2015

Undergraduate Education 2015

College of Engineering, Michigan Technological University

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Undergraduate Education 2015

MICHIGAN TECH ENGINEERING

BEYOND THE CLASSROOM

RESEARCH

INTERNATIONAL

DESIGN

Michigan Tech

Michigan Technological University

Wayne D. Pennington

Leonard J. Bohmann

Letter from the Deans

Michigan Tech has long established a distinguished record of delivering high-quality engineering education to our undergraduates. Our courses are taught by many of the nation's most talented and dedicated faculty. The educational experiences we provide extend far beyond the classroom, as well.

Our students take advantage of many exciting educational opportunities in the lab, in the field, and around the globe. At Michigan Tech, these experiences are not the exception—they are the rule. All engineering students participate in Senior Design, Enterprise, or Undergraduate Research programs, and many of those experiences are documented within the following pages.

Please take a few minutes to browse these stories, and we think you will understand why we are so proud of our students and their accomplishments.

Be sure to let us know your thoughts. As always, we look forward to hearing from you.

Wayne D. Pennington
Dean

Leonard J. Bohmann
Associate Dean for Academic Affairs

On the cover: Biomedical engineering student Nina Pacella holds the magnetoelastic biosensor array that she helped design. Low-cost and disposable, it is capable of multi-parameter sensing of glucose, pathogens, and more. See page 4.

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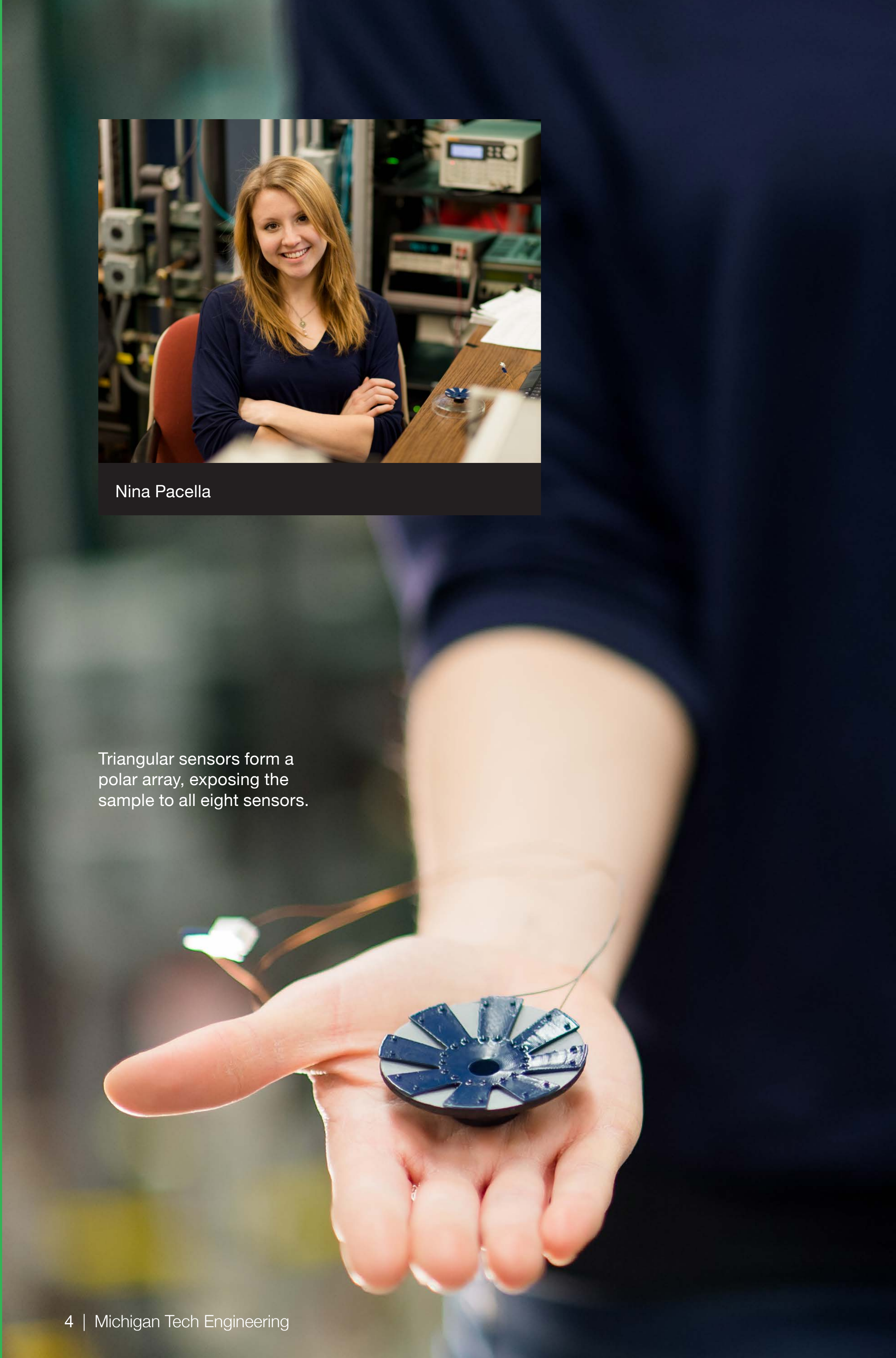
RESEARCH



Nina Pacella

Triangular sensors form a polar array, exposing the sample to all eight sensors.

Magnetoelastic flower power

Sensing more with less

Nina Pacella stumbled upon the web page for the Michigan Tech Biosensors Lab, directed by Keat Ghee Ong. She was looking for an experience outside the classroom. “I knew nothing about research, or what it might take to work in a research lab, but everyone in the lab was extremely open to answering my questions,” she recalls.

Less than one year later, Pacella has developed a sensor array with high sensitivity for detection of various pathogens, and published a scientific paper about her work in the journal *Smart Materials and Structures.*

The sensor, which is disposable, can be used to perform rapid microbial detection. Potential applications include sensing *E. coli* for food quality and safety or monitoring hospital-acquired infections, such as MRSA.

“The array uses the properties of magnetoelastic materials to sense certain parameters in a target analyte,” Pacella explains. “Its flower design, comprised of triangular ‘petal-shaped’ magnetoelastic material, allows us to track multiple sensors at once. This type of sensor system is very low-cost and extremely quick. The ability to sense multiple samples at once cuts down sensing time, too,” she adds.

“The triangle shape of the magnetoelastic materials is significant because it greatly increases the sensitivity of the sensor and is more streamlined, allowing for more sensors to be arranged together in a smaller area.”

To date, most magnetoelastic sensors are rectangular and are designed to sense a uniform coating of target analyte over the entire sensor surface. Pacella, Ong and the research team developed a new magnetoelastic sensor design with higher sensitivity, achieved by applying non-uniform coatings and altering the sensor to a triangular shape. The new design allows the magnetoelastic sensor to form a sensor array that requires only a fraction of the sample volume for multi-parameter sensing compared to the current sensor design.

Pacella was responsible for characterizing the response of the triangle sensors, as well as designing and building the actual handheld sensor device to hold the triangles. “The design started out as very large and bulky. Through many revisions, we eventually ended up with the streamlined flower device,” she says. “I really enjoyed the design portion because it required use of our 3D printer, and I thought it was especially rewarding to compare previous designs with the sensor as it is today.”

In addition to increased sensitivity, triangular magnetoelastic sensors can also be formed into a polar array with their tips concentrated in a small region. As a result, only a small quantity of test sample is needed for all sensors. Pacella and the team fabricated and tested a detection apparatus, including a new sensor holder, a spiral coil, and custom electronics to demonstrate the feasibility of this sensitive magnetoelastic sensor array with a minimized sample size. Their new design may lead to the development of biological or chemical sensors for the detection of glucose, pH, *Bacillus anthracis* (anthrax) and other pathogens.

“The most challenging part about research is trying not to get frustrated when a project doesn't work the first time. If I've learned one thing from working in a research lab, it’s that you have to try thousands of different designs and processes before something works out. It’s hard to keep trying, but the struggle makes it that much more exciting when a project finally works, and you get good results.”

“I was really excited to publish the research—I felt like I was contributing to something important and leaving my mark in the world. Hopefully I will have more publications in the near future, but the publishing process does take a while. I was very fortunate to have received a lot of help with this project from Dr. Ong as well as the graduate students in the lab.”

Graphene biosensor

Creating a handheld malaria detector

Malaria is caused by *Plasmodium* parasites, transmitted by the bite of an infected mosquito. The parasite enters the blood, travels to the liver and then re-enters the bloodstream, invading the red blood cells. Infected red blood cells burst, releasing even more *Plasmodium* parasites into the blood. This happens every 24-48 hours, causing cycles of fever, chills and sweating.

The disease has a devastating impact on people's health and livelihoods around the world, particularly in Africa, where it kills almost half a million children under five each year. Prompt diagnosis and treatment is essential.

Chemical engineering major Pennie Winters is working with three chemical engineering professors—Caryn Heldt, Adrienne Minerick, and Julie King—to design, build and test a malaria detection microdevice with the potential to help many people in malaria-ridden countries.

"Our group is using a four-probed graphene device as a biosensor for the detection of malaria parasites, viruses and pathogens," Winters explains. Their end goal is to create a low-cost, handheld device. "Our preliminary work focused on placing a drop of sample on graphene paper. Our current research focuses on obtaining more accurate results using the addition of a polydimethylsiloxane (PDMS) polymer channel to the four-probed device."

Winters uses the protein BSA to test the devices. "The device works by pumping a sample through the channel and across the graphene paper. A set current is conducted through the outer electrodes and we can measure the voltages across the inner electrodes. We then use the current and voltage data to calculate surface resistivity," she says.

Winters's work in the lab is usually done in stages. "One day I will go in and mix up the PDMS polymer and mold my channels so they can sit in the oven to cure. The next day I will fabricate my devices using glass slides, epoxy, tape and graphene paper, and adhere the PDMS channels. Then I make my BSA solutions at a few different concentrations. Finally I will take my devices and test them using the pumps and solutions to determine how the electrical resistance of the paper changes with different protein concentrations."

The most difficult part of research, she says, is getting an understanding of the project. "A research project is not something that you can read an overview of and just go start working. I feel like every time I head into the lab I am learning something new about my devices. Also, it is challenging to learn that research takes patience and time. This is not something where you get immediate results, and so this project is helping me to learn the importance of taking your time, being patient, being careful, and being observant," she adds.

"I really enjoy being able to work with my hands on something meaningful. That is the best part of becoming an engineer, having the opportunity to make the world a better, safer, and healthier place."

Pennie Winters

Mosquito nets in Prey Mong Kol, Cambodia. Drug resistant malaria has emerged in SE Asia.

Alesha Fumbanks

Open burning of rice straw

Rice straw

Investigating a biofuel feedstock

Rice is the primary food staple for half the people in the world. It is the highest yielding cereal grain—one seed of rice yields more than 3,000 grains. It can thrive in many kinds of environments and soils, and is grown on every continent except Antarctica.

Once rice is harvested, the stalks that remain need water and/or time to decompose. In temperate areas of the world, the result is often an overabundance of rice straw left in the field. Open burning of this straw is common in China, India, and many other Asian countries, which together produce more than half of the world's rice.

Alesha Fumbanks, a chemical engineering senior, is hoping to help turn "straw into gold." She has spent the past year conducting research on how to best use rice straw as feedstock for the production of biofuel.

Fumbanks is working with chemical engineering graduate student Suchada Ukaew and Robbins Chair and professor David Shonnard to investigate pyrolysis as a conversion technology for rice straw. Pyrolysis is a technique for decomposing organic materials at high temperatures in the absence of oxygen. After pyrolysis, the resulting material from the rice straw can be converted to a hydrocarbon biofuel.

In the lab Fumbanks prepares rice straw samples for the pyrolysis process. She also helps Ukaew, a Royal Thai Scholar, perform composition analysis, measuring the hemicellulose, cellulose, and ash content. The team uses fast pyrolysis, a thermal conversion process in which rice straw is directly converted to liquid fuel. Rice straw is rapidly heated (within 1 second) to temperatures between 500-600°C in the absence of oxygen, and the resulting vapors are condensed rapidly. The result may include anywhere from 35-55% liquid bio oil, 20-25% solid char, and 20-30% gas. "Through our research we have found that the large ash content of rice straw might pose a hindrance to it being used as a biofuel via pyrolysis," Fumbanks explains. They are now investigating a pretreatment step that would remove ash and other mineral components.

"The global production of rice straw is about 730 million metric tons per year, making it one of the world's most available biofuels feedstock," adds Ukaew. "Open-field burning of rice straw not only increases in greenhouse gas emissions and air pollution, but it also destroys soil nutrients and soil fertility. Fast pyrolysis is one way to add value to rice straw."

Alternative energy has captured Fumbanks's interest ever since she was a first year college student. "Being able to help with graduate level research has been one of the best experiences I've ever had at Michigan Tech. I like learning things in a hands-on environment. It's also great to not always know what the end result of a given experiment will be," she says.

After she graduates Fumbanks will be starting as an engineer with energy powerhouse Enbridge. She will be working in a different US or Canadian location of the company every year for the next four years. Her next goal? Fumbanks is considering law school and a career in patent law.

SLAM systems

Mapping—and more—in real time

Let's say you're walking around a new building," says Joshua Manela, an undergraduate researcher in the Michigan Tech Intelligent Robotics Lab (IRL). "Inherently whether you know it or not you're figuring out where you are. You see a bunch of walls, doorways, and usually when you look around you get a general idea of what your environment looks like. You are simultaneously localizing yourself and mapping your surroundings without even knowing it. In the robotics world, this is known as SLAM—Simultaneous Localization and Mapping."

Manela, an electrical engineering major, is working with a research team in the IRL with director Tim Havens to develop a sensor pod for UAVs (Unmanned Aerial Vehicles) that will combine information from LIDAR, camera, and sensors to measure 3-D information about road and bridge surfaces for the Michigan Department of Transportation.

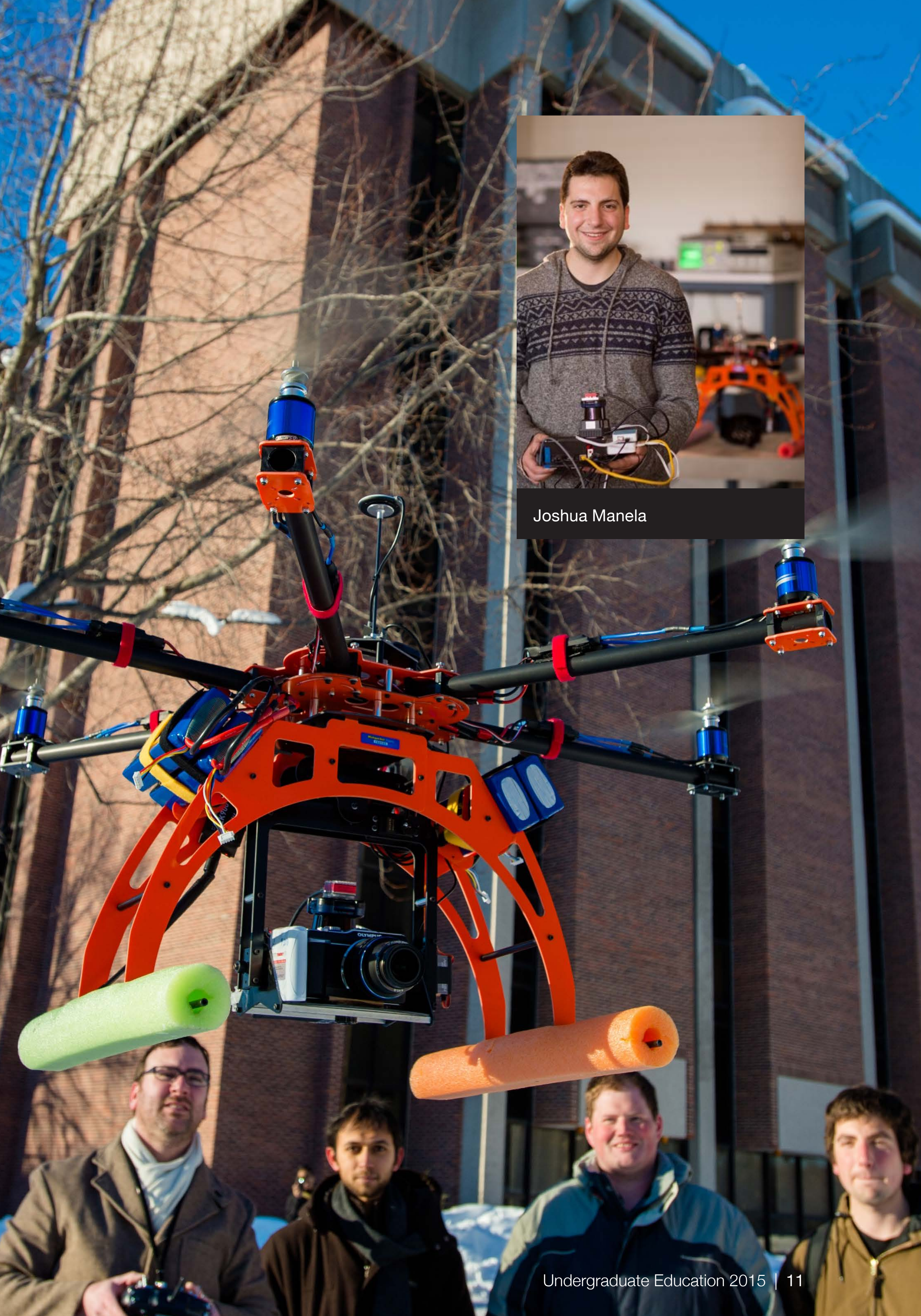
Last summer Manela worked in the lab full-time as a summer undergraduate research fellow, which gave him the opportunity to write SLAM algorithms for testing purposes. He used those algorithms to map out random areas with a UAV, scanning 3D environments such as hallways and intersections. Havens and Manela also drove downstate to fly the UAV across a bridge over a major highway, then went back to the lab and re-created the bridge in 3D space with the team.

Manela also helped design the LIDAR sensor system for the team's UAVs along with PhD student Erick Wonacott and another undergraduate researcher, computer engineering major Tim Bradt. "LIDAR is like radar on an airplane but uses lasers instead of radio waves," he explains.

"Application-wise, the possibilities are infinite. Consider a robot that can walk through a building and create a floor plan in real time to help law enforcement officers enter an unfamiliar, dangerous area. Consider autonomous vehicles, how do you think they know how to get around? They use SLAM! That little rotating sensor on the top of the Google car is actually a laser scanner, which grabs all the points in the surrounding area. Being able to match up those points with points around it allows the car to know exactly where it is down to the centimeter, while also giving it a clear map of its surroundings."

Staying up-to-date with the newest technologies is the most challenging aspect of the work. "The research we're doing in the IRL is the stuff you see in comic books and science fiction movies. The idea behind research is to try and find the next coolest thing that can revolutionize your field, and help everyone else at the same time. Basically I love seeing the future and trying to invent past it," he says.

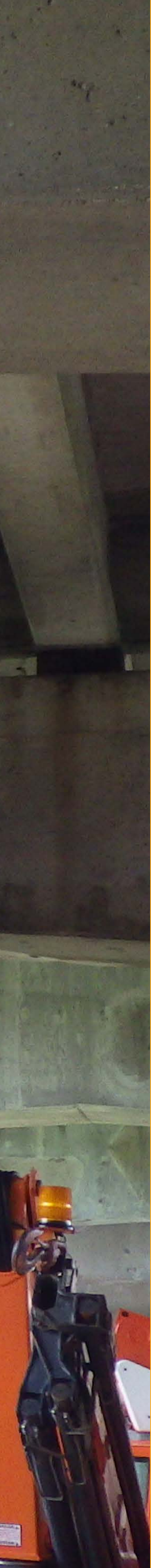
Manela plans to attend graduate school and wants to become a professor. "The two things I love in life are teaching people and doing cool stuff, which is exactly what being a professor entails. I taught robotics camps and classes to K-12 students for a couple years, and I've been hooked on teaching ever since. I just like to do cool stuff and help other people do it!"



Joshua Manela

Cattelino conducts a field demonstration for MDOT workers in Grand Rapids, Michigan.

Jason Cattelino



Active IR thermography

Making concrete bridge deck assessment fast and portable

As with people, concrete bridges start getting sick long before they develop obvious symptoms. Potential problems include cracking, spalling (potholes), scaling (like a fish, but on a concrete surface), delaminations (subsurface air pockets within the concrete), and more.

Detecting subsurface damage has long been a challenge for bridge inspectors and transportation authorities. This type of deterioration can appear on the bridge deck or girder; however, areas underneath the bridge can be more critical in terms of safety.

Jason Cattelino, a civil engineering major, has spent the past year working as an undergraduate researcher in the Michigan Tech Center for Structural Durability. His goal: to help inspectors better assess potential problems under the bridge deck. “Delamination occurs when layers of concrete separate due to moisture migration and corrosion of rebar, which causes air pockets to form,” says Cattelino. “Over time, delaminations are one of the leading causes of spalls and deck replacement.”

Visual inspection does not provide enough information about possible internal defects and deteriorations. One method that does is thermal infrared (IR) imagery, a technology based on measuring the radiant temperature of a bridge deck. On sunny days delaminations and anomalies appear as hot spots on a thermal IR image as they interrupt heat transfer through the concrete. But because too little of the sun’s energy reaches the bottom of the bridge deck, other techniques need to be used there.

“Very few people have addressed the limitations of IR thermography on the underside of concrete bridge decks,” says Cattelino. “That’s where we come in.”

Cattelino and his faculty mentor, Tess Ahlborn, have developed an active IR thermography test set-up that is both portable and easily deployable for bridge inspectors. “Instead of relying on the sun’s energy to provide the necessary thermal gradient, we use an external heat source—an infrared patio heater—to actively heat the concrete,” he explains.

According to Cattelino, testing is fairly simple: “Heat an area of concrete that is suspected to have areas of delamination for a specified amount of time. Record and monitor the area using an IR thermal imaging camera. If a delamination is present, it will appear with a temperature contrast to the surrounding sound concrete. Transfer the data to a computer for processing. Use either a subjective visual analysis method to determine the area of delamination or a statistical method."

“Learning how to set up and run experiments was relatively easy compared to learning how to conduct the analysis procedures,” adds Cattelino. He sought help and began to better understand the methods after putting them into practice.

Now a senior, Cattelino had been considering the possibility of working in a research lab ever since starting at Michigan Tech. “I spoke to Dr. Ahlborn a number of times about the research she was conducting and offered to help out,” he says. “When one of her PhD students graduated, she needed someone to finish up the MDOT project. We’ve been moving forward with the research ever since.”

INTERNATIONAL

Quebrada y pozo

Designing water systems in rural Panama

In Panama much of the population is without access to clean water. Organizations including Panama's Ministry of Health, the US Peace Corps, and now Michigan Tech through its International Senior Design Program (iDesign), have increased technical support to rural communities in Panama to help solve this problem.

Last summer a student team from Michigan Tech traveled to Panama to improve the water system in Nidori, in the province of Bocas del Toro. The team, comprised of civil and environmental engineering majors Adam Tuff, Madie Martin, Logan Anderson, Kellie Heiden and Tia Scarpelli, worked with Peace Corps volunteer Colleen Hickey to assess the needs of the community, gather data on existing water sources, and complete a survey for a new water distribution system.

"It was very difficult just to make it to the community," says team member Adam Tuff. "To get there we flew into Panama City, took a bus to David District and stayed there for the night, then in the morning took a bus to Chiriqui Grande, then a small boat. The community is definitely off the grid."

The rural area is part of the Ngöbe-Buglé Comarca, one of the areas set aside by the government for the various indigenous groups of Panama. The Ngöbe people rely on water transportation throughout the community, often by canoe, due to the location of the homes and schools, as well as the rough surrounding terrain.

"Our project was a little complicated, as we serviced one community with two smaller aqueducts," explains team member Kellie Heiden. "The first portion of our project came from the newly found quebrada 'mountain stream' water source. We utilized this source by designing a stream dam that siphoned water through PVC pipes to five homes that currently have no water distribution system at all. This means that they carry buckets to and from a water source a few times a day to get adequate water. The second portion of our project collected water from the pozo 'spring' water source. This required the designing of a spring box and a distribution line that feeds into a concrete tank. The water collected in the tank will be used to service twelve homes that have a water distribution system only during the wet season."

"It was difficult to figure out how we could design a simple system that would last," adds Tuff. "It is not the same as designing a system in America where the people and parts needed to fix problems are readily available." The team worked closely with the community members to figure out what they would be able to maintain. Back on campus, they produced a report in both English and Spanish detailing the design process, technical design components, construction, maintenance, feasibility, recommendations, and impact their project will have on the community. Implementation depends on funding, but the team is optimistic.

"Our time in Panama was difficult due to factors like weather—full days of rain—and access limitations. Just getting to the sites was an adventure," says team member Tia Scarpelli. "But the field experience was very rewarding. The people of Nidori really wanted to know how they could help."

Adds Scarpelli: "Studying abroad and especially programs like iDesign are very helpful if a student is considering something like the Peace Corps—it will give you a great snapshot of what that sort of experience is like without the full-on commitment."

Michigan Tech students L to R: Kellie Heiden, Tia Scarpelli, Madie Martin, Logan Anderson, and Adam Tuff

Jacob Braykovich

Biodegradable scaffolds are cut with a water jet.

Production Technology Centre, Leibniz Universität, Hannover

An unconventional summer

Investigating myocardial graft materials in Hannover

Jacob Braykovich wanted to do something different the last summer before earning his undergraduate degree. The previous summer he had an internship at start-up InPore Technologies, working on polymeric water filtration systems. And the materials science and engineering major had spent two years working in the Michigan Tech Surface Innovations lab, helping to develop biodegradable zinc-based cardiac stents.

Braykovich thought about going overseas, and began looking into options. That's when he discovered the RISE program, or Research Internships in Science and Engineering. The RISE program is for students in the USA, Canada, or UK who want to spend a summer researching science or engineering at German universities. Braykovich applied for and won a scholarship to attend Leibniz University in Hannover, Germany.

Braykovich joined a team of researchers at Leibniz University Institute of Materials Science working on myocardial graft materials. Myocardial grafts, both biological and synthetic, are used to help restore damaged myocardium, or heart muscle. Whether from heart attack or disease, damage to the myocardium can result in scar tissue, which can diminish the heart's ability to contract and pump blood effectively.

"The Liebniz team, led by Hans Jürgen Maier, has developed a biodegradable magnesium alloy scaffold designed to mechanically support a myocardial graft and then gradually lose its function as the graft develops its own strength," Braykovich explains.

"The work was similar to my research here at Michigan Tech, so I was able to hit the ground running," he says. Braykovich worked on perfecting the abrasive water injection jet cutting strategy employed to produce the scaffolds—analyzing design, cutting-edge roughness, and burr generation. "I ultimately determined the optimum pressure, flow rate, abrasive size and material, traverse rate, and orifice diameter of the cutting technique," he says.

He started each day with coffee and a pastry from a local bakery and headed to work on the train. His tasks at work ranged from cutting samples in the manufacturing facility to using the 3D laser microscope to take images of the cuts, which he then analyzed.

"Through the experience, I found the hierarchy of the education/research system at Liebniz to be much different than what I have known, and with that the expectations were much different. But through making mistakes, I gradually began to understand and appreciate the diverse culture," he says.

Outside the lab each weekend Braykovich traveled solo to a new city or country. Berlin, a short 90-minute train ride from Hannover, was his favorite city. "There are people living in Berlin from almost every country you can possibly imagine, making the cultural dynamic something unlike I have ever experienced," he says.

"Ultimately, working in a foreign country has allowed me to see past my current horizon onto new ideas and experiences," adds Braykovich. "It taught me how to take a leap of faith into any unknown situation."

A change of plan

Volunteering in Cartago

Alexandra Tateosian, a mechanical engineering senior at Michigan Tech, left campus for Cartago, Costa Rica thinking she would be assisting with the construction planning of a center for disadvantaged youth as a volunteer for the non-profit organization UBELONG. Tateosian wanted to spend time abroad before beginning a full-time job at 3M. After tutoring many international friends in English while studying in Australia, she began considering living abroad to teach English or for other volunteering opportunities. Her experiences as an intern for two international companies, Bemis Company and 3M, also sparked her interest in working abroad at some point in her career.

The day she arrived in Cartago she learned that instead she would be working at a care center for the elderly. "The drastic change in projects was a good lesson in the nature of volunteerism as well as the importance of flexibility and adapting to local needs," says Tateosian. "I have been able to make the most out of this new experience and learned a lot by approaching it with an open mind."

While the center is very familiar with having volunteers come to assist staff, Tateosian is the first international volunteer to come with the objective of working on a specific project. "The first step was to identify areas of need," she says. "We decided to focus on the Taller de Carpintería (the woodshop)." One portion of her volunteer work now involves assisting in safety recommendations for the tools and equipment. Another involves designing specific woodworking projects to get more of the seniors involved. One such project involves building and painting puzzles that can be used in other areas of the center as mind exercises. "Our goal is to train some of the seniors to be leaders for future projects after I leave." Tateosian works closely with the staff to coordinate all the details. "It is certainly an amplified lesson in the importance of communication due to the language barriers," she says.

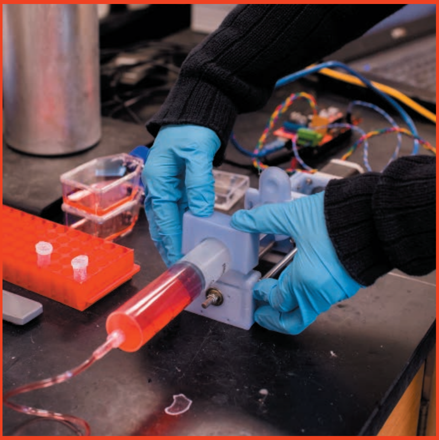
"Exposing myself to different places and cultures has become an important part of my life. I am learning about human nature and how people interact similarly and differently and reasons for these differences," adds Tateosian.

Cartago is about a one-hour bus ride from San José, the capital city of Costa Rica. There are many restaurants, museums, and other sites to see in the city. Tateosian has been to the top of Volcán Poás and plans to go to Volcán Irazú. She eats dinner each night with her host family and has also gone rock climbing and mountain biking nearby. On a trip to nearby Nicaragua to explore Ometepe Island she happened to meet a fellow Tech student who is currently in the Peace Corps Master's International Program.

But her most memorable experience while living, working and studying abroad? "At the elderly care center we ran an activity with the seniors where they reflected on what amor (love) meant to them. Afterwards, an elderly woman approached me and said 'este es amor' (this is love) and gave me a big hug."

Alexandra Tateosian

Basílica de Nuestra Señora de los Ángeles in Cartago, Costa Rica



DESIGN

Renew-U

Improving a high-intensity exercise device

Students in the Velovations Enterprise team at Michigan Tech usually work with companies in the forefront of the bicycle industry—Cane Creek Cycling Components, Specialized Bicycles, and Saris, to name a few. But this past spring the team took on a different kind of client: Steven Elmer, a researcher in Michigan Tech's Department of Kinesiology and Integrative Physiology.

Elmer developed an ergometer that provides high-muscle force, low-energy cost exercise for training muscles in the upper body. He sought out the Velovations team for help in redesigning the ergometer specifically for wheelchair users.

Elmer's ergometer, the RENEW-U (Resistance Exercise via Negative Eccentrically-induced Work for Upper extremities) exercises elbow, shoulder, and trunk muscles by resisting the reverse moving handles of a motor-driven arm cycle. It offers a high-intensity exercise for muscle, yet requires little whole-body effort. In particular, for paraplegics with spinal cord injury, the RENEW-U provides a way to exercise upper-extremity muscles to improve their strength and wheelchair mobility.

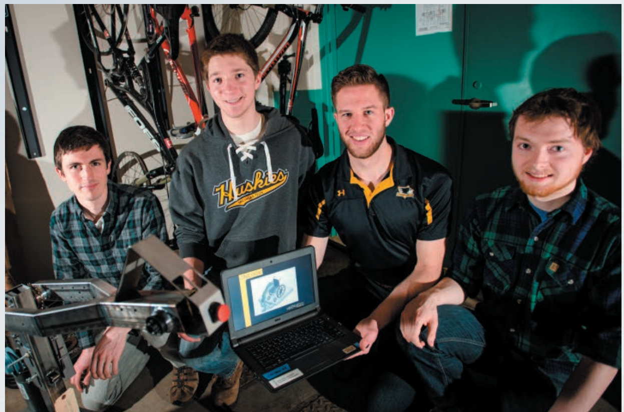
Six students in the Velovations Enterprise formed a team to develop a more adjustable and accommodating design for the ergometer. They started with Elmer's original prototype, which allowed them to use the device, find areas to improve on, and determine which aspects of the prototype they liked and wanted to keep. They were also able to meet and work with a person in a wheelchair who used the current prototype and to gain his feedback about design changes and improvements.

"The most challenging part of this project has been trying to develop a design that will safely incorporate the widest range of patients and their wheelchairs," explains Dan Krudy, who is majoring in mechanical engineering. "All wheelchairs are different, mostly to provide the specific requirements of the people who use them. Our goal is to develop a safe and secure design that will not limit the scope of Dr. Elmer's study."

The team also set out to improve safety features and create a lightweight, compact design. The RENEW-U 2, their novel prototype, gives wheelchair users greater adjustability and individual control. "We created a system that will allow wheelchairs to attach to the ergometer while it is being used," says Ian Connick, a mechanical engineering major who worked with Krudy on the project. "The ergometer can also be plugged into a standard household power outlet," he adds.

"The drive on this project is the ability to challenge all the concepts and fundamentals that we have learned over the last few years of school," adds Krudy. "When those concepts can be applied to assisting people, it is so engaging and rewarding. It gives one a sense of community."

In addition to Connick and Krudy, Eric Isaacs, Joe Billman, Ryan Walton, and Helen Karsten worked on the project with advisor Steve Lehmann. The Velovations Enterprise team took first place in the Rekhi Enterprise Funding Challenge on Superiorideas.org, Michigan Tech's crowdfunding site. In just thirteen days they raised $4,280 to develop the Renew-U Ergometer. By winning, the team doubled their money with a matching gift from Michigan Tech alumnus and longtime donor Kanwal Rekhi.



Ian Connick, Joe Billman, Dan Krudy, Eric Isaacs

The redesigned RENEW-U improves upper body strength for daily living and fitness.

Kealy Smith

One of the Upper Great Lakes Observing System (UGLOS) buoys

Buoy power

Managing power on the Great Lakes observation buoys

The Upper Great Lakes Observing System (UGLOS) provides coastal observations throughout the harsh and expansive Upper Great Lakes. The UGLOS network presently consists of twelve coastal monitoring buoys, the Tech waterfront meteorological station, and one underwater observatory distributed through Lakes Michigan, Superior, and Erie with an additional buoy being added later this year. The buoys report all meteorological and oceanographic parameters every ten minutes throughout the navigation season.

In the fall months the buoys sometimes fail due to the lower amounts of solar energy and end up being pulled early. The problem is with the power management system, or, actually, the lack of one, according to Kealy Smith, an electrical engineering major and member of the Robotic Systems Enterprise team. Smith should know. He spent the past year working on a new power management system for the buoys on behalf of the Great Lakes Research Center at Michigan Tech, which leads the UGLOS effort.

"Say your cell phone dies; you plug it in and it will recharge," notes Smith. "Remote systems like weather buoys do not have the luxury of being recharged by simply plugging in. For remote systems every watt is sacred. It is never certain that a buoy's solar panels will collect enough energy during the day to continue running the system throughout the night."

The power management system that Smith designed samples the batteries to determine available power. "If it finds that the power is too low, it will reduce the number of sensors running to ensure power is being conserved for the more critical components. Once all the sensors are off, the system enters a power saver mode and waits for the power to climb to an acceptable level. Then it will turn on all the desired sensors."

"Although the buoys have about ten sensors on them, I wanted to create a system that would make it trivial to add more. The power management system I developed can support up to 64 individual devices," he adds.

For Smith, working on the project was, for the most part, a solo endeavor. "In the beginning, I found myself spending a lot of time learning crucial electrical engineering skills that were beyond my class year just to be able to ask the questions I needed to answer." Finally after a month of intense research and development Smith was able to produce his first rough prototype. "I provided a proof of concept to the GLRC, and they were very excited with the progress," he says.

"Honestly I loved everything about this project. It was frustrating at times and seemed hopeless at others. I learned new ways of thinking and approaching problems, new ways to apply hardware and software to create a beautifully elegant solution to a real-world problem, and probably most importantly I learned what I was capable of as an engineer."

Smith has recently accepted a position as a controls engineer. "Someday in the future I hope to start a business based on seamlessly integrating hardware and software together to create new technologies to improve people's lives."

Geosteering

Guiding the drill in oil and gas exploration

Imagine trying to guide a drill bit in a 30-ft thick rock formation over a mile deep and over a mile away. In the world of oil and gas exploration, that's geosteering—steering the drill bit with reference to geological markers.

Stephanie Dow, a senior in geological engineering at Michigan Tech, spent an entire summer geosteering while working as an operations geology intern for Apache Corp in Midland, Texas. "Geosteering is essentially correlating live data with a previously-obtained set of offset data in order to create a best-guess model of the subsurface geology in an area," Dow explains. During her summer at Apache, Dow worked closely with the geologist on a given project, who would select a target zone with a good production potential. Dow would then calculate the depth from the surface to the zone, as well as determine the thickness of the target and how it was behaving structurally across the length the team planned on drilling.

Dow then used her prep work to create a model of where the drill bit was and provide guidance on whether drilling should continue horizontally or the bit should be angled up or down, in order to stay in the target zone. "All this involved communicating with geologists, drilling engineers, and other operations geologists," she says. "After each well is drilled a petroleum engineer creates a plan for the hydraulic fracturing. I created a model showing where different key pieces of the fracturing job would occur along the wellbore and in relation to the geology." She also analyzed cuttings—the ground up rock bits created while drilling—to check consistency with the subsurface model.

Dow worked in an office building but also traveled to drilling rigs, where she got to tour the rigs, see drilling crews at work, and go into portable field labs, called mud logging trailers used for analysis of cuttings in the field.

"For me the first month or so in my position was pretty overwhelming," she says. "My mentor described it as 'drinking out of a fire hose' because there are so many new acronyms and so much terminology to learn," she says. "The most difficult moment in my intern experience occurred when the senior drilling engineer called me for the first time to question my recommendations for drilling. I had to trust in the work I had done and explain to him why my suggestion was the proper course of action. It was intimidating to be speaking to a man who had been in the industry for longer than I have been alive and to tell him that he was making unlikely assumptions. I had to speak with confidence and authority because if I had wavered at all I would have been brushed aside," she recalls.

The highlight? "Gaining confidence in myself," says Dow. "The more I learned on the job, the more I realized how much I still have to learn. But working and being successful—and seeing how many people are there to help me succeed and teach me—made it a very rewarding experience."

Dow plans to work a few years after graduating, then pursue a Master's degree in geology in order to move into oil and gas exploration work.

Stephanie Dow

A horizontal well drilled into the Cline shale formation in Glassock County, Texas.

Emily Hunt

The open-source syringe pump system

Cheaper, faster, and smarter

Fine-tuning an open-source syringe pump system

Furnishing a research lab can be pretty expensive. Now a team of students led by Joshua Pearce at Michigan Tech has published an open-source library of designs that will let scientists slash the cost of one commonly used piece of equipment: the syringe pump.

Syringe pumps are used to dispatch precise amounts of liquid, as for drug delivery or mixing chemicals in a reaction. They can also cost hundreds or even thousands of dollars each.

"If you're on a limited budget, it would be extremely costly for something so simple but so important," explains Emily Hunt, a second-year materials science and engineering major and undergraduate researcher on the team. Hunt worked on the project with Pearce, a professor of materials science and engineering, graduate student Bas Wijnen and research scientist Gerald Anzalone. "What we did was design our own cheaper and customizable syringe pump system that can be 3D printed," she explains.

The team went one step further and also incorporated a low-cost controller. "The software that controls the pump was written in Python and loaded onto a Raspberry Pi, which is an open source, credit card-sized computer," she says.

The first syringe pumps had already been designed and built when Hunt began working on the project. She made sure the pump was relatively easy to build, tested the accuracy of the pump and the force of the motors and then created an instruction manual on how to build and use it.

"Everything that we did is online, the 3D models, the bill of materials, and the software to control the pump. Not only does our version cost less—$60 to $150 depending on the size needed—but it is openly available for everyone to have, to tailor to his or her own needs or to improve upon."

Megan Frost, a biomedical engineering professor at Michigan Tech, uses the team's open-source syringe pump to introduce agents into cell cultures. "It lets us run three or four experiments in parallel, because we can get the equipment for so much less," she said. "We'd always wanted to run experiments concurrently, but we couldn't because the syringe pumps cost so much. This has really opened doors for us."

Their work is described in the paper "Open-Source Syringe Pump Library," published in *PLoS One*. The hardware plans, designs, and source code for the pumps is available for free at http://www.appropedia.org/Open-source_syringe_pump. Emily's instructions have been accessed over 14,000 times and the pump design downloaded more than 1,000 times—saving researchers from all over the world more than a million dollars on equipment.

"I love fixing problems and in the lab that's basically my job," add Hunt. "It's also just fun—I love working with my hands, and using a 3D printer sometimes feels like playing with a high-tech toy. I think eventually I want to become a professor myself and conduct research at a university."

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