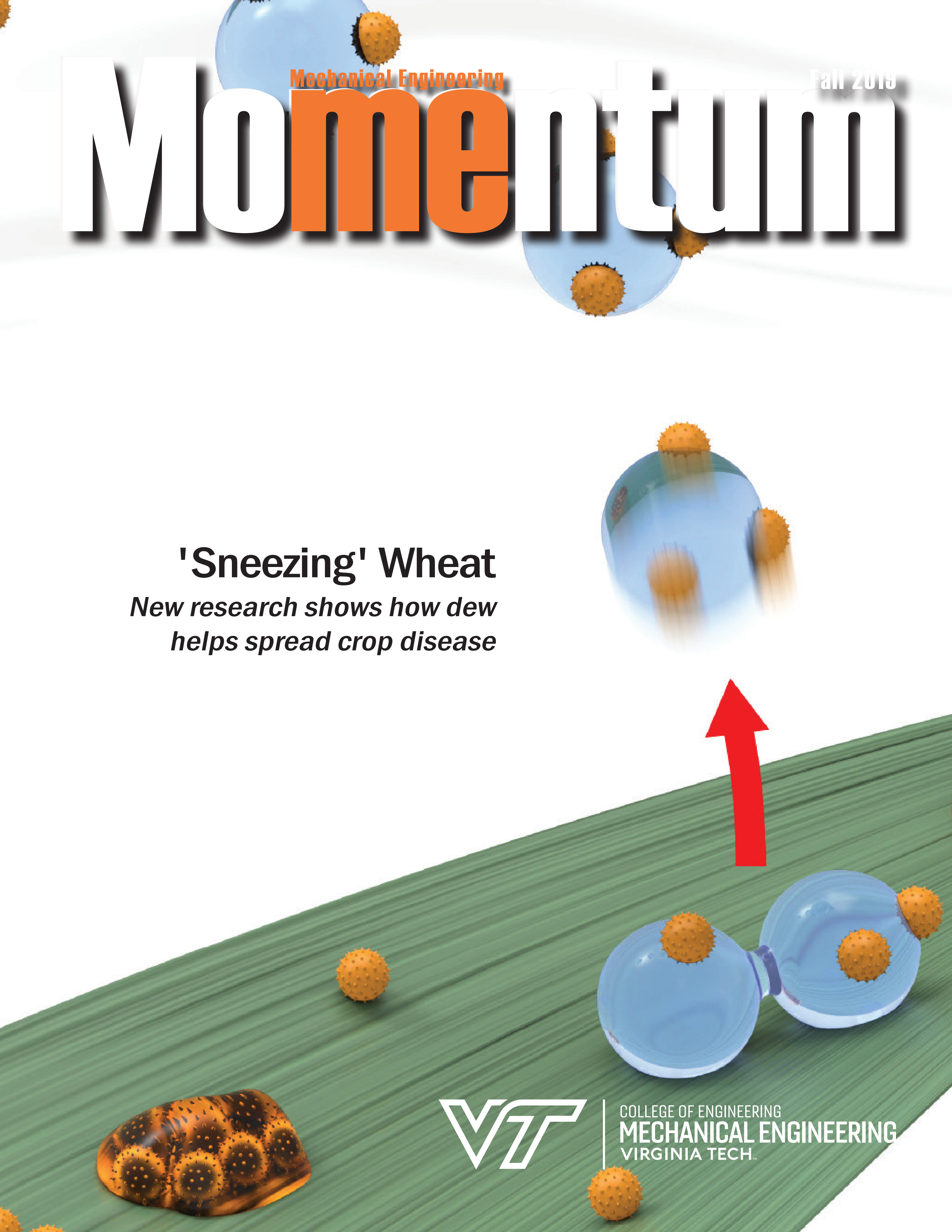
Momentum

Mechanical Engineering

Fall 2019



'Sneezing' Wheat

New research shows how dew helps spread crop disease

COLLEGE OF ENGINEERING
MECHANICAL ENGINEERING
VIRGINIA TECH™

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INSIDE

beam video of jess gannon https://www.youtube.com/watch?v=C9t790rX3Qw

As a recipient of the Clare Boothe Luce Fellowship, Jess Gannon is taking a closer look at pancreatic cancer research through device development and histotripsy. She found a sense of community at Virginia Tech, where she combines her passions for math and science with a love for working with people.

Professor Azim Eskandarian - Nicholas and Rebecca Des Champs Professor, ME Department Head
Rosaire Bushey - Communications & Outreach Manager
Contact us: 540-231-2965 email busheyr@vt.edu

ABOUT THE COVER

A graphic illustration shows how wheat rust spores can be transferred via jumping droplets. The droplets are then carried by the wind to neighboring plants, fields, and farms, helping to spread the disease.

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AZIMESKANDARIAN
NICHOLAS AND REBECCA DES CHAMPS PROFESSOR
DEPARTMENT HEAD, MECHANICAL ENGINEERING

Research and discovery

Regardless of the season or semester, one constant within the department is the tremendous research conducted by our faculty and students. As one of the largest Mechanical Engineering departments in the nation, Or annual research productivity and quality of scholarship is progressively rising. Sponsored research is growing to about $19M. More than half of our nearly 300 graduate students are pursuing PhDs, and the remaining Masters degree students are almost all engaged in thesis research. A record number of undergraduates are involved in research labs. The department's Robotics and Autonomous Systems research is attracting evermore graduates; our Additive Manufacturing is now the most comprehensive in the state of Virginia and nationwide with the addition of a new metal printing system through a prestigious MURI award in addition to a host of existing state-of-the-art 3-D printers; our propulsion group is making significant strides with aerospace industry; and the fundamental research in fluid and thermal sciences, CFD, non-equilibrium thermodynamics, multiscale modeling, vibrations and acoustics, and nuclear engineering have been reaching new heights.

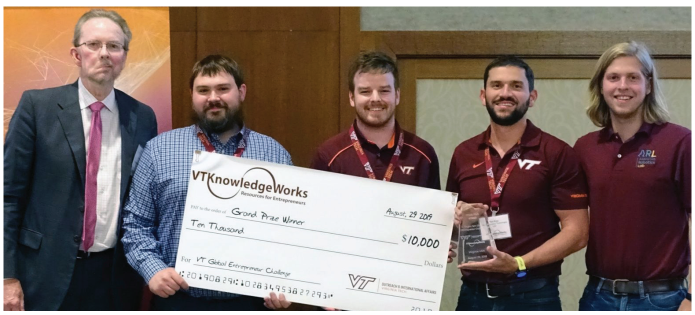
In this issue of Momentum, we are looking at just a few of the many areas of research. Our cover story looks at how new research in jumping droplets may show how plant disease spreads. From our Advanced Power and Propulsion Laboratory, research is being conducted to test filters that may help curb greenhouse gas emissions, and create a billion-dollar company in Southwest Virginia. We have research in nuclear energy security, drones in Africa, and robots that try to mimic the agility of animals.

In addition, one of our doctoral students received the Paul Torgersen Graduate Student Research Excellence Award, the College of Engineering received ASEE recognition for diversity, and an ME alum has had a building named in his honor at a Virginia Army post.

And sadly, we have lost a great friend and a brilliant engineer this summer. Walter O'Brien, J. Bernard Jones Professor, died in July. He and his research were known and respected internationally, but his work will live on through the more than 130 graduate students and uncounted thousands of undergraduates he taught and mentored in his more than 50 years of service to Virginia Tech. You can read more on Page 22.

The Lead

Virginia Tech researchers took part in a July 4 event in Brunei Darussalam in which they showcased a collaborative project on bioinspiration and biodiversity with the University of Brunei Darussalam as part of Indpendence Day activities with the U.S. Ambassador Matthew Matthews. Presentations were made to Matthews and Brunei's Minister of Education, Dato Seri Setia Awang Haji Hamzah bin Haji Sulaiman

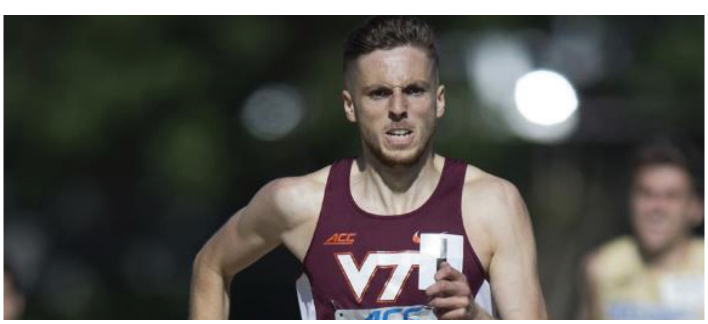


A team of mechanical engineers bested a dozen international teams to win $25,000 for their idea to create exoskeletons that make lifting easier. Maroon Assistive Technologies – represented by grad students Tim Pote, Taylor Pesek, and Jack Geissinger, and senior Andrew Bocklund – won the VT Global Entrepreneur Challenge Aug. 29, hosted by Outreach and International Affairs and VT KnowledgeWorks.

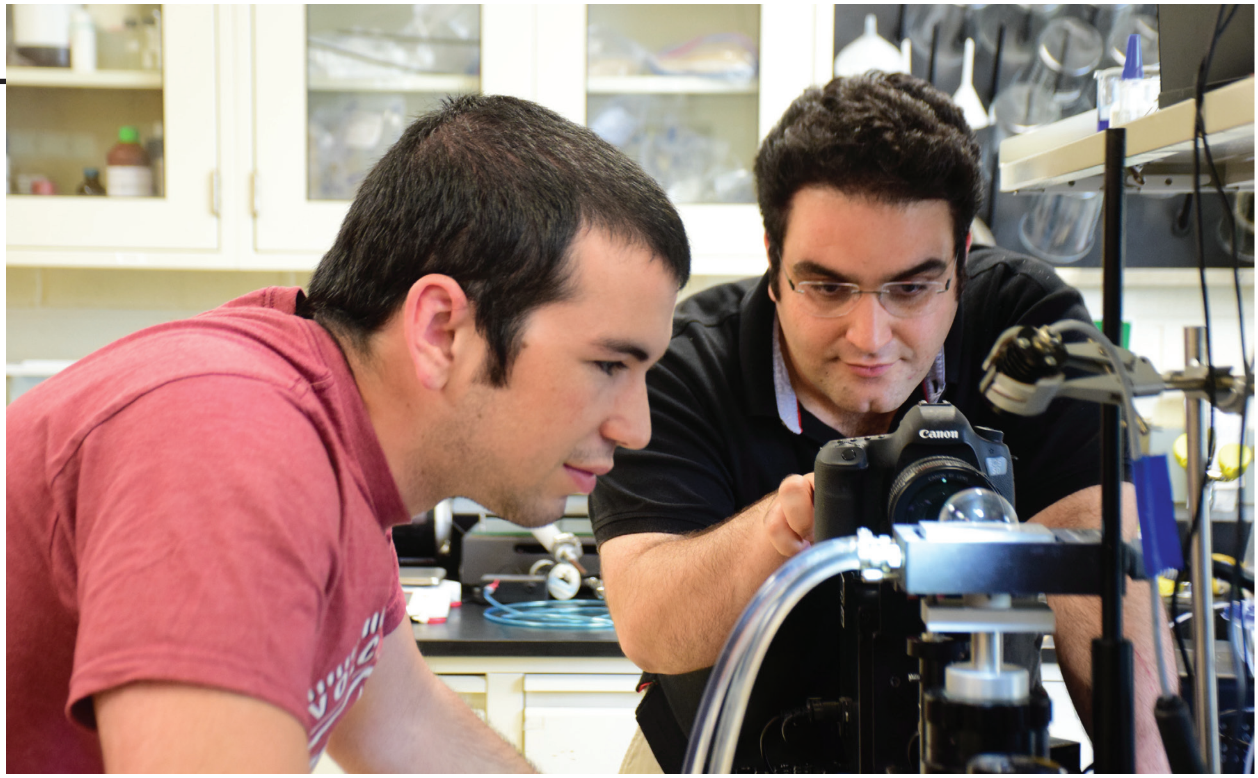
Seventeen members of the department attended the ASME IDETC conference in California. Among the attendees: Azim Eskanarian, Pinhas Ben-Tzvi, Oumar Barry, Mohammad Bukhari, Huachen Cui, Warren Hardy, Yazhe Hu, Jianyong Jiang, Shams Kondori, Nicholas Merrill, Hoda Mousavi, Robert Parker, Feng Qian, Corina Sandu, Comel Sultan, Costin Untaroiu, and Lei Zuo.

The roads in Michigan are slightly more classy thanks to these plates from ME alum Keith Van Houten, ('91). Keith is the manager, active safety and automated driving performance simulation group, General Motors' Center for Autonomous Vehicle Development.

(Alums are encouraged to send a photo of themselves showing their Hokie pride wherever they live.)



Mechanical Engineering alum Neil Gourley '18, who is a Scottish citizen, recently won the 1500m at the British championship with a 3:35.95 and qualified to take part in the World Championships in Doha Sept. 28-Nov. 6. Heats for the men's 1500 are scheduled for Oct. 3. Gourley was the anchor leg of Virginia Tech's 2018 NCAA Championship Distance Medley Relay team.



How do bubbles become snow globes?

Scientific inquiry often begins with the 'why?'

Without expecting to do more than answer a question posed by a YouTube video, Virginia Tech researchers may have changed how people think about the process of freezing.

Lead Virginia Tech researcher, Jonathan Boreyko, an assistant professor in mechanical engineering in the College of Engineering, and his student researchers were watching a YouTube video of a soap bubble freezing. The mesmerizing sight of ice crystals floating around the bubble made the engineers wonder what caused the phenomenon?

Boryeko and student researchers: Farzad Ahmadi, and Saurabh Nath, both graduate students in engineering mechanics and Christian Kingett, an undergraduate researcher in engineering science and mechanics who graduated in 2019; conducted literature research and found that no one had ever studied how soap films or bubbles freeze.

The results of the team's query, which began as a simple 'why,' has been published in the journal Nature Communications, explaining the physics behind what causes the ice crystals jump up into the bubble and swirl around, thus changing perceptions about the process of freezing.

"We started by freezing a bubble in the lab, using a frozen substrate," Boreyko explained. "What we found was that the bubble would freeze from the bottom to a certain point and then stop. We didn't get that lovely 'snow globe effect' that we saw on the video. But, Farzad made a nice model that can accurately predict where the freeze front will stop based on the size of the bubble and the air temperature."

Because the shell of a bubble is microscopically thin, the warm air temperature in the lab prevented the cold stage from completely freezing the bubble. Moving to a walk-in freezer, the team tried the experiment again, believing they would discover how the floating ice crystals were formed.

"We didn't see it in the freezer, either, at first," Boreyko said. "But we tried again depositing the bubble on ice instead of a dry substrate, and that is where we saw what we were looking for."

At minus 20 degrees Celsius and using an ice substrate, the bubble quickly filled with floating crystals which hastened the complete freezing of the bubble, and opened the researcher's eyes.

"When you deposit the bubble on an icy substrate, the bubble begins to freeze which releases heat," said Ahmadi. "The bottom of the bubble, in this case, becomes warmer than the rest of the bubble – it's freezing-induced heating."

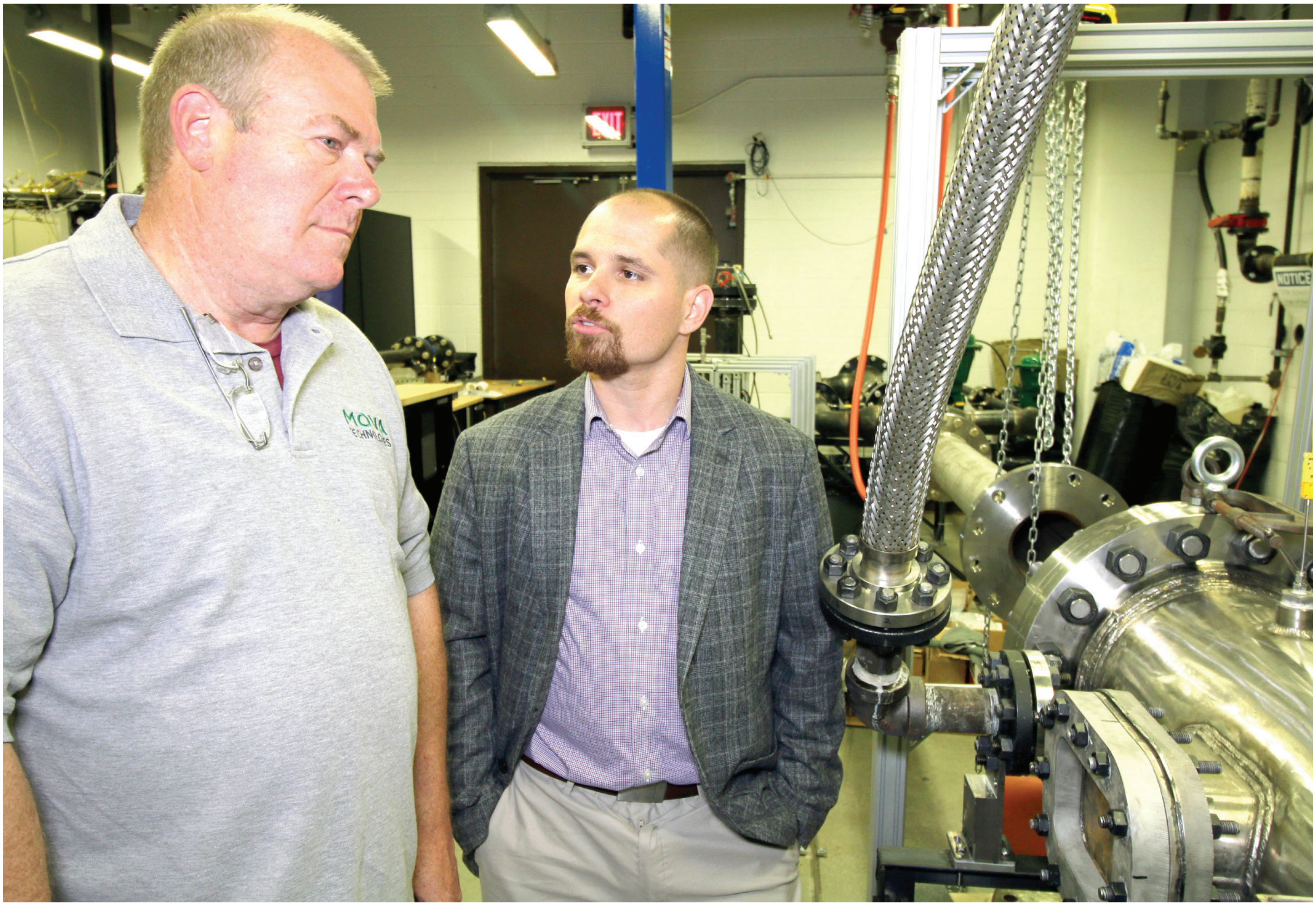
The molecular energy releases when the water molecules fuse together into a tight-packed solid lattice created a temperature difference of about 14 degrees – minus twenty at the top of the bubble and minus six degrees at the frozen base.

"The temperature gradient from top to bottom changed the surface tension," Ahmadi said. "The tension created a flow from the hot toward the cold."

This flow is known as Marangoni Flow. When it occurs in the freezing bubbles, the flow rips ice crystals from the bottom of the bubble and swirls them around the liquid shell where they enlarge until the entire bubble is frozen.

"Previously we thought that how fast we could freeze something depended on how fast the freeze front could grow," Boreyko said. "This shows us that a freezing-induced Maragoni Flow will create hundreds of additional freeze fronts from the ice crystals removed from the bottom. So, we realized it's not just how fast one front grows, but in cases like our bubble, you can manipulate the system to have hundreds of freeze fronts working together to freeze something much faster."

https://youtu.be/ICo5z1fsV34



Steve Critchfield, CEO and President of MOVA technologies, left, speaks with Assistant Professor Joseph Meadows in the latter's test cell in the Advanced Power and Propulsion Lab.

Local business using ME laboratory to test revolutionary pollution storage system

The U.S. Department of Energy has a goal of carbon filtration using solid sorbents by 2030. In June, Virginia Tech's Advanced Power and Propulsion Laboratory became home to a proof-of-concept experiment that could help launch a billion-dollar business that will have enormous implications for fossil fuel burning power plants, specifically how pollutants are collected and recycled, and thus impact the long-term goal.

Partnering with MOVA Technologies based in Pulaski, Virginia, Joseph Meadows, an assistant professor of mechanical engineering will analyze the company's panel-bed filters at his test cell in the lab. With Meadows, Stephen Martin, an associate professor of chemical engineering, will serve as the subject-matter-expert in the field of solid sorbents.

"Working with MOVA, we will measure the efficacy of the company's panel-bed filters at absorbing various pollutants, saturation time for various conditions and contaminants, and optimize the system's operational parameters," said Meadows. "In the future, we will investigate these parameters in realistic temperature and pressure environments."

Traditional scrubbers remove pollutants en masse leaving tons of collected waste that requires expensive specialty treatment or storage. MOVA's panel-bed filters are designed to selectively remove individual contaminants, which can then be easily sold on as products in their own right – lowering the amount of pollutants that are put into storage by recycling waste into products.

Examples of applications that use recycled waste include: fly ash used in cement, sulfur dioxide used in preservatives and wastewater treatment, nitric oxide used by the fertilizer and medical industries, and carbon dioxide sold as carbon emission credits.

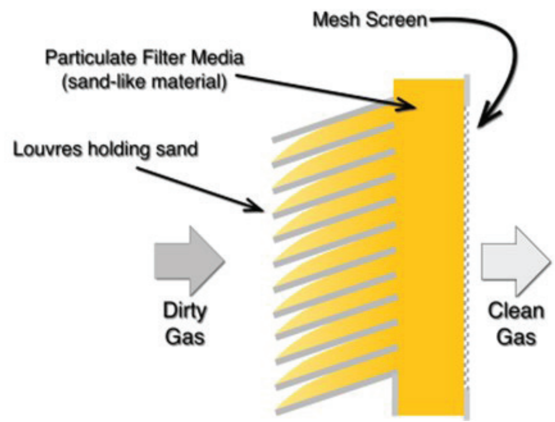
"Currently, industry and power plants have scrubbers that remove pollutants from their smokestacks. These pollutants are sealed and stored in what are essentially large vacuum cleaner bags, waiting to be shipped off for storage," said Steve Critchfield, CEO and President of MOVA Technologies.

Meadows will spend six months putting the filters through various operating conditions and contaminants to test the efficacy and to characterize the gas that passes through the filters pre- and post-filtration. Martin's role as a subject matter expert is to modify the solid sorbents that capture the pollutants as needed during the analysis and testing.

"We will be testing the panel-beds and several other subsystems to characterize the temperature, humidity, pressure, flow composition, flow rate, flow velocity, and the internal filtration velocity," said Meadows. "It's a very thorough and exhaustive experiment to ensure the system can meet the future needs of industrial power plants and to capture pollutants from industrial buildings."

The DOE's filtration goal is one Critchfield believes MOVA can beat to market by a decade. In-depth studies have identified the panel-bed's potential to reduce capital and operating costs by 15% and 25%, respectively, compared to competing bag filter technologies, in part due to simultaneous pollutant removal, operating with higher temperatures, a lower pressure drop, and a reduced footprint.

MOVA is a product of the late Arthur Squires, Distinguished Professor Emeritus of Chemical Engineering. Squires, a key figure on the Manhattan Project, was elected to the National Academy of Engineering in 1977 for contributions to the research and understanding of coal gasification and the recovery of organic chemicals from coal. He created eight patents that formed MOVA to commercialize his technologies. He also formed the A.M. Squires Trust that will use a portion of money raised through commercialization to support the arts in Southwest Virginia, and to supporting several colleges at Virginia Tech, according to Critchfield.



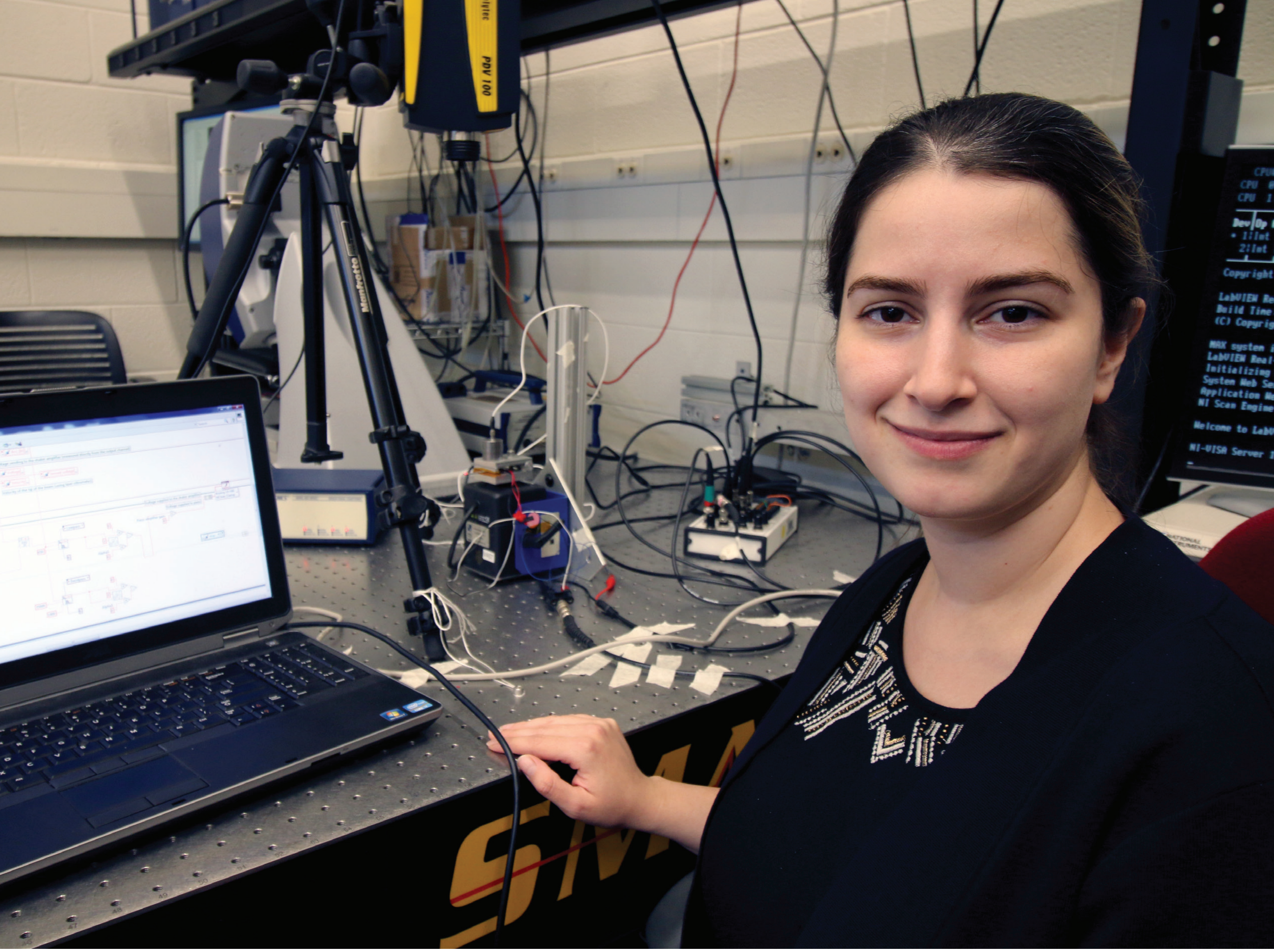
"We will be able to use this technology designed by Dr. Squires to allow modular power plants to operate on coal or even burn automobile tires more cleanly than current power production facilities," he said.

According to a Virginia Tech Knowledge Works market study, the panel-bed filtration system has the potential to generate between $500 million and $1 billion annually.

"In 2010 when Dr. Squires started thinking about how to more cleanly burn fossil fuels, he was thinking about the growing response to the carbon footprint," said Critchfield. "Now, we're at the point of proof-of-concept and I think he would have been very happy that Virginia Tech is able to play a pivotal role."

Critchfield received a bachelor's in agriculture economics and a minor in computer science from Virginia Tech. He leads a team of three young Virginia Tech alumni: Matthew Gulotta, Luke Allison, and James Compton.

We're pleased to keep development of the panel-bed in Southwest Virginia," said Compton. "The majority of our capital investors are from this region, and the technology is designed for applications that could benefit Virginia's economy, with a specific emphasis on Southwest Virginia. Proof-of-concept testing at Virginia Tech coincides with our company operations and future goals."



Sheyda Davaria, a doctoral student in the VAST Lab, at her workstation where she tests artificial hair cells that are meant to one day help people with hearing issues.

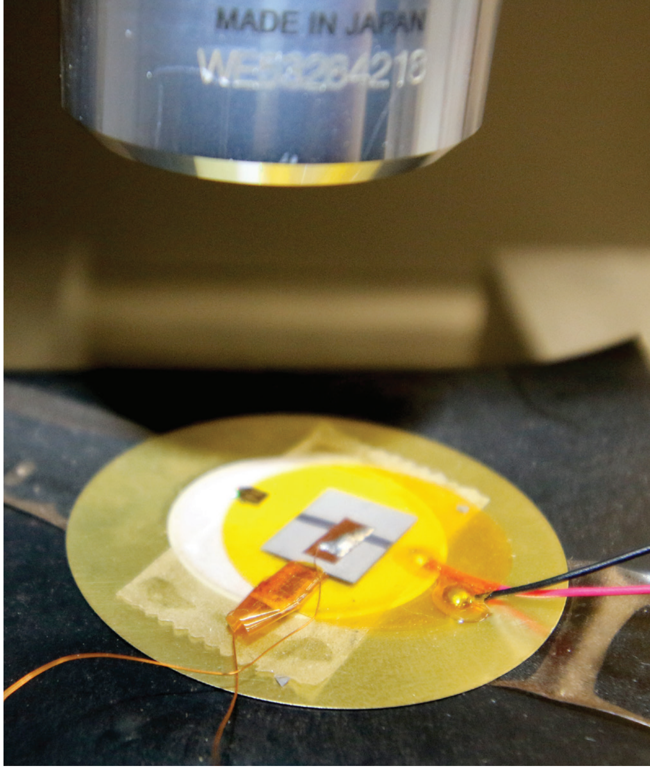
VAST lab student wins Torgersen Graduate Student Research Excellence prize

For the second time in three years, a mechanical engineering doctoral student has earned the Paul Torgersen Graduate Student Research Excellence Award. The award recognizes the top research done by a graduate student.

The first place award, presented in the spring, was given to Sheyda Davaria, a student working in the Vibration, Adaptive Structures and Testing Lab with advisor Pablo Tarazaga, associate professor of mechanical engineering and John R. Jones III Faculty Fellow.

Born in Maryland but raised in Iran, Davaria graduated from the University of Tehran with bachelors and master's degrees in mechanical engineering, and arrived at Virginia Tech in 2015.

"During my first year here, I was a teaching assistant and I took a vibrations class with Dr. Tarazaga and at the same time I was looking at different faculty's research to choose my project and advisor," Davaria said.



Davaria's father and uncles, all engineers, have degrees from different universities, and they encouraged her to come to Virginia Tech. "I was looking at top 30 graduate programs, especially those with faculty researching in areas such as biomedical applications, vibrations, controls, and mechatronics," she said. "Virginia Tech was the perfect university for me."

Though struck originally by the small town and green surroundings of Blacksburg, what Davaria found in Tarazaga's lab, both in terms of research and community, made choosing her project easy.

Her mother was part of the reason Davaria chose to develop active artificial hair cells.

"A few years ago, my mom lost partial hearing in one of her ears, and it was a sudden loss," Davaria explained. "She woke up and couldn't hear anything. From that time I wanted to work on the ear and for people with hearing loss. After I joined the lab I told my mom about the project and it is really interesting that I can give her information that is very different than what she gets from her ENT doctor."

The project Davaria is working on, and that won the Torgersen award, is an NSF-sponsored $300,000 project called Developing Active Artificial Hair Cells Inspired by the Cochlear Amplifier.

When sound enters the ear it travels from the outer ear to the inner ear and reaches the cochlea, where it decomposes into its frequency contents. These frequencies are captured by two types of sensory hair cells. One is responsible for amplification or compression of the sound, and the other for converting the mechanical motion caused by sound waves into electrical signals that can be processed by the brain.

"Our ears compress large sounds, such as at a concert, to protect the ear, which is why we can hear over a large range of sound pressure levels," Davaria said. "The same system amplifies sound so we can hear faint noises or catch bits of a conversation amid other sounds. This important process is called the cochlear amplifier and it is what we are trying to mimic with our research."

Currently, the research is using large scale structures to mimic the hair cells' function in the ear. These cantilever beams use piezoelectric materials which convert the mechanical motion of the beam into electrical signals.

"We shake the base of the beams and measure the velocity at the tip of the beam with a laser vibrometer," Davaria explained. "Then we pass the signal through a nonlinear controller, feed it back to the beam's piezoelectric layers and try to mimic the cochlear amplifier. The system amplifies or compresses the output based on the level of input and because of this it works very similarly to biological cochlea."

The current work, in scales of 1-inch beams, needs to be reduced to micro scales more comparable to the biological system, but Davaria is confident the algorithms that she has developed are working.

"We're trying to provide algorithms that work – and it works perfectly for large scale artificial hair cells," Davaria said, "but we need to miniaturize the system and then use bio-compatible materials. We still have a long way to go, but the results so far are promising."

COVER STORY

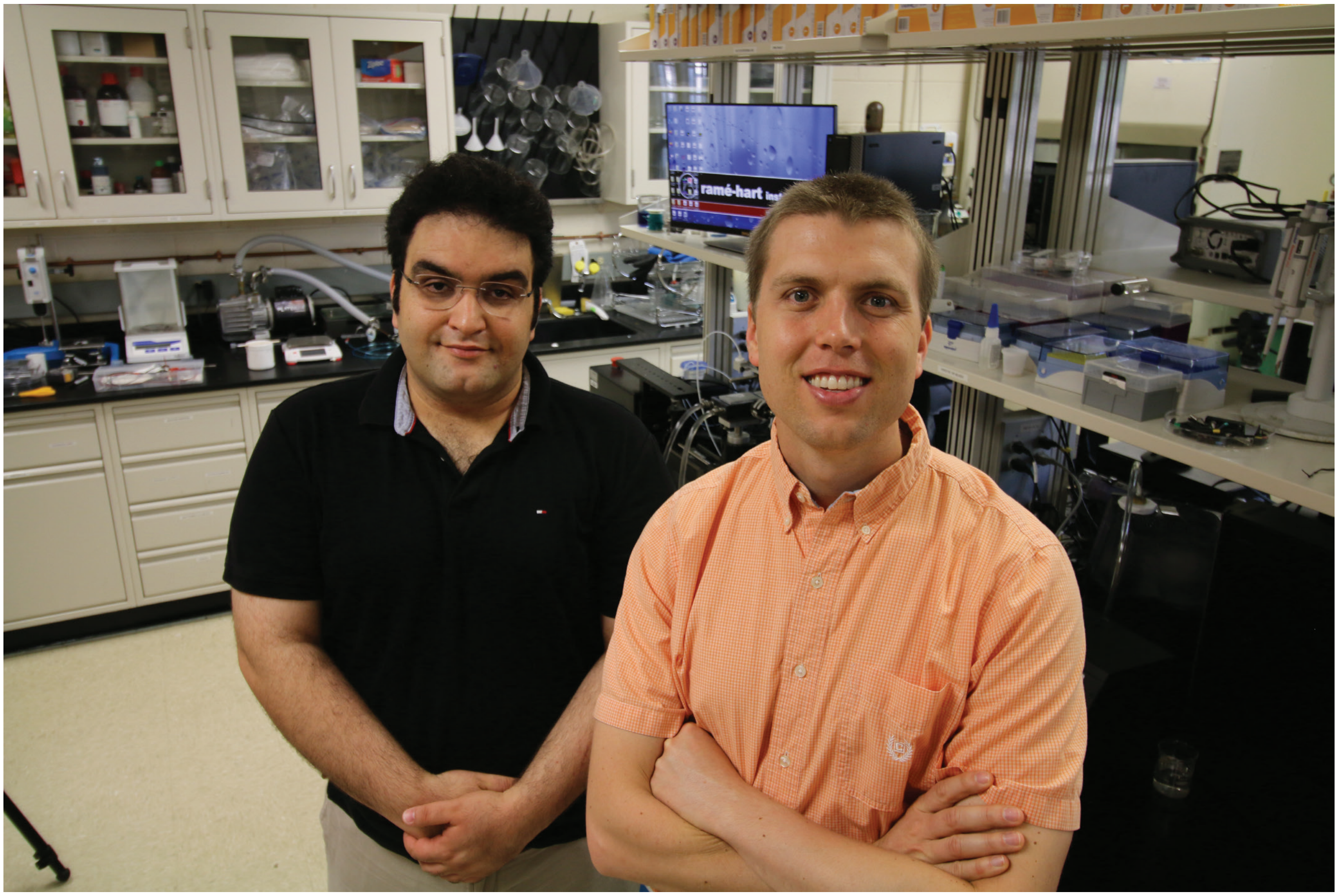
When plants 'sneeze' they can spread disease

‘Sneezing’ plants contribute to disease proliferation

In an article published June 19 on the cover of the Journal of the Royal Society Interface, Virginia Tech researchers have found that wheat plants ‘sneezing’ off condensation can vastly impact the spread of spore-borne diseases such as wheat leaf rust which can cause yield losses of up to 20 percent or more in the United States, and higher average losses in less developed agricultural nations.

The study is part of a three-year grant obtained in 2017 from the US Department of Agriculture’s National Institute of Food and Agriculture to study the dispersal of wheat pathogens by rain splash and jumping-droplet condensation. Jonathan Boreyko, assistant professor of mechanical engineering in the College of Engineering is a co-PI on the grant. David Schmale, professor of plant pathology, physiology and weed science in the College of Agriculture and Life Sciences is the primary investigator of the nearly $500,000 project.

“Professor Schmale had seen some of the work we’ve been doing on condensation and was curious to see what we could learn about condensation on wheat https://youtu.be/YC1T4_yXVYc

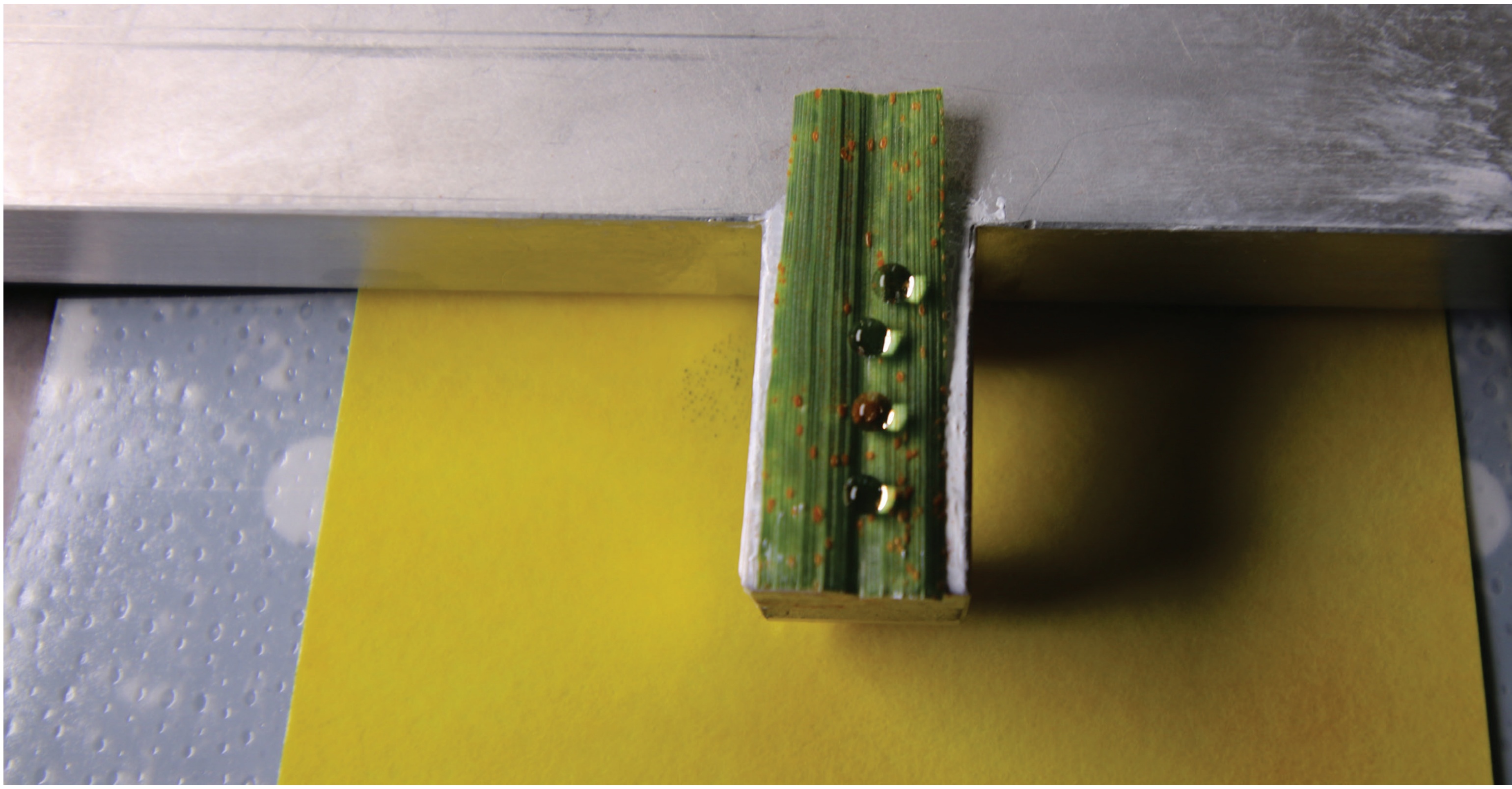


leaves," said Boreyko. "The project didn't start with any expectations, but people already knew that rain splash and wind caused pathogenic spores to be removed from plants and spread to others, and we wanted to see if condensation might also have a role to play in spore dispersal."

The students involved in the study were told not to expect jumping droplets in their condensation tests, as the droplets are known to only occur on specific surfaces, namely superhydrophobic surfaces normally associated with exotic materials such as lotus leaves and gecko skin. Superhydrophobic surfaces are non-wetting, and when spherical condensate grows, droplets merge together to release surface tension, which is converted into kinetic energy which propels them from the surface.

"Conceptually, what the plants are doing is sneezing," Boreyko said. "The jumping droplets, at the rate of 100 or more an hour, are a violent expulsion of dew from the surface. It's good for the plant because it is removing spores from itself, but it's bad because, like a human sneeze, the liquid droplets are finding their way onto neighboring plants. Like a cold, it's easy to see how a single infected plant could propagate a disease across an entire crop."

The paper, co-first-authored by Saurabh Nath and Farzad Ahmadi, engineering mechanics graduate students in Boreyko's lab, showed the jumping droplets can dramatically increase the dispersal of disease spores.



“We wanted to find out, first if the condensation droplets can carry spores, and while 90 percent of them carry only a single spore, we have seen instances where a droplet has carried as many as 11,” Ahmadi said. “We also looked at how high the spores can jump, and whether they can get past the boundary layer of the leaf.”

The boundary layer, which is about a millimeter thick, is the region of air near the leaf’s surface where the wind doesn’t affect the droplet. If the kinetic energy from merging moves the jumping droplet above the boundary layer, the droplet can be taken by the wind. Depending upon the wind speed, it’s feasible for the droplet to then be moved great distances, including to neighboring fields or farms.

“Using water-sensitive paper we measured how high the droplets can jump,” Ahmadi said. “A blue dot on the paper shows us a droplet, and a reddish dot shows us a spore, so in this way we can calculate both the height and the number of spores in the droplet.”

The droplets in Ahmadi’s tests routinely jumped from 2-5mm from the surface of the leaf, well above the distance necessary to be taken by the wind to be re-deposited elsewhere.

“It’s important to realize these droplets are microscopic in size,” explained Boreyko. “Each droplet is about the same size as the thickness of a human hair – about 50 micrometers, so this is all happening at a scale we don’t notice. A 0.1 meter per second wind can support the weight of a jumping droplet, whereas a droplet directly on the leaf requires a wind of 10 meters per second – 100 times stronger to be removed. Once it’s in the wind, there is, hypothetically, no limit to how far it can be carried.”

The low wind speed needed to carry the droplets means that the spore-ridden dew drops can have a large impact on crop health over a very wide area. “We know now that wind and rain aren’t the only factors in the spread of disease among crops,” Boreyko said.

The next phase of the continuing experiment for Boreyko and his team is to see how far the wind can carry the spore-bearing droplets. Using water-sensitive paper spread out in varying distances from a wheat leaf, the team will use fans to simulate wind and collect data on droplet and spore dispersal.

Study has impact on security of nuclear energy

A fundamental study into underground permeability can help society harness nuclear energy as a safe, stable and secure energy source.

As society's demand for sustainable energy sources grows, nuclear energy is still seen as a viable and productive option for powering the nation. However, concerns over the safe and secure storage of high-level radioactive nuclear waste often keep the technology from being advanced. An example of this is the Yucca Mountain nuclear waste repository, which until recently, was being developed as a deep geological storage facility for spent nuclear fuel.

Professor Rui Qiao, John R. Jones III Facutly Fellow

Now, researchers at Virginia Tech have been awarded funding by the Department of Energy's Office of Nuclear Energy to gain deeper insight and knowledge into the permeability of the clay barriers used in nuclear waste repositories, like those at Yucca Mountain.

Cheng Chen, mining and minerals engineering assistant professor, is the primary investigator on a project titled, The Role of Temperature on non-Darcian Flows in Engineered Clay Barriers. He is joined by Professor Rui Qiao, John R. Jones III Faculty Fellow in Mechanical Engineering, who brings expertise in areas such as nanoscale fluid and ion transport and is the project's Co-PI. The project is funded for three years in collaboration with Sandia National Laboratories.

High-level nuclear waste can be permanently disposed of in subsurface geological formations, first by storing it in a container and then placing that container into a geological host rock. Low-permeability clay, such as compacted bentonite, is filled between the waste container and the host rock underground.

"For this kind of storage system," explains Chen, "long-term security and stability are critical and require an advanced, fundamental understanding of the geomechanical, hydrogeological, and thermal processes relevant to this waste disposal system."

Qiao, along with graduate researcher Chao Fang, will focus their research contributions on the development of Molecular Dynamics simulation capabilities to investigate the influence of temperature on the threshold gradient of non-Darcian flow in low-permeability porous media. The simulation results will be fitted to a continuum-scale, two-parameter predictive model proposed by Chen, which has been accepted for publication in Hydrogeology Journal.

Fitting the simulation results to the continuum-scale model will provide insights into the two parameters and advance the understanding as to how these two parameters change under varying temperatures.

"The knowledge generated from this project will directly benefit the long-term security and stability of subsurface nuclear waste repositories over a time scale of 100,000 years," Chen explained.

Read the complete story in VTNews.

AOE undergrad receives Mandela Washington Fellowship to pursue UAV research with ME laboratory

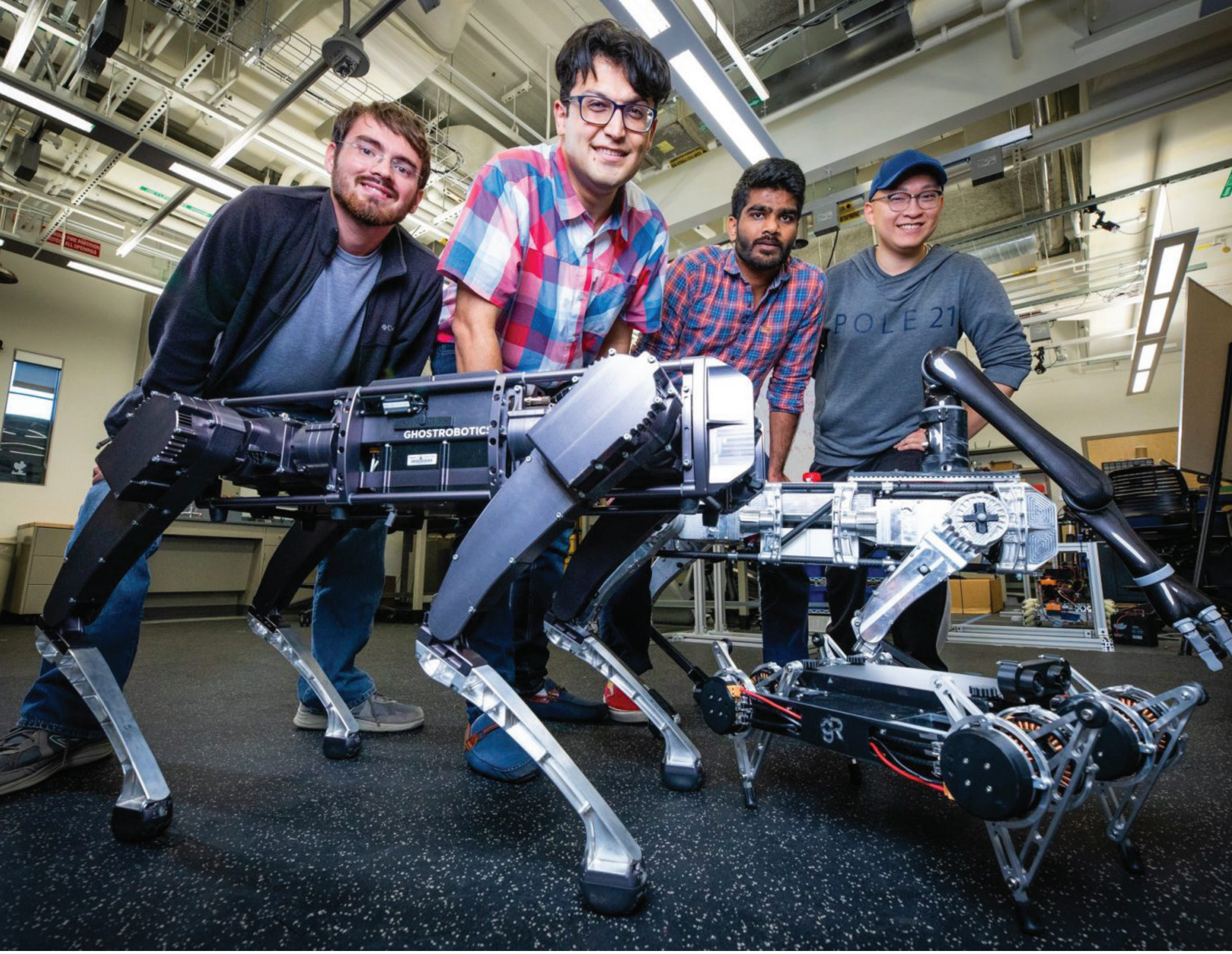
A program designed to empower young people through academic training and leadership has been awarded to Avery Sebolt, a junior in the Kevin T. Crofton Department of Aerospace and Ocean Engineering.

The Mandela Washington Fellowship Sebolt received facilitated his travel to Africa so that he could work side-by-side with an entrepreneur in drone technology, Dumisani Kaliati of Malawi. Kaliati, who himself received a Young African Leaders Initiative award, will partner with Sebolt on his work on public health services delivery using the Virginia Tech-designed EcoSoar autonomous drone.

Sebolt is spending a month in Malawi working with Kaliati and Swedish graduate student Robert Hedman to teach students how to produce, operate and maintain the EcoSoar aircraft. On June 24 they traveled to the UNICEF Test Corridor in Kasungu, Malawi, to fly clinical diagnostic samples from a remote health clinic back to the main airport.

In June 2017, members of the mechanical engineering Unmanned Systems Lab, tested the aircraft in Malawi paving the way for the current test. According to Kevin Kochersberger, associate professor of mechanical engineering and UAS Lab director, the EcoSoar is uniquely suited to collecting and retrieving small blood sample cards from rural clinics which can be tested for a variety of diseases including HIV.

The EcoSoar can be built locally using easily sourced components. Each aircraft costs about $350 to produce.



Research aims to give robots bio-inspired gaits

SUZANNE IRBY
COLLEGE OF ENGINEERING

Two years ago, Kaveh Hamed saw his son Nikaan take his first steps on his own. He watched Nikaan's one-year-old body teeter on wobbly legs as the baby walked. Nikaan would go from crawling on his belly to standing with a sway, to the first walks, to taking off across the room on two sure feet.

These memories make Hamed think about math, as he does when he watches his dog Telli run. When he sees her bound toward him and switch to a trot, he starts to wonder again about the ways he might impart her agility to a robot. For more than 10 years, Hamed has developed control algorithms that enable legged robots to walk and run more like humans and animals.

Seeing Nikaan and Telli in motion reminds him that there's so much left to learn. "It seems like a simple problem," said Hamed. "We do these things every day – we walk, run, climb stairs, step over gaps. But translating that to math and robots is challenging."

Hamed joined Virginia Tech last year as an assistant professor in the Department of Mechanical Engineering and as head of the Hybrid Dynamic Systems and Robot Locomotion Lab. Since then, he and his research team have worked to enhance bio-inspired locomotion in robots, alongside collaborators in the department and from other universities around the country. They are currently working on four projects funded by the National Science Foundation, all of which draw inspiration from humans or animals and focus on software development.

One of their projects involves examining the applications of bipedal (two-legged) locomotion to resilient locomotion of powered prosthetic legs. Hamed's research team is collaborating with Robert Gregg, an associate professor in the Department of Electrical Engineering and Computer Science at the University of Michigan, to develop decentralized control algorithms for Gregg's model of a powered prosthetic leg. Three of the team's current projects revolve around quadrupedal (four-legged) robots and the combined use of sensors, control algorithms, and artificial intelligence to improve the agility, stability, and dexterity of robotic dogs, as well as their responsiveness to their surroundings and one another.

Hamed said that though more legged robots are being built every year, the field has a long way to go before robots can match the agility of their two or four-legged sources of inspiration.

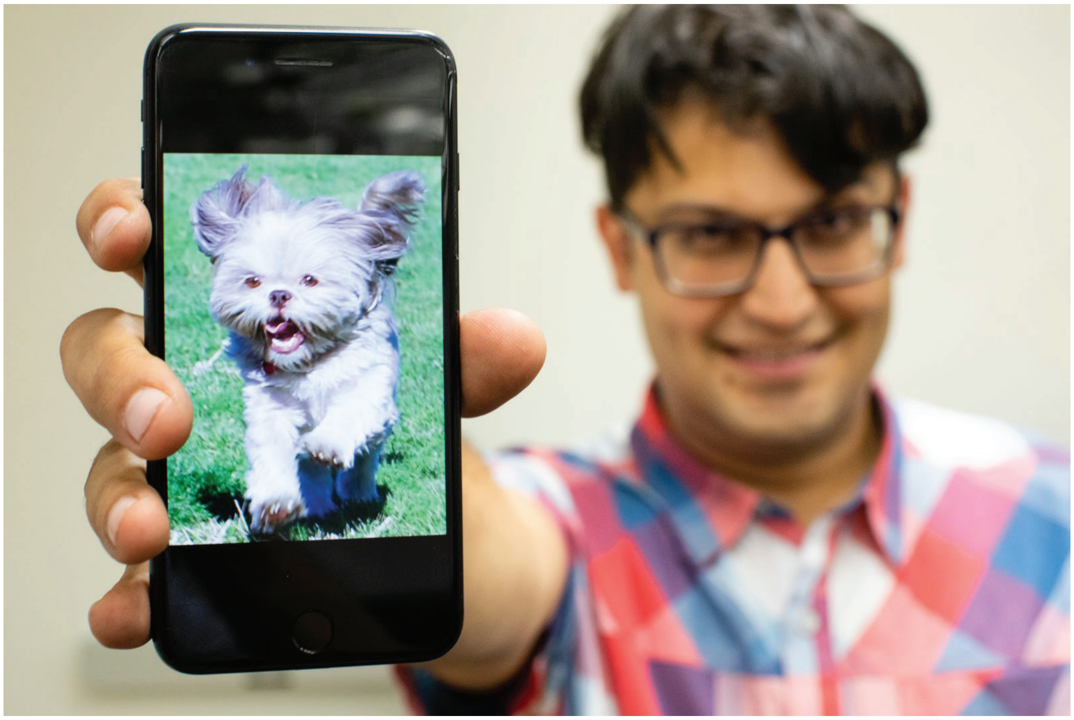
"We believe that the agility we see in animal locomotion – such as in a dog, a cheetah, or a mountain lion – cannot currently be closely pursued by robots, even state-of-the-art ones," he said. "Robot technology is advancing rapidly, but there is still a fundamental gap here, between what we see in robots and what we see in their biological counterparts."

Sourcing inspiration from four-legged friends

In his work with robotic dogs, Hamed aims to fill the gap by developing advanced and intelligent control algorithms that underline the agility and stability of animal locomotion. Integrating the use of advanced feedback control algorithms and mathematical optimization techniques with the use of sensors, his approach works in the basic biology of animals.

Balance control for vertebrates, for instance, happens mostly in the spinal cord, where oscillatory neurons communicate with one another to generate rhythmic motion. It's a natural function – the reason why legged animals and humans can close their eyes and still walk, explained Hamed. But in order to navigate more complex environments – like a set of stairs or boulders – both humans and animals need vision, and we need the brain to interpret what we see.

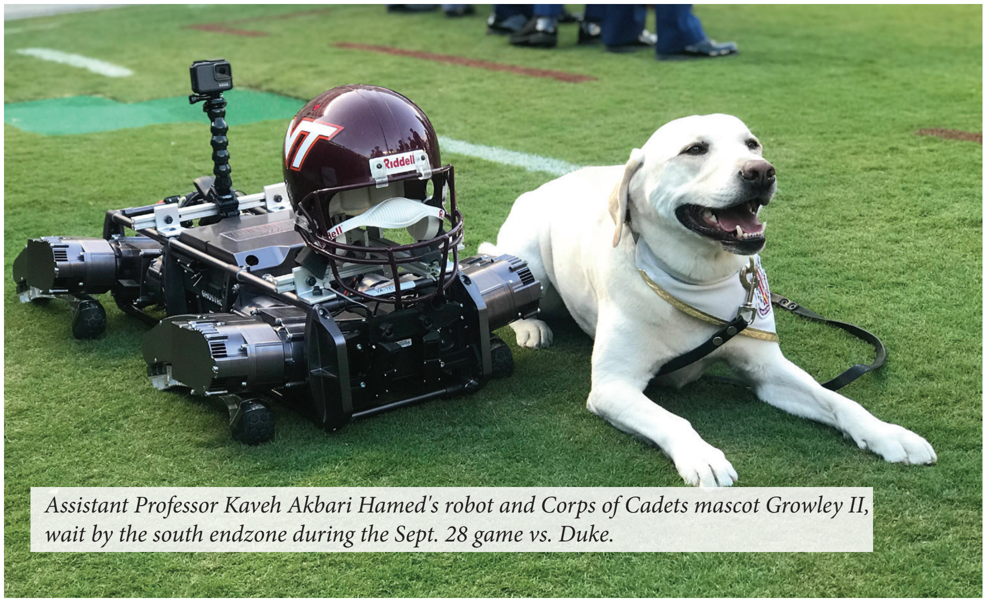
Hamed's research team uses sensors and robust control algorithms to create similar effects among their robotic dogs. They use encoders – sensors attached to joints to read their position in relation to one another – as well as inertial measurement units – sensors measuring the robot body's orientation to the ground – to create more of the balance and motion control that comes naturally to vertebrates. The team also attaches cameras and Lidar, a form of laser technology for a more precise mapping of the environment, to make use of machine



Opposite page: Kaveh Hamed and his research team at the Hybrid Dynamic Systems and Robot Locomotion Lab work to enhance agility, stability, and dexterity of four-legged robots.

Above: Hamed shares a photo of his six-year-old dog Telli in high-speed motion, a source of inspiration for his bio-inspired thinking around legged locomotion. *(Photos by Peter Means)* vision, which can better inform each robot's contact with or avoidance of obstacles.

Hamed's team has outfitted three robotic dogs, built by Ghost Robotics, a company that specializes in producing legged robots, with these sensors and has used them to test their newly-developed, intelligent and robust control algorithms. Once the robots have read measurements of their own motion and their environment, the idea is to get them to act accordingly: on-board computers calculate the robust control actions that the robots should use to steer themselves from point A to point B.



Assistant Professor Kaveh Akbari Hamed's robot and Corps of Cadets mascot Growley II, wait by the south endzone during the Sept. 28 game vs. Duke.

So far, the researchers have simulated and begun testing several different gaits mirroring those of real animals. The robotic dogs have begun to amble, trot, and run at sharper angles with more agility, balance, and speed. The team is also exploring the integration of artificial intelligence into their control algorithms to improve the robots' real-time decision-making in real-world environments.

Collaboration: Virginia Tech and beyond

Hamed leans on collaboration to adopt new concepts like artificial intelligence and safety-critical control algorithms. In two of his projects, he collaborates with Aaron Ames, Professor of Mechanical and Civil Engineering at Caltech. Together, they aim to develop the next generation of intelligent, safe, and robust control algorithms that will enable agile locomotion of quadrupedal and bipedal robots in complex environments. They also aim to build upon this work with swarms of legged robots, by creating distributed feedback control algorithms that enable legged robots to coordinate their motion in collaborative tasks.

Recently, Alex Leonessa, professor of Mechanical Engineering at Virginia Tech, has joined Ames and Hamed in a project that adapts use of distributed control algorithms for cooperative locomotion of robot guide dogs and humans.

"I learn from collaboration," said Hamed. "That is what we are doing to advance knowledge. Well-known companies are doing amazing things right now, but you can't see what they do. We would like to learn from science and math and share what we find. As we publish, we can say to other universities: 'These are the algorithms we use. How can you expand upon them?'"

Hamed sees the potential benefits and real-world applications of these enhancements in terms of mobility, assistive capability, and a combination of the two. With more than half of the Earth's landscape marked off as unreachable for wheeled vehicles, agile legged robots could better navigate rough, steep terrain, like that of the mountains or the woods. In homes and offices, the ground is flat and mostly predictable, but limitations for robots still take form in ladders and stairs designed for bipedal walkers. Hamed believes it'll be important to ensure that robots can handle the same conditions, if they are to be used to assist people with limited mobility and live with them. And as robots support or replace humans in emergency response – a rescue mission for a factory fire, for instance – they'll benefit from deft use of their legs.

Hamed finds the first tests on control algorithms with his robotic dogs promising, but the development of those algorithms will be an ongoing process. "Are the algorithms we're using actually bio-inspired?" Hamed has asked himself. "Are they actually acting like dogs? We are trying to do the math. But it must be bio-inspired. We must look at animals and then correct our algorithms — to see how they react to this scenario and how our control algorithms react."

Ft. Lee honors ME alum with building name

Gregory White, (ME '71) was honored during a building dedication ceremony at Fort Lee, Virginia May 22. White was Fort Lee's first civilian director of Public Works and Logistics, an agency he worked at for over 30 years. Friends remembered him in his 2017 obituary as a "proactive manager and natural leader who know how to listen to his co-workers." White coined the motto, "Creating a Better Fort Lee," to unify the efforts of the DPW team.

An audience of roughly 125 people assembled outside the headquarters' front entrance for the ceremony. Prominent among them were members of the White family, including his wife Juliet.

Guest speakers included Lt. Gen. Gwen Bingham, Assistant Chief of Staff for Installation Management, and a former Quartermaster General and garrison commander. She said the building dedication was appropriate, noting White's career work has made an impact beyond the boundaries of Fort Lee all the way to the halls of the Pentagon.

"I can tell you that Greg was indeed the consummate professional – dedicated, loyal, committed, selfless, compassionate, a man of principle and great integrity. … I cannot personally think of a better person who epitomizes all that is good in a teammate, and all that is good in an Army professional."

Dean's State of the College Address 2019

https://youtu.be/S8BW01plM_4

Walter O'Brien

Long time professor memorialized, honored with title Professor Emeritus posthumously

Walter O'Brien, the J. Bernard Jones Professor of Mechanical Engineering died July 25, after more than 50 years of service to Virginia Tech. O'Brien has since been posthumously conferred the title of professor emeritus by the Virginia Tech Board of Visitors.

O'Brien, who was born in Roanoke in 1937, received his B.S. and Ph.D. from Virginia Tech in 1960 and 1968, respectively, and he earned his M.S. from Purdue University. He was a member of the Virginia Tech faculty for more than 52 years, and was the first faculty member from the department to receive a named professorship.

The emeritus title may be conferred on retired professors, associate professors, and administrative officers who are specially recommended to the board by Virginia Tech President Tim Sands in recognition of exemplary service to the university.

O'Brien was the first Virginia Tech mechanical engineering professor to establish an identifiable research group, the Gas Turbine Research Institute, which he did as a junior faculty member. The effort marked a turning point in the department's evolution from a well-respected regional teaching faculty into a nationally recognized research power.

In 1987, O'Brien was a visiting scientist in the Aero Propulsion Laboratory at Wright-Patterson Air Force Base, Ohio. In 1990, he was appointed associate dean for research and graduate studies for the College of Engineering, and he was one of the founding associate deans of the Virginia Consortium of Engineering and Science Universities.

In 1993 he was named head of the Department of Mechanical Engineering, where he served until 2004. In 2002 he chaired a successful multi-university proposal to found the National Institute of Aerospace, a NASA-affiliated Research Institute in Hampton, Virginia.

During his tenure, O'Brien supervised the graduate work of more than 130 master's degree and Ph.D. students and published more than 150 technical papers and journal articles in the field of propulsion.

An internationally recognized expert in the field of propulsion, O'Brien was a Life Fellow of the American Society of Mechanical Engineering and a Fellow of the American Institute of Aeronautics and Astronautics. He was a recipient of the SAE's Teetor Award as an Outstanding Engineering Educator and the Virginia Joint Engineering Society's Pletta Award as the Outstanding Engineering Educator in the State of Virginia, in addition to many other awards and recognition.

In 2018 O'Brien was elected to the inaugural class of the Mechanical Engineering Society of Distinguished Alumni.

College of Engineering receives Exemplar status from ASEE for diversity recognition program

Jesika McDaniel is a Junior majoring in Biological Systems Engineering. She's a part of a team of students testing the efficacy of water filters in Patton Hall.

Photo Lee Friesland

The Virginia Tech College of Engineering is among the first in the country to earn a bronze award and only one of 29 institutions to receive exemplar status from the American Society for Engineering Education (ASEE) in its inaugural year of their Diversity Recognition Program.

The program was created to recognize engineering and engineering technology colleges that make significant, measurable progress in increasing diversity, inclusion, and degree attainment outcomes of their programs, according to the ASEE website. The bronze level must first be earned before an institution can be considered for silver or gold recognition.

"I am proud of the work the college has been doing in the changing landscape of higher education, especially where equity and inclusion are concerned," said Julia M. Ross, the Paul and Dorothea Torgersen Dean of Engineering. "We still have much work to do, but our efforts through the Center for the Enhancement of Engineering Diversity (CEED) under Bev Watford's leadership provide a strong foundation and as a result, we are being recognized nationally in the engineering community."

ASEE's bronze award was given to colleges and universities that signed and executed the ASEE Deans Diversity Pledge, developed in 2017, which seeks to institutionally transform issues of diversity, inclusion, and equity at engineering and engineering technology schools. Virginia Tech is one of 220 universities out of ASEE's 330 member engineering colleges from around the country that pledged to:

Develop a diversity plan with the help and input of national organizations, such as the National Society of Black Engineers, the Society for Hispanic Professional Engineers, and the Society of Women Engineers.

Commit to at least one K-12 or community college pipeline activity with explicit targeted goals and measures of accountability aimed at increasing the diversity and inclusiveness of the engineering student body.

Commit to developing strong partnerships between research-intensive engineering schools and non-Ph.D. granting engineering schools serving diverse populations in engineering.

Commit to the development and implementation of proactive strategies to increase the representation of diverse groups in the faculty.

As part of the program, the goal of the ASEE pledge is to spur notable growth in diversity enrollment, retention, and graduation rates for engineering and engineering technology students and increase the diversity of faculty and workforce employment over the next decade.

To read the entire article, please see VTNews.

Undergraduate earns Dept. of Defense SMART Scholarship

Through 2018, Virginia Tech students have earned more Department of Defense SMART Scholarships than any other university.

One of this year's recipients, William Graves of New Bern, North Carolina, a mechanical engineering student and a sophomore when he earned the scholarship in the spring, will work in DoD's civil service after graduation, a profession Graves is already familiar with from working as an intern at Marine Corps Air Station Cherry Point, North Carolina, and through his family.

The Science Mathematics and Research for Transformation (SMART) scholarship has been around since 2005 and offers students benefits including tuition, a stipend, internships, and employment after graduation. For Graves who had planned on working in the civil service even before applying for SMART, the scholarship was a welcome piece of news.

"I've been attending as an out-of-state student with no scholarships, so this is really welcome in terms of tuition, but also because it relieves a lot of stress, in not having to search for a job," said Graves.

"My father and three of his brothers are all alumni of mechanical engineering at Virginia Tech, so we always joked that I didn't have a choice but to come here," said Graves. "My father also is a civil service engineer at the Marine Corps Air Station Cherry Point, so I'm familiar with it from internships and from my father working there, and going to airshows."

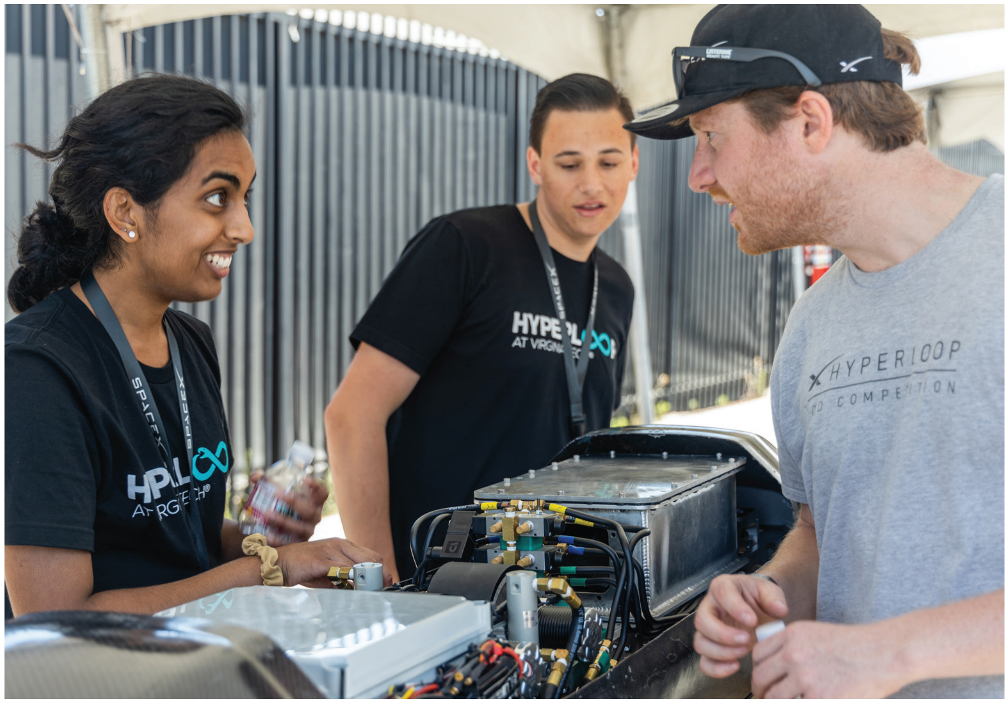
In 2018, the Department of Defense gave out 382 SMART Scholarships, awarding about 18 percent of those who applied – just over 56 percent of those were working on a bachelor's degree. It's a program Graves hadn't heard about prior to a fortuitous meeting at Virginia Tech's Engineering Expo, a student-run career fair.

"I was talking to a Naval Sea Systems Command recruiter who told me about the program," said Graves. "He gave me a brochure and I looked it up and realized it was a perfect fit, so I spoke with my advisor, Sarah Deisher, and I filled out the online application."

When he got the call that he'd been selected for the award, Graves was happy, but not as much as his mother. "It sounded like she was crying when I told her, and I'm very grateful for the opportunity."

In 2018, engineering degrees were the most awarded programs through the SMART Scholarship with computational sciences and computer engineering earning 26 percent of the scholarships, followed by electrical engineering with 22 percent, and mechanical engineering with 16 percent.

Hyperloop at Virginia Tech team gears up for Competition 5



Teja Sathi (ME '19) and Jaxson Bonsall, talk about their pod with a guest during a display event at the Fourth Hyperloop Pod Competition held in Hawthorne, California July 20-21. Sathi was with the team for three years and now works for materials science company W.L. Gore conducting new product development engineering for a medical device.

Jaxson Bonsall is an Elon Musk superfan, so as an incoming freshman he jumped at the chance to join Hyperloop at Virginia Tech.

Hyperloop aims to be a new mode of transportation, consisting of underground vacuum tubes that can propel passenger-filled pods up to 700 mph.

Bonsall had no idea he'd be practically face-to-face with the SpaceX CEO when Musk showed up during the fourth Hyperloop Pod Competition, in Hawthorne, California, July 20-21.

“It’s like seeing your favorite superhero come to life,” Bonsall said.

Musk spoke to hundreds of engineering enthusiasts at the competition, near SpaceX’s 1.25-kilometer-long hyperloop test track.

“The goal is to have an exciting engineering competition that would, I think, draw people to engineering that might not otherwise have gone into engineering and to inspire people who are already in engineering,” Musk said.

Teams from 21 invited universities vied for four test slots in the near-vacuum track to test their pod designs.

For the Hokies, a week of late nights assembling a pod to pass SpaceX’s rigorous testing requirements came up just short, but that didn’t make the experience any less powerful. Team members said the week gave them an opportunity to turn a yearlong vision into a reality.

German team TUM Hyperloop won the competition. Their pod reached 299 mph on the test track before suffering an anomaly that shattered the pod and shocked the crowd — especially considering the pod cost hundreds of thousands of dollars, according to team members.

The Virginia Tech team recognizes the difficulty of building a cost-effective pod in a competition against teams investing millions.

“If you can’t afford it, you can’t build it,” said Bobby Smyth ('91) now a mechanical engineer at Space-X and former engineering lead for the team. “When designing hyperloop pods, you have to ensure their mechanisms are safe and reliable, but also economical.”

It’s an approach the resourceful team will carry forward to the fifth competition, announced by Musk during the closing ceremonies.

Story and photos by Erica Corder

Nominations open: ME Society of Distinguished Alumni

Alumni are welcome to nominate ME alums who have achieved extraordinary accomplishments and/or stature over the course of their professional careers for induction into our Distinguished Alumni. Information can be found here, or email Brandy McCoy at brandy07@vt.edu. Deadline for nominations is Jan. 17, 2020.

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