COULD DATA SAVE YOUR LIFE?

IT MIGHT JUST REVOLUTIONIZE HEALTH CARE –
IF WE LET IT.
VISUAL ADVENTURES

MODELING AN IMMENSELY COMPLICATED SYSTEM

Jennie Bukowski attempts to use her meteorology training to pinpoint the location of a low pressure system—without any model guidance. “We often laugh at the misconception that meteorologists cannot predict the weather and that models do all of our work for us,” Bukowski, a graduate student in the Climate and Space Sciences and Engineering Department, marked her prediction and then checked the model. “We were spot on!” Score one for meteorology training. 

You can hear more from Bukowski in a video by scanning this page with the Decoder in the One Cool Thing app.

PHOTO: Joseph Xu
MISSION STATEMENT
The Michigan Engineer is a magazine for the University of Michigan College of Engineering community, and especially alumni. Its main mission is to engage the College's alumni through content that is thought-provoking, by covering the intersection of engineering, the world and their alma mater.

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THE REGENTS OF THE UNIVERSITY OF MICHIGAN
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Everywhere you look today, engineering is on the rise. Demand for innovations has grown higher as the world faces larger challenges. Students are flocking to the field in droves, creating some of the largest and best classes ever. Partnerships with industry have grown, with more than half of research and development funding in the country happening in this collaborative space. And Michigan Engineering has kept right along with it. We have grown steadily and creatively over the past decade, keeping pace with other top-ranked institutions and producing the best and brightest researchers and alumni.

But we cannot rest. We must continue to push ourselves to be innovative and competitive. For as demand rises, obtaining the funding needed to fuel this innovation is more challenging to secure. And our peers are making advances not only across the country, but also the globe. There is much work yet to be done.

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Could a Solar Flare Bring Us to Our Knees?

Evergreen, Colo.

School, it would be a happy day for me!
If I could go to Michigan for engineering, that would otherwise be impassable.
Way they allow boats to pass through areas such as the Panama Canal. I think lock systems are amazing in the way they manage the global climate.

Coastal kids from far and wide to send in their ship models to the Michigan Engineer. I taught me through my 3x6 digital screen. 😊
Thank you, MI Engineering, for all you have done! – Mary Kathleen Juntunen

Skunk Works

Thanks for your great article on the accomplishments of Clarence “Kelly” Johnson – I thoroughly enjoyed it. It turns out that my father, Stan Kilpatrick, a mechanical engineering graduate in 1928, although not attaining the fame of Johnson, also made significant contributions in aeronautical engineering through the 1930s up to the end of WWII. My dad contributed to the structural designs of such aircraft as the Martin B-1, B-10, M-130 “China Clipper,” PB4Y-1 “Widow,” and PB2M-1 “Man,” the Republic P-47 and the General Motors P-75. It would be interesting to read a chronicle of the contributions of all the Michigan alumni of that era to aeronautical development.

The following were omitted or incorrect in the list of associate deans and department chairs during the tenure of David C. Munson, Jr.: Dean Doug Niell, Biomedical Engineering, 2006-12; Eljah Kamatey-Asuubo, Biomedical Systems + Design, 2007-10; Khalil Najafi, Electrical and Computer Engineering, 2008-10; Lonnia Shee, Biomedical Engineering, 2015-16; and Associate Dean George Carignan, Research, 2005-07, and Associate Dean Ewart Lockyer, BSME ‘51.

Spring 2016 corrections:

The U.S. Air Corp’s Egin Field was spelled incorrectly in “Skunk Works.”

Another note: I also had a hand in the design test of part of the engine fuel control installed on the engine in Gary Power’s U-2. We, of course, had no idea of what was going on. We just made the control Pratt & Whitney asked for.

I had been offered a position in the Skunk Works, which I rejected in loyalty to Hamilton Standard. I had accepted, I most certainly would have enjoyed work on the Stealth.

I worked with Kelly at the Skunk Works, on the Blackbird in late 1959 and 1960s as an engineer employee of Hamilton Standard, a division of United Technologies. We designed and manufactured the engine air inlet control system and I was responsible for the testing and operation at the secret desert test area at Groom Lake.

Kelly was indeed a remarkable, hands-on type of engineer. Strictly no nonsense. “Do it, damn it!” was my father’s motto. I was amazed since when Kelly showed up at the last site for a “what’s wrong with the inlet?” meeting in light green coveralls and white “jump” boots. He was another kind.

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This is a Lego tech system to allow ships to pass through areas such as the Panama Canal. I think lock systems are amazing in the way they allow boats to pass through areas that otherwise would be impassable.

If I could go to Michigan for engineering school, it would be a happy day for me! — Rylla Hanson, age 11 Evergreen, Colo.

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ENGI-NERD FOLD-IN
The pervasive condition of “Device Disturbance” is still being studied. The volume of online hooey has become harder to filter — burying useful or interesting information. Michigan Engineering has developed a tool to combat this epidemic. To see what it is, fold in the pages as shown.

UNLOCK DIGITAL DELIGHTS WITH YOUR DECODER
Throughout the magazine, related bonus content is waiting to be unlocked. When a story mentions the “Decoder,” that’s your cue. You can also look for this ∑ by the page number.

HERE’S HOW IT WORKS.

1. Open the One Cool Thing app on your mobile device.
2. Swipe right ——— to reveal the “More Cool Things” menu.
3. Click “Decoder” and point your camera at the page.

WHAT’S THE CURE FOR MINDLESS WEB SURFING?

DOWN THE ROAD, SCIENTISTS HOPE TO ADDRESS THE SOURCE OF WEB-JUNK OVERLOAD. BUT UNTIL THEN, CAT VIDEOS AND CELEBRITY SCANDALS REMAIN A THREAT. NOT THAT WE DON’T LIKE AN OCCASIONAL FUNNY CAT VIDEO, BUT COME NOW.

9. Click “Decoder” and point your camera at the page.

THERE ARE TEN DECODABLE EXTRAS IN THIS ISSUE - INCLUDING A TIMELAPSE OF THE GERSTACKER GROVE TRANSFORMATION; FOOTAGE FROM OF A ROCKET LAUNCH; AND VIDEO OF U-M’S BIPEDAL ROBOT, MARLO, TAKING ON THE WAVE FIELD.

Decoder delights can be found on these pages: Cover, 7, 11, 13, 16, 18, 19, 25, 27, 69, 71, 72, 75.

Just look for the ∑ by the page number.
AN INJECTABLE COMPUTER

This is a picture of a tiny computer in the needle of a syringe. Developed at Michigan Engineering, it measures 10 cubic millimeters. That’s 100 times smaller than typical implantable medical devices like pacemakers. Pacemakers require surgery to be put in place. This system might one day be deployable with a simple shot.

Its key innovation is an ultrasmall two-way radio that can broadcast through muscle tissue to a receiver up to a foot outside the body—for enough to send signals to a cell phone in your pocket or on a nightstand while you sleep.

The radio was specifically designed to talk through tissue, said David Wentzloff, associate professor of electrical engineering and computer science and one of the developers. It doesn’t rely on electromagnetic radiation, as typical radios do. It uses magnetic signals. “It’s similar to near-field communications, like what’s used in Apple Pay, except we have achieved much longer distances,” Wentzloff said.

The researchers envision a host of medical applications. Maybe it could provide a noninvasive way for early detection of irregular heartbeats, or monitor glucose for diabetics. One shot could take the place of several every day.

ICE-PROOFING WITH PHYSICS

Engineers made a spray-on coating that repels ice. Its secret is a rubbery texture that relies on a phenomenon called interfacial cavitation, explained Anish Tuteja, associate professor of materials science and engineering. Interfacial cavitation causes a solid material stuck to a rubbery surface to behave differently than if it were stuck to another rigid surface. Even a small amount of shear force can cause tiny waves in the rubbery side, stressing the interface of the materials. Rigid ice crystals slide off with only the force of gravity and a gentle breeze. (Watch it work by scanning this page with the Decoder. Details on p. 9.)
Matthew Nelson graduated from Detroit’s Cody High School in 2002 and began studying at U-M the same year. An illness forced him to drop out in 2004, and after recovering, he worked as a long-haul truck driver for several years. Nelson returned to U-M in 2012 and graduated in 2015. Today, he works as an innovation and new technology planner at the Hyundai Kia America Technical Center in Ypsilanti. He’s back at Michigan Engineering pursuing a master’s in design science.

Why is being involved in the National Society of Black Engineers important to you?

NSBE gave me a community when I came back to U-M in 2012. It also helped me understand the opportunities that are out there for engineers. NSBE has a goal of nearly tripling the number of black engineering graduates by 2025, to 10,000. How will you reach that?

I think the goal itself is an important rallying cry that helps us stay focused and opens some new doors on Capitol Hill, in new areas of academia, with corporations and with very big donors. We also need to look at how we support our chapters and make sure we’re providing each student with the resources they need to graduate.

Why do you think black students are underrepresented in engineering?

A lot of black students aren’t exposed to engineering in their early education, so they don’t see it as a potential career option. When they can see what an engineering career could do for them four or eight years down the road, it’s really powerful.

You’ve traveled a long road to get where you are now. What has it taught you?

Empathy—for other people and the situations they’ve gone through. Parents, grandparents, the people that cook in the cafeteria or plow the sidewalk. They’ve all made sacrifices and I think it’s important to recognize that.

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Random Access

Faculty Perspective

How to Ride a Bike

It’s more complicated than you might think

By Stephen Cain
Research Investigator in the U-M Department of Mechanical Engineering

Humans have been riding bicycle-like machines for close to 200 years. While riding a bicycle can seem simple, the actual control process used by a human rider is still somewhat of a mystery.

Using mathematical equations, researchers have explained how a bicycle without a rider can balance itself and have identified the bicycle design features critical for that to happen. However, the stability – that is, the ability to remain balanced – of a bicycle with a rider is more difficult to quantify and describe mathematically, especially since rider ability can vary widely. My colleagues and I brought expert and novice riders into the lab to investigate whether they use different balancing techniques.

A big part of balancing a bicycle has to do with controlling the center of mass of the rider-bicycle system. The center of mass is the point at which all the mass (person plus bicycle) can be considered to be concentrated. During straight riding, the rider must always keep that center of mass over the wheels, or what's called the base of support – an imaginary polygon that connects the two tire contacts with the ground.

Bicycle riders can use two main balancing strategies: steering and body movement relative to the bike. Steering is critical for maintaining balance and allows the bicycle to move to bring the base of support back under the center of mass. Steering input can be provided by the rider directly via handlebars (steering torque) or through the self-stability of the bicycle, which arises because the steer and roll of a bicycle are coupled; a bicycle leaned to its side (roll) will cause a change in its steer angle.

Body movements – like leaning left and right – have a smaller effect than steering, but allow a rider to make balance corrections by shifting the center of mass side to side relative to the bicycle and base of support. Steering is absolutely necessary to balance a bicycle, whereas body movements are not; there is no specific combination of the two to ensure balance. The basic strategy to balance a bicycle, as noted by Karl von Drais (inventor of the Draisine, the first bicycle-like machine), is to steer into the undesired fall.

The goal of my colleagues’ and my recent work was to explore the types of control used by both novice and expert riders. In our study, novice riders knew how to ride a bicycle but did so only occasionally and did not identify themselves as experts.

We mounted sensors and used a motion capture system to measure the motion of the bicycle (speed, steering angle and rate, roll angle and rate) and the rider's steering torque. A force platform underneath the rollers allowed us to calculate the lateral position of the center of mass relative to the base of support; that let us determine how a rider was leaning.

We found that both novice and expert riders exhibit similar balance performance at slow speeds. But at higher speeds, expert riders achieve superior balance performance by employing smaller but more effective body movements and less steering. Regardless of speed, expert riders use smaller and less varying steering inputs and less body movement variation.

We conclude that expert riders are able to use body movements more effectively than novice riders, which results in reducing the demand for both large corrective steering and body movements.

Our work reveals measurable differences between riders of different skill levels. But the meaning of those differences remains unclear. Ideally, we would like to identify the measurements that quantify the balance performance, control strategy and fall risk of a rider in the real world.

This is an excerpt of an article that originally appeared at The Conversation. Read the original at myumi.ch/a82qK.
A ‘DEMONICALLY CLEVER’ BACKDOOR

By Kaiyuan Yang
PhD student in the lab of Dennis Sylvester, a professor of electrical engineering and computer science

A minuscule backdoor hardened into a computer processor rocked the security research world after it was presented at the IEEE Symposium on Privacy and Security this spring and won a best paper award for its authors: Google engineer Yonatan Zunger called it “demonically clever.” The backdoor, which fits neatly into the tiniest of empty spaces in the processor, is impossible to detect with current standards. Yet it would give an attacker full access to a computer’s operating system.

Our dream is to do the most challenging terrain that the Wave Field can offer,” said Grizzle, the Elmer G. Gilbert Distinguished University Professor and the Jerry W. and Carol L. Levin Professor of Engineering.

MARLO’s feedback control algorithms could help other two-legged robots as well as powered prosthetic leg gain similar capabilities.

By the end of July, Da and his fellow students updated the gains and algorithms to help MARLO navigate the gentler waves between the carbon moguls by integrating the controller for forward-back motion with the one for side-to-side balance. With the team beginning to break up for vacation the following week, they took one last run at the Wave Field and were astonished at MARLO’s ability to walk down one of the gullies and back. Emboldened, they took MARLO up one of the big mounds, but it crashed down on the other side.

One dream is to do the most challenging terrain variation that the Wave Field can offer,” said Grizzle, the Elmer G. Gilbert Distinguished University Professor and the Jerry W. and Carol L. Levin Professor of Engineering. MARLO’s feedback control algorithms could help other two-legged robots as well as powered prosthetic leg gain similar capabilities.
The ambitious EDA U. Gerstacker Grove project has reshaped the heart of North Campus.

The rolling grassy area now includes nearly 180 trees, five rain gardens, sand volleyball and sculptural paths that converge at a central plaza and natural amphitheater. The project’s goal was to transform the area from a place people pass through into one where they linger and connect.

Coming soon: Finishing touches that include roughly 300 cylindrical lights (think mini light sabers), and a smart swing set. The lights will shine in six shades of pink, purple, and blue to illuminate the gardens according to data from a new weather station. The ambitious EDA U. Gerstacker Grove project has reshaped the heart of North Campus.

The lights will shine in six shades of pink, purple, and blue to illuminate the gardens according to data from a new weather station. Imagine twinkling lavender during a snow flurry.

The swings, too, have several high-tech features. Their seats will light up and the higher you swing, the brighter they’ll shine. In addition, when two people work together and swing in tandem, both will go faster and higher.

“The Gerstacker Grove is one of the most iconic and sacred open spaces on North Campus,” said Sue Gott, university planner. “A fundamental goal was to create a destination spot for all members of the University community.”

The Grove is an idea nearly six years in the making. (Check out a timelapse of its construction. Scan this page with the Decoder in the One Cool Thing app. Details on p. 9.)

It makes its debut on the 20th anniversary of the iconic Ann and Robert H. Lurie Tower. Both the anniversary and the official Grove unveiling will be celebrated this October during homecoming.

Three years and countless hours of modeling, testing and prototyping had led to this moment. Finally, it was time to launch The Great Emancipator. (The students traditionally name their rockets after U.S. presidents’ nicknames.)

More than 50 teams from around the country had made the same rocket-fueled pilgrimage. And when the dust settled, the Michigan Aeronautical Science Association earned second place in the advanced category at the 2016 Intercollegiate Rocket Engineering Competition. (Watch the launch. Scan this page with the Decoder. Details on p. 9.) Setting a team altitude record, the nitrous hybrid motor rocket was MASA’s tallest, heaviest and most powerful (in terms of its total motor impulse) to date.

“A fully student-built rocket engine is a rare thing, and the fact that we successfully launched it is incredible,” said team member and electrical engineering student Nicholas Streimberg. “I can’t explain how proud I am of the team, and all of us who accomplished. Our launch was great, but we already have plans for future endeavors.”
FOND (YET STINKY) MEMORIES

Some people will remember walking across the Diag for the first time, or have fond memories of pulling an all-nighter in the Duder or the Wilson Center. For some, spotting sneakers hanging overhead on Church Street or Catherine will ring a bell. This practice is apparently common on college campuses. But in Ann Arbor, it’s generally a sign that someone has been celebrating – maybe the start of the school year, or the end of the week.

PHOTO: Joseph Xu
At the top of the world, the climate is changing fast. A Michigan Engineer tracks the planet’s vital signs.

FROM THE EDGE OF THE ARCTIC

At the top of the world, the climate is changing fast. A Michigan Engineer tracks the planet’s vital signs.

Story by: Nicole Casal Moore
Photos by: Marcin Szczepanski
It’s a cloudy March afternoon with a wind chill of -20°F as scientist and Michigan Engineering alum Bri Van Dam treks up a mountain that overlooks the station. In some directions, it’s hard to tell where the ground ends and the sky begins. In others, hoofed ridgelines jut across the horizon. The only signs of civilization are the distant camp buildings and the single road that cuts a dirty path through the snow. The closest villages are miles to the base and back, but she prefers walking and snowshoeing, off-tangent cascades along the way: Permafrost is thawing and freezing more greenhouse gases. As the northern winter warms, climate-regulating currents in the ocean and air are slowing. While all the seas are rising. The consequence of Arctic warming is rippling across the globe, and they’re on track to keep escalating exponentially.

It’s easy sometimes as a scientist to look at change through the scientist lens of, “Oh, sure, what a cool time to be studying the Arctic because the Arctic is changing as fast right now,” says Van Dam, who manages the station’s Environmental Data Center. “But when you look at that through the lens of a human lens, it becomes honestly really terrifying.”

Van Dam faces these facts every day in her work documenting climate change from its epicenter, year-round. She’s a member of the skeleton crew that stays at the station through the coldest months. The winter yields pivotal insights, and the most recent was the warmest in recorded history.

In the snowpack samples she gathers, in the wing prints of the local birds and even in the patterns she wind makes on the powders, the snow, Van Dam says, tells stories. She’s paying close attention. Her monitoring work is, peer-by-peer, helping to paint a climate picture that you have to stand way back to see.

**SCIENTIST AND STEWARD**

Van Dam has been connected to the snow much of her life. As a child, she and her brother built igloos in Michigan winters. As a doctoral student at the University of Colorado at Boulder, she studied how sunlight warms with pollutants in the spaces between fallen snowflakes. She first set foot in the Arctic while she was an undergraduate at U-M. She spent a summer in Alaska’s wilderness through an outdoor education program. During that trip, she helped rescue a fellow student from a global crevasse—and she fell in love with the far north. She connected with its raw nature, its dangers accompanied by stark beauty and otherworldly light.

“I did really fall in love with the landscape,” she says. “Love is a verb, right? It’s something that we do, and we loving the landscape, for me, means really being a part of the environment on a personal level.”

In addition to her role as a scientist, Van Dam is a steward of the world around her.

“When she’s not at the station, she lives in a cabin in Fairbanks that has no running water. Such set-ups are relatively common in interior Alaska because the frozen ground is difficult to plumb through. She gets her water for drinking and washing dishes and clothes by refilling giant jugs in town once a week. The outhouse is out back and, in Van Dam’s case, the shower’s at work in her local office. While it’s not the most convenient approach, it’s easy to conserve when you don’t have a tap.

Van Dam’s freezer is stocked with the meat of a caribou she killed in the Brooks Range. “And a hoarding partner” skinning it, quartered it and hauled it home on a sled. “I showed up to my Fairbanks office still smelling of caribou blood,” she recalls.

That animal, and wild salmon caught by a friend, will be her protein for most of the next month. As a child, she and her brother would ride snowmobiles two miles to the base and back, but she prefers to cross-country ski or snowshoe, knowing that the only carbon dioxide she adds to the atmosphere comes from her own breath. It’s a long journey for a set of photographs. But it’s an important one.

Winter is the longest and most critical season in the Arctic. It’s when ice planters still the sea coalesce until stretches of ocean are frozen over. It’s when snowpack accumulates in some places, the new layers add girth to glaciers. In others, snow lowers the ground, preventing soil from refreezing and losing the heat it collected in summer.

Winter is also the station’s busiest. Though more than 100 projects are typically underway at any given time, almost none of the researchers involved are able to get there for regular observations. So Van Dam stands in, looking in the nosoks and cramains for small signs of the bigger changes afoot. She’s a crucial set of eyes. (Scan this page with the Decoder in the One Cool Thing app to see a video of Van Dam explaining the challenges of instrumenting the Arctic. Details on p. 9.)

**POLAR ICE AND THE GLOBAL THERMOSTAT**

The Arctic is a place of extremes and opposites—frozen but melting, vulnerable but hard. It’s the 7 million square miles north of the Earth’s 66th parallel where the sun doesn’t set on Midsummer Eve or rise on the winter solstice. It’s an ocean ringed by the coasts of eight countries. The top of the world is feeling the heat much more so than the Antarctic, where the ice is thicker and higher, and a frigid ocean current encircles the continent, keeping warmer waters at bay.

Comparatively, the sea ice and snowpack north are thin. And the records here are breaking as fast as that ice is.

Month by month, 2016 is on track to be the warmest year on record. Globally, temperature changes have increased the greatest departures from average since record-keeping began in 1880, according to NASA. January was nearly

**WORLD-RENOWED ARCTIC RESEARCH OUTPOST DEEP IN ALASKA’S INTERIOR.**
Van Dam is packing for a day of measuring the environmental Data Center – one of the high-tech It’s a frigid March morning outside the Environmental Data Center, she says. This is true in many ways, but in particular, the melting of ice and snow cover is destabilizing a vital mechanism in the global thermostat. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent. Snow bounces back 90 percent of the solar energy it’s exposed to. Sea ice reflects between half and 70 percent.
AN ICE-FREE NORTHERN HEMISPHERE, WITH NO SEA ICE COVERING THE ARCTIC OCEAN AND NO ICE SHEET ON GREENLAND, IS A POSSIBLE CONDITION OF THE MODERN CLIMATE SYSTEM.

-Henry Pollack, professor emeritus, U-M Department of Earth and Environmental Studies

The weather station does a lot more than tell the locals how cold it is. The ultraviolet sensors, for example, are helping U-M researchers study how sunlight affects permafrost—a thick layer of frozen soil and plant matter under the snow Van Dam is excavating. Permafrost comprises about a fifth of Earth’s land area. Though it sounds more enduring, it technically refers to soils that haven’t thawed for at least two years. Much of it, especially in the coldest parts of the world, is far more ancient. Alaska holds a Russian variety called yedoma. It formed during the most recent Ice Age more than 12,000 years ago when glaciers overtook green valleys and grasslands. Ice Age more than 12,000 years ago when glaciers overtook green valleys and grasslands. Ice Age more than 12,000 years ago when glaciers overtook green valleys and grasslands. Ice Age more than 12,000 years ago when glaciers overtook green valleys and grasslands. Ice Age more than 12,000 years ago when glaciers overtook green valleys and grasslands.

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INNOVATION IS FOR FINISHERS

How do researchers move an idea to the marketplace? More and more are hoping startups will help them go the distance—and universities are helping them get there.

Story by: Kate McAlpine
“I NEVER STARTED OUT TO BE A BUSINESSMAN. BUT IT’S SO FANTASTIC TO BE SOMEONE TO SOLVE THEIR PROBLEM.”

As the fall of 2011, he began a journey that more and more faculty around the U.S. are making—from inventor to innovator. These entrepreneurs are helping universities to deliver on the promise that taxpayer-funded research will drive economic growth, and lately, universities are doing much more to help them succeed.

ENTREPRENEURSHIP: A NEW HOPE

Universities weren’t always going on about innovation, and professors weren’t always ready to bring their own ideas to market. Until recently, academic typically took a dim view of business.

“ar the old days, faculty members didn’t want to do a startup because they would be looked upon as someone who had gone over to the dark side,” said Fred Reinhart, a senior advisor for technology transfer at the University of Massachusetts Amherst and a leading expert in the field.

But there was another factor as well—

PHOTO: Joseph Xu

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Pathfinding

While U-M has a long history of groundbreaking research, the University has always been focused on making sure that its discoveries reach the market. This has been a challenge, especially in the early years, when university technology transfer offices were not as well-developed.

The University’s first 20 years were mostly about research and development, with little focus on commercialization. But in the 1990s, the University began to see the value of converting research into products and services.

One of the first steps was the creation of the Michigan Venture Center, which provided funding and support for startup companies. This led to the formation of Arbor Networks, a company that developed technology to help protect against cyberattacks.

As the University’s technology transfer office grew, it became more effective at helping faculty members and students turn their research into successful businesses.

The University’s current focus is on creating a culture of entrepreneurship, where faculty and students are encouraged to take their ideas beyond the lab and into the marketplace.

“In the past, we’ve been focused on research and development,” said Malan. “But now we’re looking at the whole lifecycle of innovation, from research to commercialization.”

The University is also working to improve its relationships with other universities and companies, to ensure that intellectual property generated at U-M is used to its fullest potential.

“We want to be a partner in the innovation ecosystem,” said Malan. “We want to be a hub for new ideas and technologies.”

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The College of Engineering also kicked in close to $25,000 to get started. Malan, one of the founders of Arbor Networks, getting started in the early 2000s,” said Rob Kotov, Professor of Engineering in Electrical Engineering and Computer Science (see "Before their time"). He quoted Sherwin Seligsohn, mentor and Professor of Engineering and the Paul G. Goebel Defense (DoD) to build a smaller handheld $2.7 million contract with the Department of military-grade radiation cameras in 2012. These large cameras were roughly the size of one for every nuclear power plant in the world, maybe, but no more.

H3D was too niche. At the time, venture capitalists imagined a market for just 350 or so of these cameras—too for every nuclear power plant in the world, maybe, but no more.

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It’s full speed ahead,” said Kotov. "It’s a grueling process," said Kotov. "During the program, the coaches and instructors kick your soft spots very intensely.”

The technology was advanced enough that we could take it somewhere, and see a path to using the new dividers into their existing manufacturing process. Elegus also needed to develop the idea to the point that industrial partners could see a path to using the new dividers into their existing manufacturing process. The current structure of large-scale industry, especially in the battery field, does not allow integration of new materials,” said Kotov. "The current structure of large-scale industry, especially in the battery field, does not allow integration of new materials,” said Kotov.

They did that work with help from the Michigan Translational Research & Commercialization program, run through the CFE and the U-M tech transfer office. After rounds of vetting that Kotov compares to the heavy scrutiny from I-Corps, Elegus received $175,000, funded in part by the State of Michigan. commercialization program, run through the CFE and the U-M tech transfer office. After rounds of vetting that Kotov compares to the heavy scrutiny from I-Corps, Elegus received $175,000, funded in part by the State of Michigan. Investors back out, new competing tech. To survive, H3D needed a commercial to slay dragons.”

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2012, H3D had a beta version of the hand-held Polaris-H radiation camera, which displayed an augmented-reality image of the radiation in the room on a Nexus tablet.

Wenyi Wang (MSE NERS ’08, PhD ’11) referred to the early prototypes as “Widly Kaye hack boxes,” named for the company’s president at the time, Kaye (MSE NERS ’08, PhD ’12), who took over from He as CEO in 2014, housed the crystal and electronics in off-the-shelf Pelican cases, modified by hand-dizzling and mounting parts inside out and inside.

H3D received feedback from two early adopters through 2013. In December, they took a polished product in a sleek aluminum case on the road to nuclear power plants that had expressed interest. They had four orders by the end of the month. Then, they had to build the company. “We pretty much worked through the holidays,” said Wang, now an engineer and sales director at H3D.

Demanding hours are par for the course in the startup world, but He didn’t take his team’s dedication for granted. “It was amazing to me in the startup world, but He didn’t take his team’s dedication for granted,” according to an early investor, the startup’s sales director at H3D.

He’s current CEO, Jaesang Lee, a graduate student in electrical engineering and computer science, demonstrates a new innovation in OLEDs in the lab of Stephen Forrest.

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State plays role in smoothing the startup process considerably, but one weak spot for many universities is access to investors. Startups are generally risky investments, and investors were wrong about the potential market for a room-temperature radiation camera. Some nuclear power plants now have four of the new handheld cameras, which are significantly cheaper and easier to use than the old indus-

ty-standard 40-pound cryogenic radiation detectors. H3D is preparing to launch a new commercial camera based on the cancelled grant, detectors. H3D is preparing to launch a new commercial camera based on the cancelled grant, a backlight. The screen would have better contrast and require less power. It wouldn’t need a backlight. The screen would have better contrast and require less power. It wouldn’t need a backlight. The screen would have better contrast and require less power. It wouldn’t need a

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In the face of disaster, a city’s social media is saving lives and infrastructure. Is this just the beginning for crowd-sourced salvation?

STORY BY: Ben Logan
PHOTOS BY: Marcin Szczepanski
he narrow, cracked pavement that wears into the densely tangled neighborhood along Jakarta’s Ciliwung River is still slick from the overnight monsoon storms. This vibrant cluster of life is called a kampung in Indonesian; the literal translation is “community” or “village.” But in Jakarta, the word is used to describe a slum neighborhood. On Google Maps, this one appears as just a blank gray swath. After a twirling series of blind turns, the riverbank comes into view. The overnight deluge has raised the water enough to drown fifteen feet of shoreline. Flostilla of newly immersed trash churn in the intensifying current.

For 52-year-old Ibu Atun, the water is literally at her doorstep. She’s lived in this community her whole life. Twice a month the water enters her house. When it’s really bad, her family takes refuge in the nearby school. Atun describes how the frequency of bad floods has increased over the past five years. In 2014, her house was completely submerged. She relies on flood warnings from the neighborhood leader – who receives a notification reverberating from the mosque loudspeaker, a phone call, the head of the neighborhood, their eyes or with social media – people don’t rely on just one single piece of information about flooding.

Jakarta has one of the highest concentrations of mobile devices and social media activity in the world. By combining these two things with the GPS features inherent to both, the city is tapping into a crowdsourced way of tackling its flooding problem that was not previously possible. They are leveraging something known as geosocial intelligence to make real-time flood maps fed by the social media of residents on the ground – which provides lifesaving information to individuals and emergency responders alike. It doesn’t involve costly, heroic construction projects or installing a vast array of new and expensive sensors along the exhausted canals and floodgates. Instead, open-source software elegantly taps into the on-the-ground knowledge residents have about flooding and turns it into a simple, up-to-date flood report. The emerging resource that geosocial intelligence offers is being realized in one of the most complex urban environments on earth. And what started as one small project is now providing a broad term based on the data that GPS-enabled smartphones can provide. Like with most innovations, advancements have come in waves. Coincidentally, it was an earthquake that led to an important breakthrough. The 2010 Haitian earthquake death toll was estimated at around 200,000. “During an emergency situation the number one resource we didn’t know why they occurred and we didn’t have any sensitive machinery to tell us where they were occurring. The sensors for earthquakes were human beings’ bodies and their capacity to write down and share their experience of what happened.” Those reports were the beginnings of a system which led to a theory of an earthquake.

Fast forward to today and the emergence of geosocial intelligence, a broad term based on the data that GPS-enabled smartphones can now provide. Like with most innovations, advancements have come in waves. Coincidentally, it was an earthquake that led to an important breakthrough. The 2010 Haitian earthquake death toll was estimated around 200,000. “During an emergency situation the number one resource we didn’t know why they occurred and we didn’t have any sensitive machinery to tell us where they were occurring. The sensors for earthquakes were human beings’ bodies and their capacity to write down and share their experience of what happened.” Those reports were the beginnings of a system which led to a theory of an earthquake.

There is a long history of humans working together to make sense of their environments, especially when it does scary things, like storms and shake. The way people began to understand and study earthquakes was primitive at first. “We didn’t always know what those were,” explains Etienne Turpin, cofounder of PetaJakarta.org. “We didn’t know why they occurred and we didn’t have any sensitive machinery to tell us where they were occurring. The sensors for earthquakes were human beings’ bodies and their capacity to write down and share their experience of what happened.” Those reports were the beginnings of a system which led to a theory of an earthquake.

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The recent wave of innovation has just recently crested. With ubiquitous satellite connectivity, and the mass adoption of GPS-enabled smartphones and social media, user-generated info-maps have become quite common for identifying everything from sanitation issues to crime and disease outbreaks. One of the most popular examples is the Waze app. Its millions of users open the app while driving and contribute to traffic reports, mark speed traps, and offer shortcut suggestions. Another example came in the aftermath of the Fukushima nuclear disaster. The Japanese federal government was providing broad-stroke radiation averages that may have been of limited value—a single reading for an entire city, for example. A nonprofit called SAFECAST developed Geiger counters that could be attached to bicycles, cars or backpacks to measure localized radiation levels every five seconds. Users then uploaded that data to a free mobile app, which populated a public map.

What’s happening in Jakarta has an important distinction. The PetaJakarta.org system doesn’t require people to change their behavior or do anything special, like download a new app. There’s no new hardware or reporting portal. During floods, PetaJakarta.org simply tracks and visualizes flood levels across the city. It then confirms and broadcasts those conversations onto a simple online map that visualizes flood levels across the city.

**A SINKING CITY**

Traditionally, cities tackle flooding problems with civil engineering: building walls, flood gates and canals, or in some extreme cases, redirecting the flow of rivers. Jakarta is no different, but traditional approaches aren’t doing enough—and in some ways makes things worse.

Before the evening downpour, the mid-morning sun intensifies the tropical humidity. Frank Sedlar is perched on top of an all but abandoned 180-year-old floodgates. Over his shoulder is a lopping that overhangs the banks of the Ciliwung. “You build flood resiliency through community, not concrete,” says Sedlar, U-M Civil Engineering alumnus and PetaJakarta.org visiting researcher. “We need to engage with these communities because they are the real flooding experts on the river. They know more about water conditions than any engineer in the city.” However, in many cases, these communities are being evicted to make way for construction. The homes, family businesses and favorite swimming spots will be replaced with cement canal walls. These canals are part of an elaborate system that has massive energy requirements. Yet it’s incredibly fragile. If one floodgate or pump house fails, it’s a domino effect downstream. A single break in the chain can cause flooding to inundate major thoroughfares, causing city life to grind to a halt. Water levels can rise in a flash, threatening Riverside communities. These abrupt, compounds effects mean real-time information is invaluable to residents and emergency responders.

A 30-minute ride by a train through Jakarta’s never-ending traffic leads to a cornerstone of the city’s flood fighting system, the Waduk Pluit reservoir. It’s where the water from the city’s central canal system is pumped over a precarious seawall into the ocean. Sedlar walks along the wall, which is roughly a foot thick and peaks only a few inches above the waterline. Over the decades-long endeavor is the biggest civil engineering project on earth. The homes, family businesses and favorite swimming spots will be replaced with cement canal walls. These canals are part of an elaborate system that has massive energy requirements. Yet it’s incredibly fragile. If one floodgate or pump house fails, it’s a domino effect downstream. A single break in the chain can cause flooding to inundate major thoroughfares, causing city life to grind to a halt. Water levels can rise in a flash, threatening Riverside communities. These abrupt, compounds effects mean real-time information is invaluable to residents and emergency responders.

Simultaneously, inland mega-construction sends increased runoff into the city’s swollen waterways, while contributing to a startling rate of land subsidence—parts of the city are literally sinking between 5 to 20 cm each year. “These communities … know more about water conditions than any engineer in the city.”

**FRANK SEDLAR** (BSE CEE ’13, MSEE ’15)

Small leaks trickle out of cracks into the narrow road that lines the dubious barrier. “This is all that is protecting Jakarta from the sea,” says Sedlar. “If this were to break, about 40 percent of Jakarta would be flooded to a depth of one to two meters.” It’s a frightening scenario for the poor communities that literally live on and around the wall. In the distance, dark sludge is pumped from the reservoir into a large which will be dumped offshore at the site of the new seawall project. With a price tag of nearly $40 billion, the decades-long endeavor is the biggest civil engineering project on earth. In the end, the seawall will be 60 kilometers long, more than 24 meters tall and will have displaced thousands of people. If completed, it’s difficult to know how long the lifespan of the wall will be. With no official plans released, some estimates suggest it may last only 67 to 100 years. Scan this page with the Decoder in the One Cool Thing app to watch a video that follows Frank Sedlar as he explores the reality of flooding in Jakarta and how PetaJakarta.org impacts the lives of residents. PetaJakarta.org simply tracks and visualizes flood levels across the city. It then confirms and broadcasts those conversations onto a simple online map that visualizes flood levels across the city.

**BRIDGING THE GAP**

While PetaJakarta.org doesn’t solve the fact the city will flood during the monsoon, it does address the secondary fundamental problem of information. As the Haitian earthquake so gruesomely illustrated, information is critical in an emergency situation. Jakarta has roughly 680 miles of canals and 13 big rivers that drain to the ocean. According to Sedlar, there are only 26 sensors that measure the water levels. At any given time, about half of them are either broken, stolen, or offline. There’s very little real-time information on the water levels, which is critical for making decisions when operating floodgates and pumps—not to mention warning the public.

In the absence of traditional data, the team turned to crowdsourcing. “We told the city’s emergency response department that we just installed 28 million sensors in the metropolitan area,” says Turpin. “They asked, ‘Well how did you do that?’ ‘Well, we did,’ we said, ‘we just let people turn on their phones.’” Helderness and Turpin drafted one of its proposals that won a first-of-its-kind Twitter Data grant—more than 1,300 global applications competed for the opportunity. The grant gave the team special privileges and behind-the-scenes access to Twitter’s geolocated data. If someone tweets with the hashtag #banjir (#flood), the system sees that and sends an automated request for confirmation. During floods, the system has handled 3,000 user requests within an hour, and 240 incoming tweets per second. Other residents see those tweets in real time and like or share them, which engages helps PetaJakarta.org gain popularity, creating a snowball effect.
this dashboard is the PetaJakarta.org map. “Now we’ve got a map that’s a three-by-seven meter digital dashboard illuminates its mission control and air conditioning. BPBD DKI Jakarta is the governmental unit that operates the computerized control center at Jakarta’s Disaster Management Agency at city hall’s massive digital dashboard. His visit is part of a growing trend toward smarter cities. However, at this point, that future typically involves integrating costly, energy-dependent digital sensors into the fabric of our homes and communities, a concept often referred to as the Internet of Things.

“There is no such thing as a smart sensor – a sensor is dumb, it does one thing,” says Turpin. “It reads a temperature, water height or whatever. A human being can look around, smell, hear and use a whole variety of their sensory and mediated relationships to relay information in an emergency.”

Holderness agrees. “A sensor cannot convey the criticality of a flood wall collapsing. It can merely tell you that there has been a change in the electrical signal that it measures.”

Although the team sees potential in the Internet of Things for disaster management, they suggest a different trajectory. They believe that rather than teaching computers to learn what human beings are doing, perhaps we should put more effort into using computers to work with people – to learn how to help each other. Instead of addressing challenges with more digital sensors, algorithms and code – some problems require less code, less technical brilliance. Instead of building something completely new, why not use what already exists – in innovative ways. Instead of what Turpin describes as location-based irritation – like what happens when you get a duvet advertisement on your phone when you walk by a Krispy Kreme – he asks, ‘What about location based mutual aid? How can we build tools for communities that help them share and allocate resources in ways that we haven’t come close to in our several thousand years of experimenting with democracy?’

For the researchers, the real challenge is finding ways to take crowdsourced science from where it is now to a scale where it helps cities become better designers of their own future.

Smiling, Turpin imagines returning to Jakarta in 10 years and finding their map running autonomously by its users and the government. “That is also the fantasy that I won’t be living in Jakarta in 10 years,” he laughs jokingly about his adopted, flood-prone city. For the team, an even greater inspiration is modestly described by Holderness. “We’ve built on other people’s open-source software and we hope other people will build on ours and use it elsewhere.”

In the meantime, the success of PetaJakarta.org is gaining momentum and may expand to other cities in Indonesia. Alumni Chris Chiesa (BSE ME ’85, MS ’87), deputy executive director of the Pacific Disaster Center, recently visited with PetaJakarta.org personnel. “We have a proposal for a PetaSurabaya,” he said, illuminated by the glow of Jakarta city hall’s massive digital dashboard. His visit is part of a growing interest in developing PetaJakarta.org partnerships at the national level to leverage local knowledge, like what PetaJakarta.org provides, into their own systems.

Chiesa and Sedlar exchanged “Go Blizz” after a discussion about the benefits and challenges of using a local identity within tool like these. “People want to report information because they might need assistance, but also because they want to help their neighbors,” says Chiesa. “If you didn’t do what you do on a national level, you might lose some of the significance.”

The collaboration is now poised to spread “Peta” across the country. And as extreme weather and sea levels continue to increase, it might not be long before we see a PetaBangkok, or even a PetaNewYork.

As for Turpin and the millions of other families like hers, the next devastating flood is just a matter of time. But when it does come, there will be a faster, more intelligent response.

“People want to report information because they might need assistance, but also because they want to help their neighbors.”

Chris Chiesa (BSE ME ’85, MS ’87)

After a successful trial period, PetaJakarta.org began integrating other social platforms into its system. “It was relatively painless to add new data sources thanks to the modular architecture we used,” says Matthew Berryman, the team’s IT architect at the University of Michigan’s Energy Systems Division. “And because multiple platforms are feeding the map, if one goes down then another picks up the slack. In a disaster, it’s good not to have all your eggs in one basket.”

The sensory contrast between the flood prone streets and the compartmentalized control center at Jakarta’s Disaster Management Agency at city hall is impressive. Hooting motorcycles and vocal renditions are replaced with a quiet concert of ticking keypads and clicking computer mice. Aging infrastructure and oppressive humidity give way to modern offices and air conditioning. BPBD DKI Jakarta is the governmental unit that collects incoming flood data and coordinates prioritized disaster relief.

A three-by-seven meter digital dashboard illuminates its mission control room where flood data influences emergency response. Integrated into this dashboard is the PetaJakarta.org map. “Now we’ve got a map that’s connecting the government’s formal information system and the informal information from social media all into one space,” says Holderness. “It’s the connection of all those pieces in one pipe that gives the most valuable information about flooding at that current time. From what we’ve seen, I don’t think that’s ever really happened before.”

During a flood, Rambaug Surya Putra, informatics and controlling division head, runs the show. “We need more sensors throughout Jakar- ta,” says Rambaug. “PetaJakarta.org gives us millions of sensors that we don’t have to maintain. It’s a very useful tool for us.” It’s this tool that helps emergency responders spread information to floodgate operators, who then contact neighborhood leaders – like the one who tells 52-year-old Ibu Anu when to take refuge in the school. So although people who have mobile devices can access and contribute to the PetaJakarta.org map directly, it is helping others as well. Whether it reverberates over a mosque loudspeaker, from a phone call, a neighbor or social networks, information from PetaJakarta.org permeates public awareness.

### GeoSocial Future

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HACKING HEALTHCARE

How big data is driving big changes in medicine

STORY BY: Gabe Cherry
One major branch of precision medicine is the development of higher accuracy. Doctors may be able to tailor what could be the most massive data science puzzle the world has ever seen: a move to transform medicine by harnessing information about patients more effectively. The effort, known broadly as precision medicine, is expected to help doctors diagnose treatments so individual patients’ genetic makeup, lifestyle and risk factors, and predict outcomes with significantly higher accuracy.

One major branch of precision medicine is the development of big-data tools to customize treatments. Experts envision a future in which doctors and hospitals can draw on a web of constantly churning analytical tools that make up data streams from a huge variety of sources in real time—for instance, your electronic health record, genomic profile, vital signs and other up-to-the-moment information collected during a hospital stay or via a wearable monitor and hospital data that can make to meticulously informed decisions based on an analysis of your entire medical history, from birth to right now.

Researchers like Julia Adler-Milstein, an assistant professor at the U-M School of Information and School of Public Health, say that in some ways, today’s move to data-driven medicine is similar to the move to data-driven retailing that took hold over a decade ago. Online sellers like Amazon have compiled exhaustive data on products, analyzing years of browsing and purchase history for millions of customers, then using that past data to predict what you’ll buy next. It’s obviously detailed, computationally advanced, and sometimes a little creepy—and it has revolutionized how consumer goods are sold. If a computer can analyze your purchase data to predict what you’ll buy next, why can’t it analyze your medical data to predict when you’ll get sick? It’s an enticing question for doctors and data scientists alike. But, as with most things in healthcare, it’s complicated.

“Ammons’ decisions are tightly intertwined with data. But healthcare has only started to evolve the model of decisions based on physician expertise,” Adler-Milstein explains. “That has always been exciting to me, and learning how to integrate data and information technology pieces into the complexity of healthcare is especially fascinating.”

Perhaps it’s no surprise that bringing healthcare data into the 21st century is tougher—far tougher—than building an algorithm that suggests new necks to go with your new shoes. The stakes are higher. The regulations are tighter. The costs are greater. And there’s more data. So much more data.

Eric Michielssen, the Louise Ganiard Johnson Professor of Engineering at U-M, predicts that the amount of healthcare data will eventually push past traditional science hogs like astronomy and particle physics. Much of this is estimated 500,000 patients per year in the United States alone.

The actions that can slow the spread of C. diff can be surprisingly simple, like moving high-risk patients to private rooms or limiting their movement around the hospital. But it is doctors don’t have a good way of figuring out who’s at risk.

“Ammons’ team is solving the problem with machine learning, a technology that’s already widely used in online marketing and retailing and is gaining ground in precision medicine. It enables computers to ‘learn’ by combing through vast pools of data, using elaborate mathematical algorithms to compare pieces of information and look for obscure connections. They then use those connections from past data to make predictions about the future.”

Data is the raw material that makes tools like this possible. And the team gained access to a lot of it at the project’s outset: the entire electronic health record for nearly 50,000 hospital admissions at a large urban hospital. The data also included demographic information and detailed records of each hospital stay: vital signs, medications, lab test results, even their location in the hospital and how prevalent C. diff was in the hospital during their stay.

Armed with this cache of data, they set out to build a tool that could estimate a patient’s risk of developing C. diff by gazing far beyond known risk factors and analyzing thousands of variables in a way that humans can’t. It would look for relationships between variables, calculate how due to genomics data, which gobbles up so much space that there isn’t a cloud big enough to hold it—scientists are largely limited to on-site data storage. One researcher even joked that “genomics” might soon overtake “astronomical” as a term for incredibly large things. And much of this data is piling up across a fragmented hodgepodge of systems that were never meant to work together, at hospitals and other healthcare providers that are often reluctant to share it.

“Syncing up an ocean of fragmented, inconsistent data with the advanced analytics and databases that will drive precision medicine knowledge seems like an impossible problem. But maybe that’s what makes it so attractive to engineers. Today, more of them are working in healthcare than ever before, at U-M and elsewhere. Biomedical experts, data scientists, and electrical computer science engineers are dedicating their careers to it, and healthcare providers, tech companies and the government are investing massive amounts of resources. With the challenge ahead of them, they’ll need it.”

**FIGHTING INFECTION WITH DATA**

Wien, for her part, is working on front line tools—the system of analytics and other digital machinery that will turn raw data into knowledge that doctors can use to make better decisions. Among her projects is a tool that predicts which hospital patients are at risk of developing a life-threatening infection called *Clostridium difficile*, or *C. diff*. The disease has evolved into an antibiotic-resistant superbug at hospitals, where it affects an estimated 500,000 patients per year in the United States alone.

**HEALTH DATA IS GOING TO BE VALUABLE IN WAYS WE DON’T EVEN UNDERSTAND YET.”**

**JENNA WIENS**

ASSISTANT PROFESSOR OF COMPUTER SCIENCE AND ENGINEERING, U-M

The actions that can slow the spread of *C. diff* can be surprisingly simple, like moving high-risk patients to private rooms or limiting their movement around the hospital. The trouble is, doctors don’t have a good way of figuring out who’s at risk.

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**FIGHTING DISEASE WITH DATA**

More and more researchers are finding ways to use data to keep people healthy. Here are a few examples of the latest data-driven health projects at U-M.

**MANAGING BIPOLAR DISORDER**

A proposed smartphone app could listen to the voices of bipolar disorder patients, analyzing subtle changes in voice and speech to predict episodes before they happen. Emily Movar Provost, an assistant professor of electrical engineering and computer science, Satinder Singh Baveja, a professor of electrical engineering and computer science and Melanie Motroh, the Thomas B. and Nancy Uypphn Woodworth Professor of Bipolar Disorder and Depression at University of Michigan Medical School.

**OUTSMARTING THE FLU**

A DARPA-funded research project is using big data to determine why some people who are exposed to germs like the flu get sick while others stay healthy. It could help doctors better understand the immune system and protect patients from disease. Al Hero, the John H. Holland Distinguished University Professor of Electrical Engineering and Computer Science.

**PUTTING HEART PATIENTS IN THE RIGHT PLACE**

A big-data analytics tool can predict which patients are at high risk of complications from cardiac stent surgery, enabling doctors to route high-risk patients to hospitals with the facilities to handle an emergency. Zeeshan Syed, an assistant professor of electrical engineering and computer science.

**MAKING ABDOMINAL SURGERY SAFER**

A predictive model can analyze abdominal core muscle size to predict which patients are at high risk of complications from abdominal surgery. The tool could help physicians pinpoint risks and take preventative measures to keep patients safe. Stewart Wang, an assistant professor of surgery and a professor of surgery at University of Michigan Medical School.

**PREVENTING HOSPITAL INFECTIONS**

A predictive tool can spot patients that are at high risk for a potentially deadly intestinal infection called *Colistium difficile* (or *C. diff*), enabling doctors to take measures that can keep them safe. Jenna Wienes, an assistant professor of computer science and engineering.
but it all into a numerical score that estimates an individual patient's probability of becoming infected with C. difficile during their hospital stay. It was a tall order, particularly because of the complex way the risk factors change during the course of a hospital stay. So the team needed to figure out what are called multi-task learning techniques. Multi-task learning breaks a single task into several individual problems, looks for common threads and connections between each problem, then combines them into a single model. The research team comprises dozens of experts on infectious disease and machine learning, its founding members include John Guttag, a professor in the MIT Department of Electrical Engineering and Computer Science and Eric Horovitz, Technical Fellow and Director at Microsoft. They started by crunching the patient data into binary variables that a computer can understand, ending up with around 10,000 binary variables per patient, per day. They then broke the task into six individual machine-learning problems (see equation).

Finally, they set the computer to work trawling through the data to build (or “learn”) a model. When the dust cleared, their learning algorithm found connections between C. difficile and everything from patients’ specific medication histories to their locations in the hospital. It was a model that no human could have come up with, and a far cry from the quick bedside analysis that doctors rely on today.

Tuning showed that their model was more effective at predicting which patients would get C. difficile than current methods, correctly identifying patients’ specific medication histories to their locations in the hospital. It is a model that no human could have come up with, and a far cry from the quick bedside analysis that doctors rely on today.

“MY WORK IS ABOUT COLLECTING DATA AND TURNING IT INTO KNOWLEDGE, AND SHARING DATA PUBLICLY WOULD BE SUCH A GAME CHANGER FOR THE FIELD,” she said. “There’s so much data out there, but we don’t have access to the vast majority of it.”

Much of this awkwardness can be chalked up to differences in culture, says Hitinder Gurm, a U-M associate professor of internal medicine who has spent years toiling with medical data and medicine. “We collaborate with Michigan Engineering’s computer science professors on big-data tools for healthcare. “There’s a philosophical difference between what engineers consider research and what physicians consider research,” he said. “Physicians want to look at an individual application, determine to a great degree how effective it is, see if we can improve it. To us, that’s research. But computer scientists aren’t excited about this. To them, research is developing a completely new way to do something. We need to figure out a way to bridge that gap.”

BUILDING THE BRIDGE

The Precision Medicine Initiative (PMI), first announced by the White House in early 2015, aims to provide access to the public data from medical research and health-care providers. Spearheaded by the National Institutes of Health, PMI is envisioned as a collection of billions of millions of different individuals. But getting there isn’t just a matter of doing the math. It’ll take a new level of collaboration between data scientists, hospitals and others in the health-care delivery system, and in the world’s most fragmented healthcare system, that could be even tougher than it sounds.

GOOD DATA IS HARD TO FIND

To build the kind of health system Wiens and others envision, we’ll first need better health data systems. And that’s an area where the go-go world of computer science collides most with the cautious culture of medicine. Hospitals are collecting more data than ever, but most of it is sitting idle on proprietary record systems that weren’t designed to talk to each other. And for healthcare providers, sharing comes with risks: they worry about giving away secrets to competitors, angering patients, running afoul of vague privacy regulations and a variety of other pitfalls.

But that data is the lifeblood of the work that researchers like Wiens are doing. There are some large warehouses of data, and in fact U-M has one of the largest stores of genomic data in the world. But there’s no central source of broad, widely accessible data. And that limits what researchers can do.

Wiens believes that the pace of discovery could increase dramatically if more data were publicly available. It would enable multiple researchers to use the same set of data, leading to more consistent research results and making it easier for researchers to verify each other’s findings. It would also mean that research topics would less often be limited by the types of data available.

"SOMETIMES SCIENTISTS AND DOCTORS DON’T KNOW WHAT TO LOOK FOR, AND I THINK THAT’S THIS MILLENIUM’S CHALLENGE.”

BARZAN MOZAFARI

ASSISTANT PROFESSOR OF COMPUTER SCIENCE AND ENGINEERING AT U-M

DOING THE MATH

Wiens’ team used the optimization problem above to learn a predictive model that calculates a patient’s daily likelihood of contracting a C. difficile infection during a hospital stay. They used multi-task learning to calculate a set of risk parameters $\theta$ by analyzing the electronic health records from a large set of hospital stays. Patient data included a variety of clinical information – some of which may change over time, such as patient location, vital signs and procedures – and some of which remains the same, such as patient demographics and admission details. C. difficile infection was represented by y. The expression considers each day of the stay (t, taking into account that a person’s status at admission matters less as the patient spends more time in the hospital. To reflect this, the risk parameters vary over the course of a hospital stay.

Wiens’ group calculated the set of risk parameters for different time periods simultaneously, by finding the set of values (t) that minimize the objective function given above. Then, they used these parameters to build a model that produces a daily risk score, estimating a patient’s individual probability of acquiring a C. difficile infection.
also recruit new volunteers directly, who could take a medical exam and donate the captured information to the project.

If it works as planned, the PMI cohort could provide the sort of deep, detailed and consistent data that is needed to make progress in genetic research. For example, with an initial grant of $1.5 million for fiscal year 2016, the project is in its early stages – a group of health care providers, medical records software companies and other experts are working to find the best ways to move forward.

William Riley, the director of the Office of Behavioral and Social Science Research at the NIH and a clinical psychologist by training, says the project is already bringing together disciplines between doctors and data scientists, but there’s still a long road ahead.

“These aren’t technical issues, they’re logistical and policy issues – smoothing the way for hospitals, getting electronic health record vendors to make their new versions compatible. That takes time, but we’re headed in the right direction.”

U-M’s School of Public Health, Institute for Social Research and the University of Michigan Health System are playing a role in solving some of those issues, working with Google and other partners to design some of the digital tools available so researchers and patients can participate while keeping it safe. Gonzalo Abecasis, the Felix E. Moore Professor of Biostatistics and director of the Biostatistics Department in the U-M School of Public Health, says that determining precisely who should have access to which data, and presenting that data in a way that makes sense, will be key to U-M’s role.

“The goal is to make sure scientists can ask questions about the role of particular genes,” he said. “Google’s expertise lies in making the database scalable and managing access, while our expertise lies in presenting data in a way that makes it easy to use and intuitive to researchers.”

The project’s goals are lofty, and Riley doesn’t pretend it will be easy to get a massive and disparate group of doctors, hospitals, software providers and others to work together. But he thinks they recognize that the benefits are too big to ignore.

“All of a sudden, this healthcare data is in a form that engineers and computer scientists can use,” he said. “Clinical researchers are beginning to see the value in that, but there’s still a gap in the way different people think about answering these questions.”

MAKING BIG DATA EVEN BIGGER

What could researchers do with the kind of data that Riley and the NIH are working to collect? In fact, many researchers like U-M’s Barzān Mozafari believe that helping doctors find better answers is just the beginning. They say that data could also help researchers ask better questions. Mozafari, an assistant professor of computer science and engineering and a lead in building several database systems to churn through enormous stores of data and find unseen connections that could lead to new discoveries and whole new branches of medical research, in everything from cancer to pharmaceuticals.

“Sometimes scientists and doctors don’t know what to look for, and I think that’s this millennium’s challenge, the million-dollar question,” he said. “How do we build a new generation of intelligent systems that are proactive, that can feed you hypotheses and find correlations. You can’t replace scientists with machines, at least not soon, but the idea is that the machine should be able to suggest things to the scientist.”

The problem with mining healthcare data, says Mozafari, is that today’s databases aren’t designed to do a very good job of it. They’re made for the business world, where data tends to be cleaner and researchers often know precisely what they’re looking for.

Healthcare researchers often can’t use existing data science approaches, largely because there’s just so much healthcare data. It takes conventional systems too long to chew through it, and research has found that even the most efficient systems can damage the research process, causing a noticeable lag in creativity and idea generation. And the amount of data is growing faster than Moore’s Law, so better processors aren’t likely to provide a solution.

Also, healthcare data is messy. It contains thousands of variables, and many of them are often missing, incomplete, unreadable or recorded incorrectly.

“Sometimes researchers ask better questions. Mozafari, an assistant professor of computer science and engineering at U-M, said. “Clinical researchers are beginning to see the value in that, but there’s still a gap in the way different people think about answering these questions.”

To get past these problems, Mozafari is designing a new kind of database system called “Verdict.” It uses what’s called “approximate queries.” Instead of plowing through a massive dataset with a single query to find the most accurate answer, it conducts several, slightly less precise searches simultaneously. It then compares and carefully combines these queries into a single answer. The resulting answer is 99 percent as accurate as a traditional approach, but can be done up to 200 times faster.

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BARZAN MOZAFARI
ASSISTANT PROFESSOR OF COMPUTER SCIENCE AND ENGINEERING AT U-M

Genetic data is a key piece of the precision medicine puzzle. It can help researchers understand how diseases work and lead to more targeted medications. And researchers are getting better and better at using it.

“The amount of data we can collect and process is growing fourfold every year,” said Gonzalo Abecasis, the Felix E. Moore Professor of Biostatistics. “We’re trying to build a new generation of intelligent systems that are proactive, that can feed you hypotheses and find correlations. You can’t replace scientists with machines, at least not soon, but the idea is that the machine should be able to suggest things to the scientist.”

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Healthcare researchers often can’t use existing data science approaches, largely because there’s just so much healthcare data. It takes conventional systems too long to chew through it, and research has found that even the most efficient systems can damage the research process, causing a noticeable lag in creativity and idea generation. And the amount of data is growing faster than Moore’s Law, so better processors aren’t likely to provide a solution.

Also, healthcare data is messy. It contains thousands of variables, and many of them are often missing, incomplete, unreadable or recorded incorrectly.

“Sometimes researchers ask better questions. Mozafari, an assistant professor of computer science and engineering at U-M, said. “Clinical researchers are beginning to see the value in that, but there’s still a gap in the way different people think about answering these questions.”

To get past these problems, Mozafari is designing a new kind of database system called “Verdict.” It uses what’s called “approximate queries.” Instead of plowing through a massive dataset with a single query to find the most accurate answer, it conducts several, slightly less precise searches simultaneously. It then compares and carefully combines these queries into a single answer. The resulting answer is 99 percent as accurate as a traditional approach, but can be done up to 200 times faster.

“There are more well-managed, more efficient and more successful centralized healthcare systems have a head start in building a cohesive health data infrastructure. And they’re more proactive, that can feed you hypotheses and find correlations. You can’t replace scientists with machines, at least not soon, but the idea is that the machine should be able to suggest things to the scientist.”

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Genes for Good uses social media to collect health, lifestyle and genomic data from online volunteers. It also enables participants to compare their health information to other participants and provide insight into how a disease works and lead to more targeted medications. And researchers are getting better and better at using it.

“The amount of data we can collect and process is growing fourfold every year,” said Gonzalo Abecasis, the Felix E. Moore Professor of Biostatistics. “And unlike in the past, we can now look at entire genome as opposed to just a few segments. That’s exciting. It allows us to look at a few genes, so we had to ask very narrow questions, and there was a lot of guesswork. Today we can see the entire genome and its role in disease. It’s a fantastic opportunity.”

But genomic data is ginormous – a single human genome takes up about 100 gigabytes of memory. That adds up fast when researchers are dealing with the numbers of patients, creating a vexing challenge for data scientists.

“Most campuses don’t know what to do with this data,” said Eric Michaelisken, the Louise Ganiard Johnson Professor of Engineering at U-M. “If you have 10,000 patients, the volume data associated with their data is petabytes. That’s millions of gigabytes. The storage and transport costs are incredible.”

The costs are so great, in fact, that making copies of genomic data available to researchers often isn’t practical – storing new copies would add the cost of thousands of dollars.

The Michigan Institute for Data Science (MIDAS) is working to find a better way, enabling researchers to use and share data without using multiple copies. The project’s dual focuses are on finding less expensive ways to collaborate and on building new databases that can keep patient information safe even as it’s made available to more and more researchers. You can learn more about their efforts at midas.umich.edu.

On the clinical side, Abecasis is working to gather secure, sharable genomic data for large numbers of patients. He’s heading up two initiatives that are making more genomic data available to the researchers who need it.

The Michigan Genomics Initiative aims to enable researchers at the University of Michigan Health System to volunteer their genomic and electronic health record data, making it part of a data repository. The initiative has captured data from over 32,000 patients since it began. Abecasis says that 80% of eligible hospital patients choose to participate.

Genes for Good uses social media to collect health, lifestyle and genomic data from online volunteers. It also enables participants to compare their health information to other participants and use it to make more informed health decisions. Abecasis says the program has over 10,000 participants thus far. The program is free, and any United States resident who is 18 or older and has a Facebook account can participate. To sign up, visit genesforgood.com.
The lights never turn off. Everywhere you turn, eyes are heavy as a tense silence pervades, punctuated by the sound of the frenetic race of fingers across keyboards and through notebooks filled with a semester’s worth of notes. The air wafts through the stacks of books, thick with the smell of greasy and increasingly stale food, clothes that have been slept in for days on end, and the bodies that begrudgingly live through this existence. This is a rite of passage that all Michigan Engineering students face at the end of the semester as they prepare for their final examinations, living the extremes of vigor and fatigue, hubris and self-doubt, community and isolation, and frustration and elation – all within the period of just one week.
Students congregate in whatever available study spaces they can find, spanning across campus from the “UGLi” to the “Dude.” There they spend multiple nights with each other, sharing stress-filled moments, meals and various means of procrastination that provide the needed balance.

“I COULDN’T DO THIS WITHOUT THEM. YOUR FRIENDS ARE WHAT MAKE FINALS BEARABLE AND HELP YOU GET THROUGH IT WHEN YOU DON’T WANT TO.”

- JULIA MCMURTREY, ME BSE STUDENT
Julia McMurtrey, the mechanical engineering undergrad, yawns while studying. Even though she has a week to prepare herself emotionally and physically, there’s still much stress and trepidation since she has to take all four of her exams during the last two days of finals. Bodies of students in various states of torpor can be found strewn across campus, making it difficult to distinguish between night and day. The only reliable clocks that students have are the pressing deadlines for their exams and final projects.

“IT’S A LOT TO DEAL WITH ALL AT ONCE. YOU HAVE TO BE PREPARED AND MAP OUT HOW YOU’RE GOING TO GET IT ALL DONE OR YOU’RE GOING TO FAIL.” - JULIA MCMURTREY
A group of first-year students walk back to Bursley Hall after a night of studying, talking about what the future has in store for them—what they will major in, whether or not they will live together the following year, and how they’ll be friends for the rest of college.

Pame Martinez and Donald Richardson, Industrial Operations Engineering graduate students, finished their last project of the semester just minutes before the deadlines. They celebrate with a “fishbowl” at Good Time Charley’s on South University Avenue. Others in the group include Abhilash Rao, Christian Abney, and Gary Piong.

“When I submitted my last project, I knew a journey was coming to an end. I felt proud and a little melancholic, but super excited to celebrate our big accomplishment and finally catch up on some sleep.”

-Pame Martinez, IOE MSE Student
INVESTING IN MICHIGAN

Connecting with students — and finding ways to support them — has always been a hallmark of David C. Munnun Jr., the former Robert J. Vlasic Dean of Engineering, and his wife, Nancy. It’s an inspiration that lives on at the College in a variety of ways.

Two prime examples are a new fund named in Professor Munson’s honor that supports the Center for Entrepreneurship and its worldly entrepreneurship speaker series, and an endowed scholarship fund that will be used to support undergraduate scholarships named in honor of both Dave and Nancy. “These funds were established by a set of donors we have come to know well, and who we admire and deeply respect, which makes this all the more special for us,” Munson said. A fund dedicated to enhancing student support, he said, aligns well with both the College’s needs and his own priorities.

“When I was an undergraduate, it was possible to earn enough over the summer to pay for tuition, and maybe even room and board. It was a time when state support for higher education was much higher. Well, that’s no longer possible,” Munson said. “These funds to facilitate the success of students who share my interests and those of my late husband Karl Hoenecke. ‘The same good fortune that I had.”

With a $3 million gift from the Monroe-Brown Foundation, the Monroe-Brown Seed Fund will award money to biomedical startup companies that are making the world a better place. But it’s not at all easy to get money to start up a business. The fund will invest in startups companies such as those developing medical devices, diagnostics, therapeutic delivery systems, health IT and digital health products. The money is expected to help attract and retain biomedical entrepreneurs and top-level researchers.

IN PERU, OR TEACHING COMPUTER SCIENCE IN SOUTH AFRICA.”

CIVIL, DESIGN & ANTHROPOLOGY

Three new funds will help students in need as they pursue degrees in civil engineering, design and anthropology. They are established with a $3 million bequest to the University of Michigan from the estate of Stannton R. Cook, former CEO of the media giant Tribune Company. As a tribute to his longtime friend Grenchen Hoenecke (B.S. ’50, TeacheCert ’52) to choose how the bequest should be used. She created funds to facilitate the success of students who share her interests.

A BOOST FOR BIOMED

Engineering and medicine are coming up with some of today’s most promising health innovations. Now some of this partnership’s most commercially viable ideas have a new resource to help get to market.

With a $3 million gift from the Monroe-Brown Foundation, the Monroe-Brown Seed Fund will support graduate students in civil engineering and medical schools. It will award money to biomedical startup companies that are making the world a better place.

LEADERSHIP

MICHIGAN ENGINEERS ARE STEPPING FORWARD TO TRANSFORM THE COLLEGE — AND THE WORLD — IN OUR $1 BILLION RESOURCE-GENERATION EFFORT

INVESTING IN MICHIGAN ENTERPRISE

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Students helping students

Julia McMurtrey remembers the moment in high school when her dream of attending Michigan came into reach in an instant. She was at a national competition for student leaders when she read the email on her phone: It announced a scholarship that meant her family could afford the tuition.

“I just remember crying. And at the same time I was crying, I was thinking, ‘I can’t look like a mess at the competition!’” McMurtrey said.

Her parents were going through a divorce that made their financial situation uncertain, and her family also needed to support her brother in college. Michigan did not seem like an option to her until that email came through.

“When I got my scholarship, it was a very overwhelming feeling, because it meant that someone believed in me enough to support me,” McMurtrey said. “It’s completely outside of their control. And that’s not fair.”

CARE is still building. When it is big enough, the plan is to provide one-semester scholarships of $5,000 to $10,000. The first scholarship it awards may be $25,000 to $50,000, McMurtrey estimates.

The growth of the fund has been remarkable. A little more than a year ago, the students worked hard to attract donors. “We were overwhelmed by the generosity and support we received,” McMurtrey said. “That’s the moment when we kind of made it.”

“Those who stay will be champions’ resonates a lot with us. “Those who stay will be champions.’ And that resonates a lot with us because everyone deserves the chance to stay and have that opportunity to pursue those career goals they had when they came into school.”

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Momentum has continued to build since then. Their success on Giving Blueday qualified them for a visit by U-M football coach Jim Harbaugh in the spring. Julia obatated a Michigan football helmet for Harbaugh to sign that they are planning to auction. And the group is gearing up for another Giving Blueday on Nov. 29.

The goal in the long run is to raise $1.5 million for the endowment, which would generate $67,500 in scholarships per year. That would meet the estimated need of five or six students each year.

To McMurtrey, anyone who chooses a course of study as difficult and with as much potential as a U-M College of Engineering degree deserves a chance.

“People who choose a challenging and rewarding career path deserve the opportunity to pursue those goals they had when they came into school.”

“Those who stay will be champions’ resonates a lot with us.”

A GIVING DAY FOR GIVING BLUE

Last year, Wolverines from around the world pulled together on a single day to support something they love. Giving Blueday – the University’s annual day of giving on the Tuesday after Thanksgiving – was a great day to be a Victor for Engineering.

$4 million+

Amount raised university-wide to support engaged learning, faculty and research

352

Number of donors from the College of Engineering alone who contributed gifts of all sizes

$93,000

The total for one day by those 352 people. In addition, other gifts inspired by Giving Blueday topped $320,000 for a total of more than $415,000 and 371 gifts.

The impact of those gifts rippled out into the Michigan Engineering community. They helped students overcome financial crises and stay in school, supported student teams that develop sustainable solutions with communities around the globe, funded scholarships and much more.

Michigan Engineering students push themselves every day to build a brighter future for all of us. You know. You’ve been there. Nov. 29 is Giving Blueday – your chance to support the kind of experiences that make a Michigan Engineering education unique.
FIRST THERE WAS THE U-M TEACH-IN... THEN THERE WAS EARTH DAY...

This photo was taken at a student rally held at the Diag during a four-day student-organized Teach-In on the Environment on March 11-14, 1970. The Teach-In featured at least 125 separate events – including a discussion about the future of the Great Lakes among an ecologist, a lakes scientist and an engineer. The great success of this marathon teach-in – attended by an estimated 50,000 people – fortified those who were organizing the first nationwide Earth Day, which would be held just five weeks later, on April 20. Earth Day has since played a major role in heightening public awareness and shaping environmental policy – but the U-M Teach-In that preceded it offered the first proof that a mass educational effort on this issue, if executed properly, could attract the public’s interest.
During the war, students and alumni stationed all over the world used a U.S. military system called V-Mail to stay in touch. Every letter to and from the front was censored, then photographed and recorded on microfilm. The film was shipped by plane to a post office or military post near its destination, blown up to 60 percent its original size, then printed and delivered. The system reduced 37 bags of letters to a single bag of microfilm, saving valuable space for the transport of military supplies.

U-M-affiliated men and women sent hundreds of V-Mail letters to Michigan Alumnus magazine, which published them in a special section. Here are just two of these many letters:

Dear [Engineering] Professor Townsend:

I was very glad to get your letter a few days ago, and find out that you and “the gang” at Michigan are getting on about as usual, in spite of restrictions that war necessitates.

…This lack of mail caused much weeping and gnashing of teeth…. [T]wo of the fellows found out they were the proud fathers of baby boys! …Lack of mail is especially hard on the married men, some of whom write their wives more than once a day…

Best regards,

George Bachman, ’43e

Dear Editor:

We are finally ready to believe the official confirmation that hostilities have ceased… yesterday came the pay-off. An order was issued that helmet liners could be worn in lieu of steel helmets. When that happens – it’s over.

Wars seem to end in a queer way. … The men at the front who did the fighting should be the ones to celebrate the war’s end. … At first glance, there didn’t seem to be a bit of difference in them. …

Once convinced, however, there was a subtle change noticeable in men. To one who knew them, they were more relaxed, ready to laugh, and the strain in their eye was replaced by a dreamier “thinking-of-home” look.

Sincerely yours,

Pfc. Lawrence E. Girton, ’43-'44

After the war, thousands of returning veterans enrolled at Michigan under the GI Bill – which caused an immediate housing crisis. Single dorms were turned into doubles, doubles were turned into triples and a hastily constructed village of trailers sprang up near Hill and Packard. But it wasn’t enough.

University planners found a solution in Willow Run Village – a wartime housing project 12 miles east of campus. Originally built to house workers at the massive Willow Run bomber plant, the complex found itself with extra space after bomber production ended. U-M leased the empty apartments, a bus service was set up to shuttle students to and from campus and 1,200 veterans moved in.

The simple wooden row houses were anything but fancy – streets were dirt, walls were thin and heat came from a coal stove in the living room. But at $14.50 per month for a two-bedroom apartment, the price was right and veterans formed a close-knit community.

To see more Willow Run Village and wartime campus photos on the Michigan Engineering Bicentennial Project website, scan this page with the decoder in the One Cool Thing app.
1950s

By the time Sputnik circled and beeped its way around the globe in 1957, Michigan Engineering was an established leader in the Space Race. Five U-M students would orbit the earth and three would go to the moon. Two separate Michigan Engineering crews would launch NASA’s first all-U-M crew: Edward White and James McDivitt, both of whom earned Michigan Engineering degrees in 1959.

But Apollo 15 – which blasted off on July 26, 1971 – would top that feat, with an all-U-M crew consisting of James Irwin, Al Worden and David Scott (pictured above). The fourth mission to land men on the Moon, Apollo 15 was the first to use NASA’s new Lunar Roving Vehicle. The vehicle gave astronauts the ability to explore the surface of the Moon while in orbit.

In earlier times, new Velcro (a trade name for "velcro") underwent an elaborate initiation that began with being rounded up outside of town, then marched back to the steam tunnels beneath central campus. There, they might have been chained together and doused with grease and motor oil in a nod to engineering’s mechanical origins. The Vulcans’ activities were well-known and often photographed until the 1970s, when social pressures caused the Vulcans to change some of their ways.

Membership in the Vulcans is largely kept secret, and is exclusive to those who possess the group’s hallowed “Four Qualities,” leadership, responsibility, integrity and humility. Perhaps that’s why the Vulcans’ ranks have included some of the most prominent students and faculty leaders in Michigan Engineering history.

1960s

Michigan Engineering students founded the Vulcan Society in 1904, seeking what they described as “a good hearty relationship” with faculty and fellow students. In 1915, the Vulcans helped to develop the honor code that Michigan Engineering still uses. Today, they carry on other traditions as well, such as helping those in need with scholarships and other assistance.

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VOLCANOS IN SPACE

The first match was played on the outside of the Michigan Union in 1922. The Horseshoe’s design that graces The Horseshoe’s upper rotunda to this day.

OSU GOES MAIZE AND BLUE

Maize and blue are not popular colors at Ohio State. So why, if you look closely, will you find that the upper rotunda at Ohio Stadium (also called The Horseshoe) features maize flowers against a blue background? Legend has it that a wager was placed on the outcome of the October 21, 1922, “Dedication Game” – the first matchup between the U-M and Ohio State football teams at the then-new stadium.

The Wolverines routed the Buckeyes, thanks largely to the play of right end, defensive end, kicker – and engineering student – Paul Goebel. Though he’d thrown out his knee the year before and was playing with a brace made from a crude steel hinge, Goebel kicked a long field goal, helped to develop the honor code that Michigan Engineering still uses today, they carry on other traditions as well, such as helping those in need with scholarships and other assistance.

What’s a hologram?

A hologram is a three-dimensional image that is “indistinguishable from the original object itself,” as Leith once said. Achieving this effect would take creativity, intuition, experimentation – and a bit of luck.

Dennis Gabor of the Imperial College London had first introduced the concept in 1947, but for various reasons, his work had gone dormant. Leith had been intrigued by the challenge and novelty of holography, but his other work kept him too busy to experiment with it until 1960, when Willow Run hired Juris Upatnieks as a new research assistant.

THE FIRST WORKING HOLOGRAM

At that time, the pair began their work using Loth’s radar-based signal modulation theory.

Juris Upatnieks eventually talked their way into the team at Willow Run. But Apollo 15 – which blasted off on July 26, 1971 – would top that feat, with an all-U-M crew consisting of James Irwin, Al Worden and David Scott (pictured above). The fourth mission to land men on the Moon, Apollo 15 was the first to use NASA’s new Lunar Roving Vehicle. The vehicle gave astronauts the ability to explore the surface of the Moon while in orbit.

THE SOLUTION

Leith and Upatnieks (pictured above) tried to improve the fuzzy resolution of Gabor’s holograms, and to solve the mysterious “twin image” problem that had dogged earlier attempts. The twin image solution came when the team added a second beam to the recording process, combining two light signals into one holographic image and eliminating the second, unwanted image that had baffled other scientists.

The solution to sharpening the hologram’s resolution came in the form of a laser. Another team at Willow Run was experimenting with one of the new machines, and Leith and Upatnieks eventually talked their way into borrowing it.

The new, more precise light source was a dramatic improvement over the mercury lamps that were used for earlier holograms. It enabled the team to optimize the system to produce crisp, three-dimensional reconstructions of the original objects.

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THE RACE AGAINST ZIKA

Responding quickly to the Zika outbreak has been a top priority for the National Institutes of Health's Vaccine Research Center (VRC) — especially after the Ebola vaccine's clinical trials in Africa began just as the outbreak was drawing to a close. They began clinical trials of a Zika vaccine in August, just a year and a half after the outbreak was identified in Brazil. And U-M alumn Richard Schwartz (BSE ChE '81, MSE '89, PhD '94) led the effort to mass-produce enough of the vaccine to start clinical trials — and do it quickly.

"This is a problem that could impact almost every one of us in our lives and in our families at some point, if not immediately then in the future. We need to solve it, and the vaccine is the only way that’s going to happen," said Schwartz. The VRC brought Schwartz on in 2008, after nearly two decades of process leadership in pharmaceutical companies. As the head of the Vaccine Production Laboratory, his projects have included Ebola, Marburg, laboratory, his projects have included Ebola, Marburg, influenza and HIV.

Schwartz’s team — and the VRC in general — made faster progress on Zika than it did with Ebola, in large part because Zika is so similar to West Nile. The VRC’s prior clinical trial for West Nile suggested that a relatively easy-to-make vaccine, composed of DNA rings called plasmids, could be effective against West Nile, and the team believed that a similar vaccine could work against Zika. Unlike a virus-based vaccine, plasmids are non-infectious and have a good safety record in clinical trials. That can shorten the safety testing — and it gave Schwartz’s team a head start.

While some vaccines require months of puzzling to find the safest, most efficient production process, the Zika vaccine could be made with the same process used for West Nile, using E. coli bacteria as DNA factories and then extracting and purifying the plasmids.

"If we were to make a live, or inactivated virus vaccine, development would be much more extensive and take months to years," said Schwartz. "One of the great things about the plasmid technique, especially in these outbreak type situations, is that it’s really quick to get to the clinic.”

The VRC’s Zika vaccine contains DNA sequences that instruct cells to make proteins that appear on the surface of the Zika virus. When immunized, the body produces harmless particles that bear these proteins. The immune system then makes antibodies that target the proteins, which should help it block a Zika infection. The DNA plasmids break down over the course of a few days but the antibodies remain, ready to fight the real virus if it ever shows its face.

Testing of the Zika vaccine in mice was promising — it showed that the mice did in fact produce antibodies against the Zika virus. Once this testing was complete, the vaccine moved to a pilot plant for production.

At the pilot plant, one of the biggest challenges Schwartz’s team faced was how to get as much plasmid DNA as possible out of each batch of vaccine (scan this page with the Decoder in the One Cool Thing app to see a video of both the lab and the plant during the Zika production run). They spent a month and a half on this problem, assigning one of the lab’s chemical engineering PhDs to spot bottlenecks and increase the productivity.

"As a chemical engineer, your first class is mass balances. And it stays with you for the rest of your life," said Schwartz. "You always need to know where your product is going.”

They discovered that while roughly 60 percent of the initial plasmids disappeared during purification, the biggest gains could be made in plasmid production. E. coli bacteria are capable of increasing by a factor of 3.3x10^10 in 40 hours, but they need just the right amount of food to do it. Too little, and they don’t reproduce to their full capacity. Too much, and they overeat, producing toxic metabolites that prevent peak growth and productivity. Once they stopped overfeeding the E. coli, the amount of plasmid they collected increased five-fold.

"That’s pretty good,” said Schwartz. He reckons that the yields could be even higher with further tweaking of each step, but he keeps scope in mind. "We don’t have to make millions; we have to make thousands for our clinical trials.”

The Phase 1 clinical trial underway is mostly intended to ensure that the vaccine is safe. In early 2017, the vaccine may be ready for Phase 2, involving hundreds or thousands of people in multiple countries, including Brazil. This trial is intended to quantify the immune response of vaccine recipients and hopefully show vaccine efficacy.

Phase 3, which could begin in 2018, would need to show that people who received the vaccine were significantly less likely to get Zika than an unvaccinated person. Phase 3 might also include trials in pregnant women. Schwartz says that safety problems are unlikely with a plasmid vaccine.

Now that the Zika vaccine has started clinical trials, all that’s left for Schwartz to do is make enough for the clinical trials and hope it will work. And figure out how to produce the next vaccines — for developing threats such as chikungunya or long-standing challenges like influenza and HIV.

U-M ALUM HEADS PRODUCTION OF PROMISING NEW VACCINE

Producing the plasmid

1. Filter to remove large detritus, such as fragments of cell wall.
2. Run the fluid through a column that slows down small contaminants, such as DNA fragments and proteins. Collect the fluid that contains the plasmid and run through a second column.
3. Vield out bad plasmids — those that did not close into rings or coil properly.
4. Remove fever-inducing toxins and proteins produced by E. coli.
5. Filter: Vaccine is now sterile and 95 percent pure.

Packaging for clinical trials

1. Adjust concentration of plasmid and sterile filter.
2. Fill vials, stopper and seal.
3. Inspect, label and freeze the vials of vaccine.
4. Test and release the final product.

THE HURRICANED FLUID RESEMBLES CHOCOLATE MILK AND IS ABOUT 10 PERCENT E. COI BY WEIGHT.

Schwartz shows a miniature bioreactor, used in his lab for small-scale tests exploring how to grow viruses and bacteria for vaccine production.
**MINING ASTEROIDS**

Before Hannah Goldberg (BSE EE ’03, MSE ’04) took the job as senior systems engineer at Planetary Resources Inc., the business was so secret, its founders couldn’t even explain it.

“At that point it was about trust and a personal connection,” Goldberg said. She knew and greatly respected the pair from her time at the Jet Propulsion Laboratory. So when they finally revealed that they wanted her to work at their new asteroid mining startup, she agreed.

The venture is much more public now, and has grown from five people in 2010 to 65 today, she said. She knew and greatly respected the pair from her time at the Jet Propulsion Laboratory. So when they finally revealed that they wanted her to work at their new asteroid mining startup, she agreed.

The group found their number earlier this year by multiplying 74,207,281 twos and then subtracting one. Verifying the number as prime took 31 days of non-stop computing on an Intel I7-4790 CPU.

Named GIMPS (short for Great Internet Mersenne Prime Search), the group studies a special class of prime numbers called Mersenne primes. They’ve been using freely available software to find ever-larger Mersenne primes since their founding in 1996, and have discovered all fifteen of the largest known Mersenne primes. Mary=yes is already working on his next feat — verifying the world’s largest known Fermat number, which weighs in at more than 2.6 billion digits. That’s over 100 times larger than their newly-discovered Mersenne prime.

“Folks like me . . . who are not doing nuclear weapons design, climate modeling or high-frequency stock trading don’t get dedicated access to true ‘big iron’ supercomputers, so this is a major challenge,” he said. “I optimistically estimate that the needed compute power will become available around roughly 2025. In the meantime, there is still lots of coding and number-crunching work to do!”

**A UNICORN GOES PUBLIC**

Quartz called it “the most interesting tech IPO of the year.”

In June, Twilio, a $1 billion cloud communications startup founded by three U-M alumni, went public, bringing in $150 million. The company was launched in 2007 by Jeff Lawson (BS CS ’03), Evan Cooke (MS CS ’04, PhD ’07) and John Wolthuis (BGS ’98).

Twilio is an application programming interface, or API, that lets developers easily add text, voice and video messaging to their apps. It has been popular with Uber drivers, Airbnb hosts, and Home Depot volunteers and for WhatsApp to verify users’ identities.

In 2015, Twilio became one of the rare startups to raise more than $1 billion – a “unicorns” – in tech parlance. Today, it serves more than one million developers across the globe, operates in 22 data centers and claims to reach nearly every phone on the planet.

Have a story for consideration in the next issue’s Alumni Notes? Use the Decoder in the One Cool Thing app to share your submission. See page 9 for details on the app or email us at MichiganEngineer@umich.edu.

When entrepreneur and philanthropist David Tarver (BSE EE ’75), MSE ’76 moved back to Michigan in 2007, his home state was suffering. Cities like Detroit and Flint had no shortage of problems awaiting creative solutions, but people struggled to rally the resources that would turn their ideas into action. So Tarver founded the Urban Entrepreneurship Initiative (UEI) Inc. in 2014. UEI helps aspiring entrepreneurs tackle urban problems with innovative, sustainable and profitable business solutions.

“Solving these problems requires a combination of awareness, motivation and capability,” Tarver said at the 2015 Urban Entrepreneurship Symposium. “And often, those three things don’t exist in the same people, or even on the same team.”

Tarver is no stranger to the impact people can have when they commit to a common goal. In 1983, he and two colleagues from AT&T Bell Laboratories started a tech company in Tarver’s New Jersey basement. Twelve years later they sold the company, Telecom Analysis Systems, for $30 million.

Tarver would go on to establish a nonprofit focused on improving academic performance and opportunities for the children of his Red Bank, New Jersey, community. He has since returned to Michigan, where he has taught undergraduate classes at the U-M Center for Entrepreneurship since 2015. He is the 2016 recipient of Michigan Engineering’s Distinguished Alumni Service Award.

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**PRIME NUMBER PROWESS**

In a record-shattering display of raw mathematical power, a group of enthusiasts, including Ernst Mayer (BSE AeroE ’85, MSE ’87, MA ’91, PhD ’93), has discovered a new world-record prime number. At over twenty-two million digits, the number is over five million digits larger than the previous record-holder, which the group discovered in 2013.

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**ALUMNI NOTES**

**MI BUSINESS IS HIS BUSINESS**

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In 2015, Twilio became one of the rare startups to raise more than $1 billion – a “unicorns” – in tech parlance. Today, it serves more than one million developers across the globe, operates in 22 data centers and claims to reach nearly every phone on the planet.
For those who leave Michigan, but for whom Michigan never leaves.

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Mark & Lisa Sobkow
BSEE'93/BSEE'94
College of Engineering

NAME THAT CHIP
The U-M Micro/Nano/Molecular Biotechnology Lab produces microfluidic chips that mimic the functions of human organs. They provide a safer, faster, less expensive way to test medications and medical treatments. We think they look pretty cool, too.

Can you guess which organ the chip in this photo replicates?

A. Heart
B. Kidney
C. Liver
D. Spleen

MYSTERY PIC
Can you guess where on North Campus this photo was taken?

PHOTO: Joseph Xu

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A VERY, VERY (VERY) SMALL BREAK

That’s the kind of break a nano-researcher gets. Sitting just outside the Lurie Nanofabrication Facility (LNF), this researcher uses that time to check email on an iPad. The LNF is a dust-free environment, keeping nanoscale microchips and experiments clean. While some equipment (like cameras and smartphones) can be wiped down and brought inside, this researcher apparently wanted to stay in the prep area and take advantage of the super comfy bench.

PHOTO: Joseph Xu
COULD SOCIAL MEDIA SAVE LIVES IN A DISASTER? USING HASHTAGS FOR SOMETHING THAT ACTUALLY MATTERS.

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