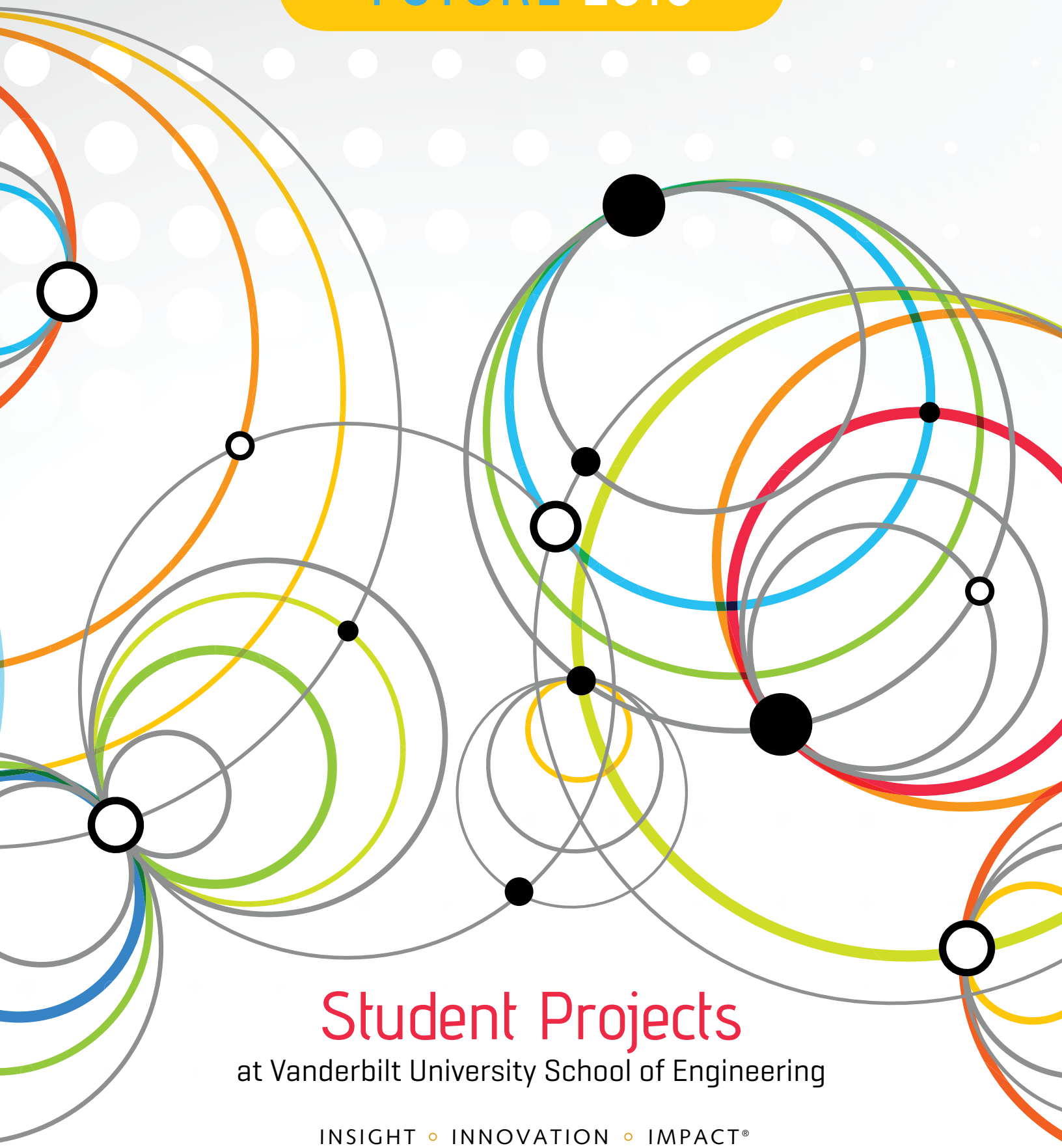
DESIGNING the FUTURE 2016



Student Projects

at Vanderbilt University School of Engineering

INSIGHT ◦ INNOVATION ◦ IMPACT®

DESIGN AT VANDERBILT UNIVERSITY SCHOOL OF ENGINEERING

Contents

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INSIGHT ◦ INNOVATION ◦ IMPACT®

SUMMER 2016

As you turn the pages of this book, you'll see evidence of an exciting movement at the School of Engineering. It's gaining momentum thanks to students' fascination, their professors' encouragement and, perhaps most strikingly, a next-gen space that joined Vanderbilt's skyline this year.

We are nurturing the spirit of making among our students. Now, the university's new Innovation Center, part of the Engineering and Science Building we're opening in August, will increase opportunities for creation and collaboration, accelerating the best ideas to market.

We're also establishing more makerspaces—wet, dry, and nano—throughout the school and tying those into the Innovation Center, which, in turn, is throwing open its doors to budding entrepreneurs in Nashville and the world beyond. (Learn more about the space and its executive director, himself a successful entrepreneur, on page 10.) The Vanderbilt Institute of Nanoscale Science and Engineering, with its faculty members from the School of Engineering, the College of Arts and Science, and the School of Medicine, will add to the building's creative milieu.

Enthusiastic participants in this maker movement have impressed me so much, some were among my inaugural round of Dean's Awards presented at April's Design Day. Let me draw your attention to the biomedical engineers pictured on the previous page, who won Best in Healthcare for their light-therapy device to treat diabetic foot ulcers. (You can read more about that device on page 25.)

On page 5, meet the four seniors whose device could end the problem of magnetic float for credit card manufacturers, eliminating the cost of tossing thousands of defective cards.

You can also learn about design of all kinds from our undergraduates, graduate students, and alumni. I hope you find them as inspirational as I do.

Best regards,

Philippe M. Fauchet
Dean

Computer science class demands user focus from start of design process

To excel in an increasingly popular computer science course, students must think past the coding challenges, past the array of possible devices, and all the way to the customers they want to reach.

Associate Professor of Computer Science and Computer Engineering Julie A. Adams launched her Human-Computer Interaction course at the graduate level in 2005, but demand among undergraduates prompted her to open it to them three years ago. Adams, who worked in the human factors groups at Honeywell and Eastman Kodak before returning to academia, has long been passionate about human-computer interaction.

Her recent class of 18 undergraduates split into several small teams, each developing, building and testing a tech concept. The most important step was involving potential users from across Vanderbilt's campus throughout the entire process.

"You can have the best mobile app idea in the world, and if people can't pick it up and use it within a few seconds, they won't use it at all," Adams said. "A lot of companies don't think about the user interface until the end. I teach this course with a focus on user-centered design."

One of the apps designed in Adams' class is available in the App Store. Megan Woodruff (CmpE'17) and Phil Hawkins (CS'17) launched Pocket Docket in response to a friend's suggestion. She had seen a movie-tracking app Hawkins created and wanted something similar to track legislation of interest to women's rights activists.

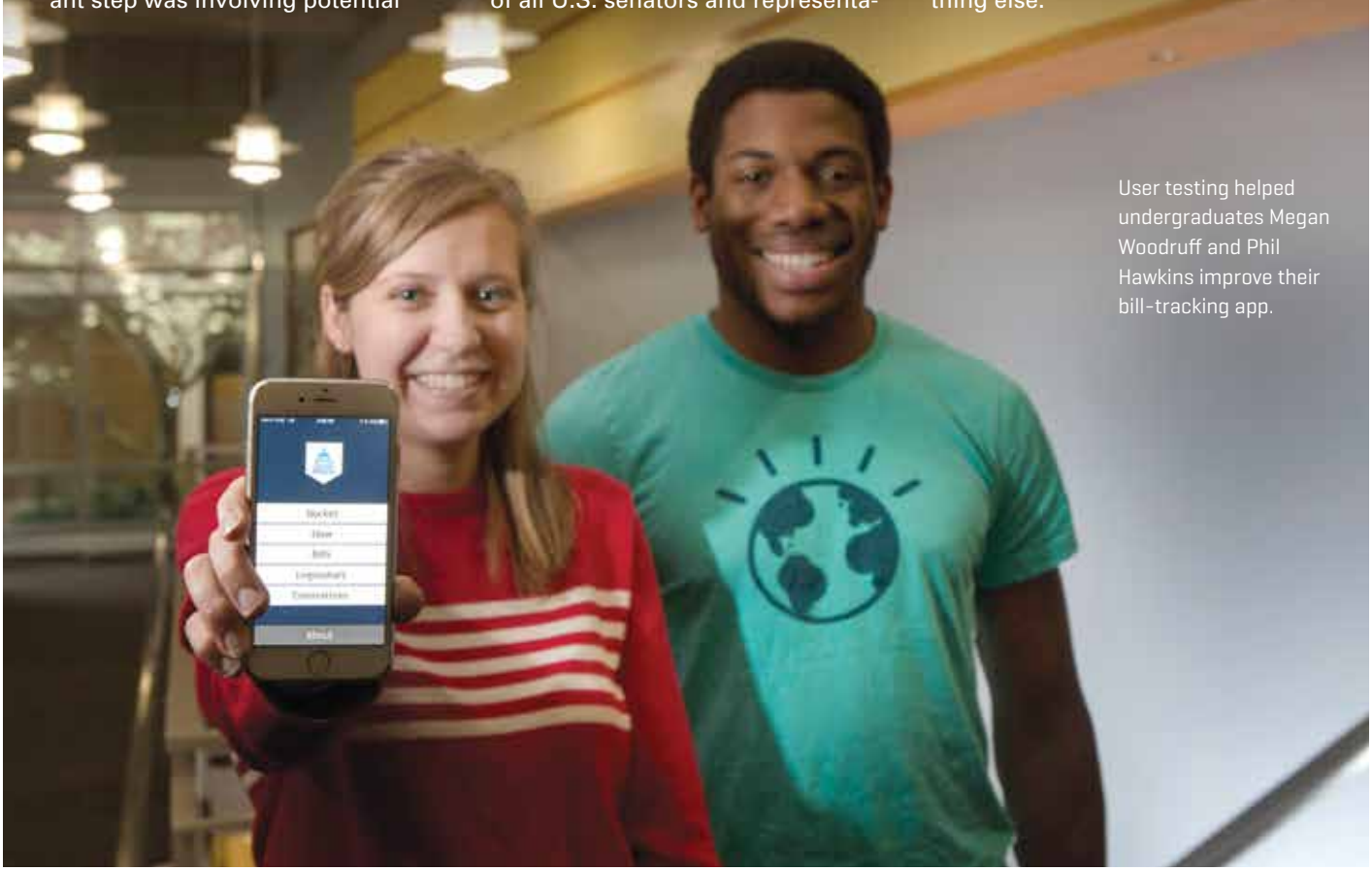
The app—similar to govtrack.us except more user-friendly, in the students' opinion—contains a full list of all U.S. senators and representatives, congressional leadership and pending bills. Users can build a personal "docket" to track the officials and issues that interest them.

The course's user-testing component helped them make adjustments, Woodruff said.

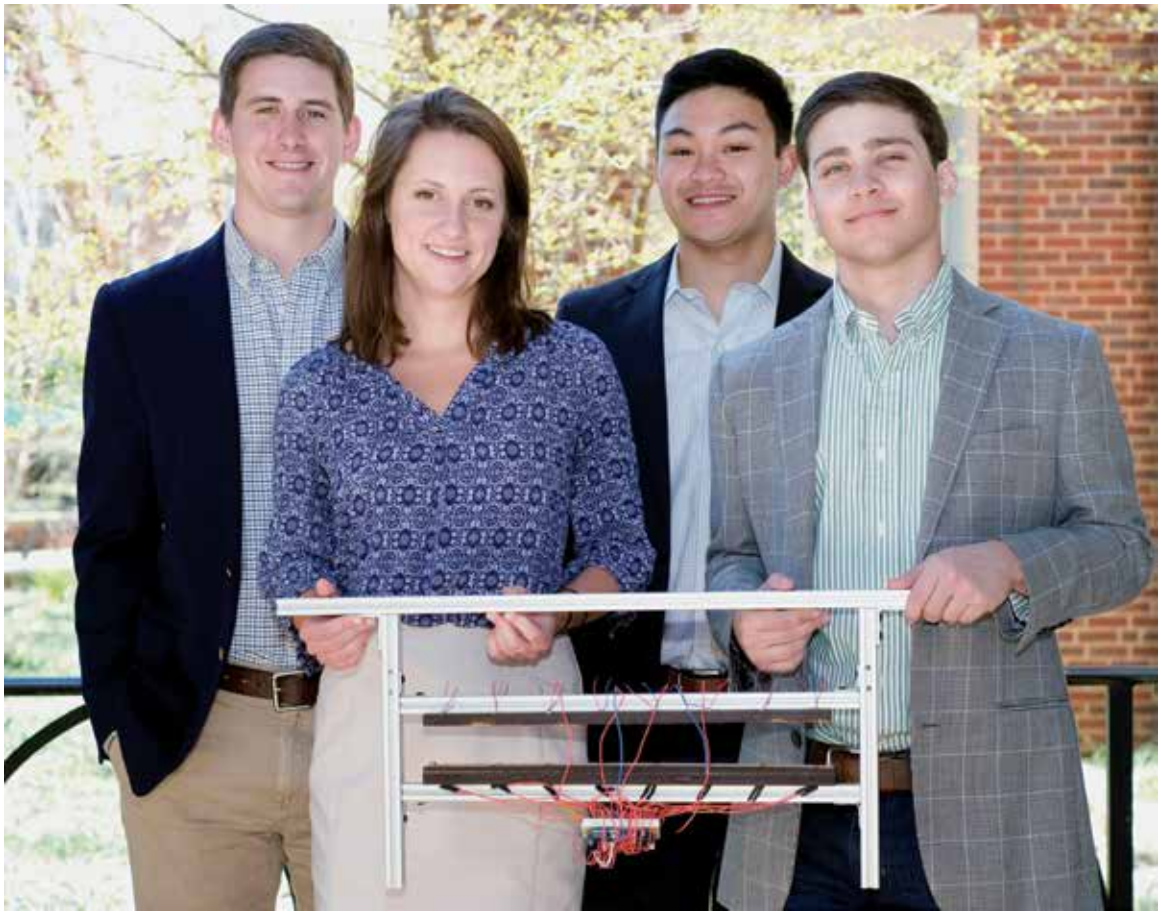
"Our design of the interface for users' fourth task, which had to do with the legislation page, didn't work well. Users had to click buttons to get to certain information," she said. "We thought it was intuitive, but it was not. People wanted to slide them."

Hawkins said users particularly enjoyed the real-time aspect.

"You can see the bills the House and Senate are talking about right now," he said. "You can say, 'This is fascinating,' track it, look at people involved with it and then go back to your docket and check on something else."



User testing helped undergraduates Megan Woodruff and Phil Hawkins improve their bill-tracking app.



While developing a solution for credit card production waste, MechE majors Kevin Groll, Olivia Hurd, Nathan Chan and Adam Rubinsky also learned how to manage, and even anticipate, problems.

Senior design team uses lasers to cut waste in credit card production

Place the magnetic stripe on a new credit card a single millimeter too high or too low, and it's worthless. Multiply that mistake by thousands of cards, and companies are stuck footing the bill for stacks of product headed for the trash bin.

The problem is called magnetic float, and a winning senior design team found the answer in lasers that assure the stripe is placed within half a millimeter of the optimal location. Their research was for project sponsor Fiserv, a financial services technology company.

Mechanical engineering majors Kevin Groll, Olivia Hurd, Nathan Chan and Adam Rubinsky explained that credit cards are PVC with a plastic overlay that includes the magnetic stripe, or magstripe. Fiserv applies the stripe, and then the finished cards are shipped, ready to be encoded with information. They said Hurd came up with the idea of using lasers for the magstripe measurement task.

"Last year, my mechatronics project was to build a laser harp that used lasers and photoresistors, with the lasers sending out certain frequencies that made specific sounds when they were covered," Hurd said. "Lasers were the first thing that came to me when I was considering the alignment problem."

In addition to learning more about credit card technology and lasers during the project, team members said they learned how to manage barriers encountered during research.

"The difference between what we theoretically wanted to do and what we practically could do was difficult to overcome," Chan said. "We had to come up with some crazy ideas in the beginning. As we went on, we got a lot better at anticipating what problems we were going to face."

The Fiserv team won an internal competition judged by industry sponsors and School of Engineering faculty and students, tying for the top spot with a project from a team of biomedical engineering majors. The other project title was Pressurized Prophylactic Treatment Delivery Device for Vascular Bypass Grafts, completed by Kelly Hainline, Morgan Satterlee, Kevin Humphrey and Cortnee Weinrich.

Innovation Realization teams engineering Ph.D. candidates with MBA, law students

A groundbreaking, nationally recognized program is teaming Vanderbilt School of Engineering students with contemporaries in the business and law schools for an entrepreneurship class that uses real-life examples.

The Innovation Realization course addresses important challenges that the teams, each composed of one engineering Ph.D. student, two MBA students and two law students, almost certainly will face during their careers.

Course developer Marie Thursby, a Georgia Institute of Technology professor, brought her Technological Innovation: Generating Economic Results (TI:GER) program to Vanderbilt in fall 2015. Thursby is also an adjunct professor ay Owen Graduate School of Management. She said deans of all three of the Vanderbilt schools involved supported and encouraged the trans-institutional course, which was ideal for the university because engineering students already have devices they want to commercialize. The teams were required to interview potential customers about their work and incorporate feedback into their final projects, which were presented to Thursby and other faculty at the end of April.

The course prompted at least one participating engineer to make adaptations to her research to ensure success in a clinical setting.

"It forced me to see my Ph.D. thesis work as a product rather than a series of scientific questions, experiments and results," said Rebekah H. Griesenauer, a Ph.D. candidate in biomedical engineering. "The value of seeing my technology in this light is that I started to think about real-world challenges associated with commercializing it."

Her team, one of four in the inaugural class, addressed the problem of tumor imaging. Before surgery, breast tumor images are taken with the patient standing up. During surgery, the patient is lying down. Griesenauer developed the Image Guidance System for Breast Cancer Surgery, a GPS-based mapping system that triangulates the position of tumors, while her teammates researched patent issues, customer bases, costs and other factors outside of engineering.

They believe their device will lead to better outcomes for lumpectomies and keep women from having second surgeries to remove remaining cancerous tissue.

Ph.D. candidate Rebekah H. Griesenauer, center, worked with MBA and law students to adapt her lab-based tumor imaging research to a clinical setting.

Coordinated through Owen Graduate School of Management, Innovation Realization is led by Thursby, Ralph Owen Dean of the Owen Graduate School of Management Eric Johnson and School of Engineering Associate Dean for Graduate Education Duco Jansen.

Jansen solicited applications from third- and fourth-year engineering Ph.D. students and helped select ideas that could work for technology transfer. Law and business students then interviewed for admission, and the number of interested students far outpaced available spaces for the inaugural class. Jansen said about 80 percent of Vanderbilt's engineering Ph.D.s ultimately work in industry, where they likely will be involved in product innovation and development, working with business and legal professionals.

Partnership with sustainable Sterling Ranch offers research from the ground up

Situated 20 miles southwest of Denver and nestled between two state parks that offer stunning views of the Rocky Mountains, Sterling Ranch doesn't look like much now. But during the next 20 years, the 5-square-mile, $4.3 billion planned community will take shape as a futuristic city.

Houses with smaller ecological footprints will be outfitted with smart water and energy-management systems. Local schools will offer the latest in curriculum and classroom design. And in the end, Vanderbilt students and faculty will have helped design and implement all of it.

That partnership is the vision of Brock Smethills (BE'13) and his father, Harold Smethills, a former Coors executive who is now chairman of the Sterling Ranch Development Co.

The partnership was launched in fall 2014. Philippe Fauchet, who holds the Dean's Chair in Engineering, along with faculty members David Kosson, the Cornelius Vanderbilt Professor of Engineering, and Claire Smrekar, associate professor of leadership, policy and organizations at Peabody College, and several other faculty and students have made multiple visits to the site for research.

"This is a singular opportunity," Kosson said. "A place for research that's of this magnitude and this cutting edge is completely in line with Vanderbilt's ideals of immersion learning and vertical integration."

A number of this year's senior design projects involved Sterling Ranch. They include creating the next generation of cyber-physical systems that integrate software to monitor and manage water quality and usage; exploring a flexible energy grid that can transition seamlessly from rooftop solar power to other electricity sources without blackouts; desalinization of brackish groundwater to supplement the existing supply; and net-zero homes that actually put energy into the grid.

The Smethills family has been working to develop Sterling Ranch for more than a decade. After spending months working on the many facets of Sterling Ranch—ranging from energy infrastructure to education initiatives—Brock Smethills, who deferred grad school at Georgetown University to help his father with Sterling Ranch, soon thought of his alma mater. He is now the development company's chief operating officer.

Smethills said that partnering with Vanderbilt seemed like a natural fit. "Vanderbilt does a great job of constantly thinking outside the box and teaching its graduates to do the same," he added.

Kosson said he immediately recognized Sterling Ranch as a chance to win one of 17 new grants through the university's Trans-Institutional Programs (TIPs) initiative—funding offered by Vanderbilt to encourage research and teaching collaboration among schools. He and Smrekar worked with several engineering professors and John Ayers, professor of earth and environmental sciences in the College of Arts and Science, to identify the wide range of potential opportunities Sterling Ranch presented for faculty as well as graduate and undergraduate students.

Read more at *vu.edu/sterlingranch*.

Sterling Ranch may sound futuristic—a flexible energy grid, net-zero homes and innovative classrooms—but an interdisciplinary team of Vanderbilt faculty and graduate and undergraduate students is making it a reality.


Thermo
130

Vanderbilt Ph.D.'s new company provides researchers 'X-ray' on cellular processes

Biotech and pharmaceutical researchers long have used cells as mini-factories to churn out fuels, medication and other products. They know what goes into cells and what comes out—for instance, yeast cells take in sugar and produce alcohol.

But exactly what happens inside the cells during that process, or which of thousands of potential pathways are the most effective, has been unclear.

Metalytics, a new company out of Vanderbilt University School of Engineering, seeks to open a window on those processes.

Lara Jazmin, who in October 2015 earned her Ph.D. in chemical engineering, and Associate Professor Jamey Young, the principal investigator on the work, are moving forward with Metalytics. Since completing the National Science Foundation's I-Corps program, which paired them with an entrepreneurial mentor and had them interview 100 potential customers, Jazmin said they are now working with the Vanderbilt Center for Technology Transfer and Commercialization.

"Within the 'black box' of the cell are these biochemical reactions, and researchers don't know which pathways are efficient or bottlenecks or which byproducts might be produced," Jazmin said. "Our technology helps other researchers pinpoint where they could optimize the cells that they're using and uncovers where bottlenecks or wasteful side pathways may be occurring."

The technology uses cell cultures, stable isotopes, biochemical profiling and mass spectrometry to produce a metabolic flux analysis—the "X-ray" that looks inside cells. She compared their work to that of an X-ray technician—their technology reveals where internal problems lie without attempting to diagnose or fix them.

Their technology could be useful, for example, to the winners of the 2015 Nobel Prize for Physiology or Medicine, who isolated chemical compounds found in plants and converted them into drugs to fight roundworm and malaria. Technology exists that allows microbial strains to produce these drugs, and Metalytics' metabolic flux analysis could help speed up the production.

The new Metalytics company, based on Lara Jazmin's doctoral research, deciphers cell processes and could help bring drugs to market faster.

New Innovation Center will be home to immersive, interdisciplinary projects for campus, city

A startup veteran and investor whose ventures range from retail to manufacturing joined Vanderbilt University this spring as the inaugural executive director of the newly created Innovation Center.

Robert Grajewski, formerly the president of Edison Nation Medical, a health care innovation incubator, and co-founder of Heritage Handcrafted and PRO-Techs Antimicrobial, both in Charlotte, North Carolina, joined Vanderbilt as the Evans Family Executive Director of the Innovation Center on April 1.

The Innovation Center, set to open in late summer, will support a maker culture that encourages innovation and creativity and bolsters implementation of the four intersecting themes that make up the university's Academic Strategic Plan: offering students a rich intellectual community and immersive experiences; investing in multi- and interdisciplinary programs; building programs that offer innovative, effective solutions to pressing health and health care problems; and transforming education models through technology and research.

"The Innovation Center will be a key resource in supporting immersive experiences for students and interdisciplinary projects for faculty," Provost and Vice Chancellor for Academic Affairs Susan R. Wente said. "It will allow them to work alongside their peers to develop and test ideas, supported by mentoring from other faculty, alumni, corporate partners and the local business community."

Executive Director Robert Grajewski stands outside the Innovation Center, set to open later this summer.

Grajewski said the opportunity to help build the Innovation Center from the ground up drew him into academia. "The Innovation Center, to me, is both a startup and a catalyst. It's a way to connect all of the schools and colleges with interdisciplinary projects, immersion and experiences," he said. "It's a very exciting and incredible opportunity, one that rarely comes about, especially within a prestigious university with such a motivated faculty and student body. This is a great time to be at Vanderbilt."

Grajewski, who holds an MBA from the University of Pennsylvania's Wharton School, a master's of public administration from Harvard University's Kennedy School of Government and a bachelor's from Harvard, sees the Innovation Center's mission as both broad and deep. "Innovation isn't just starting companies and inventing things. It's the creation of a new way of thinking or systematic approach. It can be a framework that can be applied to art, education, health care, research," he said. "We want people to leave their safe harbors and move into this ocean of real experience. We'll have a system that protects them as they try new things and explore new opportunities."

Grajewski hopes that the Innovation Center will become both the epicenter for innovation and entrepreneurism on campus and for the city of Nashville.

"I see the center as the compass for the campus—to identify, inspire and motivate innovation through interdisciplinary collaborations, improved communication, and partnerships both internally and externally—as well as seminars, business plans and hackathons," he said. "From a community standpoint, I see the center as the front gate for those who want to liaise with the university. We're the catalyst for the community."

Key features of the Innovation Center:

- 13,000 square feet
- Adjacent to the new Engineering and Science Building
- Prototyping lab and maker spaces
- Student, faculty and alumni collaboration space
- Innovators and entrepreneurs-in-residence
- Global mentoring network
- Innovation and entrepreneurship education and venture creation programs

Vanderbilt team builds program of reliable CubeSats

A tiny space hitchhiker named AO-85 is talking, and Vanderbilt University engineering researchers—along with thousands of ham radio operators around the world—are listening. And celebrating.

AO-85, Vanderbilt's CubeSat payload, was successfully launched into low orbit last fall and is beaming data back to Earth. Engineers at Vanderbilt's Institute for Space and Defense Electronics and student researchers are testing the reliability and survivability of advanced semiconductor components in the harsh radiation environment of space.

That the team's nanosatellite made a successful launch and deployment from an Atlas-5 rocket was exciting on its own, but to be transmitting usable research data is somewhat rare in university CubeSat programs.

"Our effort was conceived for, proposed for, and has been conducted as basic engineering research," said Robert Weller, professor of electrical engineering and co-PI on the project. "In fact, ours is unusual among university CubeSat programs in that it was conceived and executed for scientific objectives as opposed to solely for undergraduate education."

The ISDE team fabricated a single test bed (SRAM cards) using commercially available components worth about $200. They are modeling the radiation exposure and testing key components for radiation sensitivity, which will help them design electronics systems for greater fault tolerance.

Specifically, they are making real-time measurements of radiation-induced failures called single-event upsets (SEUs) and conducting extensive computer simulations of the performance of the electronics using unique software developed at Vanderbilt over the last decade.

CubeSats, once just a cheap way for university students to build and launch a satellite, have become one of the hottest new technologies in the space industry. NASA now offers free launches to U.S. nonprofit corporations such as AMSAT as well as universities.

AMSAT, a volunteer organization of ham radio operators that has been building and launching satellites since the 1960s, provided the 4-inch by 4-inch, 2.2 pound CubeSat with a seat on a "spacecraft bus" and is collecting and feeding the telemetry to the university via the Internet. The data are being received by ham radio operators, a unique distinction made possible by a partnership with the Radio Amateur Satellite Corporation.

"A key advantage is that the Vanderbilt-AMSAT team is building a program of reliable CubeSats," according to Robert Reed, professor of electrical engineering and the principal investigator of Vanderbilt's NASA-sponsored CubeSat project. "And, we're able to do real science."

The Vanderbilt-AMSAT team will launch several additional CubeSats over the next few months and years, confirming again that at Vanderbilt engineering is fun, and in amateur radio, fun can be engineering.

VUSE's NASA-sponsored nanosatellite is more than just a teaching tool—it's providing real data for basic engineering research.

Alum disrupts wearables market with biosensing through metal

Fashion icon Iris Apfel, left, and Vanderbilt Engineering Ph.D. and WiseWear founder Jerry Wilmink.

Put Wisewear on your wrist, and other people likely will think it's simply a fabulous piece of jewelry.

At least, at first they will.

After wowing 2016 Consumer Electronics Show visitors and appearing in a slew of tech news articles, WiseWear is gaining recognition for what it is: a fitness-monitoring, security-alert and business-management system encased in a piece of art.

Jerry Wilmink, who earned his bachelor's, master's and Ph.D. degrees in biomedical engineering from Vanderbilt, designed the unique technology that allows sensing information to be transmitted through metal, allowing for a stylish bracelet.

Wilmink, (B.E.'02, M.S.'04, Ph.D.'07), didn't set out to make jewelry. After earning his doctorate, Wilmink joined the Air Force Research Labs in San Antonio, Texas, where he set up a facility to study the biological effects of terahertz radiation—an extension of his Ph.D. work applied to a new problem.

He gained a deeply personal inspiration for the research that led to WiseWear.

"My grandfather died the day after Christmas 2010 due to a fall," said Wilmink, who still lives and works in San Antonio and has offices in New York. "After that happened, I started developing a solution for that—a hearing-aid device with biosensors built in. If a senior was about to fall, it would tell them based on changes in gait, balance and hydration. The National Science Foundation funded that device, and we called it WiseAid."

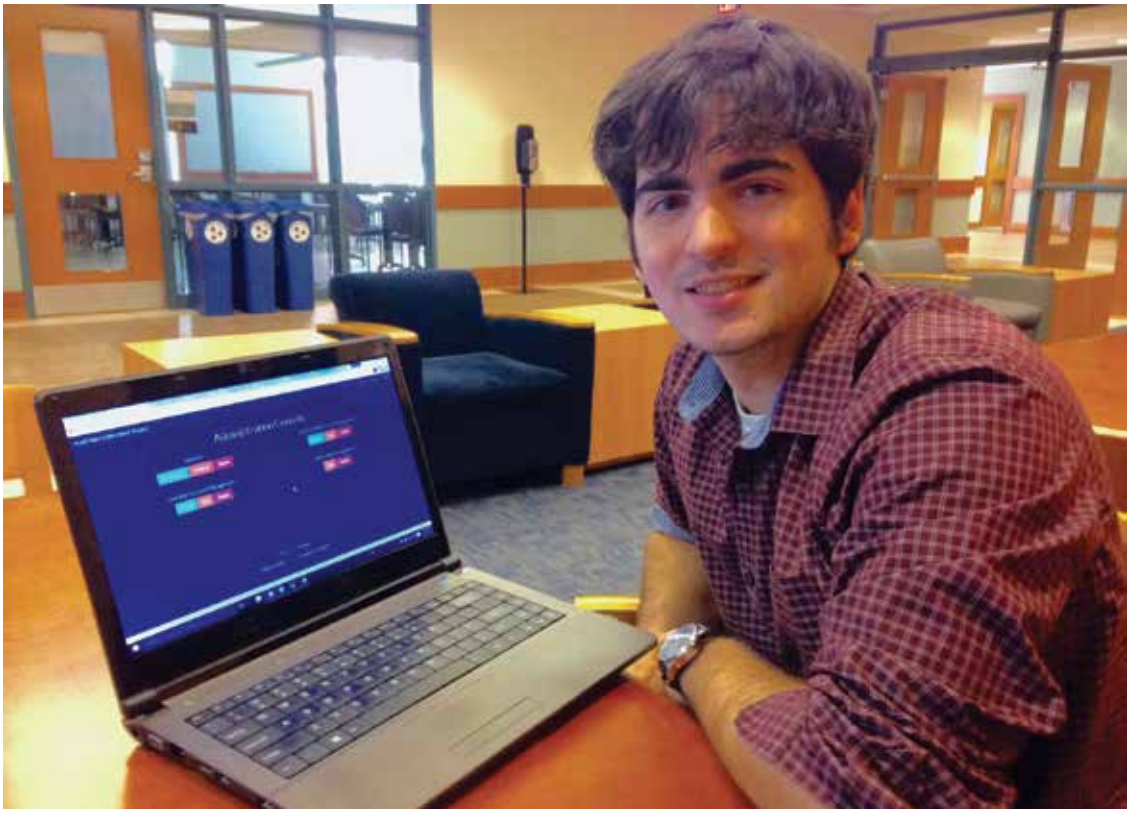
Wearables have been gaining popularity at CES for years, but reviewers at the January event set apart WiseWear for its appearance and security component. Tap the device three times firmly, and it will text your exact location and an emergency alert to preselected contacts.

Wearers can also receive tiny vibration alerts for calls, texts—any notifications they choose. The bracelet pairs with either Android or iOS devices, which is where users will get all their information. There are no screens on the jewelry itself.

Wilmink credits Vanderbilt for giving him the foundation to invent the technology and become an entrepreneur. His Ph.D. adviser was Duco Jansen, professor of biomedical engineering and associate dean for graduate education, who noted that Wilmink challenged traditional approaches to engineering and frequently volunteered to bring science and engineering lessons to high-poverty schools in Nashville.

Gorgeous cuff bracelet or the latest in wearables? Alumnus Jerry Wilmink designed the technology to allow sensing data to transmit through metal, and WiseWear was born.

Grad student's side project keeps incarcerated parents connected with their kids



Electrical engineering Ph.D. candidate Zachary Diggins developed a new web solution for a project that helps incarcerated parents stay connected with their kids, moving from CDs and snail mail to a streamlined, cloud-based system that also tracks analytics.

Zachary Diggins' hobby of designing software and his volunteer spirit recently combined to bring more joy into kids' lives.

Diggins was finishing up his electrical engineering Ph.D. at Vanderbilt University, studying the effects of gamma radiation on robots, when he discovered Companions Journeying Together. The nonprofit works with incarcerated men and women and is best known for its Aunt Mary's Storybook Project, in which prison inmates record themselves reading books to their children. The recordings are then delivered to the children, along with the actual book so the child can follow along.

In today's digital world, Companions Journeying Together was still burning CDs to mail to children—time-consuming, costly and impractical. The nonprofit's leaders were looking for a cloud storage solution.

Diggins volunteered to help and began Skyping with Scott C. McWilliams, executive director of the Chicago-based nonprofit. McWilliams said he appreciated Diggins' talents and commitment from early on in the collaboration.

"A web solution really helps a lot," Diggins said. "CDs are expensive, take time to burn, and the children's guardians don't have as much access to a CD player as they do to their smartphones." The solution Diggins developed ultimately went much further than just a storage system.

With Diggins' new system, Storybook Project volunteers help inmates select books to read, make digital recordings of them and upload those recordings to Amazon's cloud system. The website uses each book's International Standard Book Number (ISBN) to easily locate and mail hard copies to children's guardians, along with an automatically generated letter that contains login information to hear the incarcerated parent reading. The system also generates needed postage to mail the books.

The new system also allows Companions Journeying Together to track data on clients served, book popularity and other aspects of the Storybook Project.

Diggins said designing the project took a lot of time—about 10 hours a week for more than a year, wedged around his challenging robotics work with Research Associate Professor of Electrical Engineering Arthur Witulski at Vanderbilt's Institute for Space and Defense Electronics. Still, he found it fulfilling.

In addition to helping children learn to read and stay emotionally connected with their parents, he can use the skills learned in future endeavors. "The projects you can do with the web skills are so powerful," Diggins said. "Using the tools I learned, the web frameworks—there's a lot you can build off of that."

THANK YOU TO OUR SPONSORS

Our sponsors generously support the Vanderbilt School of Engineering's design program. Thank you for providing your time, experience, and financial support that help make our program a success.

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Special thanks to AT&T,
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ABOUT DESIGN DAY 2016

On behalf of the School of Engineering, welcome to Design Day 2016. This year, you'll see engineering and computer science capstone projects completed in partnership with sponsors including Carlex Glass, Fiserv Solutions, Nashville Metro Arts, Nissan North America, Sterling Ranch Development Company, Quality Manufacturing Solutions, and more.

We thank all of our project sponsors and give special thanks to AT&T for its support of our design program and of the 2016 Innovation Award. This year, Philippe Fauchet, Dean of the School of Engineering, will present the Dean's Awards.

Senior design courses provide students with experience working on real-world projects that involve design constraints, budgets, reviews and deadlines. Students learn about professionalism, licensing, ethics, teamwork, entrepreneurship and intellectual property. As their projects take form, student teams interact with their industry and faculty advisers, hold meetings, write formal documentation and present their work. By the end of the academic year, the teams produce a prototype, process design, or virtual demonstration. Design Day is their showcase.

We recognize the value of senior projects sponsored by industry and invite project sponsors—industry representatives and entrepreneurs as well as research and clinical faculty—to submit project proposals. This enriching experience allows you to work with Vanderbilt engineering seniors and discover what makes our students stand out among other applicants when it comes to employment and postgraduate study. If you or your colleagues are interested in sponsoring a project or to learn more, please contact me.

Sincerely,

Cynthia B. Paschal, Ph.D.
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The following is a reprint of the 2016 Design Day catalog.

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Brochure data were collected and managed using REDCap electronic data capture tools hosted at Vanderbilt University[1]. REDCAP (Research Electronic Data Capture) is a secure, Web-based application designed to support data capture for research studies, providing: 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources. REDCap is supported by a Vanderbilt Institute for Clinical Trials and Translational Research grant (UL1TR000445 from NCATS/NIH).

[1]Paul A. Harris, Robert Taylor, Robert Thielke, Jonathon Payne, Nathaniel Gonzalez, Jose G. Conde, Research electronic data capture (REDCap)–A metadata-driven methodology and workflow process for providing translational research informatics support, J Biomed Inform. 2009 Apr;42(2):377-81.

Stuttering Implicit Association Task

TEAM MEMBERS:

Michael Kremer
Ryan Spears

ADVISERS:

Tedra Walden, Professor of Psychology and Human Development

SPONSOR:

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Implicit biases can be informed by subconscious cognitive associations, such as the connections between stuttering and words of negative connotation. The Stuttering Implicit Association Test seeks to quantify in its users the degree of bias towards people who stutter.

The Implicit Association Test (IAT) is a popular social psychology tool that assesses how closely people's brains link concepts. A 10-minute measure, the IAT requires test takers to rapidly pair words or pictures from two target conditions (e.g., male and female) with an attribute (e.g., "kind") such that faster responses are interpreted as more strongly associated than slower responses. These unknown cognitive connections may lead to implicit bias, which may influence subtle forms of discrimination. There is a desire to apply the IAT in a research framework to better understand people's implicit biases against those who stutter, yet no currently existing software satisfies this desire. This design uses Java's Swing Graphic User Interface through a JApplet, which allows the Stuttering IAT to be accessed over the Internet and be capable of collecting and storing data. While the primary purpose is the large-scale collection of data for research purposes, the test also provides users with an estimated degree of personal preference/bias (no, slight, moderate, or extreme) for either people who stutter or people who do not stutter.

Fibrotic Liver Ultrasound-based Imaging Diagnostic (FLUID) System

TEAM MEMBERS:

Meredith Huszagh
Fahad Iqbal
Sara Keller
Patricia Twilley, BME/ChE
Alison Williams

ADVISER:

Brett C. Byram, Assistant Professor of Biomedical Engineering

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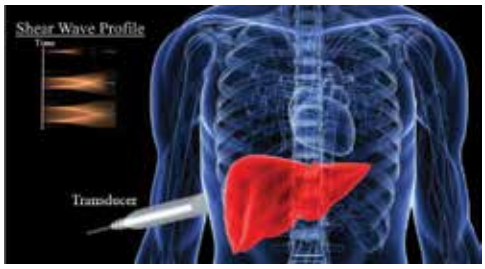
Biomedical Elasticity and Acoustic Measurement Laboratory



The transducer emits shear waves to displace liver tissue. This displacement provides a measurement of tissue stiffness, which correlates with the severity of liver fibrosis.

Liver fibrosis is a condition in which healthy tissue is replaced by scarred tissue after liver damage occurs. As fibrosis progresses, the tissue stiffens, causing impaired liver function. Consequently, severe liver fibrosis, known as cirrhosis, results in over 1 million deaths each year. Many of these deaths occur in low-resource environments due to the high prevalence of Hepatitis B and C, common causes of liver fibrosis in these areas.

A liver biopsy is the current gold standard for assessing liver fibrosis, but this technique is invasive, painful, and expensive. While non-invasive diagnostic methods using advanced imaging modalities exist, these technologies are too complex and costly for use in low-resource environments. Therefore, our team has developed a low-cost, ultrasound-based device to non-invasively assess liver fibrosis.

Our design utilizes a single element transducer and acoustic radiation force imaging (ARFI) elastography to quantitatively measure liver tissue stiffness. By transmitting a long acoustic pulse to generate a shear wave, followed by a series of short pulses, we can displace the tissue and then track the subsequent motion. The motion profile can be correlated with the progression of liver fibrosis.

Clinical Analysis of Speech Rhythms in Language Development Using MATLAB

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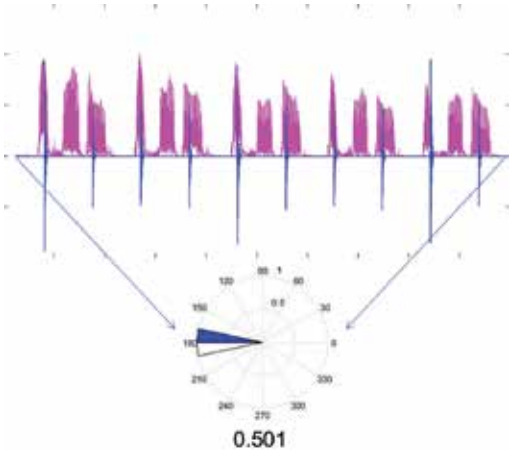
The ability to identify and produce rhythm has been shown recently to have an effect on language development in children. With new exploration in this interdisciplinary field, the need has increased sharply for a diagnostic tool that benchmarks an individual's language abilities. Currently, no technology exists to measure the rhythmic capabilities of an individual. This design affords researchers and clinicians the opportunity to automatically record, save, and analyze rhythm in speech.



A circular statistics graph compares the metronome track (presented in blue) to the speech track (in pink).

Utilizing MATLAB, speech is analyzed in accordance with a stimulus, the metronome. The metric for determining an individual's speech rhythm abilities is derived from the comparison of the recorded speech and the metronome. The degree to which the rhythm of speech aligns with the metronome is a determinant of synchrony in speech. This tool transcends current research by providing direct value to patients. Preliminary speech patterns serve as a baseline for subsequent tracking of improvement in speech production. This tool will be used in conjunction with music training to aid in determining both the quality of speakers and the impact of music on spoken language.

Pressurized Prophylactic Treatment Delivery Device for Vascular Bypass Grafts

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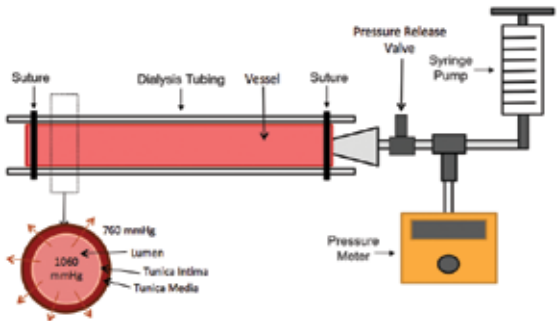
Vascular bypass surgeries are a common medical procedure, but graft failure rates can be as high as 43 percent depending on the location of the bypass. Scientists recently have developed a map kinase inhibitor that increases the patency of vascular bypass grafts and decreases their rate of failure. Homogeneous delivery of these therapeutics throughout the target tissue is limited by the inherent diffusional barriers presented by the luminal and adventitial surfaces of the graft vessel.



Schematic of the prototype of the pressurization device. Included is a diagram showing the convective flow mechanism induced circumferentially by the luminal to adventitial pressure gradient.

To address this limitation, this project focuses on developing a pressurization device to improve therapeutic delivery into the vessel wall without causing significant vessel distension and subsequent cellular damage. A pressure gradient will be induced from the lumen to the adventitial surface of the vessel to drive drug permeation into the target tissue of the graft vein while dialysis tubing will be utilized as a protective stent to prevent distension.

This dynamic pressure system will allow for faster, more effective permeation of the target tissue than the current standard of delivery. The device will ultimately reduce the failure rates of vascular bypass grafts, preventing the need for more operations.

Cardiac ICU Modeling

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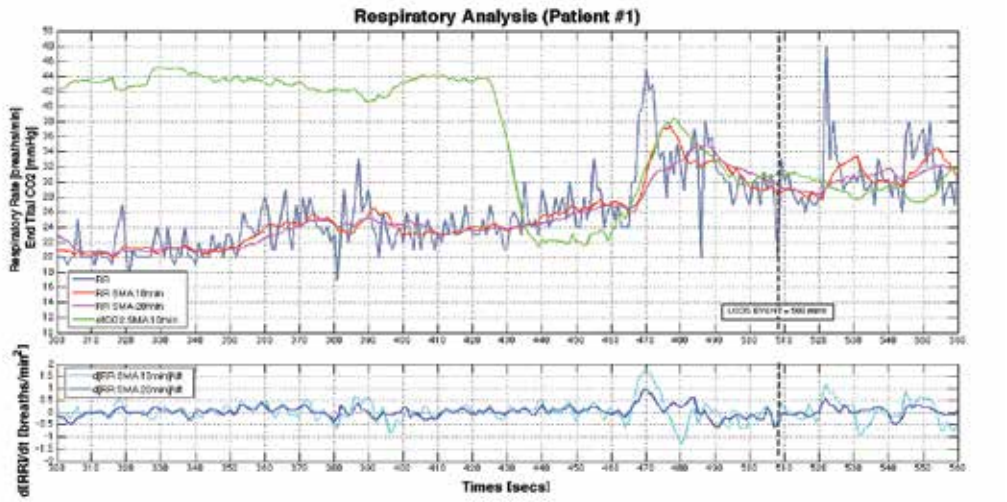

Respiratory analysis using simple moving averages for an example patient leading up to a Low Cardiac Output Syndrome (LCOS) event. The variations in these averages as well as deviations from established baselines are used to predict a future drop into low cardiac output.

Cardiac Output Syndrome (LCOS) is a clinical condition that is caused by a decrease in oxygen perfusion throughout the body. When a patient declines into a state of low cardiac output, a timely response by medical staff is important for decreased long-term effects. In a pediatric cardiac intensive care unit, there is a continuous flow of data points tracking vitals. This includes metrics for heart rate, respiratory rate, blood pressure, venous oxygen saturation, and many more.

The focus of this project is to build a model that integrates patient data in order to alert the physician of an impending cardiac event. This first involves establishing a patient specific baseline for each vital. Then, the patient's data will be compared to this baseline for variability as well as deviations. Development of an exact algorithm to be used in analysis of each patient's data is in progress. This algorithm will output a risk score that will be used by medical staff to monitor or take action regarding each patient. There are currently no options for real-time prediction of LCOS.

Preparing Oral Rehydration Solutions Using Flotation Densimetry

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Diarrheal disease is a leading cause of childhood mortality, but the condition is easily treated with oral rehydration solution (ORS). While the World Health Organization distributes packets of a salt mixture that can be added to one liter of water to create effective ORS, the care providers mixing the solutions often fail to measure the appropriate volume of water to add to the packets. The goal of this project is to eliminate the need to measure the water by creating a device whose flotation level within the ORS indicates whether the osmolarity of the solution falls within the acceptable range.

The device is a small cylinder made of layers of differing densities. The density of the middle layer is equal to that of ideal ORS, with the densities of the rest of the cylinder corresponding to solutions within and outside of the acceptable range. The device is color coded for easy interpretation. Once the water level falls within the green central region, the ORS is ready for consumption. No other device exists to assist with the mixing of ORS. Therefore, this device is anticipated to increase the number of children who receive effective diarrheal disease treatment.

The device is placed in oral rehydration solution as it is being mixed to indicate when enough salts have been added to the water or vice versa. This ensures that the resulting solution will be effective in treating diarrheal disease.

Supplemental Oxygen for Low-Resource Environments

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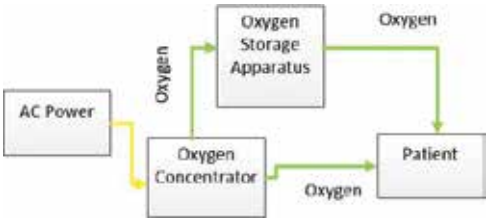
Pneumonia is one of the leading killers of children in developing countries despite increased access to antibiotic treatment. Many of these deaths are caused by hypoxemia, which can be treated with oxygen therapy using oxygen tanks or oxygen concentrators. Tanks are too expensive to deliver to remote clinics, and concentrators require a constant power supply, which is often unavailable due to unreliable power grids. The overall goal of this project is to provide an oxygen therapy solution that addresses the needs of low-resource hospitals and clinics. This design uses a combination of oxygen and power storage methods to offer a modular solution that can be adapted to fit the needs of different facilities. Storing uncompressed oxygen reduces the power required to deliver oxygen to patients compared to oxygen tank technology in current use. This project also uses a deep cycle battery to store energy and power the device for times when grid power is unavailable. The modular system offers multiple solutions to address the needs of different facilities, which will increase access to oxygen therapy and, thus, treat more patients.



Block diagram of the oxygen delivery system. The concentrator is powered by AC power either from the electrical grid or from a battery or solar panel attached to an inverter. From the concentrator, oxygen is pumped to either the patient or the storage apparatus, depending on the need. Once the storage apparatus is filled, oxygen can be pumped from it to the patient.

Laparoscopic Gastrointestinal Phantom

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Science and Technology of Robotics and Medicine Lab

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Each year, millions of animals and human cadavers are used in medical training and research settings, driving up the cost of medical discovery. Currently, phantoms of the upper gastrointestinal (GI) tract do not exist and colorectal phantoms are not widely available. Therefore, the goal of the project was to create a low-cost, environmentally friendly, and anatomically-correct gastrointestinal phantom to use for repeatable testing of new endoscopy and colonoscopy techniques and devices. The design consists of a model of the upper GI tract, which includes the esophagus, stomach, and upper third of the duodenum, made from a mold of PVC pipe and wet floral foam. The model of the lower GI tract was created using a 3D-printed mold of the colon and rectum derived from a series of CT scans. The entire mold was coated with liquid silicone, which solidified to create a model with exact dimensions and mechanical properties of a human gastrointestinal tract. This resultant model is cost-effective, durable, and eliminates the need for animals and cadavers. Implementation of this model will allow researchers and gastroenterologists to test new medical devices with the fidelity of a human gastrointestinal tract.

The finalized gastrointestinal phantom will feature anatomically correct dimensions and material properties. The phantom will allow for qualitative testing of new endoscopic devices. The four quadrants of the figure display a) the 3D printed mold of the colon, b) the mold coated in liquid silicone, c) the removal of the cured silicone, d) the silicone phantom.

Spatial Hearing Web Application

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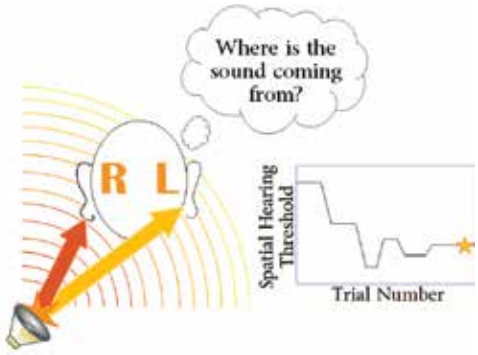
There are an estimated 285 million people with visual impairments worldwide. These individuals have a difficult time with daily tasks, such as crossing streets. One way to mitigate this problem is to learn more about how people perceive sound. Currently, there is no quick and easy way to test hearing ability, which prompted us to develop a website application for auditory testing. The application is user-friendly for visually-impaired individuals and brings the testing environment to the subject. The tests measure perceived sound level difference and sound time difference between each ear. The level difference test measures a loudness difference between the right ear and left ear. The time difference test measures the time interval between when a sound hits each ear. More data about how people perceive sound will be acquired from our application and will give researchers a better sense of how people of all visual abilities localize sound. This will allow for development of improved technologies and safer interactions for people who are visually impaired.



People use various auditory cues to locate sound sources. Gradually decreasing stimulus differences between the two ears will allow identification of a spatial hearing threshold.

Dynamic Alarm System for Hospitals (DASH) to Address Alarm Fatigue

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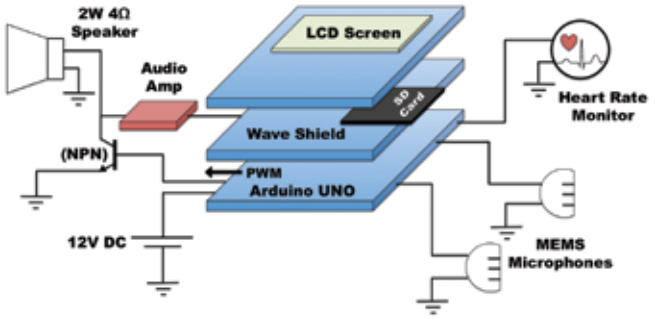
Alarm fatigue, or failure of staff to promptly respond to valid alarm conditions, has been identified as a top health technology hazard by national regulatory bodies. Current medical alarms elevate ICU noise levels and negatively impact hospital personnel performance, which ultimately leads to alarm fatigue. The project objective is to develop a dynamic alarm system that regulates alarm volume relative to the background noise and, consequently, avoid unnecessarily loud alarms.



This device monitors and displays heart rate and allows the user to control alarm presentation and volume relative to background noise. The sound quality of the alarm is improved by the wave shield and the audio amplifier, while the volume is controlled by input from the microphones.

The device also addresses other aspects of conventional medical alarms associated with fatigue, such as rhythm and acoustic profile. An advantage of this device compared to conventional medical alarms is the incorporation of novel sounds to reduce the impact of alarm fatigue. An example of novel alarms is a "lub dub" sound to represent the physiological sounds of a heartbeat.

The principal components of the device are an Arduino UNO, a wave shield, an LCD screen, and a pulse sensor. Users can select alarm type (conventional or novel) and relative volume. Compared to a previous design, the current device features increased sensitivity, variable alarm sounds, and physiological monitoring. This device aims to improve psychoacoustic properties of alarm system presentation and hopes to enhance the quality of medical care globally.

FeedRite Feeding Tube Placement System

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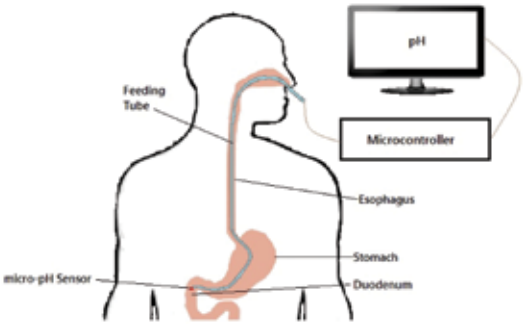
Gastric bypass is an invasive, risky procedure to promote weight loss and the reversal of obesity-related conditions such as Type II Diabetes. Unfortunately, this procedure is expensive and has restrictions on age, health, and minimum BMI, which results in a narrow patient population. Current analogs include naso-duodenal feeding tubes that rely on repeated fluoroscopic procedures, exposing the patient to unnecessary doses of radiation, or are expensive and unreliable.



The FeedRite Feeding Tube Placement System tracks the physiological environment of the tip of the feeding tube to alert the health care provider to the tube's current position along the gastrointestinal tract as it travels through the nasal cavity, esophagus, stomach, and into the duodenum.

The FeedRite feeding tube consists of a removable insert placed inside a standard feeding tube. The insert tip contains microsensors that measure various physiological values. Data are sent to signal calibration units via fiber optic wires, finally interfacing with an Arduino microcontroller to display the physiological parameters detected. The health care provider conducting the placement can then ascertain where the end of the feeding tube is located by comparing the reported values to a list of reference values. The use of radiation-free techniques detecting naturally occurring physiological changes makes the FeedRite feeding tube safer, more affordable, and more reliable than existing analogs to gastric bypass. This design will help patients who cannot afford, or do not qualify for, gastric bypass lose weight until they make lifestyle changes necessary to maintain weight loss.

Medical Rounds Communication System

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Bedside education, a period of time when a physician speaks directly with a patient, is crucial to the patient's understanding of their medical condition. Physicians' rounds are loosely scheduled and patients can become frustrated by waiting or unintentionally miss their physicians, causing ineffective education. Improving education is important for increasing patient compliance and, thus, reducing the number of readmissions to the hospital.

Devices utilized in the Dr. Roundabout System – beacon, smartphone with app, and computer

Our system, Dr. Roundabout, seeks to increase communication between physician and patient by allowing the patient to have an estimated arrival time of the physician during rounds. The system uses Bluetooth communication between beacons and the physician's phone in order to determine when the physician is present on a specific floor of the hospital. A smartphone app will allow the doctor to communicate whether or not they are performing rounds. The patients on the floor will then be notified with a time estimate for when the doctor will arrive. No current technology is utilized to enhance this patient-physician connection in hospitals. This technology will optimize bedside education time, improve patient compliance, and increase hospital efficiency.

Hearing Aid FM Device

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Frequency-modulated (FM) technology for hearing aids has been developed so individuals receive a wireless signal to an ear-level receiver coupled to the hearing aid from a speaker using a microphone. One limitation of this technology is that regardless of where the speaker is within the transmission radius, the speech signal remains at a constant amplitude and is the same for both ears, known as mono. Considering that any acoustic cues indicating distance are lacking, the goal is to recreate multiple cues through software modification of the mono signal so the user has an understanding of speaker distance. This code must be lightweight, as its hardware will eventually be within or a small attachment to a hearing aid, yet must provide cues nearly as strong as cues normal hearing offers.

Headphone used in testing that is similar to hearing aids.

Although our project calls only for functioning code, we have hardware to display its full functionality. An Arduino gathers an input sound, receives a distance value, applies the filters, and outputs the signal to headphones. As the distance data changes, the listener will be able to detect changes in the output sound. This is a definitive advantage over all current FM hearing aid systems, as they lack any localization cues. This system has the ability to be applied as an added feature to current FM devices.

Anatolution

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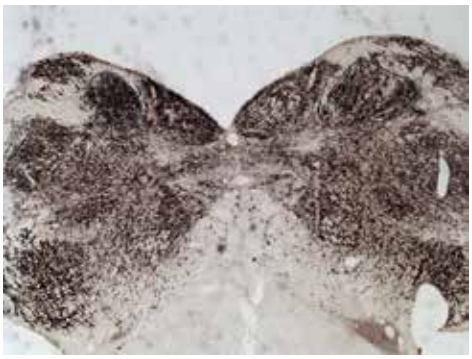
Current methods employed in stereological research can be extremely tedious and require a high level of expertise. From acquiring images of neural tissues to quantifying the biomarkers within those images, there are several sub-processes that can be streamlined or automated.



Sample tissue from a primate's visual cortex. Note the high cell concentration within the highlighted cuneate nuclei.

Our proposed design solution comes in three parts: automation of image acquisition, creation of a web-hosted database, and post-processing segmentation. Using Micro-Manager, an open source microscopy software, we were able to automate image acquisition across a user-identified region of interest. Instead of manually moving to each probe and focal depth, this program is able to capture hundreds of images automatically. Furthermore, once captured, these images are uploaded to a cloud-based server to allow open access post-processing via our website. However, prior to manual processing, each image is passed through a MATLAB segmentation pipeline that identifies in-focus cells and quantifies cell sizes and counts. Researchers can then use the imaging toolbar to complete quantification of these semi-processed images. Once integrated into the Kaas lab, this system will greatly expedite the imaging process, increase accessibility to these images, and standardize potentially subjective components of imaging research.

A Slimmer and Improved Hip Protector

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HipCheck

Hip fractures in the elderly due to falls is a serious problem. These hip fractures not only incur billions in health care costs every year, but also severely impair the victims. The mortality rate for the year following a hip fracture is a shocking 33 percent. Current hip protectors show some efficacy but suffer from very poor compliance rates due to their bulkiness.

The HipCheck team is designing and testing a hip protector that is slim (less than 1 inch thick) yet still effective at preventing a hip fracture during a fall. A hip protector protects the user from a fracture by attenuating the force that reaches the upper femur and/or distributing the force away from the upper femur. To achieve proper protection without sacrificing thickness, the team is testing many different foams, gels, and shapes to determine the best combination thereof to be used in a final prototype. A vertical drop tower machine was designed and built by our team to simulate falls for testing the device. Prototypes were shown to nursing home residents to validate that the designs are sufficiently subtle, which is has been the major obstacle to hip protector acceptance. This hip protector is expected to achieve compliance rates unparalleled by the competition due to its slimmer and stylish design while still effective at protecting from a fall.

Hip protector prototype. Despite its slim and stylish design, it still effectively prevents hip fractures in the event of a fall.

LUMASIL: A Device for Treating Diabetic Foot Ulcers

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Diabetes affects approximately 29.1 million Americans today. Twenty-five percent of diabetic patients develop diabetic foot ulcers (DFUs) over their lifetime. About 80,000 lower-limb amputations occur in the U.S. every year as a result of DFUs. The current standard of care passively treats the DFU with an off-loading total contact cast. Due to this passive healing method, DFUs may not heal completely, which increases the risk of infection and possible amputation. In recent years, studies have shown that low-level light therapy (LLLT) is a viable, active treatment method that accelerates wound healing and decreases the incidence of infection. This team developed a medical device, LumaSil, utilizing LLLT with infrared (IR) and blue light to actively heal DFUs as an addition to the standard of care.

LumaSil is a low-risk, waterproof, shock resistant device that seeks to actively heal DFUs with no additional effort from the patient. This device automatically controls the therapeutic dosage of light using custom circuitry. Incorporated into the cast, the device is simple to apply, durable, and low-profile. Through a feasibility study, the team worked to prove that LumaSil is safe, automated, and will reduce healing time and incidence of infection.

3D rendering of LumaSil, a low-level light therapy device to aid diabetic foot ulcer healing. Light generated in an external module on the cast is delivered to the wound via fiber optic cables embedded in a silicone halo.

SteadyScan: MRI Stabilization Device

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Department of Biomedical Engineering

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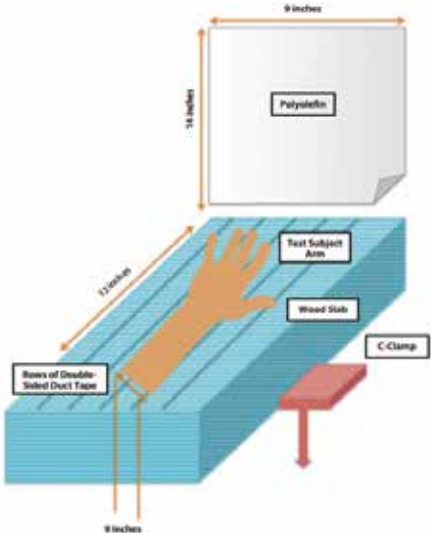
Of the approximately 30 million MRI scans performed each year in the United States, many must be repeated because a patient involuntarily or unknowingly moves during the scan. These small movements cause image registration issues, which undermine diagnosis. Retaking images wastes both time and money. Our team created an effective, comfortable, low cost, and easy to use solution to this problem. The result is SteadyScan.

SteadyScan consists of a silicone base and a unique polymer plastic that conforms to the patient and adheres to the silicone base. A technician places the silicone base on the surface where the patient rests and exposes the adhesive surface. In our example, a technician places a patient's arm atop the base, then places a plastic sheet atop the patient, molds it to the patient's body, and adheres it to the base. This results in movement confined to less than 1mm without sacrificing comfort, which eliminates significant registration issues, and saves time and money.



SteadyScan diagram

Design Day 2016 in the Student Life Center.

Developing Software for Optimal Heat Exchange Networks

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Chemical Engineering Design Advisory Board

Through an intuitive user interface and graphical solving method, our software allows users to design optimal heat exchange networks, leading to significant energy savings in an industrial setting.

Rising energy costs, along with growing demand for environmentally responsible manufacturing, have pressured chemical production plants to reduce environmental impact and energy usage. The use of heat exchange networks (HENs) generally results in 20-30 percent energy savings in heating and cooling utilities, creating the need for a method efficient in designing and optimizing these networks. Our software enables the design of optimal HENs considering various user inputs, design parameters, preliminary cost estimates, and plant constraints. The program will produce various results to aid in designing a HEN, including a graphical representation of the optimally designed HEN, stream data for all material streams involved (at least 50), a preliminary cost analysis of the utilities and capital equipment used, and an intuitive user interface. While there currently are programs that assist designers in producing various aspects of HENs, there is no readily-available and fully comprehensive HEN optimization software. Our program provides such a comprehensive solution. Integration of this program into manufacturing companies will enable engineers to more effectively create optimal HEN designs, and thus, reduce energy usage and utility costs for operations.

Industrial Water Use and Reuse System Design

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Our dynamic software aims to reduce the amount of wastewater that is discharged by industrial plants, which allows for greatly reduced utility costs.

Chemical companies spend a substantial amount of money on water usage and wastewater disposal. Often, plants exclusively use fresh water feeds rather than recycle slightly contaminated streams. Production costs can be greatly reduced by integrating these partially impure streams with more robust unit operations.

Software capable of identifying an optimal wastewater recycle system can aid designers in generating a more cost-effective process on either new or renovated plants. Our software will predict an optimal recycle configuration for up to 25 water users and 25 wastewater generators. It will also be equipped with a cost estimator to predict the return on investment for every water integration process that the program designs. This prediction will allow the designer to discern which improvements would be most economical.

An Excel-based program will be used as the user interface. This will allow for widespread implementation and simple customization of our product. In addition to an optimal recycling network, our product will contain features that allow the designer to manually force or forbid certain stream connections, effectively generating more practical, but suboptimal direct recycle systems and water purification methods.

Selective Catalyst System

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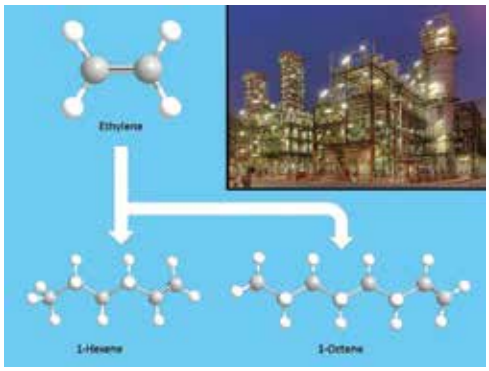
Linear Alpha Olefins (LAO) are straight chain alkenes with terminal double bonds that are used as co-monomer units in polymer manufacturing. Applications for LAO include polyethylene plastics, lubricant additives, and surfactant intermediates. Traditionally, LAO manufacture produces a wide distribution of monomers. The team sought a process to maximize the yield of 1-hexene and 1-octene, the most commercially viable products. We achieved this by using inexpensive ethylene feedstock reacting with a newly discovered and highly selective catalyst system that only produces the two desirable compounds at adjustable ratios that meet market needs.



Using a reaction pathway from ethylene to 1-hexene and 1-octene products enabled us to design and cost a linear alpha olefin commercial production facility.

We designed an economically feasible plant capable of producing 100 MM lbs/year of LAO. As a function of the catalyst system, the product ratios are adjustable. Additionally, our plant operated within environmental and safety regulations. This design will accrue higher profit margins than other existing competitors because of its ability to reliably generate the lucrative compounds in high yield.

Designing a Phosgene-Free Process to Produce Polycarbonates

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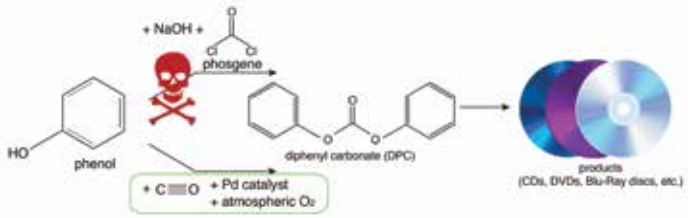
Polycarbonates are widely used in many applications such as in phones, DVDs, and bullet-resistant windows because of their optical clarity and impact resistance. In the past, polycarbonates have been made with phosgene ($COCl_2$) as a reactant to create an intermediate, diphenyl carbonate (DPC). Phosgene is known to be harmful to the atmosphere and highly toxic to humans, causing major injury or even death. In the chemical manufacturing industry, minimizing economic and environmental waste is highly desirable, whether it is through production of highly toxic intermediates in a synthesis plant, disposition of potentially useful chemicals, or pollutant production.



Phosgene-free diphenyl carbonate production from phenol. DPC is a primary component for polycarbonate, which is used in optical discs due to its high impact strength and optical clarity.

The overall approach is to create a phosgene-free plant design incorporating the direct oxidative carbonylation of phenol to DPC. The process requires a palladium halide catalyst with one of many nitrogen-containing heterocyclic compounds as co-catalysts. An economic analysis is carried out to ensure that the process is economically feasible and profitable. We hope to produce a design that meets the specified production goal of 100 million pounds per year of DPC while also being sustainable and cost-effective.

Designing a Chlor-Alkali Brine Concentration Process to Improve the Recycling of Electrolysis Reagents

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A chlor-alkali electrolysis process we aim to improve by recycling reagents that leave in the waste stream.

An existing electrolysis process of brine to produce chlorine and caustic soda can be significantly improved by retrofit. The recycle capabilities of such a process can be enhanced, allowing for a more efficient overall process. Our goal was to design and optimize a brine concentration process to recycle sodium chloride from a spent brine stream back to the electrolysis unit. This recycle would reduce the water utility and raw material costs of the existing process. Multiple separation technologies including, but not limited to, crystallization, reverse osmosis, and evaporation will be considered to determine the most cost effective process design. The final design could use a single separation process or a hybrid combination. Our analysis will yield multiple practical design solutions with different separation techniques. These solutions will allow us to identify an optimal process design based on each technology's strengths and weaknesses.

Mobile Wastewater Treatment System for Hydraulic Fracturing Waste

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A Dissolved Air Flotation (DAF) tank, shown above, forms the basis of our process to remove chemicals and suspended solids from hydraulic fracturing flowback fluid.

Hydraulic fracturing (fracking) is an economically viable method of extracting natural gas from shale. The fracking process involves pumping millions of gallons of water into gas wells over a mile beneath the surface, creating fissures in the formations to recover oil and gas. Fracturing fluid consists mostly of water but also contains sand, surfactants, gelling agents, corrosion inhibitors, proprietary chemicals, and other compounds. Approximately 15-80 percent of the injected fluid and naturally occurring chemicals return to the surface as flowback fluid. The fluid can be harmful to the environment, so it is typically stored in surface containment ponds and disposed of in deep-injection wells.

The goal of our project is to design a mobile waste treatment system that treats the waste stream and prepares it for reuse in subsequent fracturing operations. This mobile system will use various chemical processes to remove any constituents hindering the performance of the fracturing fluid. Treated waste streams will be combined with freshwater to produce a fracturing fluid available for reuse. Such a design will help recycle the flowback fluid, reduce water utilities, and minimize the environmental impact the fracking process will cause.

Production of Chemicals from Ethane Derived from Marcellus Shale

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The project goal is to design a plant that uses ethane to produce 100,000 tonnes of ethylene, 200,000 tonnes of acetic acid and 200,000 tonnes of vinyl acetate monomer (VAM) annually. Ethane can be derived from Marcellus shale which spans across most states in northeastern America, and contains a rich supply of natural gas. Ethane gas is extracted from the shale by drilling and hydraulic fracturing before being supplied to the plant for further processing. Our strategy is to use an integrated ethylene-vinyl acetate monomer process to yield the desired chemicals at the targeted production rate. This process involves the oxidation of ethane to ethylene and acetic acid, and the production of VAM through vapor-phase acetoxylation of ethylene. It is selected based on the information available on the processes, and the ease of simulation. The plant design outperforms existing solutions in energy conservation, product purity, and plant expenditure.

The goal of our design project is to optimize an ethane plant producing ethylene, acetic acid and vinyl acetate monomer.

Conversion of Natural Gas to Aromatics

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Approximately 14 million tons of benzene, toluene, and xylene (BTX) are produced annually by the United States petrochemical industry. These aromatics are traditionally produced from crude oil by catalytic naphtha reforming or by naphtha steam cracking. With the resurgence of domestic fracking, natural gas can be used as a cheaper feedstock than crude oil to produce BTX with modified zeolite catalysts. Our goal is to design an economical and environmentally friendly process converting natural gas to BTX with a higher fraction of para-xylene than conventionally produced aromatics.

Our design consists of a two-step reaction process. The first step uses a modified zeolite dehydrocyclization catalyst to convert methane in natural gas to benzene. The second step uses another zeolite catalyst to alkylate the benzene to toluene and mixed xylenes with a high selectivity toward para-xylene.

Benzene alkylation requires either methanol or syngas as a reactant. The reactant used in our process is determined by an economic analysis of importing methanol by pipeline versus producing syngas on-site. The rest of our process focuses on isolating valuable para-xylene, which is used in the polyethylene terephthalate (PET) value chain. The remaining BTX is separated into component streams and sold with the pure para-xylene.

A commodity chemical production facility, as commonly seen in the Port Arthur, Texas area. A facility designed for BTX production contains similar infrastructure as that seen above.

Multi-product Brewing

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Beer brewing is one of the largest industries in the world. Every day, breweries produce more than 100 million barrels a day of beer in various styles and flavors. It is important for beer companies to design their breweries to optimize efficiency and savings while minimizing environmental impact.

An example of typical brewing equipment used by breweries to produce beer.

Our team designed a large-scale microbrewery capable of 100 million barrels per year. The designed brewery should produce 5 year-round varieties of beer, including IPAs, stouts, pilsners, and lagers, in addition to 4 seasonal and 4 limited edition brews. The design is expected to maximize the recycling of waste products of the process with zero emissions. Our design is more environmentally friendly than the competition. In addition to designing the process, we decided whether to build a new brewery to make all the beers, contract out the production to an existing brewery, or use a combination of the two methods based on economic analysis. We expect our design to be economically optimal while still producing the required volumes of quality beer and meeting the other specified requirements.

Designing a Production Facility for a New Pegylated Fusion Protein to Combat Vision Loss

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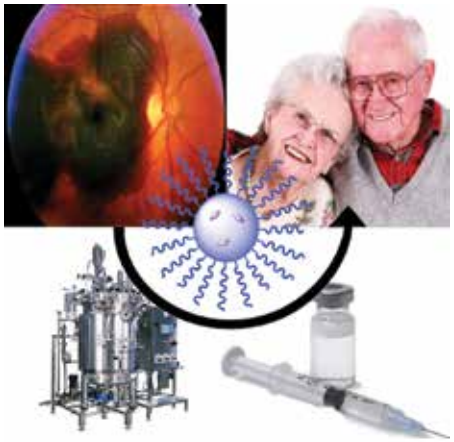
Chemical Engineering Design Advisory Board

Currently, more than 2.75 million people are affected by Wet Macular Degeneration (WMD) and Diabetic Macular Edema (DME) across the United States and Europe. These two diseases cause chronic vision loss due to leakage from blood vessels into the eye. The team's goal is to meet the demand of the U.S. and European markets for treatment of these diseases. We accomplished this goal by producing a new pegylated anti-VEGF protein that allows for fewer injection treatments and is longer acting than current products. The team designed the manufacturing process and production facility needed to produce the life-improving protein product on a commercial scale.



A manufacturing process for new pegylated monoclonal antibody. This antibody can be used in the treatment of multiple eye diseases.

For the facility design, a combination of traditional and disposable technologies were used to ease and expedite production. A balance between technologies was determined based upon capital costs, budget, and process efficacy. These technologies were applied across different process stages from vial thaw to purification. The manufacturing facility that was designed allows the company to deliver high quality product to the market and impact the level of care for WMD and DME patients globally.

Manufacturing of Lysine Ethyl Ester Triisocyanate for Automotive Clear Coats and Biomedical Materials

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Pranjal Gupta
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Lysine ethyl ester triisocyanate (LTI) has optical properties that can be used in automotive clear coats and resorbable capabilities that can be used in biomaterials. However, the original discontinued production pathway of LTI followed hazardous and expensive processes and materials. A new design offers a more environmentally friendly, cost-effective, and safe method to produce LTI with the decomposition of triphosgene to phosgene and production of lysine ester trihydrochloride salt from lysine hydrochloride and ethanolamine hydrochloride. This design achieves the target production of 1000 kg/year with a $60/kg LTI production cost, one-fifth the cost of the previous method. The raw materials can be purchased or manufactured on-site, so cost analysis determines which method is the most profitable for each raw material.

This design centers on the manufacturing of LTI through scaling a more cost-effective design. A more effective design will lead to a lower cost production of the chemical needed for bone grafts and automotive clear coats.

Visual Interface and Data Collection System for the ChBE Unit Operations Laboratory

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Iffat Alias

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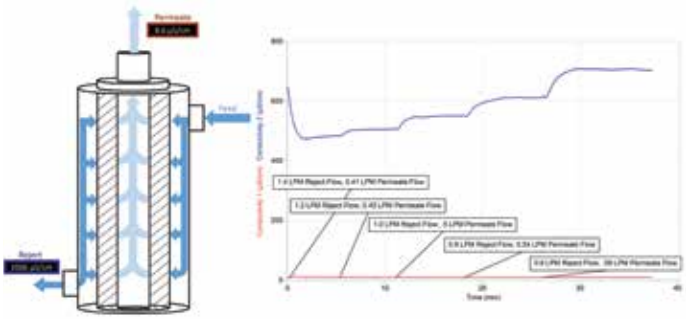
Vanderbilt's unit operations lab in the Department of Chemical and Biomolecular Engineering allows students to experience the systems that chemical engineers encounter regularly. Each system has a series of probes that must be continually monitored throughout the lab, yet no existing software relates the readings on these probes to a visual representation. This project connects the measurements from each of the laboratory unit systems to live and unique visual representations. The interface permits greater understanding of the labs while allowing instructors to monitor the progress of the experiments.



The interface created (example shown above) displays real-time updates of laboratory probe measurements and provides basic graphical interpretations for the users.

A range of connections will link the probes to their station computers. Once connected, LabVIEW programming will process the readings into a user friendly format displaying basic figures and current data on a system-specific diagram. The visual will be wirelessly transferred from the computer to the corresponding external monitor positioned above each station. Previous iterations of the project incorporated basic attempts at interacting LabVIEW with probe readings. Our efforts will complete the connection between these values and the user interface. The interface will provide a clear visual connection between the measurements being made and the system itself. Ideally, the process will be convenient and viable enough to be consistently incorporated in undergraduate labs each semester.

Design and Implementation of a Sensor Inventory System for Chemical Engineering Labs

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In 2013, a measurement lab component was incorporated into chemical engineering undergraduate labs, requiring student groups to design, conduct, and present individual lab experiments. These experiments are to be conducted throughout the course with sensor equipment provided by the School of Engineering's Department of Chemical and Biomolecular Engineering.

More than 100 students use these sensors each semester. However, no computerized inventory system is in place to manage the use of the 50 different sensors and interfaces. To keep track of these expensive pieces of equipment, the team designed a universally accessible, computerized inventory system that not only records the user, date, and location of each of the devices, but also displays the availability of equipment. The inventory system incorporates a series of scanners, the creation of barcodes for each piece of equipment, and the design of Excel software to optimize the sensor check out process. Ideally, the goal is to overlook the implementation of the designed inventory system in all 16 undergraduate lab groups and provide additional mentorship to the groups throughout the course.

Integration of an automated inventory tracking system for ChBE labs, connecting RFID technology to a spreadsheet, will greatly improve the efficiency and freedom of use of sensors in the lab.

Design Studio President Dominic Ghilardi (ME'18) readies a 3D printer for a project.

Steel Team 6: ASCE-AISC Student Steel Bridge Competition

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Kaitlyn Taylor
Megan Huntsinger
Philip Williamson
Zachary Taylor

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Rich Teising, Staff Engineer

SPONSOR:

American Society of Civil Engineers

The 1:10 model bridge weighs 285 pounds, spans 20 feet, and stands 5 feet tall.

The objective of the ASCE-AISC Student Steel Bridge Competition is to foster learning and innovation in engineering students by challenging them to apply their skills in a real-world situation. As part of this competition, a team of five civil engineering students designed, fabricated, and constructed a bridge capable of supporting 2,500 pounds. The team identified three priorities to guide design. These priorities—simplicity, efficiency, and aesthetics—led to a bridge design that included a three-dimensional lower truss system and an arched overhead truss. The result was a unique and inspiring bridge design. Through this project, students learned valuable skills such as MIG welding, and gained significant respect for safety, cost, material selection, fabrication, construction, and project management. These considerations can impact design severely but are not always addressed in the classroom. A winning bridge must excel in the areas of lightness, stiffness, deflection, and construction speed.

Steel Team 2: BYOB (Build Your Own Bridge)

TEAM MEMBERS:

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Charlie Gagne
Lorin Rogers
Jeremy Tucker
Kendale Johnson
Madison McMurray

ADVISER

Lori Troxel, Associate Professor of the Practice of Civil and Environmental Engineering
Rich Teising, Staff Engineer

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BYOB team members construct their bridge at the Vanderbilt mock ASCE Steel Bridge Competition held Feb. 20, 2016.

The goal was to create a steel bridge in accordance with the American Society of Civil Engineers guidelines with the hopes of competing in the regional competition this year. A major goal was to fabricate a bridge that could hold 2,500 pounds of loading. Given that time and money are concerns in every construction project, the bridge also was designed to be lightweight and easily constructed. The members of this team worked collaboratively to design and fabricate the bridge, utilizing a modular design for the truss sections spanning the bridge. The design is simplistic with the goal of allowing a short construction time and efficient fabrication process. After the first test loading, BYOB decided to modify the bridge and add an under-truss to strengthen the span of the bridge. While BYOB will not be the team representing Vanderbilt at the ASCE regional competition, the project has been worthwhile and has tested all members' project management and civil engineering skills.

Colorado Foothills Zero Energy Home at Sterling Ranch

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Tucker Kirven, CompE

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Eric Sheffer, LEED AP BD+C, Principal

Clark n, PE, CEM, LEED AP BD+C, BEMP, Building Performance Engineer

Dane Christensen, Senior Engineer/Engineering Manager, NREL

Bill Wood, Owner, Epic Homes

SPONSORS:

Sterling Ranch
Smith Seckman Reid, Inc.
National Renewable Energy Lab
Epic Homes
Vanderbilt University

A shortcoming of most home designs today is that they fail to account for their environmental impact and long-term energy costs. Our team is researching methods of producing a cost-effective, zero-energy alternative for the emerging energy-conscious homebuyers of Sterling Ranch, a sustainable development being constructed in Highlands Ranch, Colorado. Using cloud computing to run large-scale simulations in BEopt, an energy and cost optimization program developed by the National Renewable Energy Laboratory, our team analyzed multiple home designs to economically optimize the construction materials and appliances selected.

3D Revit rendering of the Colorado Foothills home design being analyzed for Sterling Ranch

A home obtains zero-energy status when its on-site energy consumption is balanced by an equal or greater amount of on-site renewable energy production. In order to best offset the house's energy demands, photovoltaic cells and other sustainable energy technologies were evaluated in consideration of Sterling Ranch's climate, geography, and available resources. The Colorado Foothills home is one of three floor plan designs being built by the homebuilder Epic Homes in Sterling Ranch's second filing next year. Our team's goal is to provide Epic with a zero energy home design that meets or exceeds the aforementioned criteria in a cost-effective and easily reproducible approach.

Gabbey Tate (left) and Tucker Kirven work in the Vanderbilt Motorsports lab.

Modern Prairie Zero Energy Home at Sterling Ranch

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Uendel Rocha
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Dane Christensen, Senior Engineer/Engineering Manager, NREL

Bill Wood, Owner, Epic Homes

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Revit rendering of Modern Prairie on site at Sterling Ranch

In the world of design, sustainability is an important factor that is breaching the walls of commercial development and making its way into residential developments, including the Sterling Ranch development. Sterling Ranch is a 12,000-home, 3,400-acre development located southwest of Denver, Colorado, that is emphasizing sustainability for its modern homes. The goal of the project team is to design a Zero Energy Home (ZEH) to be implemented within Sterling Ranch. A ZEH intersects energy efficiency and renewable energy generation in order to produce as much—or more—on-site energy as energy that is consumed by the home. Throughout the project, the team worked closely with Sterling Ranch, the National Renewable Energy Laboratory, and local engineering design firm Smith Seckman Reid, Inc. Initially, the team completed a preliminary energy analysis on the given home to understand the baseline energy usage and identify areas for improvement. During the rest of the year, the team set out to achieve both greater energy efficiency and energy generation through research and selection of optimal building materials, appliances, and solar panels to complete the Zero Energy Home Design.

Civil engineering majors Maia Alexander, Austin Channel and Kofi Christie (L-R) lab test wind shears and wind speeds from the blades.

Sterling Ranch Community Water Monitoring System

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Andrew Reed
Ben Cook, CompE

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Hiba Baroud, Assistant Professor of Civil and Environmental Engineering

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Beorn Courtney, P.E.

Thushara Gunda, Environmental Engineering Graduate Student

Rossane Delapp, Research Engineer

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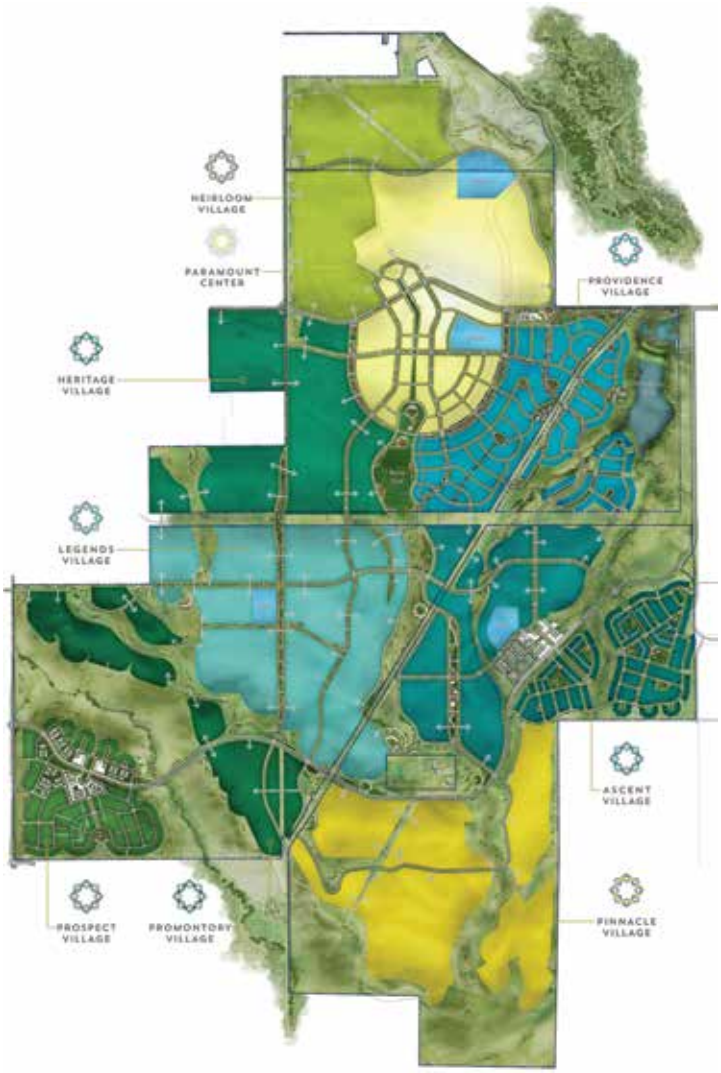
Due to water scarcity in Colorado, Sterling Ranch places high emphasis on sustainable water management practices to ensure that residents have long-term access to safe and affordable water resources while minimizing impacts to the environment. To assist Sterling Ranch in its efforts, the team's goal is to develop a water quality monitoring system and sampling and analysis plan to gather information throughout the site in order to support decisions regarding collection, storage, and reuse of harvested rainwater. Based on Sterling Ranch objectives, hydrologic analyses, and site plans, the team developed recommendations for key water quality monitoring points, monitoring equipment, a monitoring strategy, and corresponding cost estimates. ThThese items were included in a proposal package for Sterling Ranch. The team's recommendations were presented and a decision will be made regarding implementation of the team's work. The deliverables represent a cost-effective system developed through an iterative design and feedback process that provides data to support the sustainable efforts of the community through continued system modification. This system embodies the ideal of sustainability by meeting both the present and future needs of Sterling Ranch.

This shows the proposed water monitoring sampling locations and their relationship to the Sterling Ranch development and the Chatfield Watershed.



CIVIL & ENVIRONMENTAL ENGINEERING

Solar Powered Desalination with Capacitive Deionization (CDI)

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SPONSORS:

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COLORADO

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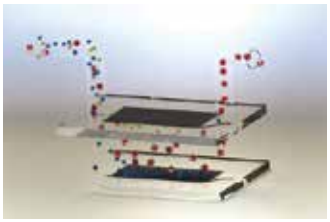
Access to safe drinking water remains a significant challenge to many communities, especially those with limited access to large-scale infrastructure of power and water supply. Furthermore, in some of these areas, the only possible water source left is brackish groundwater, which contains variably less saline than seawater. Existing water treatment technologies all have significant limitations when applied in small-scale and off-grid brackish groundwater desalination. For instance, reverse osmosis is more suitable for continuous operation, which poses a challenge using the intermittent solar energy, whereas distillation processes are inherently energy inefficient.



The device will desalinate a salt solution by attracting the ions in the water to oppositely charged electrodes.

The solution to this issue is the emerging desalination process known as Capacitive Deionization (CDI), which deionizes water by applying an electrical potential difference over a pair of porous carbon electrodes. During the process, anions (negatively charged ions) are removed from the water and stored in the positively polarized electrode; likewise, cations (positively charged ions) are stored in the negatively polarized electrode. Consequently, this has motivated our goal for the project which is to design and build a scalable, integrated solar-powered water desalination system using CDI as the core technology. Ultimately, the team would like to implement a pilot system in a relevant community in the U.S. or abroad for field testing.

Sterling Ranch Community Energy

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Sterling Ranch Development Company
Xcel Energy
Vanderbilt University

Sterling Ranch is a sustainable community currently under construction a few miles south of Denver. The community energy team is working to determine the amount of energy that can be generated at the Sterling Ranch development site by photovoltaic (PV) solar panels. The community energy team is utilizing a tool developed by the National Renewable Energy Laboratory named BEopt to generate models of the homes in the development. These models can be used to estimate the amount of energy the PV panels will generate as well as the amount of energy consumed by the home. This data will be used to determine time-of-day PV generation and analyzed to determine what house designs and orientations generate the most energy for the community. Additionally, consideration of a 2 megawatt solar farm will be included in analysis. The team will present a final recommendation to the Sterling Ranch Development Company to help them optimize the layout and development of future housing projects.

Photovoltaic (PV) Water Heating System

TEAM MEMBERS:

Nurnabilah Abu Hassan Sha'ari
Noor Aisyah Amran
Noor Liyana Baharin

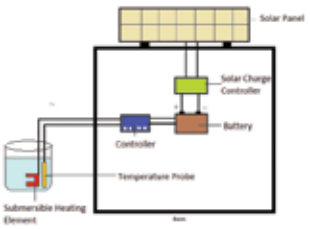
ADVISER

Ralph Bruce, Professor of Practice of Electrical Engineering

SPONSOR:

Amaroo Hills Emu Farm

Water freezes in sub-zero temperatures, thus threatening the water supply for the emu birds at Amaroo Hills Emu Farm. The current method used to counter this problem involves manually replacing the frozen water from the container with fresh water. The present method is less efficient and time-consuming. Therefore, our main purpose of this project is to design a system which utilizes solar energy to provide drinkable water for the birds. This system negates the manual labor required to replace the frozen water. By using renewable energy, we are able to create a system which is environmentally friendly and sustainable. The sunlight collected during the day will be stored in the battery, which will then provide power to the heating element at specific conditions. The system will be activated when the temperature falls below -2 degrees Celsius. Overall, the system provides an easy solution for farm owners to ensure a sufficient amount of drinkable water during extreme cold weather.



The overall system design for the PV-based heating

Autonomous Utility Robot

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SPONSOR:

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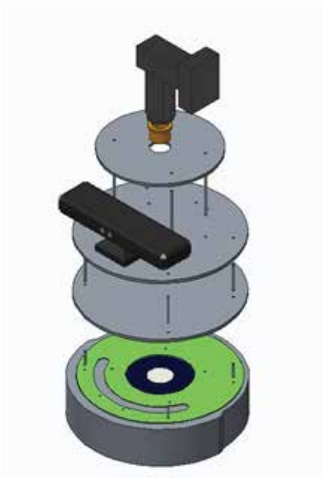
Traditional asset tracking systems require objects to be scanned manually or necessitate that specific infrastructure be in place before an asset's location can be ascertained. The Autonomous Utility Robot aims to solve this problem by automating the asset location process. To do this, the team developed a robot capable of driving around mapped surroundings and completing this tracking process without a need for human intervention. Operating in a well-defined space, the robot continuously navigates its environment, searching for assets. Once located in space, the robot updates the asset's location relative to its position on an internal world map. The end result is a user-faced map of the entire environment containing the location of every asset detected throughout the process.



Model of a constructed Autonomous Utility Robot

Navigation is achieved using a combination of internal odometry and simultaneous localization and mapping (SLAM). Once an initial map of the environment is generated, the asset location process begins. Tracking is achieved using a combination of radio-frequency identification (RFID) tags and an ultra-high frequency (UHF) receiver. All local processes are completed through Robot Operating System (ROS) on the onboard system on a chip (SoC) computer before being shared with the end-user through a web-based platform.

Android Application Security Analyzer

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SPONSOR:

Metova

Metova, the project sponsor, is a professional services company that develops mobile applications. Recently, Metova expanded into the government sector and thus needs to ensure security in the mobile applications it develops. Metova currently has an internal application that depicts the status of its various mobile applications. However, only two security tests exist in this internal application.

An illustration of the analyzer

The project is to build a web application that analyzes the security of mobile applications. Authorized users will be able to add Android applications for automated testing. The web application will provide robust reporting tools which will help engineers quickly identify the origin of security issues in the application. The team has been leveraging free, open-source software to implement portions of the project. Metova plans on integrating what the team develops with their own mobile application dashboard. This will provide a valuable service to Metova, since it will allow them to have a better way to test their mobile applications and only allow safe applications to get to the market.

Walk-all-Ova: Indoor Positioning System

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SPONSOR:

Metova

IPS workflow

We are Walk-all-Ova, the Metova Indoor Positioning System (IPS) team. The Metova IPS project serves to solve the complications that arise from being in an office: "Where is John Doe employee?" "How long has John Doe been gone today?" or even "I forgot to turn off notifications for my meeting." These problems are disparate, but they have a common solution. Tracking smartphones over time throughout the day will allow a company to know where their employees have been, for how long, and other exciting possibilities. The goal of this project is to track Bluetooth-capable phones through an office.

By placing Bluetooth-emitting beacons around the office, an individual's phone can tell a web-based application which beacons it is close to. This data is cross-referenced with a list of what beacons are where. The results are a searchable database of smartphone locations around the office. This is better than a word-of-mouth system, or any other employee-based system, because it is passive; there need not be any input from other employees.

ISDE Satellite Tracking and Communication

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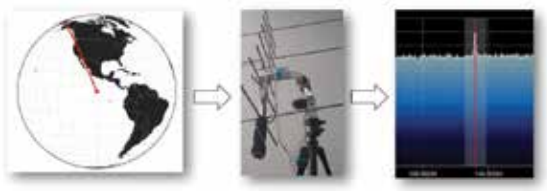
SPONSOR:

Institute for Space and Defense Electronics



An overview of project sub-systems

Just last fall, the Institute for Space and Defense Electronics (ISDE), in partnership with the Amateur Radio Satellite Corporation (AMSAT), launched a small satellite called a CubeSat containing experiments regarding radiation effects on electronics in space. ISDE has several other CubeSats scheduled for launch in the near future but currently has no ground station of their own for communicating or gathering data from their satellites in orbit. For now, the satellite data can be accessed through AMSAT's extensive network of amateur radio operators worldwide. Our project's objective is to design and build ISDE a low-cost, complete satellite tracking and communication system of their own, making use of a software defined radio (SDR) to handle the central signal processing.

To accomplish this, the team developed an application that tracks satellites in real time. These data are then fed to a mechanical rotation system, which points an antenna directly at the satellite as it passes across the horizon. Signals received from the antenna are processed and decoded using the SDR, and from there the results are sent to the web for further research and analysis. Ultimately, this system will be handed off to ISDE and will be instrumental in facilitating their growing CubeSat program and future research efforts.

Acoustic Pill Mass Sensor

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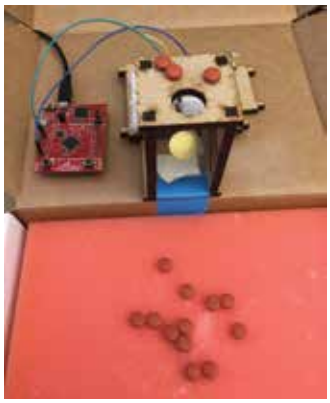
SPONSOR:

Quality Manufacturing Systems Inc.

QMSI

Automated mail-order pharmacies fill thousands of prescriptions every day, and it is crucial that they dispense the right pills in the right quantity for every patient they serve. Pharmacies have safeguards to ensure the correct medication is loaded into each dispenser, but contaminants or broken pills cannot be detected once the machines are filled. Our team is building a sensor to enable a new generation of pill-dispensing machines that will not only count at high speeds but also check that every pill is intact.

Our design bounces each pill on a glass plate, and it measures the energy as the plate vibrates using a piezoelectric microphone. Besides accurately counting pills, the sensor will alert the facility's operators if an object that is too heavy or too light passes through. This analysis runs in real-time on a low-power microcontroller, enabling dispensing rates exceeding three pills per second.



An early prototype of our sensor analyzes the sound that pills make as they drop onto a glass plate.

Vandy Van Bus Shelters

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SPONSOR:

Vanderbilt University Police Department

VANDERBILT UNIVERSITY

Vanderbilt provides a valuable service to its students in the form of the Vandy Van system, but it lacks shelters to protect its patrons in inclement weather. The Vandy Van Bus Shelter design is a protective, useful, and aesthetically appealing shelter that will enhance user experience by providing riders with services they did not previously have available to them. This design incorporates safety, utility, and seating through elements that are both sustainable and ergonomic in order to satisfy the needs of students. The proposed solution is based on Vanderbilt architecture and includes electronics and security features, such as live route information and an emergency phone, that are absent in most standard urban designs. The brick and limestone model provides a more substantial construction that will seamlessly blend with campus architecture and add another visually pleasing structure to the university. It is the hope that, upon installation, students will come to value this resource as essential, driving the construction of shelters campus-wide.

Digital rendering of the proposed bus shelter at the Branscomb stop location

OCRicket: Optical Character Recognition Service and Web Application

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Vanderbilt University School of Engineering

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VANDERBILT UNIVERSITY

{"response":{"language":"en","textAngle":0,"orientation":"Up","regions":[{"boundingBox":"9,95,255,72","lines":[{"boundingBox":"9,95,255,72","words":[{"boundingBox":"9,95,255,72","text":"OCR1cKe"}]}]}]}}

Results of the OCRicket system parsing an image of the handwritten word "OCRicket"

So often, end users of software are required to enter information themselves that is easily accessible from another source. Unfortunately, the data contained in these sources (images, sounds, videos) are incredibly difficult to parse, clean, and store as machine-readable information. The best optical character recognition (OCR) engines are normally reserved for scientific research and are not available to the masses. OCRicket aims to fix this issue and help even the amateur developer build smarter apps through OCR. OCRicket is a service that allows users to submit images (via a url), which it analyzes, pulls out text in the image, and returns a data structure containing that text. OCRicket is a multi-layer web application exposing a RESTful API with publicly accessible routes allowing a user to "textify" their preferred images. To power the image-to-text conversion capability of the API, OCRicket utilizes Microsoft's Beta version Project Oxford, providing Artificial Intelligences as a service. Recent tests of OCRicket have revealed proper operation of the API and impressive parsing results from Microsoft's OCR service. Future implementations of this software could include features such as tiered-usage plans, personalized OCRicket profiles, and social sharing options.

Locale

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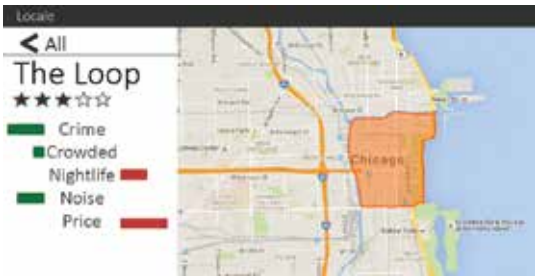
When moving to a large city, it is often difficult to find a community that matches your personality and budget. Locale aggregates data collected by municipalities, allowing users to easily compare communities. First, users answer simple questions to gauge their tolerance for crime, noise, nightlife, and several other metrics. Locale then uses these preferences to rank communities relative to the city average and displays the results on an interactive map.



This is a proposal for the final user interface. Here, the user has selected a community that matches three out of five criteria. The colored bars indicate which criteria match and how much each differs from the city average.

Publicly available data is retrieved from city databases, Google Places, and Trulia. This data is then normalized and stored for quick lookup. No existing solution combines data from multiple sources or allows users to easily compare multiple communities. Once completed, users will be able to quickly find a compatible community, which will dramatically narrow their housing search.

SurveyGen: A Versatile, Intuitive and Secure Survey Application for Research Scientists

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Surveys are critical data collection tools for sociologists, psychologists, and biologists. They allow research scientists to gather self-reported and automatically reported data from large samples of targeted individuals over an extended period. SurveyGen provides scientists with a streamlined but still privacy-conscious means of creating and disseminating intuitive surveys for mobile devices.

Screen shots of surveys

Most currently available survey generators do not support collection of nonstandard data types. They also do not offer easy-to-use interfaces for survey managers and survey participants. The few survey generators that do advertise these features fail to provide intuitive, dynamic mobile interfaces. SurveyGen avoids these pitfalls by supporting the collection of geolocation data and periodic data, offering convenient user interfaces for both managers and participants, and by using stringent security protocols that meet the standards of research scientists. These improvements increase the incisiveness of surveys and lower the barrier to survey creation and participation, all while maintaining compliance with academic standards.

Clique: A Democratic Approach to Creating Playlists

ELECTRICAL ENGINEERING & COMPUTER SCIENCE

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At house parties across college campuses, the choice of music is usually decided by the party host. This system will almost certainly fail to satisfy the people going to the party. The phone application Clique will try to solve this problem by making the playlist-building process dynamic and democratic.

A screen shot of Clique

When using this application, one user will have "master" status to the playlist. The master user will set a password for the playlist. Anyone wishing to connect to the playlist must know this password to participate. Once someone has input the password to the playlist, they will be able to vote for any song that is local on the phone. All participants will be available to vote for which song should be played next. If the song is not a local file, participants can also suggest a song from YouTube. The app will use a node.js express backend using mongoDB as a database and will be implemented on Android and iOS. Other applications usually use platforms such as Spotify to create playlists like this. Not everyone has these platforms. Our application is more accessible and flexible through the use of YouTube.

Pixel Perfect Recreation of Maze War

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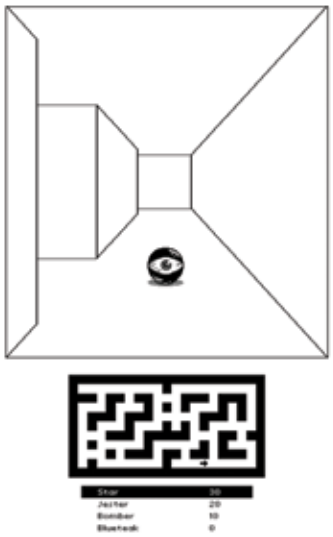
Maze War was the first First Person Shooter (FPS) game ever created and a fundamental piece of software that paved the way for many of today's modern games. The goal for this project was to recreate the 1977 version of Maze War for the Xerox Alto with pixel-perfect accuracy so that current and future generations can experience this key part of software and videogame history.

This project integrated outdated visual technologies such as one-point-perspective 3D rendering with current artificial intelligence, rendering, and network systems. Most of the work to recreate this game was dedicated to finding and implementing reference materials. Fonts, user interface layouts, and perspective points had to be carefully measured and recreated to achieve a pixel-perfect replica. Additionally, care was taken to ensure that any additional features added did not affect the visual aesthetic or gameplay of the original. The final product's source code is openly available on GitHub and can be run natively on Windows and OSX, or through a web browser using WebGL.



Final gameplay UI for Maze War

Hanseatic: A Model-Integrated Gaming Framework

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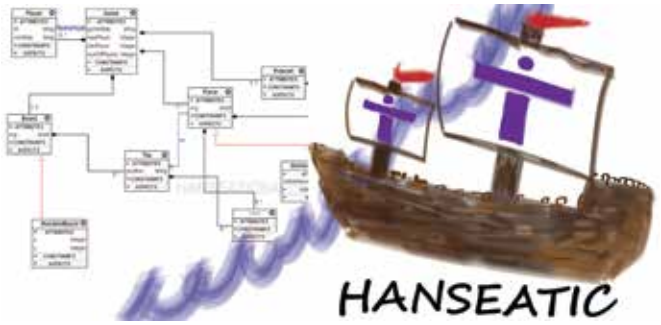
Tabletop games contain a limitless variety of functional elements. Players of these types of games interact with dice, cards, pieces, rules, and win conditions in both cooperative and competitive contexts. By applying the principles of Model-Integrated Computing, a high-level programming paradigm that provides a simple framework for the auto-generation of code from generic models, our team has created a framework called Hanseatic for modeling tabletop games. The end goal of our project is to create a flexible web platform whereby players can both play classic tabletop games as well as innovatively create, share, and test new games within an online community.



Hanseatic League, the future of game design

Hanseatic is completely model-driven. The WebGME engine that backs the project captures individual game elements and their associated functionality as a state machine. Hanseatic unites back-end scripts written in JavaScript with a graphical user interface generated using the react.js framework. By applying a model-based approach to tabletop game design, Hanseatic allows players to combine elements of familiar games without confronting the entry barriers typically associated with online game development. We believe that this tool will revolutionize the way that new games are created.

Arena–Sports Pick'em App

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Screenshots from the Arena app from left to right: Splash screen, Game Feed, The Arena, Player Profile, and Leaderboard

There are currently no pick'em leagues that offer all sports in one interface with the option of challenging individual friends. Current pick'em leagues have limited functionalities and are not optimized for mobile. Arena provides a simple, clean, and quick way to predict winners of sports games. Arena also allows users to see how they stack up against themselves, their friends, and users worldwide. The app is split into four main sections: the Gamefeed, the Arena, the Leaderboard, and the Player Profile. These four sections are dedicated to game selection, league creation, ranking, and displaying user performance. Users can either challenge their friends in a League or a Callout. A League is a private group of users that are assigned selected games to pick. The user who selected the most number of games correct is deemed the winner. A Callout is the same as a league except it is a one-on-one matchup. The goal of this project is to gain experience doing the front- and back-end development of an app and to release a polished app to the App Store.

ELECTRICAL ENGINEERING & COMPUTER SCIENCE

Android Automation

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The Android icon

Many college students always have their eyes glued to their phones. This can cause a plethora of issues, whether it be with safety, loss of human interaction, or even loneliness. Why do we spend so much time on our phones? Because there are some things that we can only do on our phones, such as texting, alarms, etc. To combat these issues, this application provides an innovative and more efficient way to interact with your Android phone. Need to send a text, but you are on your computer and your phone is in the other room? How about setting an alarm on your phone from your computer? This application is designed to extend the usage of your Android phone onto your computer. Users are able to schedule texts, alarms, events, and perform other tasks, all from a web-based interface on a computer. This simple concept profoundly extends your control of your Android device and its capabilities without the need for "root" or a special home screen. By providing this web-based scheduling interface, users are able to increase efficiency, interact with their phones from their computers, and have some time away from their phones.

Social Application–esc

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This design project focuses on building a social application for the iPhone to connect students during their free time. It lets other users know whenever there is a break in a friend's schedule for a quick meet up, to grab a bite to eat, or connects with other students in your classes to form a study group. There will be three categories users can express availability in: eat, study, and chill. The application will also be able to specify the duration of their availability, as well as the option to set the user's profile so that availability will be sent only to those they follow and have been added to their friends list. If the location service is turned on, the app can automatically let friends know where the user currently is, otherwise the app will require users to specify their location so others can locate them easily. If the private feature has been turned off, the user can connect with strangers who have also signed up for the app. Users will be limited to the college campus community to encourage safe meet ups.

The picture represents the three choices that the user can make: eat, study, or chill. Once the user presses one of the buttons, the duration and location of availability will need to be specified.

Experimental Scheme-Based Programming Language

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This variant of the scheme programming language is intended to address the tradeoff between ease of development and semantic verification as well as the difficulty in facilitating code reuse. This programming language is an attempt to unify the strengths of languages that check the semantics of a program before execution with the strengths of languages that check semantic validity of an operation as it is performed. This compromise is achieved by allowing, but not requiring, semantic meaning to be checked before a program is executed. This approach allows the programmer to quickly create a prototype and then lock down meaning once the benefits of having strongly-enforced interfaces outweigh the benefits of being able to very rapidly write code.

Proposed logo

To aid in allowing code to be reused, this language is designed such that programmers are encouraged to decompose algorithms into small functions that may then be used generically without tying an algorithm directly to the representation of the aggregate data on which it operates.

Predicting the Price of Magic: The Gathering Cards Using Machine Learning

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A subset of predicted prices vs. actual prices is the result we hope to achieve.

As Magic: The Gathering becomes more and more popular, many players have been spending a large amount of money on buying the cards. Some even buy cards and re-sell them as a way to profit. Despite the growing market, no one has yet published anything about price prediction of the cards. In addition, the traditional method on predicting stock prices or other prices of products may not be applicable here. Thus we plan to use various tools of machine learning techniques such as neural network, SVR, and decision tree to predict prices based on the various features of cards like power, magic cost, etc. We are going to collect our price data from eBay, as well as websites like mtgprice.com. We hope to get our predicted prices to be within a 20 percent error range of the actual prices after trying different algorithms.

Predicting eBay Auction Prices

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eBay auctions allow one or many parties to place bids on items being sold by a single user. An intrinsic question of this model is whether or not the final prices accurately reflect the items' retail value and what factors might contribute to the inflation or deflation of the final auction price. The auction environment provides a unique set of potential learning features, as it is conjectured that final selling price will be a function of both the item's intrinsic value as well as the variable attributes of the auction itself. Using the predictive information, both buyer and seller strategies can be improved. The prospective ending price for an auction can inform the bidding behavior of interested parties, especially in cases where the item is predicted to sell at a price that is higher than its intrinsic value. Similarly, if an item is projected to sell at a loss, or to not gather any bids, the seller can restructure auction attributes or gravitate toward auctioning more popular items. Finally, the group bidding behavior that results in an item being sold with higher profit margins can further explain what attributes of an object may increase its perceived value, such as uniqueness or collective interest.

Learning Mutation From Nanopore Currents

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DNA can be damaged in a variety of ways, including methylation and UV dimerization. Quickly and reliably quantifying the amount and type of DNA damage in a sequence opens the door for greater insights into causes of DNA damage and their relative effects. Currently, recognition of DNA damage with nanopores has been limited to a simple approach of applying a chemical tag and detecting whether the nanopore current breaches a given threshold value. Our lab is investigating whether a more complex machine learning approach using a Hidden Markov Model or other related construct would allow for reliably detecting multiple types of damage without extensive preprocessing. Nanopore devices read DNA sequences five bases at a time and produce a recognizable current spike on each type of 5-mer. We would attempt to classify whether the current spike deviates significantly from a recognizable spike for all known types of 5-mers.

We are seeking to reliably detect multiple types of DNA damage without extensive preprocessing.

Sentence-Level Sentiment Analysis of Reviews Using Topic Modeling for Clustering

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Our project is the binary sentiment classification of sentences, where a classifier determines whether a sentence has positive or negative sentiment. There are numerous reasons someone might want to analyze sentiment. For example, sentiment analysis can be very useful in understanding reviews on sites like IMDB, Amazon, and Yelp. By understanding the overarching sentiment in reviews, these sites can provide an aggregate of people's feelings toward a particular movie, product, or business. Sentiment analysis is a much-studied problem with many proposed techniques. In this work, we test a variety of methods for sampling from training data to build a general classifier that performs well when the original sentence source (i.e. IMDB, Amazon, or Yelp) is unknown. The data consist of a total of 3,000 sentences, each labeled 1 (positive) or 0 (negative) originating from IMDB, Amazon, and Yelp reviews.

Sentiment analysis allows us to quickly extract the feelings people express in text without needing to read everything they have written.

Project Premonition Unmanned Aerial Vehicle

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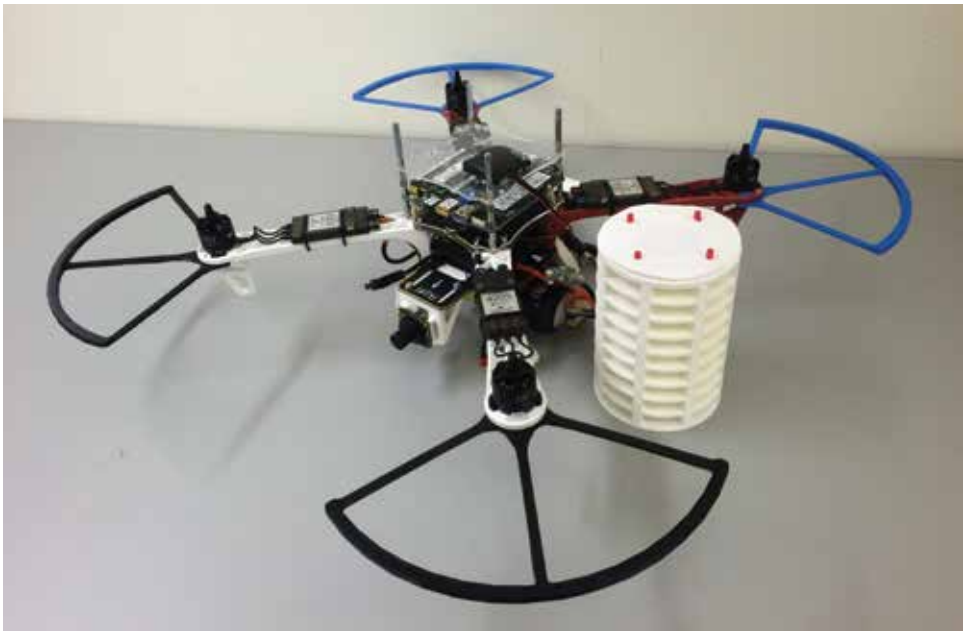
SPONSOR:

National Science Foundation



A quad-rotor unmanned aerial vehicle

This project is modifying an existing quad-rotor unmanned aerial vehicle (UAV) to address the challenge of distributing and collecting a specially designed mosquito trap as part of Microsoft's Project Premonition to detect infectious diseases and a National Science Foundation Cyber-Physical Systems research grant. Four sub-teams are focused on sensing the trap's location in the environment, picking up and putting down the trap at specified locations, autonomous flying, and simulating various missions, including deploying multiple UAVs and traps simultaneously. This interdisciplinary class requires hands-on effort towards successfully competing in a competition based on Project Premonition. The ability to fly with, pick up and put down the trap requires knowing the UAV's approximate location based upon an a priori map and on-board sensing. The UAV must sense the trap's position in order for the UAV to position itself properly to manipulate the trap, which can be impacted by wind, sensor errors, miscalculations, and hardware failures. Team members designed a mechanism to manipulate the trap and worked with other sub-teams to ensure that the mechanism will not impede sensing the environment and trap or the UAV's ability to fly.

Redesign of Carlex Blade Dispensing System

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ADVISERS:

Joseph Thatcher, Engineering Manager

Daniel Pfeffer, Project Engineer

SPONSOR:

Carlex Glass Company

Redesigned blade dispenser and blade cartridge

This project seeks to redesign a blade dispensing system in a large manufacturing environment in order to decrease system errors and wasted materials. Windshields are created by heat-treating two pieces of glass with a layer of vinyl between them. At Carlex Glass Company, the resultant vinyl edge is trimmed using razor blade-wielding robotic arms. The mechanism by which blades are delivered to the arms has caused ongoing and costly failures resulting from three factors: positional inaccuracy of the dispensed blade, dispensation of multiple blades at once, and magnetism or residue applied to the blade.

Our design addresses these issues while also allowing blades to be loaded into the dispenser without pausing the production line. This design employs rotating arms and an actuator to carry cartridges of blades into position within the production cage. A solenoid ensures positional accuracy by locking the arm in place as it moves into the path of dispensation. The plunging solenoid then pushes a blade through an aperture toleranced to the width of a single blade. An array of sensors, integrated with the mechanical control of the dispensing system, signals the solenoid to dispense another blade or move the next cartridge into position when necessary.

CubeSat Solar Panel Deployment System

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Patrick Hull, Structural and Mechanical Design, Technical Assistant

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School of Engineering

Depiction of CubeSat system with solar panels fully deployed

CubeSats are miniaturized satellites typically designed for use in experimental research. Because of their relatively low cost and complexity, CubeSats offer a popular alternative to conventional satellites for extraterrestrial research. Recently, increasingly ambitious research goals have raised the demands placed on CubeSat's onboard power systems. For instance, the CubeSat which served as the inspiration for this project, NASA's NEA Scout, has especially high power requirements so that it can perform reconnaissance on a near-Earth asteroid. To generate power, CubeSats rely on high efficiency solar panels. Since power generation is directly proportional to the total solar panel working area, increasing power requirements have led to ever-increasing area requirements.

The objective of this project is to develop the first off-the-shelf solution for a large-area, remotely deployable CubeSat solar array. The design can be divided into two main subsystems: the securement system and deployment system. The securement system consists of a synthetic tie-down cable which is released with a nickel-chromium thermal knife, while the deployment system uses two servo-motors which engage a nested cylindrical driving mechanism to fan out six solar panels - one set of three from each of two corners. The advantages of such a system over existing deployment mechanisms include: high area-to-volume ratio, no reliance on bulky hinges, compatibility with off-the-shelf electronics, and modularity.

Exhaust Gas Recovery Device

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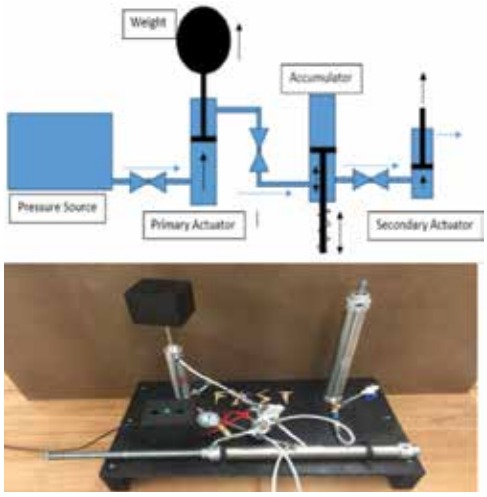
ADVISER:

Robert Ridley, North American Production Engineer

SPONSOR:

DENSO Manufacturing Tennessee Inc.

DENSO uses compressed air to power pneumatic cylinders that are fired back and forth to cut, bend, and move automotive parts. Each time compressed air fires the cylinder in one direction, the leftover compressed air from the previous firing in the other direction is exhausted into the plant. When this compressed air, which still has the capability to do work, is exhausted, money is lost. DENSO's goal for us is to create an economically viable way to reuse the energy in that air, and propose practical scenarios for implementation.



Schematic diagram (top) and system setup (bottom) of Strain Energy Accumulator

In order to accomplish this objective, we implemented a "Strain Energy Accumulator," which stores the exhausted air in a spring/pneumatic cylinder device. This device holds the energy until it can be used to fire another cylinder. The accumulator is electronically programmed to release its accumulated energy in between the timed cycles of the DENSO machines to prevent delays. This system could result in significant cost savings for DENSO if calibrated appropriately to the cylinder it collects exhaust from and the cylinder it fires.

Optical Inspection System for Magnetic Float

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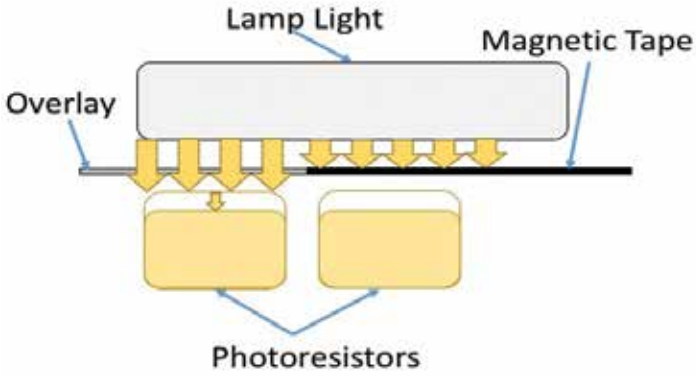
SPONSOR:

Fiserv

Fiserv is a global financial services technology company that manufactures credit, debit, and other types of cards in Nashville. Magnetic float, the misalignment of magnetic stripes, is a common and costly manufacturing process error when making these cards. The goal of the project is to create a system to determine if the magnetic float occurs during a specific step of the manufacturing process. Our team's solution uses a system of light and photoresistors to ensure that the magnetic stripes are in the correct place. If magnetic float is present, the system alerts operators that magnetic float is occurring so the manufacturing process can be stopped. Previously, Fiserv did not have a solution to inspect this part of the manufacturing process. Our team anticipates that the solution will identify where magnetic float occurs during the manufacturing process and aid Fiserv in reducing instances of magnetic float.



An aligned magnetic stripe and a single set of light and photoresistors

Automated Fender Manipulation

TEAM MEMBERS:

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Beau Kyster

ADVISER:

Jason Mitchell, Research Assistant Professor of Mechanical Engineering

SPONSOR:

H.E. Parmer Company

Fender flipper prototype

H.E. Parmer is a metal fabrication company that has been operating in Nashville since 1889. The company manufactures high quality metal parts, as well as custom metal parts. Currently, steel sheet metal used for several different trailer fenders is cut by a die machine, creating a burr on the top-side. The metal blank must then be manually flipped so that the burr is on the bottom of the blank for safety reasons. Our design team was tasked with automating the flipping process. The team engineered a solution that uses an adjustable angled conveyor and a flipping bar. The metal blank travels over the angled conveyor and rolls out onto the flipping bar. The blank begins to flip and falls onto the second conveyor, which completes the flip. The conveyor is adjustable so that it can flip multiple sized blanks. This solution frees an employee to work on more productive tasks and increases the speed of the assembly line. The team utilized a spare conveyor at H.E. Parmer, and with their help converted it into an adjustable angled conveyor. After additional evaluation at Vanderbilt to ensure the safety and precision of the conveyor, it will be installed on site.

Mobile C-Arm Robotic Platform

TEAM MEMBERS:

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Professor of Urologic Surgery

SPONSOR:

Vanderbilt Institute in Surgery and Engineering

C-Arm on an automated platform

C-arms are medical devices used for intra-operative imaging. Currently, two types of C-arms are employed: stationary C-arms and mobile C-arms. Stationary C-arms require a dedicated operating room, but allow for direct position control by the surgeon. Mobile C-arms can be easily moved throughout the hospital, but they are passive and require a technician for intra-operative positioning. The goal of this project is to provide a robotic platform that can support the weight of a C-arm and give direct position control of the C-arm to the surgeon.

The core element of the robotic platform is a mecanum drive, consisting of four independently driven mecanum wheels. A mecanum wheel is a type of wheel with passive, angled rollers attached along its circumference. By using four of these wheels with independent speed and direction controls, the platform can be driven in any direction without turning. The robotic platform also features positional memory, which is useful in surgeries that require frequent motion between specific positions. Ultimately, this system improves the surgeon's control of a mobile C-arm and could reduce or eliminate the need for a technician.

MRI Tactile Stimulation Device

TEAM MEMBERS:

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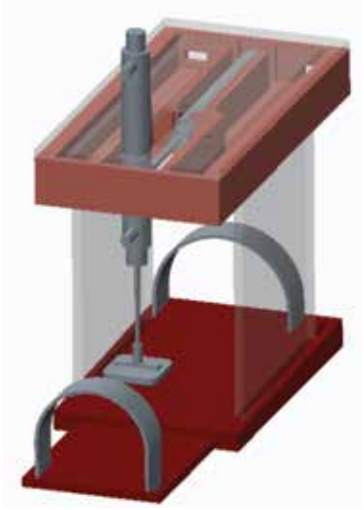
SPONSOR:

Vanderbilt Kennedy Center

VANDERBILT KENNEDY CENTER for Research on Human Development

The team was tasked with creating an MRI-compatible device that applies tactile stimulation to a section of a subject's arm. The purpose to provide the Vanderbilt Kennedy Center with the ability to analyze neural response to the stimulus in order to reliably identify the earliest risk markers in Autism Spectrum Disorder (ASD). ASD is not yet able to be reliably diagnosed in time for preventative treatment. Recent research has shown that the tactile response of infants can provide important information regarding sensory trajectories that can be extremely useful in identifying ASD. This design solution uses pneumatic cylinders powered by a compressed air system to stroke the subject's arm linearly in one direction in order to safely mimic affective touch. Currently, this is done manually with little precision and an inability to accurately monitor brain activity. It is anticipated that this device will aid in the progression of ASD research.



3-D model of Tactile Stimulation Device

NASA Additive Manufacturing Project

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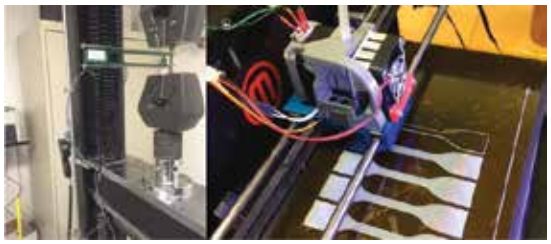
SPONSOR:

NASA Marshall Space Flight Center

NASA



The printing process and test procedure.

A 3-D printer was installed in the International Space Station in late 2014, creating a cost-effective and versatile method of solving problems for the astronauts. Using additive manufacturing, a variety of tools can be produced. However, before solid tools can be utilized in space, proper material testing of the 3-D printed ABS plastic must be conducted. Materials testing as well as the design of 3-D printed tools are 3D0G's (3-Dimension in Zero Gravity) project goals. We are performing load frame and instrumentation tests to accurately characterize the material printed with various 3-D printer settings. These settings include infill percentage, infill shape, layer height, and angle offset. Using the experimental data, analysis can be performed on Stress-Strain curves to calculate necessary properties. The team has created a database of these material properties that can be referred to for more precise design for in-space printing solutions. Using the experimental material properties, 3DOG is able to perform finite element analysis on the designed CAD tools. FEA allows for the optimization of the designs by minimizing material, and improving strength and reliability through stress and strain analysis.

Nashville *Citizen*

TEAM MEMBERS:

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Anne-Leslie Owens, Public Art Project Coordinator

SPONSOR:

Public Art Program, Nashville Metro Arts

Citizen is an art installation of two statues in downtown Nashville. The statues are intended to be dynamic, interactive pieces. A large wheel at the base allows passersby to rotate the pointing figure at the top. However, the mechanical system that allows these statues to rotate is non-functioning, in addition to requiring excessive maintenance. The statue is suffering from issues of overloading stemming from weak components, public misuse, and a higher frictional load than the components can handle. Any proposed solution must maintain the artistic integrity of the pieces while addressing both financial and feasibility concerns.

The male Nashville *Citizen*

For a prototype, the team has constructed an approximately one-third scale model of the statue with similar mechanical components in order to replicate both the physical constraints that a real-world solution will need to overcome as well as test for the impact of adding components. The final solution to Metro Arts is a tiered repair plan, consisting of recommendations ranging from "quick fixes" (torque limiter, smaller wheel) to a complete repair of the internal mechanism (replacing bearings, shaft, sprockets, and chain).

Nissan Karakuri Engine Kit Cart

TEAM MEMBERS:

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Wan Mohamad Zakari
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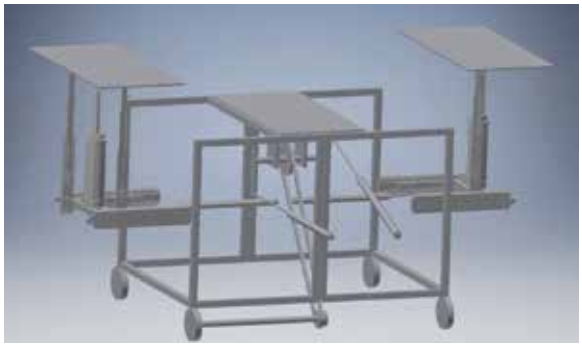
Mark Larson
Stuart Smith
Joel Wotruba
Dustin Nichols
David Blaylock
John Tian

SPONSOR:

Nissan North America

The Nissan Karakuri Team is working with engineers from Nissan's Smyrna, Tenn., manufacturing plant to redesign an engine kit cart. Currently, engine components sit on a 30-inch high cart with an engine suspended above the cart. To improve the assembly process from an ergonomic standpoint, the parts will be raised 6 inches. Because the cart is on an assembly line, the solution must require very little maintenance and not interfere with existing assembly methods. In addition, the cart must be designed with Karakuri principles, meaning that it must be a zero-impact solution. The cart cannot use any of the plant's electricity, compressed air or hydraulics.



Engine kit cart illustration

Our solution is to generate air pressure using the motion of the cart throughout the factory. Using a drive wheel, chain and sprocket, rotating arms and air pumps, the cart generates compressed air from motion. When parts are needed by a technician, a switch is flipped and pneumatic cylinders on the cart actuate using the stored air and move the trays of parts 12 inches horizontally, to avoid the engine, and 6 inches vertically, to make them more accessible. Once the assembly process is complete, the technicians toggle the switch to return the platforms.

SAE Baja Off-Road Vehicle

TEAM MEMBERS:

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ADVISER:

Phil Davis, Engineer,
Vanderbilt School of Engineering

SPONSOR:

Vanderbilt University

2016 VU Motorsports Baja SAE off-road vehicle

The Society of Automotive Engineers hosts a yearly competition challenging collegiate teams to design and fabricate a vehicle capable of traversing rugged terrain. The Vanderbilt Motorsports team has designed, fabricated, and tested a vehicle to compete in the SAE Baja design series. The team designed the vehicle to be low cost, lightweight, safe, durable, easily serviceable, and ergonomically accommodating to drivers of various size. Innovative solutions and high manufacturing standards optimized vehicle dynamics while remaining compliant with the extensive competition rule guide. These solutions began with a TIG welded 4130 Chromoly steel chassis and a lightweight fiberglass/carbon fiber composite seat. The drivetrain utilized a CVT to ensure maximum performance from the required Briggs & Stratton engine. The braking system was constructed with dual vertically-mounted master cylinders, a single inboard rear brake, as well as custom wave rotors. The suspension employs progressive air shocks, independent double A-arms, and rack and pinion steering in order to allow 10 inches of vertical travel, minimal bump steer, and a 7-foot turning radius. Optimized vehicle dynamics combined with driver experience and training increase of points awarded through a series of both static as well as dynamic events at competition.

Electromechanical Paper Ejection Mechanism

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Ahmad Luqman Asmat Nizam

ADVISER:

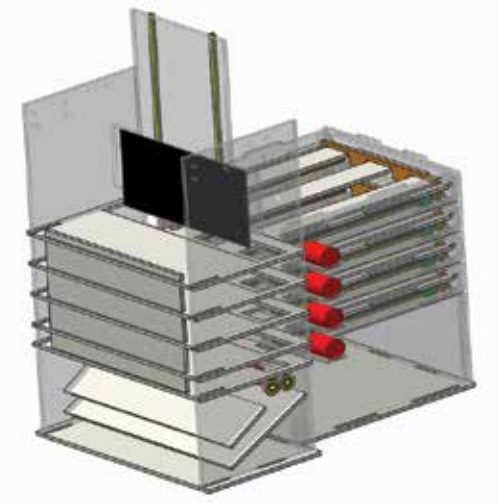
Lie Tang, Ph.D, Control Specialist

SPONSOR:

Quality Manufacturing Systems, Inc.

QMSI designs automated pharmacies whose main purpose is to process labels and package pill bottles with prescription information to send to customers. Currently, the medical paper packets are ejected from a collator and manually folded and placed into a package with a patient's prescription. In order to avoid misplacement of medical information documents that violate a patient's privacy rights, the process of ejecting and folding these documents must be automated.

In this solution, an operator presses a button that triggers the ejection of a specific tray. A horizontal rack and pinion setup will slide paper from the called collator tray onto the folding platform. A dull metal blade attached to a vertical rack and pinion pushes the paper at its midline through a set of spinning rollers below the folding platform. The rollers crease the paper and eject it through a chute to be packaged. By harnessing an automated mechanism, the possibility of an operator wrongfully placing one's medical information into another patient's packaging is minimized.



Automated ejection and folding mechanism

Suborbital Rocket with Monopropellant Hydrogen Peroxide Thruster

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Justin Broughton
David Hirsch
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Andrew Martin
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Amrutur Anilkumar,
Professor of the Practice of
Mechanical Engineering

SPONSOR:

NASA Marshall Space
Flight Center

Full-scale rocket with open payload window before launch

Rockets designed for spaceflight require thrusting capabilities for attitude control, liquid fuel management under varying g conditions, and structural analysis for insuring structural integrity and minimizing weight where available. This year's Student Launch team takes on all of these challenges by designing, building, testing, and launching a fully reusable rocket to a mile above ground. The rocket payloads include a "green" monopropellant hydrogen peroxide thruster, a slosh abatement system that provides a continuous source of fuel to the thruster, and a suite of accelerometers to provide vibrational data for structural analysis. In addition, the rocket sees up to 12gs of acceleration, necessitating a carbon fiber body.

Extensive results from testing the rocket and its payloads verified the design functionality for each of the aforementioned payloads. The H_2O_2 thruster was verified as an excellent "green" alternative to standard attitude control methods with up to 10N of thrust after a minimal 190ms startup time. The slosh abatement system extracted 75% of the fuel in a worst-case -1g condition. The structural analysis payload used ground based tap tests and in-flight data to correlate a finite element model within a 4% error for the first and second bending modes, demonstrating the high fidelity of the model and ensuring a satisfactory factor of safety. The work done for this year's rocket has required tremendous team cohesiveness and attention to detail to ensure mission success.

Improvements on a Paper Product Packaging Process

TEAM MEMBERS:

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Wan Sabri
Tengku Hafifie
Muhammad Nabil Aiman

ADVISERS:

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Finishing Manager,
Lebanon Folding

Blake Oakley,
Forming Department Manager

SPONSOR:

WestRock

The team tests a prototype at the WestRock facility.

The finishing department of WestRock in Lebanon, Tenn., produces paperboard six-fold food trays for a variety of companies such as Church's Chicken and Dunkin' Donuts.

Currently, WestRock uses Jagenberg packing machines to collect finished paper goods from the gluer machine and package them into cases. However, the Jagenberg packer cannot be used to package six-fold trays because the thickness of the trays causes them to collide when fed sequentially into the case. Instead, an operator manually collects the trays from the production line and packs them into the cases.

Our team has designed a solution that allows six-fold trays to be packed into boxes in a semi-automatic fashion, dropping all of the trays into a case at the same time instead of packing them sequentially. The design solution is expected to work for a variety of tray sizes. WestRock will be able to pack at the same speed with half as many operators, and our solution improves ergonomics for an operator, which can reduce the risk of back injury.

A record number of design projects and relocation to the university's Student Life Center ballroom drew a crowd of 400 visitors for the School of Engineering's annual Design Day in April.

DESIGN AND PROJECT FACULTY

We take great pride in recognizing these faculty members who are the core of our design program. Their outstanding contributions and excellence as instructors, advisers, and mentors in our senior design and project courses have led to the work exhibited at Design Day 2016 and have transformed our Class of 2016 into young professionals.

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RALPH BRUCE
Professor of the Practice of Electrical Engineering

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Professor of the Practice of Chemical and Biomolecular Engineering

SANJIV GOKHALE
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THOMAS WITHROW
Assistant Professor of the Practice of Mechanical Engineering

VANDERBILT
School of Engineering

The Build Your Own Bridge team members are (L–R) Jeremy Tucker, Colin Tait, Kendale Johnson, Charlie Gagne, Lorin Rogers and Madison McMurray. Learn more about their ACSE steel bridge project on page 34.

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For additional information about Vanderbilt University School of Engineering or Design Day, visit engineering.vanderbilt.edu. Vanderbilt University School of Engineering's design projects catalog is published annually in the spring.

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