MECHANICAL ENGINEERING | UNIVERSITY of WASHINGTON

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The MEssenger

NEWSLETTER

Developing innovative solutions through mechanical engineering research
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Turning ideas into action

In UW ME, we're proud of our commitment to impact. Every day, ME researchers are developing solutions to key challenges in health care, energy and manufacturing, and we're improving people's lives through our leadership in innovation.

Engineering is not just about problem-solving; it's about problem-solving and taking action. Our department attracts students who want to make the world a better place. To set them up for success, and to help meet the increasing demand of engineers in Washington State, we must invest in innovative research and facilities.

Our students and faculty have already launched many successful startup companies, and they continue to fuel more. I hope you enjoy learning about some of them in this issue, as well as the ways in which we're cultivating the spirit of innovation in our students through research and hands-on learning opportunities.

Today's students will be tomorrow's engineering leaders; discover how you can help them transform the world at me.uw.edu/giving.

Per Reinhall
Mechanical Engineering Chair

Research awards

Nicholas Boechler, Mark Ganter and **Duane Storti** are part of a multidisciplinary research team that received a U.S. Army Research Office grant to support a four-year project on integrated design, additive manufacturing and mechanoresponsive materials.

Steve Brunton received Young Investigator Program awards through the Army Research Office and the Air Force Office of Scientific Research for uncovering nonlinear flow physics with machine learning control and sparse modeling.

Dayong Gao was elected to the Washington State Academy of Sciences. He also received Center for Dialysis Innovation grants to develop wearable artificial kidney systems.

William Ledoux received U.S. Department of Veterans Affairs and Seattle Institute for Biomedical & Clinical Research grants for prosthetic device development and research.

Jiangyu Li received the 2017 *Microscopy Today* Innovation Award for his work developing scanning thermo-ionic microscopy.

Brian Polagye was named director of the Northwest National Marine Renewable Energy Center, a multi-institution organization focused on advancing marine renewable energy through research, demonstration, education and outreach.

Jonathan Posner received a National Institutes of Health grant for point-of-care diagnostic for HIV viral load.

Eric Rombokas received funding from the virtual reality technology company Oculus for motor control and sensory fusion research.

Eric Seibel received funding from VerAvanti to develop an endoscope for cancer detection and a University of Michigan grant for molecular imaging of the esophagus using multi-modal endoscopy.

Nathan Sniadecki was awarded a National Science Foundation (NSF) grant to research the mechanobiology of engineered heart tissue. He also received funding from the global nonprofit organization Wings for Life for work on the regeneration of spinal cord lesions.

The Federal Aviation Administration renewed funding for the **Center of Excellence for Advanced Materials in Transport Aircraft Structures** (AMTAS), directed by **Mark Tuttle.** A consortium of academic institutions, aerospace companies and government agencies, AMTAS seeks solutions to challenges associated with composites and advanced materials application for commercial aircraft. Tuttle also received funding from the Bridgestone Company to study failure mechanisms in heavy-duty mining truck tires.

Junlan Wang's research team received a NSF Major Research Instrumentation grant to acquire an advanced nanoindentation system for multidisciplinary research and training.

Tradition with a modern twist

The UW Human Powered Sub team blends traditional boatbuilding with aerospace and marine engineering to create an award-winning submarine.

As far as self-powered submarines go, Knotty Dawg is a work of art: 15 feet long, its hull is hand crafted from western red cedar and finished with an African mahogany wood veneer. Standing next to it, one can't help but touch its smooth surface, trace the wood grain and admire the intricate design details.

But for the vessel's creators — the UW Human Powered Sub team (UWHPS) — it's more than just a visual wonder. It's an engineering accomplishment, one that paid off this summer at the International Submarine Races in Potomac, Maryland, where the team won first place in the fastest two-person sub competition with a speed of 3.27 knots.

"This sub has been a return to tradition for us," said ME senior Andrew Farrell, who is one of this year's team captains. UW students started competing human powered submarines in 1989. They built their first hull from wood, but then moved on to foam, plastics, carbon fiber and other composites — materials used by most teams in the competition.

The idea to revisit wood as a medium came from former captain Bentley Altizer, BSME '16, who wanted the team to create a sub that looked smart, gave them a competitive edge and honored the heritage of Pacific Northwest wooden boatbuilding.

Last year the team reached out to the Northwest School of Wooden Boatbuilding in Port Hadlock, Washington, an institution that teaches traditional and contemporary wooden boatbuilding skills. The school's boat builders were excited to learn about the project and began working with the students to create the hull.

The opportunity to partner with artisan boat builders was an experience most team members never expected to have as engineering students.

"But, then again, everything we do tends to be unexpected, curious and challenging," said Farrell. "That's the nature of the competition, and it's what drives us."

In even years, competitions are held at an aquatic center in Gosport, England; in odd years, they take place at the U.S. Navy's Naval Surface Warfare Center, Carderock Division, near Washington, D.C. The UW team uses the same hull for two years, modifying the controls and drive mechanics so it performs well in both locations.

Keep up with UWHPS at uwhpsub.com

Subs have either one or two pilots, who must squeeze inside and use their hands to steer, feet to pedal, and a scuba regulator to breathe. The submarines aren't watertight, so pilots must be scuba-certified. In a two-pilot sub, like Knotty Dawg, one pilot faces forward while the other faces backward, their feet meeting in the middle.

While top speed is the goal at competition, good engineering is what really matters.

"Without solid design and construction, it doesn't matter how fast your pilots are; they're not going to be able to perform well if they don't have a top-notch sub," noted Farrell.

INNOVATION IMPACT

Mechanical Engineering empowers students and faculty to learn, discover and build solutions to tomorrow's challenges.

For over 100 years, the UW has graduated creative engineers and developed novel solutions through research, and Mechanical Engineering (ME) has been a leader on campus in transforming ideas into action.

"Innovation training in engineering is training for life, and UW ME is committed to this idea," said ME professor and chair Per Reinhall.

The Puget Sound is a global hub for advancing science, inventing new technologies and powering markets and industries, and much of that spirit is reflected in ME's labs and classrooms. From developing new football helmet technology that reduces impact forces to building generators that convert heat into electricity for communities in need, ME's faculty and students are doing their part to create a healthier, cleaner and safer world.

Students are introduced to innovation in their ME courses and are encouraged to participate in workshops, events and competitions offered by partners on campus, such as UW CoMotion and the Buerk Center for Entrepreneurship. They can also take part in the department's student clubs, which spark curiosity for discovery and collaboration, and have free access to the ME's prototype shops and campus makerspaces.

The department's faculty members are encouraged to connect with the rich innovation community across campus. CoMotion, for example, can assist innovators in all stages of research translation — planning and developing strategies, navigating the commercialization process, identifying and securing funding. UW researchers can apply for and receive grants and seed funding through CoMotion's Innovation Fund and Amazon Catalyst.

To encourage research translation, ME supports and advocates for faculty and student partnerships with industry. Engineering Innovation in Health, ME's signature capstone program, is built around innovation, providing students and faculty the opportunity to collaborate with clinicians in the development of affordable solutions to pressing health care needs. And each winter, the department invites alumni and industry partners to present on topics such as entrepreneurship, commercialization and career development as part of ME's leadership seminar series.

"Innovation is equivalent with impact, and it's the best way to share our work with the end users for whom we're designing devices and technologies," said Reinhall.

"Because of their commitment to cutting-edge research and their entrepreneurial drive, our faculty and students have launched numerous successful startup companies and regularly license technology to industry partners. This not only fuels the economy; it also transforms lives," he added.

ME STARTUPS

Companies that have emerged from recent ME faculty and student research include:

Alchemai provides advanced data analytics for supply chain risk management.

Alpenglow Optics is developing 3-D microscopy technology to enable nondestructive slide-free pathology of clinical specimens for better disease detection, diagnosis and treatment.

BluHaptics is a software company pioneering new technology for better control of augmented robotics.
bluhaptics.com

JikoPower builds generators that convert heat into electricity for disaster preparedness, camping and low-resource communities.
jikopowerinc.com

Marine Construction Technologies has developed technology to reduce noise from pile driving and protect wildlife while improving the efficiency of marine construction projects.
marinecontech.com

MarineSitu makes marine environmental monitoring instruments accessible to turbine developers and other renewable marine energy companies.
marinesitu.com

Micro Phone Lens turns cell phones and tablets into microscopes.
microphonelens.com

Phoresa is developing an innovative test for infectious diseases to help doctors better diagnose and treat patients in a single visit.
phoresa.com

SonoMotion is developing non-invasive solutions for kidney stone disease.
sonomotion.com

Stasys Medical Corporation is commercializing a device to assess platelet dysfunction in trauma patients within minutes, helping emergency physicians save lives.
stasysmedical.com

VerAvanti is developing a laser-based medical camera to help cardiologists better diagnose and treat individuals who are at risk for stroke and/or heart attacks.
veravanti.com

VICIS has developed a helmet designed to mitigate impact forces in NFL, college and youth football.
vicis.co

Visiongate is a clinical stage pharmaceutical and diagnostics company developing products for the early detection and treatment of lung cancer and lung dysplasia.
visiongate3d.com

MARKET IMPACT

The UW was named the No. 1 most innovative public university in the U.S. by Reuters in 2017. ME is a leading department at the UW for innovation, commercialization and industry collaboration. From 2012-2017, ME has been responsible for:

404 patents filed

263 reported inventions

149 patents issued

13 startup companies resulting from faculty and student research

Learn more at me.uw.edu/innovation

DATA REFRESH

ME graduate student helps researchers better understand how marine energy equipment affects life underwater.

Through devices such as tidal turbines and wave energy converters, marine energy conversion systems harness the power in ocean / tidal currents or surface waves. An emerging market, this form of alternative energy has the potential to someday meet a significant percentage of U.S. energy needs.

But do turbines and converters endanger or alter the behavior of marine life? Researchers have long been interested in better understanding how such devices affect underwater environments. Now, thanks to ME graduate student Emma Cotter, they may be a big step closer.

Cotter works with a team of engineers, led by ME associate professor Brian Polagye, who design and build turbines and converters, tools for monitoring underwater energy sites, and software to process the data they collect. Their research takes place in conjunction with the UW's Applied Physics Lab and as part of a multi-institution organization, the Northwest National Marine Renewable Energy Center.

To study marine environments, researchers use recording equipment — sonars, visual cameras and hydrophones — strategically placed at marine energy sites. Polagye's team has developed multiple monitoring systems: Drifting Acoustic Instrumentation Systems (DAISYs) float along the water's surface and collect acoustic data, swarms of μFloat (pronounced "micro float") drift underwater, and Adaptable Monitoring Packages (AMPs) mount to the seabed or stationary energy converters and transmit data back to shore. Of these, AMPs are furthest along in development, thanks to support from the U.S. Department of Energy's Water Power Technology Office.

The data collected by these systems is a blessing and a curse. For example, AMPs generate so much data that it is nearly impossible to sort through it all or subsample from it to detect specific moments of marine life interaction, such as a seal or a school of fish moving through the field of view.

But Cotter has recently developed a way to drastically reduce the volume of data yielded by current monitoring. Using machine learning, she has created a detection system to determine — in real time — when marine life is present in the areas being monitored.

This way, researchers can record only those moments, reducing the extreme amount of low-value data they would otherwise have to collect, and focusing their attention on environmental study rather than data management.

Cotter's technology advancements will also help researchers better identify and classify the kinds of marine life in a specific underwater location.

"It's difficult to tell what, exactly, we're seeing when reviewing the data, but by collecting more focused data, we can begin to identify patterns," she explains. "Doing so helps us better assess which sorts of creatures are present, how frequently they appear and how they behave."

Cotter is now working to enhance the machine learning so that researchers will be able to classify marine life in real-time — not just to detect that something is present, but to determine what that something is.

BETTER ANEMIA MONITORING

A ME research team has developed a device to improve anemia detection worldwide.

About one quarter of the world's population suffers from anemia, a disease caused by a concentration deficiency of hemoglobin in red blood cells. To reduce the burden of anemia, health officials need a better picture of the disease's global impact, an understanding made viable by a portable and affordable way to analyze blood.

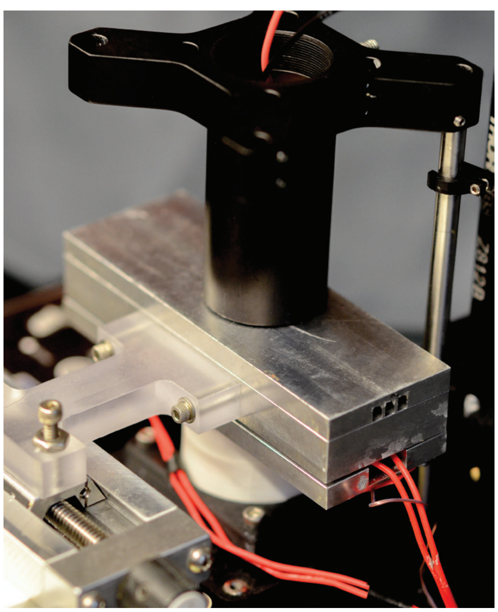
Blood analyzers currently on the market measure hemoglobin by chemically rupturing the red blood cells in a sample. This technique requires hands-on expertise to prepare and run a sample, limiting the ability to monitor anemia in many parts of the world.

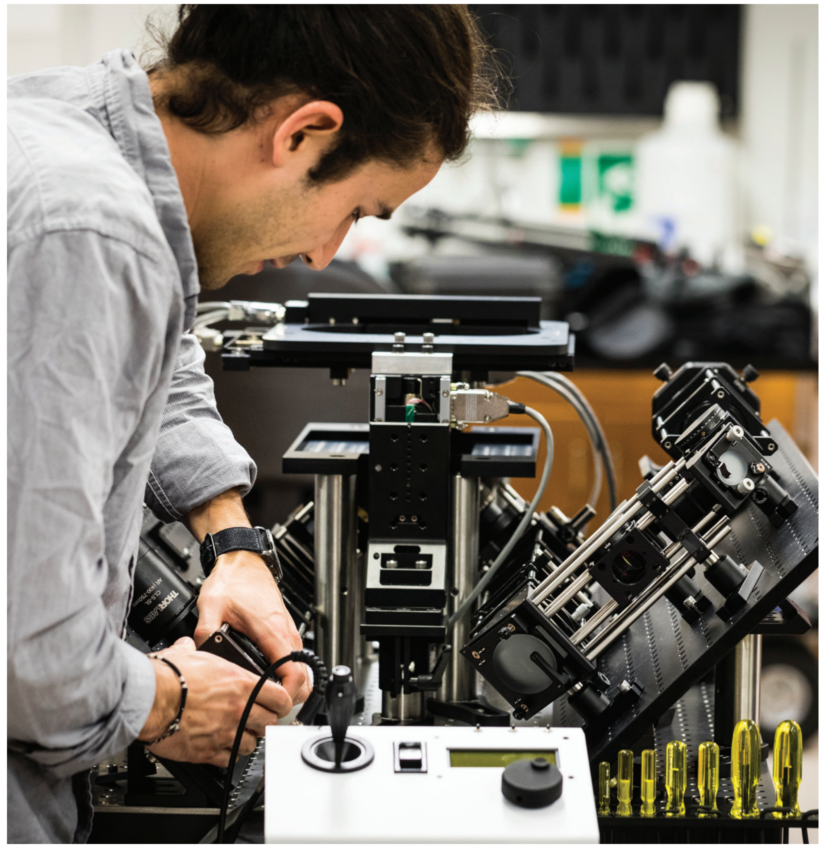
But ME researchers have developed a device that can detect the level of hemoglobin in whole blood samples using optical absorbance.

"The most exciting aspect to this analyzer is that it uses whole blood and does not require the additional steps and reagents to prepare a sample," said ME associate professor Nathan Sniadecki.

The device only requires a few drops of blood for analysis.

"You just run blood into the channel and that's it," said Nikita Taparia, a ME doctoral candidate in Snaidecki's lab who is also working on the device. "It can be used anywhere."





IMPROVING TUMOR DETECTION

A microscope developed by ME researchers and UW pathologists can scan tumors during surgery and examine cancer biopsies in 3-D.

When women undergo lumpectomies to remove breast cancer, doctors try to remove all the cancerous tissue while conserving as much healthy tissue as possible. But currently there's no reliable way during surgery to determine whether the excised tissue is cancer-free at its margins — the proof doctors need to ensure that they removed the entire tumor. It can take several days for pathologists to process and analyze the tissue.

That's why many women undergo multiple breast conserving surgeries — to remove cancerous cells missed during their initial procedures.

A new microscope invented by a team of UW mechanical engineers and pathologists could help solve this, and other, problems. It can rapidly and non-destructively image the margins of large fresh tissue specimens with the same level of detail as traditional pathology — in no more than 30 minutes.

"If we can rapidly image the entire surface or margin of the excised tissue during the procedure, we can let surgeons know if they still have tumor left in the body or not," said ME associate professor Jonathan Liu. "That would be a huge benefit to cancer patients."

The new light-sheet microscope offers other advantages over existing processes and microscope technologies. It conserves valuable tissue for genetic testing and diagnosis, quickly and accurately images the irregular surfaces of large clinical specimens, and allows pathologists to zoom in and "see" biopsy samples in three dimensions.

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Robot skin senses shear force

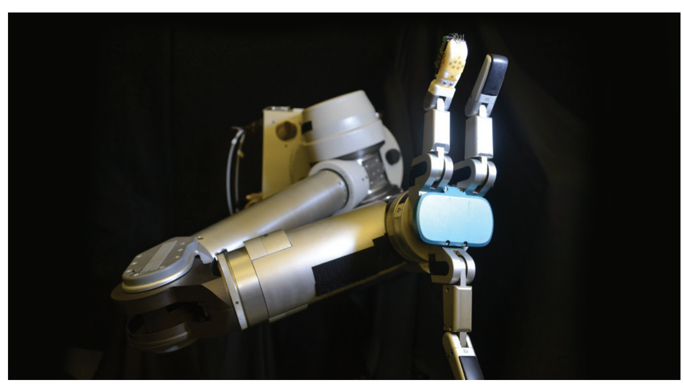
Flexible "skin" developed by ME researchers can help robots perform everyday tasks.

If a robot is sent to disable a roadside bomb — or delicately handle an egg while cooking you an omelet — it needs to be able to sense when objects are slipping out of its grasp.

Yet to date it's been difficult or impossible for most robotic and prosthetic hands to accurately sense the vibrations and shear forces that occur, for example, when a finger is sliding along a tabletop or when an object begins to fall.

Now, an engineering research team led by ME professor Jonathan Posner has developed a flexible sensor "skin" that can be stretched over any part of a robot's body or prosthetic to accurately convey information about shear forces and vibration that are critical to successfully grasping and manipulating objects.

"Robotic and prosthetic hands are really based on visual cues right now — such as, 'Can I see my hand wrapped around this object?' or 'Is it touching this wire?' But that's obviously incomplete information," explained Posner. "If a robot is going to dismantle an explosive device, it needs to know whether its hand is sliding along a wire or pulling on it. To hold on to a medical instrument, it needs to know if the object is slipping. This all requires the ability to sense shear force, which no other sensor skin has been able to do well."



"Our electronic skin follows the cues of human biology," added Jianzhu Yin, who recently received his doctorate from UW ME. "It bulges to one side just like the human finger does and the sensors that measure the shear forces are physically located where the nailbed would be, which results in a sensor that performs with similar performance to human fingers."