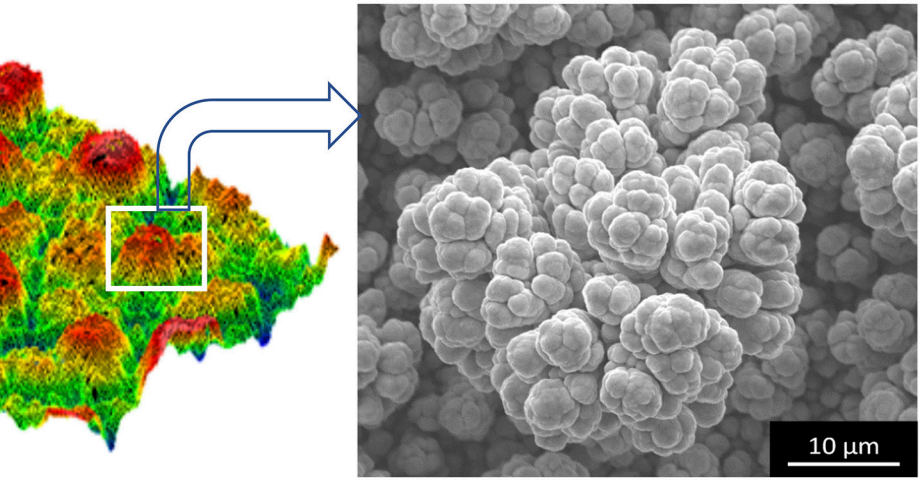
Coating the receiver is one way to help absorb more energy and solar selective coatings, as they are called, have been around for a long time in a simple form - a particular type of black paint. Unfortunately, as the temperature rises, the paint becomes less stable and peels off, requiring the receiver to be shut down and recoated - adding to the cost of electricity generation.

To fill the vacuum that exists in the area of solar coatings at high temperatures, Pitchumani looked at the surface of the receiver.

"It's mostly smooth," he said. "The light hits it and there is not much to absorb the photons except the small surface roughness. So, we thought, 'what if we can deliberately texturize the coatings and make a complex surface structure so when the light goes in, it's like a maze of cavities where photons can be captured and converted to heat'?"

Which brings us back to fractals.

Pitchumani and Jain asked, "Can we create fractal textures on engineered surfaces with multiple scales of roughness elements that can trap the photons? That's the motivation. We've been working on a process using electrodeposition, which under certain conditions generates highly fractal surfaces. Electrodeposition is industrially well established and can be easily done on large scale structures like solar receivers."



To create the fractals, Pitchumani starts with an electrochemical process where smaller currents generate higher voltage and larger currents generate lower voltage.

"Near the point where the voltage is almost zero, there's an inherent instability in the process that creates a fractal surface," Pitchumani said. That discovery lead to a patent for manipulating the process parameters and intelligently architecting a desired surface.

"A key advantage of this process is that the coating is built integrally on the base material," he said. "Often the Achilles' heel of coatings is the interface between the coating and substrate materials which is a weak link causing the coatings to degrade or peel off - think of the space between paint and wood. In our process, we can grow the coatings using the same material as the base, such as copper on copper or nickel on nickel. Native surfaces are inherently durable and you don't have to periodically recoat the surface. This process will allow us to significantly upgrade the energy absorbed by the receiver."

The team created multi-scaled fractal textured coatings and tested them extensively for their performance and durability as solar selective surfaces. The work appears in a recent issue of Solar Energy Materials and Solar Cells. "We found that fractal textured coatings show a remarkable threefold increase in the ability to capture photons efficiently and convert them to heat," Pitchumani said. "This is paradigm altering," he added, "it paves a new way to design thermal receivers for next generation solar thermal plants and bring down their costs."

FARMER ROBOTICS:

RESEARCHERS DEVELOP WEARABLE TECH FOR FARMERS

$1.5 MILLION

TO RESEARCH ROBOTIC ASSISTANCE FOR VIRGINIA FARMERS

Two National Science Foundation grants of approximately $1.5 million, awarded to Virginia Tech researchers, will bring robotics and technology assistance to provide physical safety and to enhance the quality of life for Virginia farmers.

The first project partners with industry to use robotics to aid farmers with mobility impairments. The Partnership for Innovation (PIC) grant is a collaborative effort between Virginia Tech's College of Engineering and College of Agriculture and Life Sciences (CALS), and community partner AgrAbility Virginia, a program that assists farmers with illnesses, injuries, or disabilities that are impeding their ability to work safely, effectively, and productively. The research will aid farmers through the use of wearable robotics, and other robotic apparatus, targeting back, knee, and hand applications.

The Research Coordination Network (RCN) grant, the second project, is a collaboration with U.S. and international researchers to enhance technology on mid-sized farms.

Alexander Leonessa, professor of mechanical engineering, is the principal investigator for the PIC grant and a co-investigator for RCN grant. Leonessa is partnering with colleagues Divya Srinivasan, assistant professor in the Grado Department of Industrial and Systems Engineering, and Kim Niewolny, associate professor in agricultural, leadership, and community education in CALS, on both grants.

Partnership for Innovation grant

Working with partners, such as TORC Robotics, researchers will use robotics systems to generate additional discoveries as they learn from partner farmers. The project will address the human factors component of the technology and the need to educate farmers. The team will evaluate the farmers' daily activity and human-factors and agriculture experts will work with farmers to provide inputs to the design processes.

"The robotics we're looking at are things we've already developed, but need to modify to the individual and adapt to the particular function," explained Leonessa. "We are working with Total Motion Physical Therapy for baseline information on farmers in the program. Then we work to personalize robotics specific to the individual farmer's needs."

The work will initially focus on mobility impairments associated with an aging demographic such as arthritic hands and knees, but also devices to assist with lifting.

"These devices will be something the farmers will wear to fulfill their daily tasks," said Leonessa. "Many of our older farmers have issues such as arthritis, and by providing this technology we can ensure they can complete their tasks. The goal is not for farmers to work until they are 90, but to allow them to work with less fatigue and be able to continue to do what they love while staying healthy."

The devices will assist with various functions, including movements associated with farming, such as using a shovel or driving a tractor. By the end of the three-year project, participating farmers will have wearable prototypes to assist them in their activities.

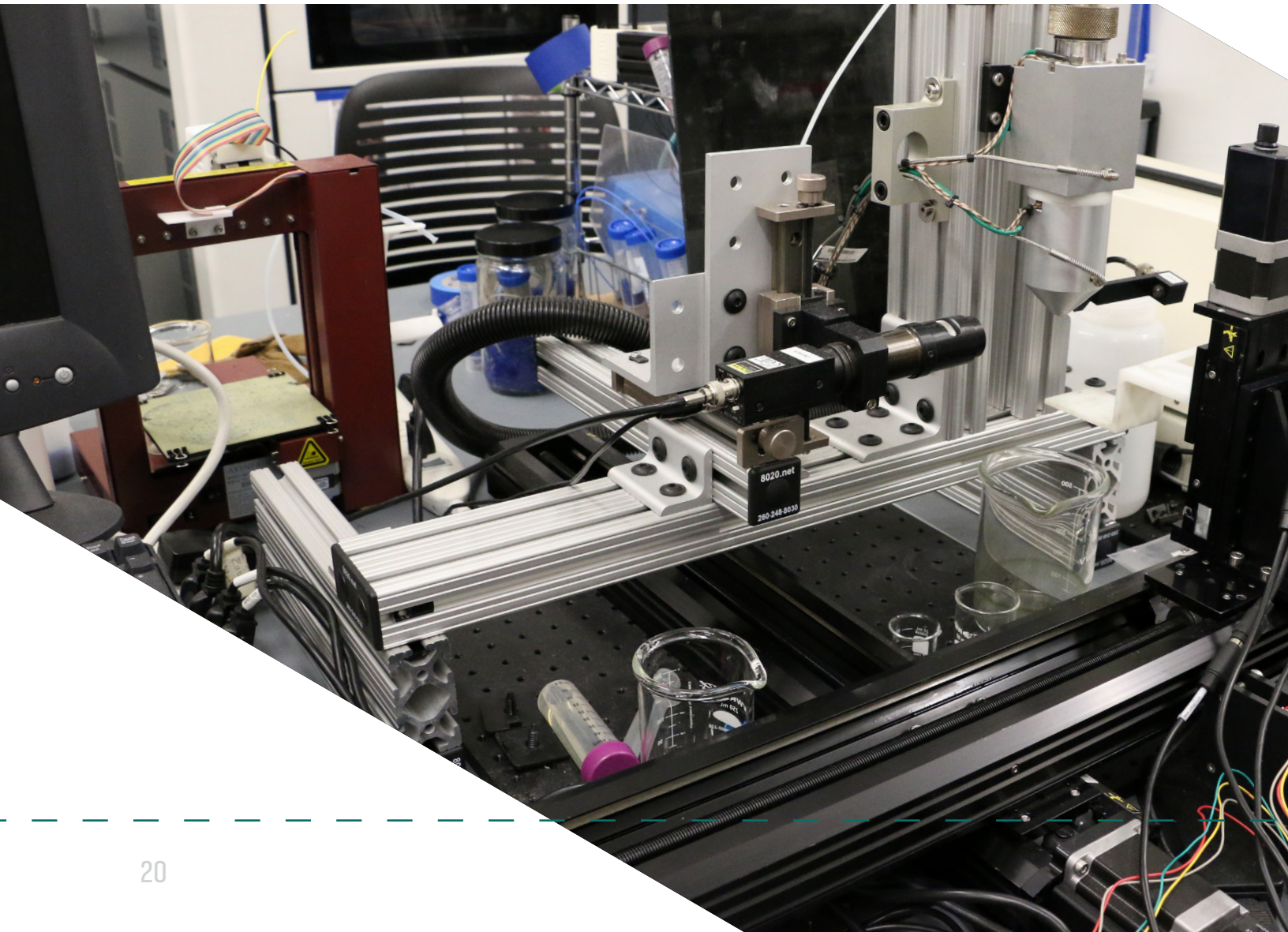
The RCN grant brings together expertise from around the world to look at how technology can help mid-sized farms compete in an increasingly challenging and automated agricultural economy. The network brings together researchers in technology, human factors, sustainability, systems engineering, STEM education, and outreach, with the goal of tackling the problem from a multidisciplinary perspective. Currently, the grant consists of 21 researchers from Virginia Tech, Purdue, Arizona State, University of Iowa, and universities in Canada, Ireland, and Australia.

The program is part of the first-ever Convergence Award from the NSF to enhance small and mid-level farm viability through a systems-based research network that links technology with sustainable development and practice. The Convergence Award is one of eight focused on "Work at the Human Technology Frontier," and one of two earned by Virginia Tech.

As the network develops, the NSF aims to gather research to develop tools to share human-technology partnerships, improve worker performance, increase career longevity and job satisfaction, and promote lifelong learning.

MULTI TECH 3D PRINTER:

DREAM MACHINE ALLOWS FOR MULTI-MATERIAL 3D PRINTING



By combining several additive manufacturing technologies into a single desktop unit, researchers have created a new way to manufacture complex, multi-material products.

The device, known as the Dream Machine, was based on an undergraduate senior design project, which aimed to revolutionize 3-D printing by allowing users to print multiple materials in a single build using multiple types of deposition tools.

The machine advances additive manufacturing (AM) by tackling the lack of integration among multiple technologies.

"There are many ways to print things, but at the end of the day we're still stacking layers to create an item," said Danny Rau, a mechanical engineering graduate student. "Bringing all these AM technologies into a single system is a novel concept," Rau said.

"WE'RE THE PIONEERS OF THIS TECHNOLOGY, AND THAT FEELS PRETTY GOOD TO SAY"

The AM technologies the team worked with for their product were filament extrusion, paste extrusion, vat photopolymerization, and binder jetting.

Despite the ability to simultaneously print with multiple technologies, not all formats work with each other. For instance, binder jetting only works in conjunction with paste and filament extrusion. However, most formats work with a majority of the other print types; for example, the machine can use paste extrusion to selectively deposit conductive ink into a high temperature epoxy part that is printed using vat photopolymerization.

The Dream Machine also features a method of modular construction that will allow it to continue to grow.

"The machine is more than just the print heads," said Grady Wagner, a 2017 mechanical engineering graduate who now works at Space-X as an additive manufacturing engineer.

"The build plate is also important. For instance, for light-based printing, the build plate can't be reflective, but for plastic based materials, it needs to be heated. We've developed a modular platform where the user can change the size of the build plates, which allows for printing large parts and enabling researchers to work with small batches of experimental materials. In addition, the modular nature of the printer allows new print technologies to be incorporated as they become available."

"We're the pioneers of this technology, and that feels pretty good to say," Rau said.

In addition to Rau and Wagner, the Dream Machine team includes graduate student Lindsey Bass, Mitchell Wolf and David Wolf who work for Northrup Grumman, and Scott Ziv, with the Naval Sea Systems Command. The team has filed a provisional patent for the device.

AUTODRIVE:
TEAM DELIVERS ON LONG HISTORY OF AUTONOMOUS VEHICLE COMPETITIONS

"AN UNDERDOG SUCCESS STORY"

Mechanical engineering's AutoDrive team took third place in the first year of an autonomous vehicle competition held by the Society of Automotive Engineers (SAE) and General Motors.

Victor Tango AutoDrive was the only one of eight teams to successfully complete all three portions of the AutoDrive Challenge, held at the GM Desert Proving Ground in Yuma, Arizona. The challenges were based on complex perception, navigation, and behavior algorithms for a self-driving car, such as stopping at stop signs or staying in lane lines.

Each team was tasked to develop a fully autonomous passenger vehicle using a 2017 Chevy Bolt and present on the social impacts of autonomous vehicles before putting their electrical designs and coding to the test by navigating a closed test track in autonomous mode.

"It is really an underdog success story," said Andy Cohen, a mechanical engineering ('18) and a member of the controls subteam and the business subteam lead.

Less than a month before the competition, the battery on the Bolt died, and the car had to be sent back to GM for servicing. With the car in Detroit, the team considered pulling out of the competition if the car didn't make it back in time to complete the necessary testing to ensure the safety of student vehicle operators.

"...Later that week, we got notice [from GM] that said, 'We've fixed your car, we're sending it back," said Cohen.

With 10 days to go before competition, the team had to complete 100 hours of testing. Working around the clock, the team had just enough time to complete all the testing they set out to accomplish, and according to Cohen, the time crunch enabled their success as the team was forced to use a "fusion of old school and new school," methods integrating traditional

environment mapping with complex perception algorithms.

"Everyone else at the competition didn't rely on maps because they figured they could do it entirely with perception," Cohen said. "But the environment wasn't as well regulated as they thought."

Because their vehicle could navigate the faded lane lines, Victor Tango AutoDrive was the only team to complete the second, lateral challenge.

In year one of the three-year competition teams focused on concept selection by becoming familiar with sensing and computing software. They wrote a concept design, and completed an on-site evaluation with dynamic tasks such as straight roadway driving and object avoidance and detection.

The team placed in the top three in each category including first in the lateral challenge and third in social responsibility report, social responsibility presentation, mapping challenge, and object detection and avoidance challenge.

Over the next two years the car will carry out more complex tasks, such as moving at higher speeds, making U-turns, and dodging a dynamic object. By 2020 the team will produce a level four autonomous vehicle - capable of steering, braking, and responding to traffic without the need for human intervention, according to SAE standards.

AUTODRIVE TAKES 3RD IN GM COMPETITION


agBOT
CHALLENGE
Champion
WATERMELON
HARVEST
COMPETITION
2018
VT AgBOT


VT AgBOT

AGBOT:
SENIOR DESIGN ROBOTICS TEAM TAKES TOP PRIZE WITH AUTONOMOUS HARVESTER

The Virginia Tech agBOT team clinched first place in the third annual 2018 agBOT Challenge at Gerrish Farms in Rockville, Indiana, earning a top prize of $30,000.

The national event, hosted by Gerrish Farms and airBridge LLC, was broken into two separate challenges - weed and feed and harvesting - with university and industry teams competing head-to-head for $100,000 in prizes.

Virginia Tech's team won the watermelon harvesting challenge by creating an autonomous system that could locate, identify, sort, and harvest ripe watermelons in a field. Teams were scored in mechanics, software, innovativeness of their solution, and execution of their solution.

Two separate teams were formed to tackle the competition challenges. A mechanical engineering senior design team was tasked to design and build a harvester, while a second special studies team was responsible for the autonomous vehicle that towed the harvester. The latter was composed of volunteer mechanical, electrical, and computer engineering undergraduates and computer science students.

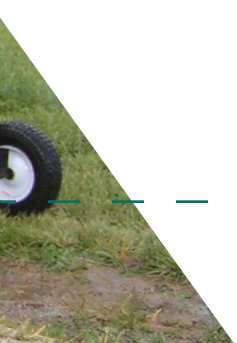
As team lead for both teams, Hongxu "Howard" Guo, a double major in mechanical and electrical engineering, coordinated the work of 14 people.

With the tow vehicle, Guo and his special studies group used computer vision and machine learning technologies that allowed the vehicle to locate watermelons. When no melon was in sight, the vehicle used way-point navigation to find its way through the fields. When a watermelon was spotted, the machine's cameras guided it toward the fruit. Once there, the harvester determined whether or not the melon was ripe.

The process humans have used for centuries to determine if a watermelon is ripe is to slap it and listen for a deep, hollow sound. This sound has a particular frequency range, which the team made into a mathematical model to develop their automated system.

"We placed a microphone under the unit and angled it to the bottom of the melon where it captures the reverberations from the slapper," said Guo. "If the audio analysis indicates a sound ratio above a particular threshold, what we call the sub-band short-time energy ratio, then the watermelon is ripe and harvested. If not, it is left on the ground."

As the vehicle rolls past melons, they are channeled into a funnel where the slapper hits the melons and the sound is analyzed; melons that meet the frequency for ripeness are scooped up into the machine's storage unit. A linear actuator relays how much current is used to lift the scoop and this provides a size and weight estimate for the melon.



DES CHAMPS CHAIR:

ALUMNI GIFT CREATES DEPARTMENTAL CHAIR

Azim Eskandarian, head of the Department of Mechanical Engineering, has been named the Nicholas and Rebecca Des Champs Chair in Mechanical Engineering by the Virginia Tech Board of Visitors.

The Nicholas and Rebecca Des Champs Chair in Mechanical Engineering was established in 2017 in honor of Nicholas and Rebecca Des Champs, who endowed the position with a $2 million gift. The appointment will be held continuously by the head of the department and expire when the recipient no longer serves as department head. Nicholas Des Champs enjoyed a distinguished career in the heating, ventilation, and air conditioning, or HVAC, industry after earning his bachelor's degree and Ph.D. from Virginia Tech in mechanical engineering in 1962 and 1967, respectively.

Eskandarian, an internationally known researcher in the field of autonomous vehicles and vehicle safety, has been professor and head of the department since 2015. During his three years at the university, Eskandarian has proven himself to be an engaged and effective leader, with an ability for building consensus and bringing different groups together for the sake of the department. His energy and enthusiasm are evident, especially with respect to departmental organization, faculty recruiting, and his work to implement a strategic plan for the department.

Eskandarian has developed strategic directions for the department and started several new initiatives to enhance the quality of scholarship, the student experiential learning, and diversity within the department, and streamlined several departmental procedures with new policies. He has made significant contributions to developing new academic curricula at both graduate and undergraduate levels and has expanded several international academic exchanges and partnerships leading to both student exchanges and scholarship activities among collaborating institutions.

He is a Fellow of the American Society of Mechanical Engineers and a senior member of the Institute for Electrical and Electronic Engineers.

Eskandarian received his bachelor's degree and Ph.D. from George Washington University and a master's degree from Virginia Tech.

TOP: AZIM ESKANDARIAN

LEFT: NICHOLAS DES CHAMPS

MIDDLE: REBECCA DES CHAMPS

RIGHT: VIRGINIA TECH PRESIDENT TIMOTHY SANDS

AWARDS & PROMOTIONS
FACULTY LIST
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AWARDS AND PROMOTIONS

Alan Kornhauser
Named Associate Professor Emeritus

Alexander Leonessa
Promotion to full professor

Arvid Myklebust
Professor emeritus, Outstanding Alumnus of the Mechanical and Aerospace Engineering Department at the University of Florida

Azim Eskandarian
IEEE ITS Outstanding Researcher Award

Brian Vick
Inducted to North Carolina State University Mechanical and Aerospace Engineering Department's Hall of Fame

Celine Hin
Promotion to associate professor with tenure

Clint Dancey
College of Engineering Dean's Award for Excellence in Teaching

Corina Sandu
Elected a Fellow of the SAE
Appointed editor-in-chief of the Mechanics Based Design of Structures and Machines Journal

Jiangtao Cheng
Best Paper Award at 13th International Conference on Health Transfer Fluid Mechanics and Thermodynamics

Joseph Schetz
AIAA Aerodynamic Measurement Technology Award

Lei Zuo
Received the ASME Leonardo da Vinci Award
ASME Dynamic Systems and Control Division Vibrations Technical Committee Best Vibrations Paper Award

Michael von Spakovsky
Named Robert E. Hord Jr. Professor

Pinhas Ben-Tzvi
Appointed associate editor of the ASME Journal of Mechanisms and Robotics; Selected as associate editor of the IEEE Robotics and Automation magazine; selected as associate editor for the IEEE Robotics and Automation Society's conference editorial board
Appointed College of Engineering Faculty Fellow

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Reza Mirzaeifar
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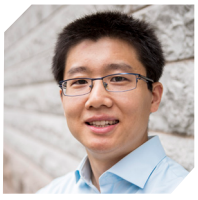

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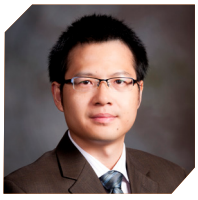

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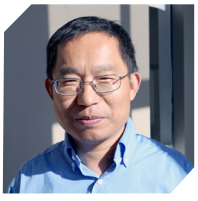

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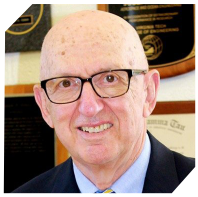

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*The following list represents a sample of publications by the faculty of the Mechanical Engineering Department in Academic Year 2017-2018

Alireza Haghighat

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with N. J. Roskoff: Experimental and Computational Validation of RAPID, 16th International Symposium of Reactor Dosimetry

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M. J. Wang and A. Haghighat: A Novel Detector Response Formulation for RAPID, Proceedings of PHYSOR

V. Mascolino, N. J. Roskoff, and A. Haghighat: Benchmarking of the RAPID Code System Using the GBC-32 Cask with Variable Burnups, Proceedings of PHYSOR

Bahareh Behkam and Amrinder Nain

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Christopher Williams

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Corina Sandu

with Ivanov, V., Savitski, D., Ausburg, K., Els, S.P., Kat, C.-J., Botha, T., Dhaens, M., Sandu, C., Rui He, Sterling McBride Granda, Alatorre, A., and Victorino: Challenges of Integrated Vehicle Chassis Control: Some Findings of the European Project EVE, IEEJ J. of Industry Applications

with Rui He, Aamir Khan, Gutherie, G., Els, S.P., Hamersma, H. A.: Review of Terramechanics Models and Their Applicability to Real-time Applications, Journal of Terramechanics

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with Ricardo Burdisso with Tan Li: A Literature Review of Models on Tire-Pavement Interaction Noise, Journal of Sound and Vibration

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with Schreiber, V., Ivanov, V., Augsburg, K., Noack, M., Shyrokau, B., and Els, P.S.: Shared and Distributed X-in-the-Loop Tests for Automotive Systems: Feasibility Study, IEEE Access

Jiangtao Cheng

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Lei Zuo

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NS

Michael von Spakovsky

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Pablo Tarazaga

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Pinar Acar

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Robert Parker

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Rui Qiao

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Y. Song, D. Johnson, R. Peng, D.K. Hensley, P.V. Bonnesen, L. Liang, J. Huang, F. Yang, F. Zhang, R. Qiao, A.P. Baddorf, T.J. Tschaplinski, N.L.

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*The following list represents a sample of publications by the faculty of the Mechanical Engineering Department in Academic Year 2017-2018

Engle, M.C. Hatzell, Z. Wu, D.A. Cullen, H.M. Meyer III, B.G. Sumpter, A.J. Rondinone: A physical catalyst for the electrolysis of nitrogen to ammonia, Sci. Adv.

W. Zhao, X. Liu, F. Yang, K. Wang, J. Bai, R. Qiao, and G. Wang: Study of oscillating electroosmotic flows with high temporal and spatial resolution, Anal. Chem.

C. Fang, X. Wu, F. Yang, and R. Qiao: Flow of quasi-two dimensional water in graphene channels, J. Chem. Phys.

F. Yang, S.M. Ali Mousavie, T.K. Oh, T. Yang, C. Farley, R.J. Bodnar, L. Niu, R. Qiao, Z. Li: Sodium-Sulfur Flow Battery for Low-Cost Electrical Storage, Adv. Energy Mater.

Z. Yu, F. Zhang, J.S. Huang, B.G. Sumpter, and R. Qiao: Ionic Liquids-Mediated Interactions between Nanorods, J. Chem. Phys.

M. Qin, Y. Liu, S. Luo, R. Qiao, and Z. He: Integrated experimental and modeling evaluation of energy consumption for ammonia recovery in bioelectrochemical systems, Chem. Eng. J.

W.L. Xu, C. Fang, F. Zhou, Z. Song, Q. Liu, R. Qiao, and M. Yu: Self-assembly: a facile way of forming ultrathin, high performance graphene oxide membranes for water purification, Nano Lett.

Saied Taheri

Clontz, M. and Taheri, S.,
Decoupling tyre and suspension via frequency based substructuring, International Journal of Vehicle Noise and Vibration

Motamedi, M., Taheri, S., Sandu, C., and Legrand, P.,
Characterization of Road Profile Based on Fractal Properties and Contact Mechanics, Rubber Chemistry and Technology

Lee, H. and Taheri, S.,
Identification of tire parameters based on fusion technology of intelligent tire and tire model, ASME Journal of Dynamic Systems, Measurement and Control

Seyedmeysam Khaleghian, Anahita Emami, Saied Taheri,
A Technical Survey on tire-Road Friction Estimation, Journal of Friction

Thomas Diller

Zou, S., Kanimba, E., Diller, T. E., Tian, Z., and He, Z.
Modeling Assisted Evaluation of Direct Electricity Generation From Waste Heat of Wastewater via a Thermoelectric Generator, Science of the Total Environment

Cirenza, C. F., Diller, T. E., and Williams, C. B.
Hands-On workshops to Assist in Students' Conceptual Understanding of Heat Transfer, ASME Journal of Heat Transfer

Shenoy, S. K. and Diller, T. E.,
Heat Flux Measurements from a Human Forearm under Natural Convection and Isothermal Jets, International Journal of Heat and Mass Transfer

Zheng Li

Lowering the Bar on Battery Cost, Joule

Zhiting Tian

Significantly High Thermal Rectification in an Asymmetric Polymer Molecule Driven by Diffusive Versus Ballistic Transport, Nano Letters

AFFILIATE FACULTY

John Robertson

Exploring the activity of a polyazine bridged Ru(II)-Pt(II) supramolecule in F98 rat malignant glioma cells, Chemical Communications

Expression and activity of the urokinase plasminogen activator system in canine primary brain tumors, OncoTargets and Therapy

The development of a thin-filmed, non-invasive tissue perfusion sensor to quantify capillary pressure occlusion of explanted organs, IEEE Transactions in Biomedical Engineering

3D printed conformal microfluidics for isolation and profiling of biomarkers from whole organs, Lab on a Chip

Variance change point detection under a smoothly-changing mean trend with application to liver procurement, Journal American Statistical Association

The Rametrix™ LITE Toolbox v1.0 for MATLAB®, Journal of Raman Spectroscopy

Effects of internal electrode cooling on irreversible electroporation using a perfused organ model, International Journal of Hyperthermia

Romesh Batra

Bikramjit Mukherjee, Romesh C. Batra, David A. Dillard: Edge debonding in peeling of a thin flexible plate from an elastomer layer: a cohesive zone model analysis, Journal of Applied Mechanics

Puneet Kumar Patra and Romesh C. Batra: Stress wave propagation in Boron-Nitride nanotubes, Computational Materials Science

Puneet Kumar Patra and Romesh C. Batra: Nonequilibrium temperature measurement in a thermal conduction process, Phsyical Review

P.H. Shah, R.C. Batra: Stress singularities and transverse stresses near edges of doubly curved laminated shells using TSNDT and stress recovery scheme, European Journal of Mechanics A/Solids

Yaoke Wen, Cheng Xu, Yongxi Jin, R.C. Batra: Rifle bullet penetration into ballistic gelatin, Journal of the Mechanical Behavior of Biomedical Materials

Enqiang Lin, Xiaorong You, Robert M. Kriegel, Ronald D. Moffitt, Romesh C. Batra: Binding affinity between small molecules in solvent and polymer film using molecular dynamics simulations, Colloids and Surfaces A: Physicochemical and Engineering Aspects

Bikramjit Mukherjee, Romesh C. Batra, David A. Dillard: Effect of confinement and interfacial adhesion on peeling of a flexible plate from an elastomeric layer, International Journal of Solids and Structures

B. Sobhaniaragh, R.C. Batra, W.J. Mansur, F.C. Peters: Thermal response of ceramic matrix nanocomposite cylindrical shells using Eshelby-Mori-Tanaka homogenization scheme, Composites Part B

Anup Pydah, R.C. Batra: Crush dynamics and transient deformations of elastic-plastic Miura-ori core sandwich plates, Thin-Walled Structures
Enqiang Lin, Xiaorong You, Robert M. Kriegel, Ronald D. Moffitt,

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Romesh C. Batra: Interdiffusion of small molecules into a glassy polymer film via coarse-grained molecular dynamics simulations, Polymer

Anup Pydah, R.C. Batra: Shear deformation theory using logarithmic function for thick circular beams and analytical solution for bi-directional functionally graded circular beams, Composite Structures

Yegao Qu, Romesh C. Batra: Constrained moving least-squares immersed boundary method for fluid-structure interaction analysis, Int J Numer Meth Fluids

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Arka P. Chattopadhyay, Romesh C. Batra: Load's temporal characteristics for annulling forced vibrations of linear elastic plates, Mechanics Research Communications

U. Taetragool, P. H. Shah, V. A. Halls, J. Q. Zheng, R.C. Batra: Stacking sequence optimization for maximizing the first failure initiation load followed by progressive failure analysis until the ultimate load, Composite Structures

Yegao Qu, Ruchao Shi, Romesh C. Batra: An immersed boundary formulation for simulating high-speed compressible viscous flows with moving solids, Journal of Computational Physics

Anup Pydah, R. C. Batra: Analytical solution for cylindrical bending of two-layered corrugated and webcore sandwich panels, Thin-Walled Structures

Shantanu R. Ranade, Youliang Guan, Robert B. Moore, John G. Dillard, Romesh C. Batra, David A. Dillard: Characterizing fracture performance and the interaction of propagating cracks with locally weakened interfaces in adhesive joints, International Journal of Adhesion and Adhesives

PH Shah, VA Halls, JQ Zheng, and RC Batra: Optimal cure cycle parameters for minimizing residual stresses in fiber-reinforced polymer composite laminates, Journal of Composite Materials

Anup Pydah, R.C. Batra: Blast loading of bumper shielded hybrid two-core Miura-ori/honeycomb core sandwich plates, Thin-Walled Structures

David A. Dillard, Bikramjit Mukherjee, Preetika Karnal, Romesh C. Batra, and Joelle Frechette: A review of Winkler's foundation and its profound influence on adhesion and soft matter applications, Soft Matter

Rafael Davalos

HJ Cho, SS Verbridge, RV Davalos, YW Lee: Development of an in vitro 3D brain tissue model mimicking in vivo-like pro-inflammatory and pro-oxidative responses, Annals of Biomedical Engineering

S Bhonsle, MF Lorenzo, A Safaai-Jazi, RV Davalos: Characterization of nonlinearity and dispersion in tissue Impedance during High Frequency Electroporation, IEEE Transactions on Biomedical Engineering

B Mercadal, CB Arena, RV Davalos, A Ivorra: Avoiding nerve stimulation in irreversible electroporation: a numerical modeling study, Physics in Medicine and Biology

Y Zhao, S Bhonsle, S Dong, Y Lv, H Liu, A Safaai-Jazi, RV Davalos, C Yao: Characterization of conductivity changes during High-Frequency Irreversible Electroporation for treatment planning, IEEE Transactions on Biomedical Engineering

A Rolong, EM Schmelz, RV Davalos: High-frequency irreversible electroporation targets resilient tumor-initiating cells in ovarian cancer, Integrative Biology

EL Latouche, MB Sano, MF Lorenzo, RV Davalos, RC Martin II: Irreversible electroporation for the ablation of pancreatic malignancies: A patient specific methodology, Journal of Surgical Oncology

EM Wasson, JW Ivey, SS Verbridge, RV Davalos: The feasibility of enhancing susceptibility of glioblastoma cells to IRE using a calcium adjuvant, Annals of Biomedical Engineering

M Bonakdar, PM Graybill, RV Davalos: A microfluidic model of the blood-brain barrier to study permeabilization by pulsed electric fields, RSC Advances

JW Ivey, EL Latouche, ML Richards, GJ Lesser, W Debinski, RV Davalos, SS Verbridge: Enhancing irreversible electroporation by manipulating cellular biophysics with a molecular adjuvant, Biophysical Journal

JH Rossmeisl, K Hall-Manning, JL Robertson, JN King, RV Davalos, W Debinski, S Elankumaran: Expression and activity of the urokinase plasminogen activator system in canine primary tumors, OncoTargets and Therapy

T Miklovic, EL Latouche, MR DeWitt, RV Davalos, MB Sano: A comprehensive characterization of parameters affecting high-frequency irreversible electroporation lesions, Annals of Biomedical Engineering

TA Douglas, J Cemazar, N Belani, DC Sweeney, EM Schmelz, RV Davalos: A feasibility study for enrichment of highly aggressive cancer subpopulations by their biophysical properties via dielectrophoresis enhanced with synergistic fluid flow, Electrophoresis

PA Garcia, B Kos, JH Rossmeisl, D Pavliha, D Miklavcic, RV Davalos: Predictive therapeutic planning for irreversible electroporation treatment of spontaneous malignant glioma, Medical Physics

I Goswami, S Coutermarsh-Ott, RG Morrison, IC Allen, RV Davalos, S Verbridge, LR Bickford: Irreversible electroporation inhibits pro-cancer inflammatory signaling in triple negative breast cancer cells, Bioelectrochemistry

Shane Ross

Tube dynamics and low energy Earth-Moon transfers in the 4-body system, Advances in Space Research

Control of gliding in a flying snake-inspired n-chain model, Bioinspiration & Biomimetics

A tube dynamics perspective governing stability transitions: An example based on snap-through buckling, International Journal of Mechanical Sciences

Costin Untaroiu

Yates, K.B., Untaroiu, C.D.: Finite element modeling of the human kidney for probabilistic occupant models: Statistical shape analysis and mesh morphing, Journal of Biomechanics

Baker, W., Chowdhury, M.R., Untaroiu, C.D.: Validation of a Booted Finite Element Model of the WIAMan ATD Lower Limb in Component and Whole-Body Vertical Loading Impacts with an Assessment of the Boot Influence Model on Response, Traffic Injury Prevention

Untaroiu, C.D., Pak, W., Meng, Y., Schap, J., Koya, B., Gayzik, F.S.: A Finite Element Model of a Mid-Size Male for Simulating Pedestrian Accidents, ASME Journal of Biomedical Engineering

Baker, W., Untaroiu, C.D., Crawford, D., Chowdhury, M.R.: Mechanical characterization and Finite Element Implementation of the Soft Materials used in a Novel Anthropometric Test Device for Simulating Underbody Blast Loading, Journal of the Mechanical Behavior of Biomedical Materials

PATENTS

M.E. AND AFFILIATE FACULTY

MECHANICAL ENGINEERING FACULTY

Bahareh Behkam and Amrinder Nain were awarded a U.S. patent for methods and systems associated with measuring single and multi-cell inside-out and/or outside-in forces on a nanofiber grid.

R. Cherry, C. Cirenza, and **Thomas Diller**, filed a U.S. Utility Patent for a Thermal Flow Meter Using One or More Heat Flux Sensor(s), Temperature Sensor(s) and Heating Unit(s).

Haghighat, A., W. Walters, and N. Roskoff: RAPID Particle Transport Methodology for Real-time Simulation of Nuclear Systems, Provisional Patent Application Filed

Haghighat, A., V. Mascolino, and N. Polys: Collaborative Virtual Reality System for Scientific Computing

Robin Ott and student Andrew Bolkhovitinov, filed a provisional patent for a folding wheelchair lift device.

Christopher Williams filed a U.S. patent for Compositions and Methods of Additive Manufacturing of Aromatic Thermoplastics and Articles Made Therefrom

Christopher Williams filed a U.S. patent for Scanning Vat Photopolymerization - Additive Manufacturing of layerless textured surfaces.

Christopher Williams filed a U.S. patent for Multi-Tool Additive Manufacturing Machine.

Christopher Williams filed a provisional U.S. patent for Additive Manufacturing of Metal Parts from Jetting a Particle-free Metal Ink as Binder

AFFILIATE FACULTY

John Robertson and co-inventors were awarded a patent: Irreversible electroporation using tissue vasculature to treat aberrant cell masses or create tissue scaffolds

John Robertson and co-inventors filed provisional patents for the following devices:

- Raman-Urinalysis for detection of bladder cancer
- Raman-Urinalysis for detection of kidney disease
- Flow controller for water conservation in hemodialysis treatment
- In-line waste dialysate sensor for real-time monitoring of waste dialysate composition

Crandall, J., **Untaroiu, C.D.**, Maslen, E., Bose D.: System and Method for Minimizing Occupant Injury during Vehicle Crash Events, Patent No. US9539969B2

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