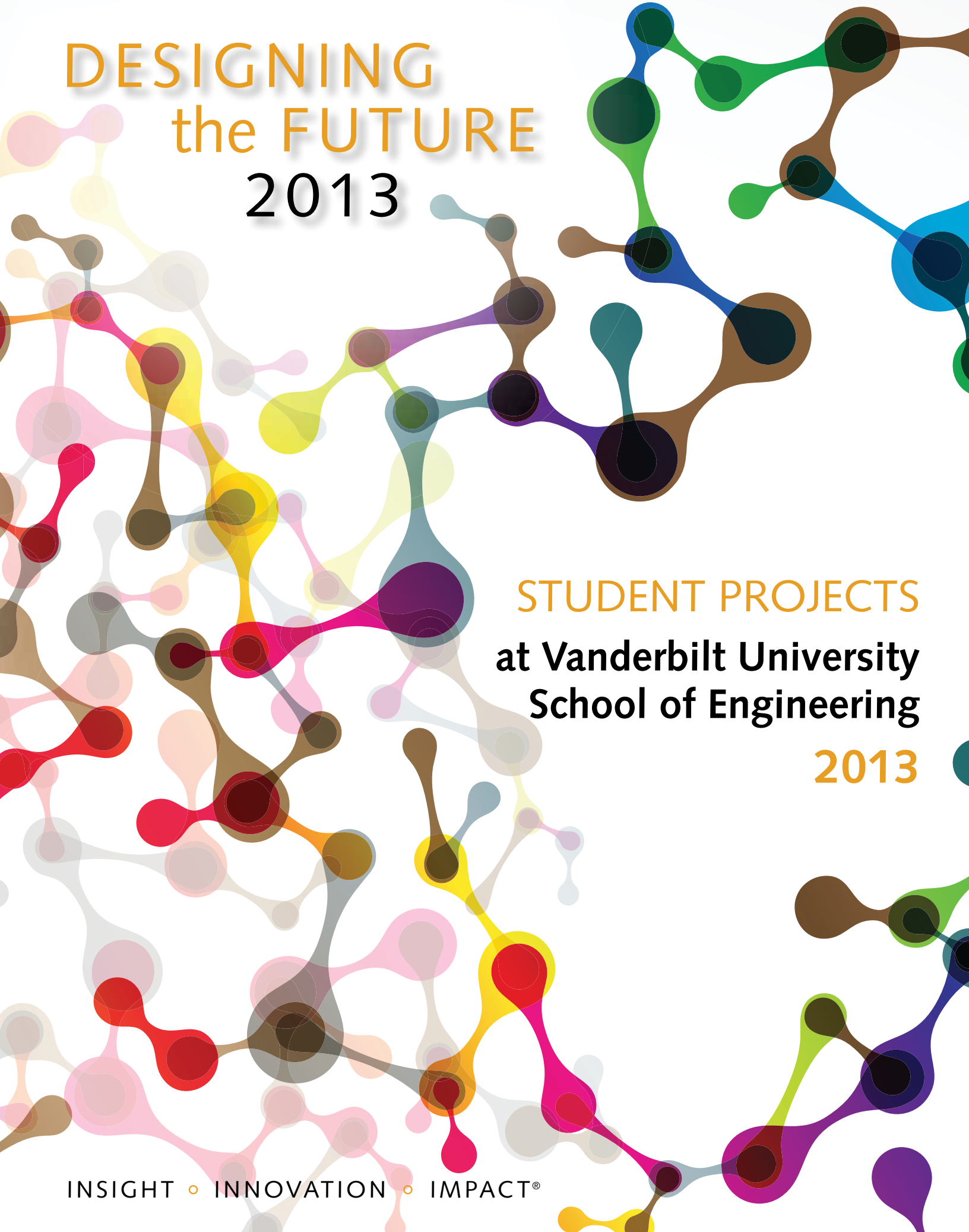
DESIGNING the FUTURE 2013



STUDENT PROJECTS

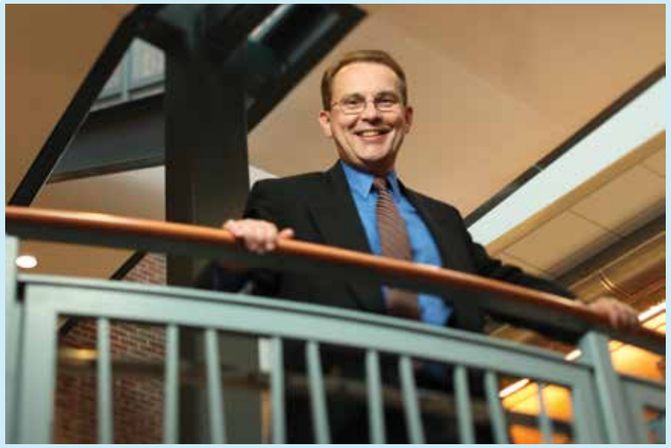
at Vanderbilt University School of Engineering

2013

INSIGHT ◦ INNOVATION ◦ IMPACT®

SUMMER 2013

At the Vanderbilt University School of Engineering, we are fortunate to admit some of the brightest engineering students in the country and from around the world. We teach these students a rigorous curriculum and welcome them to state-of-the-art laboratories. We also go one step further: We prepare these talented students to be leading independent thinkers, problem solvers and innovators in engineering or any other field through the design experience.



JOHN RUSSELL

At Vanderbilt, student design teams solve contemporary industrial problems, which adds legitimacy and the external vetting of ideas. This helps turn ideas into reality. The results are the creation of intellectual property, establishment of startup companies, and most important, use in the real world.

Engineering design does not happen in a silo where one discipline is isolated from another. Many design projects involve undergraduates from different majors using their combined skills to solve a real problem for a real client. In a departure from other design courses, our engineering management students also take part, focusing on product development, commercialization strategy and entrepreneurship. Design projects are selected to prepare students for the real-world expectations of networking, communication, team building, project planning and management, and working with constraints and ill-defined problems.

The culture of innovation and creativity doesn't stop there. It is nurtured in and explored by our graduate students, who go on to be leaders in academia and research. It flourishes in our talented and accomplished alumni, who put what they learned at Vanderbilt to work every day as engineers, industry leaders, and entrepreneurs. It is embodied in our outstanding faculty who constantly seek innovative solutions to problems and who are excited by possibilities.

The next pages highlight representative profiles of undergraduate, graduate, and alumni design and research at Vanderbilt, followed by our 2013 catalog of creative student design projects. Outstanding projects include the invention of a smart car seat, utilization of NASA software to improve vacuum cleaners, creation of a robotic nurse assistant and development of a startup company working on an improved blood cooling and transport system. Design projects resulted in several patent applications filed this year.

Our design project structure is one area where the Vanderbilt School of Engineering differentiates itself from many of our peers. I trust you will enjoy reading about the work of our talented students. I am proud of them, our faculty and our industrial partners for creating such a robust and dynamic environment.

Best regards,

Philippe Fauchet
Dean

STUDENT PROJECTS
at Vanderbilt University School of Engineering

Contents

INSIGHT ○ INNOVATION ○ IMPACT®

THE ONLY WAY TO LEARN TO BE AN ENGINEER IS TO BE AN ENGINEER

Behind student design at VUSE

A passion for solving problems is the cornerstone of a career in engineering. In the real world, it's a life built on recognizing opportunities and asking fearlessly, "What else? Why not? What next?"

To succeed, new Vanderbilt engineering graduates must be ready to explore challenges that have multiple answers, no good answer or no answer at all. In the engineers' working world, adaptability, persistence and perseverance matter more than grade point average.

JOE HOWELL

Barnett and King

Think like an engineer

Simply put, the only way to learn to be an engineer is to be an engineer. For more than 25 years, the Vanderbilt School of Engineering has worked strategically to draw students into the actual practice of engineering early and often. The goal? Cultivate a passion for scientific inquiry and an appetite for solving big problems right from the start. These skills are honed in bachelor of engineering seniors via the school's yearlong senior design experience, usually incorporating a multidisciplinary seminar, design courses and teamwork and culminating in a one-time showcase, Design Day.

Incorporating design at the undergraduate level was new territory when it was introduced in the early 1990s, says Paul King, professor of biomedical engineering and mechanical engineering, emeritus. King is credited with bringing senior design to the school's curriculum, having taught biomedical design to more than 1,280 learners and more than 526 teams over 21 years. In 2011, he was honored during the BMES conference with a lifetime achievement award for his outstanding achievements in BME design instruction.

King and mechanical engineering's Joel Barnett were the longtime leaders of the school's innovative, multidisciplinary senior design seminar that continues today. While Vanderbilt's curricular structure fosters discipline-specific learning, the seminar brings together students from different majors in integrated instruction.

Whether through departmental courses or the seminar, the core of the student design process is a focus on students working with real clients on real engineering problems, producing practical solutions and then presenting their ideas at Design Day. King says senior design and Design Day jump-start careers by enabling seniors to gain hands-on experience in the working world.

Real clients, real work

Senior design project sources are diverse and over the years have resulted in patents, product improvements and national awards. They range from the modification of a child's toy race car to work for the EPA, Nissan, Oak Ridge National Laboratories, GAF Life Recovery and Northrop Grumman. Each project provides an opportunity for students to analyze, experiment and design innovative solutions. In order to find those real-world engineering projects, the faculty who teach design (see pg. 12) invest hours identifying, meeting and recruiting project sponsors. Their goal is to provide projects that are a great fit between the sponsor's design needs and the educational and professional development of their students.

The projects also promote teamwork that simulates the workplace. Vanderbilt was ahead of many other engineering schools in its implementation of senior design. The consistent success of senior design projects attracts companies and individuals who ask student teams to turn problems into solutions.

The multidisciplinary Senior Design Seminar occurs in the fall. It explores ethics; budgeting; patents, trademarks and licensure; job hunting; career development; contracting; discrimination and liability; and risk assessment and reduction. The seminar also features speakers on professional subjects essential to the practicing engineer.

Also during the fall semester, students and Design Day projects are matched. Interdisciplinary collaboration is encouraged, with teams of three to six students working on each project. For example, a biomedical engineering student might work on an electrical or mechanical engineering project. Some students also elect to complete an engineering management capstone project in their own discipline.

Turn off the vacuum

Then research and innovation begin. Faculty meet with students throughout the process to assess team ideas, advise and make recommendations. Even so, each team is responsible for its own dynamics, research, design development and solutions. It all culminates in a spring event known as Design Day.

Engineers don't work in a vacuum in the professional world. Knowing how to assemble a team of collaborators who can pull together in a high-stakes setting, communicate with bosses, work with clients and get the job done is what matters.

"Industry doesn't work in silos of specialization, so why should our students?" asks Chris Rowe, associate professor of the practice of mechanical engineering. Rowe is director of the Division of General Engineering and oversees engineering communications. "Our students learn early that cohesion, collaboration and healthy conflict are where creativity and problem solving are found."

Faculty members from appropriate disciplines serve as design advisers and teach courses. They bring approaches tailored to the skills and projects relevant to their areas.

Joel Barnett, associate professor of the practice of mechanical engineering, establishes his mechanical engineering design course not as a class, but as a workplace. Students sign employment contracts and take on the vocabulary of the working engineer. "In the classroom, students work alone and can look up answers," Barnett says. "In senior design, solutions come from teamwork and finding the best answer within customer constraints."

Vanderbilt's engineering management program contributes business plan development, commercialization and product development strategies. Its advisers emphasize budgeting, deadlines and managerial basics such as cost-effective purchasing. Many employers favor Vanderbilt engineers because of the management fundamentals they learn in developing their design projects and through the school's engineering management minor.

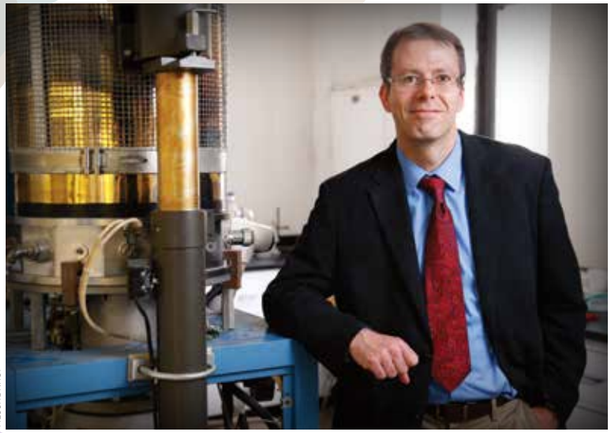
By graduation, Vanderbilt engineering seniors are prepared to hit the ground running. "They have the skills and they also have the experience," says Rowe. "It's the human factor and the practical experience that set our students apart."

JOHN RUSSELL

Senior Chelsea Stowell demonstrates the Kid Sense smart car seat her team developed and for which the team filed a U.S. provisional patent application.

DESIGNING THE FUTURE

Before they walk across the stage at commencement, all Vanderbilt engineering undergraduates put research and design principles into practice. Some hone those skills in labs under top researchers. Faculty advisers guide others in projects that culminate in Vanderbilt's annual Design Day. All take their talents and knowledge into the real world as working engineers, researchers, business leaders, teachers and entrepreneurs. We'd like to introduce you to just a few of those engineers and their work.



JOHN RUSSELL

Jennings

POWER FROM PLANTS

EPA-funded research moves to prototype phase

Creating environmentally safe energy from plants is fertile ground for engineering researchers who are passionate about discovering clean, innovative ways to power the world.

The pursuit of a unique solar energy-generating system that also has a light environmental footprint drives the research of engineering undergraduates under Kane Jennings, department chair and professor of chemical and biomolecular engineering. At the heart of their research is a protein complex extracted from spinach that could lead to harnessing photosynthesis as a source of energy.

This is the second year for undergraduates to work on this biohybrid cell project as part of the School of Engineering's student design course. Students work on specific aspects of the interdisciplinary research on which Jennings and David Cliffel, associate professor of chemistry, have been collaborating for more than 10 years.

Green means go

The protein complex—PS1—is highly efficient in converting light to electrochemical energy. Previous student design teams assessed the capacity of PS1 with substrates such as silicon and gold for maximizing energy transfer. They found that silicon was the most efficient. The most recent team of students built on those findings by miniaturizing biohybrid cells, a move that advances the system toward marketability.

The student research received a Phase I $15,000 grant from the Environmental Protection Agency's People, Prosperity and Planet Award Competition, as well as a Phase II renewal grant of $90,000. The results have also piqued the curiosity of a Fortune 50 company.

Tapping into potential

Paul Matthew McDonald, BE'12, was part of a team of chemical and mechanical engineering students who worked on the project in 2011–12. McDonald says it not only solidified his interest in research, but it was also a plus in his job search after graduation. He now works for Praxair, an industrial gas company.

If the project's current trajectory of miniaturizing and increasing voltage and current levels continues, mature solar conversion technologies could be achieved in three years. Within 10 years, they could reach the marketplace and compete with photovoltaic cells.

Challenges do remain

Right now, the amount of power generated is small compared to commercial photovoltaic cells. The longevity of the biohybrid cells is another issue that needs more research. Even so, the Jennings and Cliffel team has kept a PS1 cell working for nine months with no drop in performance.

The project changes in fall 2013 when a new team of undergraduates moves it into the prototype phase. Their goal will be to mass-produce their predecessor's design and connect the cells into larger assemblies to create high-performance biohybrid cells. "This work has solidified my commitment to alternative energy," says Anton Cottrill, BE'13, who sees his undergraduate involvement in the project as laying groundwork for a career in research. "The earlier you have the opportunity to do research, the more quickly you can get involved and the more impact you can have."

The research was supported by EPA grant SU-83528701, National Science Foundation grants DMR 0907619 and EPS 1004083, and by the Scialog Program of the Research Corporation for Scientific Advancement.

STEM TOUCH

Haptic technology expands learning for visually impaired students

Learning science, technology, engineering and math subjects depends heavily on students' ability to see charts, graphs and shapes and changes within them. Visually impaired students find fully engaging in these subjects challenging.

In response to this need, Jenna Gorlewicz, PhD'13, created software for the Android tablet touchscreen that incorporates haptic (vibration) feedback and sound. It allows visually impaired students to feel or hear the graphs and shapes that teachers illustrate on a blackboard or tablet screen.

In exploring the potential for haptic learning, Gorlewicz, then a doctoral candidate in mechanical engineering, drew on her experience in Vanderbilt's Medical and Electromechanical Design Laboratory and the support of her adviser, Robert Webster, assistant professor of mechanical engineering. Following initial discussions with faculty in biomedical engineering and at Vanderbilt's Peabody College of education and human development, she worked with teachers and students at local schools who provided first-hand insight.

DANIEL DUBOIS

Webster and Gorlewicz

In the classroom

Visually impaired students typically learn STEM material with the help of an aide who sits beside them, replicating teachers' work using pipe cleaners, a bulletin board and pushpins. Significant barriers to independent learning are inherent because the student is dependent on the aide's translation of the visual to the tactile.

Gorlewicz's software enables haptic-ready tablets to vibrate or generate specific sounds when a user's fingertip touches a line, curve or shape on the screen. The software causes the device to generate vibrations in varying frequencies and with multiple sounds based on where images on the screen are touched and manipulated. The result is tactile imaging that meshes with a visually impaired student's style of learning.

Visually impaired high school students tested the prototype software. "Engaging the end user through their sense of touch is a rich sensory channel for learning," says Gorlewicz, a National Science Foundation fellow and Vanderbilt Education Research fellow. Her research interests include human-machine interaction and novel learning technologies. "Touch is one of our first sensory experiences," she notes.

In the future

The potential for haptics stretches beyond basic STEM teaching. When haptics are incorporated into tablets, visually impaired students can work independently to solve problems ranging from simple geometry to structural engineering. Even the periodic table of elements could be interactive when haptic capability is linked to speech.

"My overarching goal is to use haptics to enhance the classroom experience for different kinds of learners," says Gorlewicz, who wants to refine haptic capability and explore its full potential as a learning tool. "In doing so, we could bring all kinds of learners together in ways that enable them to interact with multimodal information in real time."

This work was supported by Gorlewicz' NSF graduate fellowship and Robert Webster's NSF CAREER award (IIS-1054331).

JOE HOWELL

A haptic tablet translates the teacher's graphic to touch.

ACCELERATING RESEARCH AND RESULTS

Doctoral student and entrepreneur fast-tracks work on bacteria identification

Bacterial infections can be common, costly and life-threatening. Antibiotics are the first line of defense but deciding which to use depends on the type of bacteria. Currently, bacterial identification takes three to five days.

JOHN RUSSELL

Charleson Bell

Charleson Bell, BE'07, MS'09, a doctoral candidate in biomedical engineering, is accelerating identification through a startup company, BioNanovations Corp. The company, founded by Bell, Andre T. Stevenson, BE'12, and Todd Giorgio, department chair and professor of biomedical engineering, makes use of nanotechnology and a handheld device to cut identification time of *Staphylococcus aureus* bacteria to about 30 minutes.

Traditionally, identification requires culturing a blood sample to create a large enough group of cells to identify the bacteria. During Bell's graduate studies at Vanderbilt, he and Giorgio developed TestQuick, which relies on nanotechnology to identify the unique proteins the bacteria release. The identification can be done at the patient's bedside and thus eliminates the delays associated with samples sent to labs for culture.

The focus on each bacterium's unique proteins, not its direct identification, is a paradigm shift that can save lives and relieve suffering.

The change emerges naturally from a Vanderbilt University School of Engineering strategy of fostering student researchers who focus on solving high-impact problems. By collaborating with top researchers and the Vanderbilt University Medical Center, students like Bell and Stevenson are able to hone in on research that links directly to patient care.

Path to approval

"Currently, the speed of diagnosis is a function of biology," says Bell, who became interested in nanotechnology as an undergraduate. "If we ask 'how can I make the speed of identification a function of technology, not biology?' new possibilities emerge."

Bell is working to establish TestQuick's reliability and to meet Food and Drug Administration criteria for a new medical device and take it to market.

In 2012, he was awarded $50,000 and a spot in the ZeroTo510 medical device accelerator program in Memphis, Tenn. The name refers to the FDA approval process for new medical devices that are equivalent to existing ones but safer and more effective. Bell also received $100,000 in follow-up funding.

The capital enabled Bell to set up a lab where TestQuick is undergoing rigorous testing and refinement on the path to FDA approval. He hopes to then apply the TestQuick process and device to identify other bacteria species that require rapid detection, as well as viruses and possibly fungal infections. Bell has tabled completing his doctorate for the time being, but will use TestQuick's data to complete his dissertation and doctorate. Stevenson has returned to school full time to earn his graduate degree.

The business side of innovation

Meanwhile, ZeroTo510 is introducing Bell to the business side of innovation through the support of mentors, workshops, networking and forums. The goal is to introduce participants to business fundamentals such as strategies for getting capital, sales resources and fulfilling FDA requirements.

"ZeroTo510 has changed the way I think about new ideas," Bell says. "Now it's about what high-quality product can I develop to help the most people."

TestQuick is expected to come to market in 2017.

JOHN RUSSELL

Kenneth Pence, associate professor of the practice of engineering management, asks the Oreck-NASA team to discuss its design.

PAY DIRT

Students design a better bagless vacuum

Chris Paterson, Oreck Corporation's global director of product innovation and design, told eight Vanderbilt engineering seniors that he wanted them to work on a 'clean-sheet design' for a new Oreck bagless vacuum cleaner. Paterson gave the students a set of requirements and challenged them to think differently. "Don't be afraid to try something new, something no one else has thought of…Experiment, fail fast, fail cheap, learn and refine," he told them.

The design team had an additional partner. NASA's Marshall Space Flight Center in Huntsville, Ala., offered its proprietary computational fluid dynamics software to estimate the system-level performance of the vacuum. NASA also provided aerospace technologist Alok Majumdar to work with faculty adviser Haoxiang Luo, assistant professor of mechanical engineering.

"This is a great example of industry, a government agency and academia working together to solve real-world problems for consumers," Paterson says.

The Oreck-NASA design team—seven mechanical engineering seniors and one chemical engineering senior—had seven months to tackle Paterson's three design challenges: Increase the low-energy conversion efficiency of upright bagless vacuums, improve the agitation system to increase cleaning performance and find a way to compact dirt. Consumer interviews revealed that bagless vacuum users hated the dusty mess of emptying the debris canister.

DESIGNING THE FUTURE

Analyze and experiment

The team set to work, using a range of theoretical tools to perform design and analysis. "They used NASA pipe-flow software to estimate the system-level performance and they also used COMSOL, commercial software for advanced multiphysics modeling, to analyze the flow pattern in some of the key machine components," Luo says. "It was through the combined theoretical/experimental activities that they were able to bring their design to a new level of rigor and depth."

Mechanical engineering senior Clayton Carson valued working with computational fluid dynamics. "I was able to use my knowledge of CFD to help improve a real product as opposed to simply solving a canned problem," he says.

Through CFD testing, the team simulated and optimized various internal airflow path configurations before settling on a final design for construction and experimental testing. They also used CFD testing to determine the performance of the dirt agitation system and dust compaction system.

JOHN RUSSELL

Oreck Corporation's Chris Paterson, right, explains the new design developed by Vanderbilt students.

By April 19, the day they had to present their design, the Oreck-NASA team had adjusted the number and sweep of the vortex vanes to improve the centrifugal separation in the debris canister. This would prevent filter clogging and improve the system's efficiency. The team added corner vanes and selected an airfoil to match the changes. To improve cleaning performance, the team developed an air agitation system to complement the mechanical brush rolls used in traditional cleaners. A series of air jets discharged high-velocity air into the carpet; the team tested for the optimal angle of the jets when powered by a high-pressure air supply.

"Our final design consisted of air discharged through a series of orifices in a hollow cylinder and directed at the carpet at an angle," Carson says. "Based on experimental testing, this configuration improved cleaning performance by approximately 10 percent."

Answering consumers' needs

To compact dust and debris into a more manageable disk that could be removed intact, the team used water to tame stray dust particles and suggested a manual compression system to compact the debris.

"In our final model, a pipe was routed through the bottom of the canister and debris was manually compacted through a donut-shaped compression plate at the top of the canister. The water reservoir was moved outside of the canister so that the user could deliver and refill water without having to open the lid," senior Judson Keel says.

Paterson said the design challenges are problems the company's engineers also are trying to solve. "We wanted a fresh perspective. We were pleased with their imaginative and disciplined approach to solving these problems," he says. "Vanderbilt should be proud of the caliber of engineers who come through their programs. Some of these designs could be seen in future Oreck products."

WELCOME

The Vanderbilt University School of Engineering held Design Day 2013 on April 19. This year our students showcased 68 projects sponsored by 55 companies, organizations and laboratories.

Senior design courses provide students with experience working on real-world projects that involve design constraints, budgets, reviews and deadlines. Students learn about the principles of design, professionalism, licensing, ethics, entrepreneurship and intellectual property. This tradition is a culmination of their undergraduate education.

Projects are completed as part of capstone design courses in each department. Students are encouraged to work in an interdisciplinary manner, with an integrated design seminar facilitating the exchange of ideas and talent from multiple disciplines. This exposes students to the kind of multidisciplinary teamwork they are likely to encounter in industry.

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 or demonstration of their design. 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.

If you or your colleagues are interest in sponsoring a project or to learn more, please contact me.

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Each year, the Vanderbilt University School of Engineering publishes a catalog of projects presented at Design Day. The following is a reprint of the 2013 edition.

CONTENTS

ADVISERS

Our faculty advisers are an important and vital part of the senior design program. We take great pride in recognizing their outstanding contributions and excellence as instructors, advisers and mentors.

Joel Barnett
Associate Professor of the Practice of Mechanical Engineering

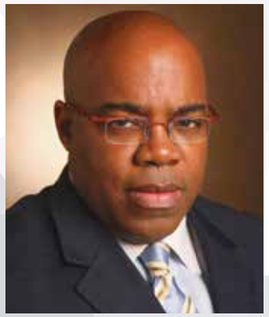
John Bers
Associate Professor of the Practice of Engineering Management

Ralph Bruce
Professor of the Practice of Electrical Engineering

Kenneth Debelak
Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn
Professor of the Practice of Chemical and Biomolecular Engineering

Sanjiv Gokhale
Professor of the Practice of Civil Engineering



Matthew Walker III
Associate Professor of the Practice of Biomedical Engineering

Robert Webster
Assistant Professor of Mechanical Engineering

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

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Vanderbilt University Medical Center, Department of Cardiology
Vanderbilt University Medical Center, Department of Urologic Surgery
Vanderbilt University Plant Operations

Low-Cost, Stand-Alone Microformulator for Systems Biology Research

TEAM MEMBER:
Will Matloff

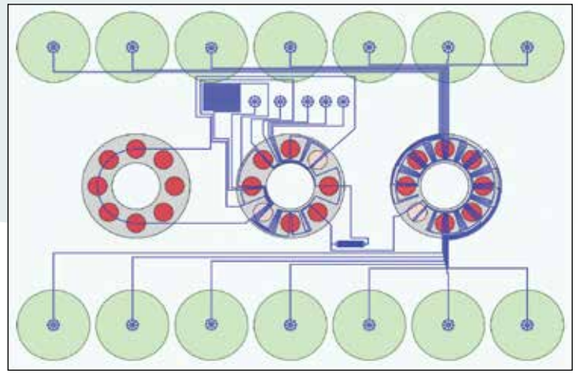
ADVISER:
John Wikswo, Professor of Biomedical Engineering

CLIENT:
Vanderbilt Institute for Integrative Biosystems Research and Education

Project Description

The creation of chemical mixtures, an important task in biological research, is traditionally accomplished through the use of a pipette and numerous vials. This is effective for simple experiments. However, as experiments become more complex and require multiple mixtures of dozens of different chemical mixtures, the use of traditional techniques becomes too tedious and wasteful. A new class of microfluidic devices, called microformulators, solves this problem by enabling the automatic creation of chemical mixtures through the use of valves and pumps; however, current implementations of microfluidic formulators are both difficult to use and prohibitive in cost to most researchers.

Newly developed rotary planar peristaltic pump and rotary planar valve (RPV) technology developed within VIIBRE may provide an excellent platform for implementing the valves and pumps necessary for microfluidic formulation in a way that is both low cost and easy to use. To this end, we developed a microfluidic device consisting of a network of channels that when interfaced with the stepper motors of the rotary planar technology can create user defined chemical mixtures of up to 14 different chemicals in about five minutes. This was a challenge due to the physical limitations of the RPV.



Schematic of the microfluidic channel network of the Rotary Planar Formulator.

Arco Pump

TEAM MEMBERS:
Christopher Hasselwander
Kyle McCann

ADVISER:
Aaron Fitzsimmons, Executive Director of Prosthetics

CLIENT:
The Surgical Clinic, PLLC

Project Description

There have been many advancements in prosthetic limb technology, but relatively few devices are intended to make the fit more comfortable. The goal of our project is to create a comfortable, dynamic vacuum pump attachment system for a prosthetic leg that will automatically adjust to the activity level of the user. The device senses leg movement and downward force to identify whether the patient is sitting, walking or running and adjusts the vacuum level accordingly in a program written on an Atmega-328 microcontroller. We've included a manual override button to lock the device on the highest vacuum level for activities that include more rapid changes in activity level and a button to release the vacuum. This is an advantage over existing models because there are not currently any products that offer the option to lock into a vacuum level while still having a fully automatic pump.

The key challenges in designing the vacuum pump include programming the microcontroller that operates the output and monitors the sensors, compacting the size of the device and orienting the device so that use of the pump is not restricted by the patient's height.

Improved Cervical Access System

TEAM MEMBERS:
Lowell Hays
Anne-Marie Crochet
Will Stokes
Kristen Findley
Mohsin Tejani

ADVISER:
Anita Mahadevan-Jansen, Professor of Biomedical Engineering

CLIENT:
Vanderbilt University

Project Description

Single access tube combines all of these instruments while decreasing procedural complexity, patient discomfort and ambient light interference.

Our team's goal is to enable the use of Raman spectroscopy for detecting cervical precancers in low resource settings. Raman spectroscopy is an optical technique that interrogates molecules within a detection volume. Each molecule has a distinct Raman signature and changes in things such as collagen content, hormone levels and cellular organization can all be identified.

The complexity and cost of current procedures and equipment inhibit the adoption of Raman technology. Low resource settings typically lack highly-trained medical personnel required to manage the current complex diagnostic protocol. Difficulties include visualizing the cervix without causing pain or discomfort, the need to block all room light from the probe, as well as requiring numerous instruments to complete the procedure. Additionally, all components which come into contact with the patient must be easily disinfected or disposable to prevent transmission of disease between patients.

The final design allows an untrained user to painlessly visualize the cervix using a USB compatible camera housed in an insertion channel. In addition, the channel houses all necessary components for cleaning and interrogating cervical tissue while blocking ambient light.

Micro-Heart for Physiological Study and Drug Screening

TEAM MEMBER:
Zhengda Zhao

ADVISER:
John Wiskwo, Professor of Biomedical Engineering

CLIENT:
Vanderbilt University

Project Description

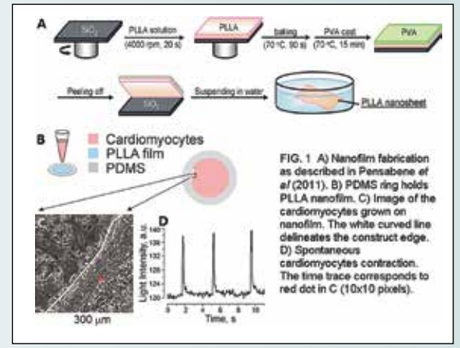


FIG. 1 A) Nanofilm fabrication as described in Pensabene *et al* (2011). B) PDMS ring holds PLLA nanofilm. C) Image of the cardiomyocytes grown on nanofilm. The white curved line delineates the construct edge. D) Spontaneous cardiomyocytes contraction. The time trace corresponds to red dot in C (10x10 pixels).

Cardiovascular disease is the main cause of death around the globe. Due to the insufficient number of organ donors and limited cardiac regeneration, there is a burgeoning demand for the development of engineered heart tissues for transplantation, drug screening and physiological study. Therefore, a standardized analysis method for cardiomyocytes is needed. Current approaches include muscular thin film, cardiac microtissues, and micropillar arrays. However, these techniques are not ideal because of the stiffness of PDMS and instability of hydrogel. This project proposes designing an ultrasensitive, stable and easily-automated technique for cardiomyocytes's mechanical and electrophysiological properties analysis.

The technique consists of fibronectin-micropatterned nanofilms, cardiomyocytes, a microfluidic device and an image recording system. Cardiomyocytes are cultured in certain pattern on the nanofilm which is around 30-40nm thick. Nanofilms with cardiomyocytes are clamped in the microfluidic device which has a chamber filled with media. A glass tube is connected to the chamber. The spontaneous contraction of cardiomyocytes deflates and inflates nanofilm resulting media level change in the glass tube which is recorded. The contraction rate and contraction force can be calculated accordingly.

Coffee Ring Diagnostics

TEAM MEMBERS:

Scott Palmese
Stephanie Anderson
Stephanie Preston
Jiemi Zhu
Erica Von Stein

ADVISER:

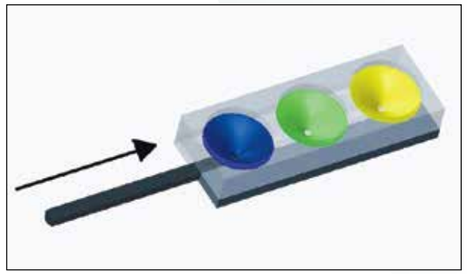
Rick Haselton, Professor of Biomedical Engineering

CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description



Three-chambered prototype extracts malaria biomarker from saliva (blue), washes off surfactant (green), and allows for evaporation.

While adequate treatment and preventative measures for malaria are in place, affordable diagnostic tests remain inaccessible to resource constrained communities. Diagnosis via blood smear requires a trained professional and a microscope, while rapid diagnostic tests are damaged at high temperatures and require a technician to draw blood. Developing communities need a heat-resistant, cheap, oral, point-of-care tool for the diagnosis of malaria. Recent studies have quantified histidine-rich protein II (HRPII), the malaria biomarker, in saliva. Using saliva not only eliminates the need for healthcare personnel, but also avoids the cultural stigma associated with drawing blood.

An evaporating colloidal suspension, such as a coffee drop, leaves behind a characteristic ring pattern. The presence or absence of poly-L-histidine, an HRPII mimic, can produce visible changes in particle deposition (Trantum et al. 2011). However, unaltered saliva contains surfactant and will not support ring formation. Using magnetic beads functionalized for HRPII affinity, we will extract the biomarker from the saliva, and then wash the beads to remove surfactant. Washed beads are resuspended in a controlled volume of water with nonfunctionalized colorimetric particles as a control. Our three chambered prototype allows an untrained user to diagnose malaria with the turn of a dial.

Heterodyne Chemistry

TEAM MEMBERS:

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Madeleine Durkee

ADVISER:

John Wikswo, Professor of Biomedical Engineering

CLIENT:

Vanderbilt Institute of Integrative Biosystems Research and Education

VIBRE

Project Description

Biochemical regulatory networks can be described as a complex integration of cycles and cascades, controlled by positive and negative feedback loops to produce reaction pathways that are linear, hyperbolic, sigmoidal and oscillatory. Such complex, intertwined, dynamic systems occurring in and between cells can lead to misinterpretation of results from perturbed biochemical networks and whole cell studies.

A more complete understanding of the dynamics of these regulatory networks can be developed through mathematical and physical models of individual reactions occurring within cell signaling pathways. A technique to further investigate these dynamics has been developed by applying a radio-wave signal processing technique (called "heterodyne") to chemical and biochemical reactions.

However, the process is currently limited to tracking fluorescence as a biomarker. It also suffers from a large amount of noise introduced between calibration and experimental steps.

Our team has designed a microfluidic pH meter and device that can track reaction pH as a biomarker in real-time. We are testing fabrication methods for this device design and implementation of the pH micrometer into the microfluidic environment and calibration of this meter for model reactions for the heterodyning of chemical reagents. An in-line, fully automated calibration system schematic has also been designed to reduce the introduction of noise into the highly sensitive, time-dependent signal acquisition process of heterodyne chemistry. Once the heterodyne chemistry process is fully developed, our products will be marketed as hardware for this process, which will be employed as a screening assay to track the interaction of drugs with a cell with high sensitivity to kinetic interactions.

Development of Hand Hygiene Sensor for Compliance Improvement

TEAM MEMBERS:

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Emily Bush
Chen Li

ADVISERS:

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Jon Wanderer, M.D.

CLIENT:

Vanderbilt University Medical Center, Department of Anesthesiology

VANDERBILT UNIVERSITY MEDICAL CENTER

Project Description

The integrated sensing system above tracks doorway entry and hand sanitization in order to record and improve hand hygiene compliance.

Hospital acquired infection poses a persistent threat to patient safety and is a leading cause of morbidity and mortality. Current data from Vanderbilt University Medical Center reflects that hand hygiene compliance ranges from 60 to 95 percent by department. Current solutions, such as manual observation, are time and resource intensive and have failed to achieve the level of compliance desired.

Our project aims to develop a real-time sensing system to evaluate usage of alcohol based foam dispensers when entering patient rooms. The multisensor design will enable a distinction between compliant and noncompliant events. By tracking room entry and hand hygiene compliance, we can evaluate the effect of interventions, such as an alarm, on compliance rates.

Key challenges included the unpredictable nature of human behavior, the reliability and robustness of a hospital-wide system, price point and integrating the system with the existing workflow and infrastructure. We accomplished this using off the shelf electronic components and by modifying existing alcohol based foam dispensers. We designed novel components that allow for the integration of existing sensor and micro-processing technology to interact within our system parameters. We are testing performance and reliability in a clinical setting to determine the system's compliance tracking and behavior modification capabilities.

Automated Quantification of Tumor Tissue for the Diagnosis of Cancer

TEAM MEMBERS:

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ADVISERS:

Jon Eric Pettersson, Commercial Development Manager
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CLIENT:

Insight Genetics

INSIGHT GENETICS

Project Description

Currently, the process for deciding whether to accept or reject a tissue slide for lung cancer diagnosis is highly subjective and has a low throughput. Our ultimate vision is to develop a system that analyzes the slides and provides the amount of total tissue and tumorous tissue on the slide, and dictates whether the slide should continue onto further processing. This will be accomplished by adding a step to the existing protocol. We also aim to streamline the operations, resulting in a rapid and reliable cancer screening and ultimately a faster, more informative outcome for the patient.

One challenge that we have faced is the lack of standards for samples coming into the lab. This has caused us to narrow our scope to tissue slides with H&E staining. Another challenge is the need to find a cost-effective microscopic imaging system that the lab can use. In addition, the small amount of data available for comparison makes it difficult to assess the effectiveness of our solution.

We developed an image-processing program that identifies the surface area of the tissue on the slide and alerts the user if it is below the threshold and should be tossed. The processing software also has the ability to differentiate between tumorous and non-tumorous tissue of an H&E stained sample and if the amount of tumorous tissue is below the set threshold, the user will be notified. This will allow Insight Genetics to save both time and money by eliminating the slides that will not yield accurate results.

A Polymer Nanofilm for the Delivery of a YARA-MK2i Therapeutic to Combat Intimal Hyperplasia

TEAM MEMBERS:

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Hak-Joon Sung, Assistant Professor of Biomedical Engineering

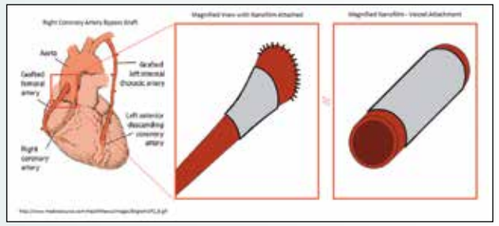
Todd Giorgio, Chair and Professor of Biomedical Engineering

CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description



Drug-loaded nanofilm wrapped around graphed venous tissue directly delivers therapeutics in a sustained manor to deter intimal hyperplasia.

Blockage of a coronary artery leads to myocardial infarction and is alleviated by coronary artery bypass surgery, or the transplantation of a vein graft to bypass the blockage. A significant amount of such grafts fail in the first year following transplantation due to intimal hyperplasia, or the inflammation and infiltration of graft smooth muscle cells into the vessel lumen. Currently, an effective localized therapy to remedy intimal hyperplasia does not exist other than repeating the surgery, but there is an inhibitor drug, YARA-MK2i, which can deter the intracellular events leading to intimal hyperplasia.

Nanofilms are thin sheets that can be constructed from various polymers to load with drugs and adhere to wet tissue. Our goal was to produce a YARA-MK2i loaded nanofilm of optimal thickness and therapeutic loading concentration which is biocompatible and can cause inflammatory marker knockdown in vitro.

Our group has constructed YARA-MK2i loaded films which display first order release kinetics after an initial burst release, and which can be varied in both thickness and amount of loaded drug. We currently are testing such films for cytotoxicity and inflammatory marker knockdown in vitro to display biocompatibility and effective treatment of the pathway leading to intimal hyperplasia.

Blood Cooler Project

TEAM MEMBERS:

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CLIENT:

Vanderbilt University Medical Center, Department of Anesthesiology

VANDERBILT UNIVERSITY MEDICAL CENTER

Project Description

Blood Monitoring Solutions

Our goal is to create a blood delivery process that reduces red blood cell wastage through the utilization of a temperature feedback system. Due to the high cost of blood units and FDA storage temperature regulations, large scale hospitals can lose hundreds of thousands of dollars in non-expiratory blood wastage each year. Our system aims to help refine the blood delivery process in order to reduce this wastage and save hospitals money.

During this project, we built design requirements around the needs of the Vanderbilt University Medical Center by consulting with doctors, blood bank workers and by observing habits in operating rooms. The cooler is designed around detecting if blood is present, sensing the temperature of each unit, transmitting temperature to the blood bank, alerting the appropriate personnel when blood products are about to exceed a threshold temperature for safe return to refrigeration.

This process will ensure that we design our system with testable parameters and stakeholder needs in mind. The process will also be iterative, using various checkpoints to ensure we are on the right track.

MRI Pacemaker Interlock

TEAM MEMBERS:

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Michael Shannon
Joshua Stewart
Sam Walling

ADVISER:

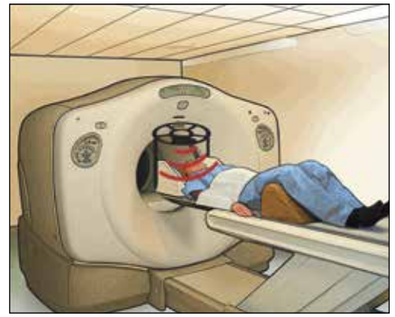
Will Grissom, Assistant Professor of Biomedical Engineering

CLIENT:

Vanderbilt University Institute of Imaging Science

VUIIS

Project Description



A pacemaker detection system is mounted on a MR scanner to prevent patients with implanted pacemakers from undergoing MR scans.

Patients with implanted cardiac pacemakers (PMs) that undergo magnetic resonance (MR) imaging can experience a wide range of adverse physiologic consequences, including death, as a result of unfavorable interactions between the PM and the magnetic fields produced by the scanner. In independent imaging clinics and low resource and rural hospitals, the safety protocols in place are inadequate to screen patients undergoing MR imaging for PMs. As a result, many unintentional and contraindicated scans of patients with PMs occur each year. Our mission is to revolutionize these safety protocols for MR scanners with respect to reliable detection of cardiac PMs.

In order to accurately screen each patient, our design employs a metal detector mounted on an MR scanner to assess each patient as they enter the bore of the magnet. If the detection coils sense a PM in the scanner, a warning is activated, which alerts the technologist. This configuration presents many challenges as the detector cannot adversely affect the image quality of the MR system and must be able to detect all types and brands of PMs in a wide range of patients. Our primary goal is to develop a highly sensitive detector that is MR compatible and easily incorporated into current screening protocol.

Mobile Phone-Based Detection of Neonatal Jaundice

TEAM MEMBERS:

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ADVISERS:

Chetan Patil, Research Assistant Professor of Biomedical Engineering

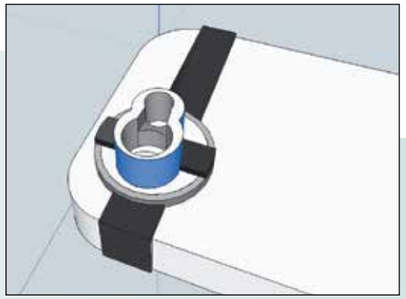
Quyen The Nguyen, Research Associate of Biomedical Engineering

CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description



The ultimate vision for this project is to create a non-invasive, cost effective tool for detecting neonatal jaundice that will provide an accurate and efficient means for diagnosis. Our group aims to develop a smartphone based system that detects neonatal jaundice by measuring skin reflectance at specific bilirubin-associated wavelengths through the RGB specifications of the phone's camera.

For our project, we are developing external hardware containing a triple bandpass filter that will be attached to an elastic band that stretches over the phone's camera and selects for specific bilirubin, hemoglobin and melanin associated wavelengths. The smartphone application will be able to measure bilirubin levels based on pictures that are taken with the phone's camera in combination with the triple bandpass filter hardware. The camera will capture three images; two on the forehead and one on the sternum, which will be averaged and used for analysis. The application will be programmed in such a way that the optical data will be correlated to the serum blood bilirubin levels that is the current gold standard for diagnosing jaundice. The graphical user interface will be optimized so that minimum technical training is required. As users open the application, message prompts directing when and where to capture the images will appear. The software will detect the natural language settings of the phone and adjust the interface accordingly. The driving force of the project is to create a low cost deliverable, as the application will be implemented in Sub-Saharan Africa, a resource constrained area.

Smart Car Seat

TEAM MEMBERS:

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Chelsea Stowell
Laynie Boland

ADVISER:

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VANDERBILT UNIVERSITY

Project Description

Caregivers unknowingly expose their small children to dangerous temperatures by leaving them unattended in cars. About 38 infants or toddlers die annually when they become trapped in hot cars because they are both physically and physiologically vulnerable to heatstroke. Since about 50 percent of cases are due to children being forgotten, our goal is to alert the caretaker when a child has been left and if the car is reaching a dangerous temperature. Our design consists of a smart car seat that communicates the child's presence and information about the car environment to an associated key fob held by the caretaker.

A series of alarms begins when the caretaker turns off the car without immediately retrieving the child and increases in intensity if the child remains in the car. Two Arduino microcontrollers gather sensor inputs and trigger alarms in both the car seat and the key fob through RF communication. If the car becomes dangerously hot or cold, the highest intensity alarm alerts even passersby to rescue the child. The smart car seat is differentiated from existing devices by enhanced reliability, minimal required set-up and improved ease of use and additionally features temperature detection and a graduated alarm system.

CompleteControl

TEAM MEMBERS:

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ADVISER:

Mark Rickter, President, Max Mobility

CLIENT:

Max Mobility, LLC

max mobility

Project Description

The CompleteControl unit including switch, wireless module, battery and charging port.

The CompleteControl remote device is a revolutionary new add-on to MaxMobility Inc.'s SmartDrive Power Assist unit. The original SmartDrive provides power to the user's standard wheelchair, increasing the range and speed of typical use. However, the SmartDrive itself is limited in control and sensitivity, preventing maximal user comfort in many real-world situations.

The CompleteControl remedies these issues. Functioning as both a throttle and a cruise control, the device allows for exact, real-time adjustment of speed with limited user input. By acting as an override for the SmartDrive's standard control inputs, problems with undesired power termination are also solved. The unit's handheld, single-button interface provides universal compatibility and simple, intuitive operation, while its ergonomic design allows the user's hand to remain free to grip the wheel for uninterrupted steering control.

This device greatly enhances the capabilities of wheelchair users equipped with the SmartDrive. This addition to the existing device is simple, inexpensive and fulfills a major user need.

Endoscopist Evaluation by Kinect Motion Tracking

TEAM MEMBERS:

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Jason Zack, ME
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ADVISERS:

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Keith Obstein, M.D.

CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description

Windows Kinect placed on Endoscopy Monitor to record Endoscopist movement.

The goal of this project is to determine an objective method to measure the competency of an endoscopist. Currently the proficiency of an endoscopist is determined by the number of procedures performed, and that number varies greatly amongst different standards boards. It is important to establish an effective way to designate expert endoscopists, because the number of procedures performed is not necessarily a valid indication of expertise.

Our project is based on the anecdotal observation that endoscopist expertise is highly correlated with head, shoulder and arm movements during procedure. The design for this project uses a Microsoft Kinect motion capture device to observe the endoscopist's skeletal movements. The movements are analyzed using an algorithm that provides a score based on the body motion deviation and smoothness, as well as the length of the procedure and the time spent looking at the endoscopy monitor. The resulting score will then be compared to the scores of designated expert endoscopists. The primary goal of the project is to validate the observation that head, shoulder and arm movements are related to endoscopist expertise. The long term goal is to develop a scoring system based on these validated observations, and have the scoring system accepted by industry for the purpose of evaluating and training new endoscopists.

Automatic Inflatable Abdominal Binder

TEAM MEMBERS:

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CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description

The prototype can detect a change in sitting or standing and inflate or deflate the belt automatically.

Orthostatic hypotension afflicts thousands of people every year, hindering movement and physical activity and in the worst cases, causing syncope or death. It is more prevalent in the elderly and patients with low blood pressure, and presents as a drop in blood pressure when moving from a supine or sitting position to a standing position. Research has shown abdominal compression to be an effective treatment for orthostatic hypotension, but current elastic binders that can be worn on the abdomen are uncomfortable to wear for long periods of time.

Our novel device automatically applies pressure to the abdomen only when standing, maximizing comfort and convenience for the user. With our project, we've improved an automatic inflatable abdominal binder prototype that applies 40-50 mmHg of pressure to the abdomen via an inflatable bladder. The transition from sitting to standing is detected by a thigh-mounted accelerometer. We will continue to optimize the belt and hardware design, and then clinically test the effectiveness of the device. Ultimately, we hope to market and distribute our refined device to physicians who can distribute it to patients as an effective treatment for orthostatic hypotension.

The Extractionator

TEAM MEMBERS:

Benjamin Childs
Noah Hoh
Premal Patel
Andres Arango
Bharat Kumar

ADVISER:

Rick Haselton, Professor of Biomedical Engineering

CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description

The original vision behind The Extractionator was to develop a self-contained device for contaminant-free extraction and detection of target molecules, specifically malarial biomarkers, for use in low resource environments. Biological samples used to detect malaria contain interferents that can affect the sensitivity of the test, so there needs to be a system for filtering out target molecules using cleaning solutions. The current design provided by our sponsor, Rick Haselton, utilizes magnetic beads that attach to a target molecule. The beads are run through a series of cleaning solutions separated by air gates, and these solutions remove the interferents from the sample.

The Extractionator tube with the magnetic field applicator.

Our approach in innovating the Extractionator was to keep the device self-contained and conserve the resources necessary to run the test. The primary objective of our design was to decrease the unwieldy amount of tubing currently required and to eliminate the need for electricity. The challenge was to develop a new tubing system that would decrease the amount of tubing while maintaining stable surface tension air gates between the cleaning solutions. Our new tubing prototype drastically reduces the amount of tubing necessary by utilizing a three chamber concentric tube. The use of a manually operated magnet also eliminates the need for electricity.

UV Light Disinfection of Amputee Liners

TEAM MEMBERS:

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ADVISER:

Aaron Fitzsimmons, Executive Director of Prosthetics

CLIENT:

The Surgical Clinic, PLLC

Project Description

There are an estimated 1.7 million amputees in the United States. Lower limb amputees typically wear a gel liner on their residual limb when using a prosthetic as this minimizes the amount of friction and discomfort generated between the limb and the prosthesis. However, routine physical activity results in the proliferation of undesirable odor causing bacteria in gel liners that are difficult to remove using conventional cleaning methods such as soap and water.

Our project objectives are to design a cost effective light-based bactericidal device to destroy odor causing bacteria growing in amputee gel liners and to quantify the bactericidal efficacy of our device.

We are testing two different models of our prototype; one utilizing ultraviolet light (UV) and the other using blue light. The major concern of our UV model is the potential degradation of polymer-based gel liners upon exposure to the UV spectrum. While the use of a blue light, avoids polymer degradation and radical generation of the gel liner stand, the primary concern with this model is its bactericidal efficacy, as literature has suggested that blue light has a lower efficacy than UV. In order to maintain optimal bactericidal efficacy while minimizing gel liner degradation, it may be necessary to determine the optimal wavelength between the UV and blue light spectrum for effective bacterial elimination.

Our ultimate vision is to design a light-based, user friendly, and cost effective bactericidal device that can be successfully integrated into pre-existing gel liner stands, packaged and sold with every gel liner, upon assembly.

The Rangefinder Project

TEAM MEMBERS:

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Taylor Coston
Adil Faqih
Caleb Huber
John Lantz, EE

ADVISORS:

Matthew Keller, Ph.D.

Duco Jansen, Professor of Biomedical Engineering

CLIENT:

Lockheed Martin Aculight

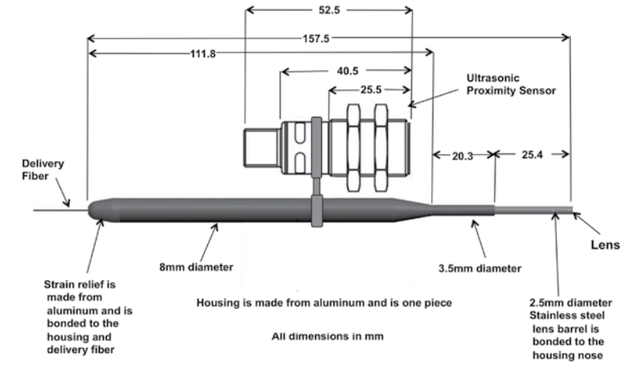
LOCKHEED MARTIN

Project Description

Stimulation of nervous tissue using an infrared-range laser requires precise knowledge of distance to the exposed nerve. If the laser is too close, the spot size will be small and the power density delivered to the tissue could be damaging. If the laser is too far away, the spot size will be large and the power density delivered to the tissue will be insufficient to cause action potentials.

Our project was divided into two phases. First, our team extensively investigated a wide variety of methods for determining the distance with high accuracy while preventing the cost of the Rangefinder from rising above 10 percent of the cost of the laser itself. After a thorough analysis of the various options, our team chose an ultrasound approach. Thus the second phase of the project began, and involved the creation of a proof-of-concept to validate our solution.

The greatest challenges of this project have included evaluating different approaches to a single problem, choosing vendors for devices and finding devices that do not add significantly to the weight of the pre-existing laser device. We hope to show that ultrasound distance sensing can be used to precisely, accurately and safely measure distance to exposed nervous tissue.



Schematic of prototype including the Rangefinder, the laser pen and the clamp that holds the two together.

Quantification of PKD Benign Cysts

TEAM MEMBERS:

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Ray Wang
Sean Fitzpatrick
Maya Seunarine

ADVISORS:

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S. Duke Herrell III, M.D.

CLIENT:

Vanderbilt University Medical Center, Department of Urologic Surgery

VANDERBILT UNIVERSITY MEDICAL CENTER

Project Description

Polycystic Kidney Disease (PKD) is a hereditary disease in which fluid-filled cysts form in the kidneys. These cysts enlarge the size of the kidney while simultaneously replacing the normal structure and compressing neighboring nephrons, negatively affecting kidney function. Our senior design project aims to create a program that will supplement MRI or CT scans of PKD cysts to quantify their volume and track PKD progression. There isn't a way to correctly identify the PKD induced degradation rate of the kidneys. Consequently there is a need for an algorithm to monitor PKD progression in order to better estimate the timeline for surgical intervention.

This system would depend on a gray scale value that we determine for each of the major tissue components of the kidney such as kidney tissue, fat and cystic tissue. The system would compare each pixel value to a gray scale value and determine the regions of interest for the cysts and kidneys. The system would then determine the total area for each MRI slice and would integrate over depth to get total volume of the cysts and kidneys. Our ultimate vision is to have the algorithm output a ratio of cystic tissue to healthy tissue.

Bio Inspired Solar Cell

TEAM MEMBERS:

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Naveed Bakh
Nur Nabilah Mahfuz

ADVISER:

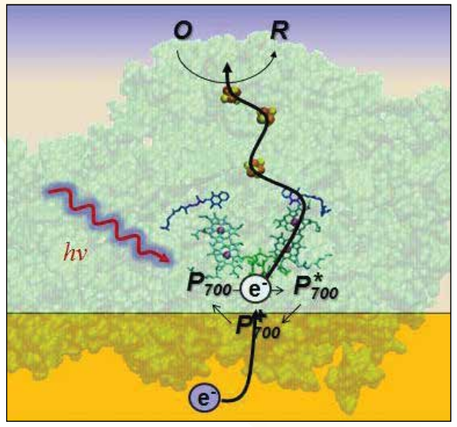
Kane Jennings, Professor of Chemical and Biomolecular Engineering

CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description



Current silicon-based solar cell technology employs the use of highly purified silicon electrodes in order to achieve advantageous energy efficiencies. However, the construction of a dye-sensitized silicon solar cell that incorporates photosystem I, a photosynthetic protein, can provide a significant enhancement in photocurrent. In turn, this photocurrent enhancement relaxes the requirement for a high purity silicon electrode, which is a major factor in the expense of solid state semiconductor solar cells. The basic design for our dye sensitized solar cell consists of a working electrode, a sensitizer (thin film of PSI), an electrolyte, a mediator, and a transparent electrode. The sensitizer, a thin film of PSI deposited onto the working electrode, accepts an electron from the working electrode. The accepted electron is subsequently excited by radiation that is absorbed by the sensitizer. The excited electron is transferred to a mediator, which diffuses to the transparent electrode and becomes oxidized. This results in a net current flow of electrons. Overall, this project's focus is optimizing a single cell that incorporates PSI and highly p-doped silicon. This incorporates optimizing the transparent electrode and the mediator species. Our team is attempting to reduce the electrode separation to the micron scale in order to investigate the effect of mediator diffusion path length on solar cell performance.

Alternative Fuels for Vanderbilt Dual-Fuel Combined Heat and Power Plant

TEAM MEMBERS:

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Nor Fatin Nabilah Mohd Apandi
Adam Okoe Mould

ADVISERS:

Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description

The Vanderbilt dual-fuel combined heat and power plant uses primarily coal and some supplemental natural gas to produce steam and electricity. Due to environmental and sustainability issues, there is a need to replace the current fuel with an alternative fuel such as biomass. The goal of the project is to choose the most suitable alternative fuel to replaced coal. We developed a process model using Aspen process simulation software to study the use of alternative fuels as well as coal and natural gas in the boiler system. The process model includes the fuel handling system, the Detroit Stoker combustion system, steam turbine, the bag house, and bottom ash handling system. Economic, environmental, emission and sustainability criteria will be analyzed to evaluate the current plant and any modifications necessary to use alternative fuels. Included in the overall cost of converting to the selected alternative fuel is the consideration that any changes must be beneficial to the power plant. The recommended alternative fuel will be able to produce the same amount of steam and electricity at the lowest cost possible while reducing the emission of harmful gases below the EPA permit limits, and will be readily available in the future.

Carbon Dioxide Capture Using Aqueous Ammonia – Team 1

TEAM MEMBERS:

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Syazwani Zakwan

ADVISERS:

Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description

While carbon dioxide is a naturally occurring gas with many useful functions, there is well documented concern about its role in global warming and the rate at which it is increasing in the atmosphere. The rapid increase in atmospheric carbon dioxide has led many to focus on industrial sources of CO_2. The objective of our project is to develop a process flow sheet that involves a detailed design of a carbon capture process using post-combustion absorption. A process was designed to remove 90 percent of the carbon dioxide in the flue gas stream of a power plant with a net output of 550 MWe that burns 15510 metric tons of coal/day and a composition of 13.50 mol% carbon dioxide, 15.17 mol% water, 68.08 mol% nitrogen, 2.43 mol% oxygen, and 0.82 mol% argon at a temperature of 57.2°C and 1 atm, and that the carbon dioxide out stream is supercritical. The process is able to remove 1.904×10^8 moles of carbon dioxide/day. The treated flue gas also contained less than 150 ppm (wt/wt) of ammonia to meet environmental regulations. The capture process was designed with minimum cost of electricity. The viability of the power plant was determined by an economic assessment. The designed process is more advantageous than typical carbon dioxide capture by mono ethanolamine because aqueous ammonia has higher absorption capacities and removal efficiency.

Carbon Dioxide Capture Using Aqueous Ammonia – Team 2

TEAM MEMBERS:

Nor Diana Ramli
Nur Hafifah Ismail
Nurul Azirah Abd Azid
Mohammad Khair Zaki Suhaimi

ADVISERS:

Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description

Carbon dioxide's characterization as the primary greenhouse gas emitted through human activity and its association with global warming has led to great interest in reducing CO_2 released into atmosphere. The most effective way to reduce carbon dioxide (CO_2) emissions is to reduce fossil fuel consumption. Coal-fired power plants emit flue gas containing huge amounts of CO_2 into atmosphere daily. Among conventional CO_2 removal processes, the monoethanolamine (MEA) process has been studied and used in chemical plants. This process could trim operating costs by up to 40%. However, slower reacting amines require a larger absorber. Aqueous ammonia can be used to capture CO_2 from flue gas with quick reaction rates, high CO_2 loading capacity, high removal efficiency and low energy requirement for regeneration. Our team is designing a process flow sheet showing CO_2 gas capture using aqueous ammonia to extract approximately 90% of CO_2 from the inlet flue gas. The major byproduct of the reactive absorption is ammonium bicarbonate, NH_4HCO_3. It is used as a crop fertilizer in some developing countries to enhance crop root development and leaf growth. And, the absorption byproducts are thermally decomposed to release CO_2 from the solution of ammonium compound. One challenge is the absorption rate between CO_2 gas and aqueous ammonia, which is faster at low temperature; however, the kinetics of reaction to form ammonium bicarbonate is faster at high temperature.

Next Generation Vaccine

TEAM MEMBERS:

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Caitlin Fechter

ADVISER:

Tiffany Rau, Ph.D.

CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description

Influenza is a serious disease that can lead to hospitalization and sometimes even death. According to the U.S. Centers for Disease Control, the single best way to protect against influenza is to get vaccinated each year. Flu vaccines currently administered are produced on egg-based platforms. Although the egg-based platform is well tested and approved worldwide, its slow development and long production cycles make the traditional vaccine ill-equipped to meet seasonal flu needs or a worldwide epidemic. Our goal is to develop a process and a manufacturing facility for production of a flu vaccine using a cell-based method. The host system we selected for the vaccine is *Escherichia coli*. The *E. coli* will produce the protein hemagglutinin as the viral antigen, which will be injected into patients and induce an immune response. The advantages of *E. coli* as a platform are that genetic manipulation is relatively easy, growth media is inexpensive and production levels are high. The vaccine will be manufactured in a fed-batch process. We will design all parts of the process from vial thaw to purification. Our goal is produce 35-37 million doses of the vaccine and distribute it throughout the United States and Europe. In the future, this new platform will be beneficial for the manufacture of a variety of vaccines.

Chem-E-Car

TEAM MEMBERS:

Tony Guan
Brian Shen
Trent Rothaus
Muhammad Syazwan
Mohamed Amin

ADVISERS:

Scott Guelcher, Associate Professor of Chemical and Biomolecular Engineering

Matthew Lang, Associate Professor of Chemical and Biomedical Engineering

CLIENT:

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VANDERBILT UNIVERSITY

Project Description

The AIChE Chem-E-Car competition provides chemical engineering students with the opportunity to participate in a team-oriented, hands-on design and construction of a small autonomous, chemically-powered car. The goal is to demonstrate the ability to safely control a chemical reaction that moves the car with a specified load over a given distance and stop. The major design challenge is providing enough power to move the car and up to 0.5 Kilograms of water to a distance between 15 and 30 meters with control to bring the car to a clean stop without using any mechanical or electrical timing devices. Our team focused on the design of lightweight but power-dense zinc-air batteries to power a low-voltage, high torque motor from an electric drill. The control was devised from a microcontroller and an iodine-clock reaction used as a chemical timing device.

Design of a Mobile Wastewater Treatment System or Hydraulic Fracturing Waste – Team 1

TEAM MEMBERS:

Brett Taylor
Doug Woodcock
Meredith Quast
Paige Poulin

ADVISERS:

Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description

Hydraulic fracturing is a commonly used technique to more efficiently recover natural gas reserves. Because of negative public opinion about fracking and environmental concerns about the amount of water used – about 3 million gallons per well – it will soon become necessary to treat the onsite wastewater to a level suitable for surface water discharge either due to federal regulations or because current treatment and disposal processes are unsustainable. The goal of our design is to develop a mobile system that can clean hydraulic fracturing wastewater to a purity level suitable for surface water discharge. The purification of the water will require a number of steps. First, the suspended solids and heavy metals will be precipitated and filtered out. The organics will then be vented and combusted. The last step involves removal of dissolved solids by mechanical vapor recompression. This design will improve current processes because we will remove heavy metals first, which will decrease hazardous waste disposal, and we are addressing organics removal rather than allowing them vent into the atmosphere. The process will decrease the environmental footprint of hydraulic fracturing wells by reducing wastewater, increasing water reuse ability, and limiting the amount of trucking needed for water transportation.

Design of a Mobile Wastewater Treatment System or Hydraulic Fracturing Waste – Team 2

TEAM MEMBERS:

Matthew Claussen
Muhammad Faiz Talib
Marc Panu

ADVISERS:

Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description

Hydraulic fracturing is an important well stimulation technology that has contributed significantly to the boom in domestic production of natural gas in the United States over the past two decades. This technique involves pumping fluid at high pressure into a well to fracture the shale formation and increase the flow of gas into the well. Increasing regulation of the disposal of this fluid, commonly called flowback, has forced fracturing operators to ship flowback from well sites to stationary water treatment plants. This, in turn, has led to a demand for a mobile treatment solution that could be deployed to treat flowback at well sites. Our team is addressing this problem by combining several treatment technologies to produce a mobile-scale process that can treat flowback for reuse near the well site. The process features activated carbon that treats for small organics, a dissolved air flotation unit (DAF) that removes suspended solids, a reverse osmosis unit that treats the lower dissolved solids concentration portion of the flowback, and an evaporator unit to treat more concentrated portions of flowback. We are developing methods to optimize the operation for each well site based on its unique chemistry.

Ethoxene Process: Conversion of Ethane to Ethylene, Acetic Acid, and Vinyl Acetate Monomer

TEAM MEMBERS:

Ulalo Chirwa
Tomas Salazar
Christopher Watkins

ADVISERS:

Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

CLIENT:

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VANDERBILT UNIVERSITY

Project Description

Fracking of natural gas from the Marcellus shale formation in the eastern United States is a relatively new source of fuel and other carbon-based products. Our team's goal was to use the ethane found in this natural gas to produce ethylene, acetic acid and vinyl acetate monomer. These carbon-based compounds have a variety of uses worldwide, ranging from food products to plastics. We developed a plant that uses the integrated ethoxene-vinyl acetate monomer (IEVAM) process to produce these final products. This process involves a two-step catalyst-based reaction process. The first converts ethane to ethylene and the second takes those two products and converts them to vinyl acetate. Based on an input of 14 million ft3/day of wet gas, our target production goals are 100,000 tonnes per year of ethylene, 200,000 tonnes per year of acetic acid, and 200,000 tonnes per year of vinyl acetate monomer.

Converting Remote Natural Gas to More Easily Transportable Liquids

TEAM MEMBERS:

Elizabeth Otting
Brian Moran
C.J. Osman

ADVISERS:

Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description

Refineries in the Prudhoe Bay area in Alaska currently use about 8.5 million gallons of methanol per year as antifreeze, and they must ship it in from the lower 48 states, incurring high transportation costs. There are many natural gas wells available in close proximity to the refineries with virtually unlimited supplies of methane. The goal of this project is to design a well site process with a small environmental footprint to convert the available methane to methanol for the refineries, allowing them to save transportation costs. We chose a three-step process to produce the 8.5 million gallons per year methanol required by the refineries. First, methane and steam will be converted to syngas in a steam reformer. Then, the syngas will be reacted to methanol over a Cu/ZnO/Cr2O3 catalyst in a boiling water reactor. The last step in the process is to purify the outlet stream of the reactor to 99% methanol, which is the purity required for antifreeze. The separation process will consist of a flash vessel and a distillation column. We are working to optimize this process in order to maximize the refineries' economic savings with our process.

Olefins and Alcohol Production from Wet Natural Gas – Team 1

TEAM MEMBERS:

Sarah Williamson
Marc Harton
Noryang Saira Ahmad Shuhaini

ADVISERS:

Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description

A recently discovered well of wet natural gas contains a wealth of simple hydrocarbons, which can be converted to valuable olefins and alcohols. Our goal is to maximize the amount of product formed while minimizing ongoing costs of reaction, separation and purification. The intent is to maximize plant profits by converting butane and pentane into alcohols. In addition, there is potential to sell the propane if the market is favorable. Our process began by separating the components of the source gas, at which time the propane can be returned to the well or sold as preferred. The C4 and C5 alkanes are then sent to reactors where they are converted to olefins via dehydrogenation with platinum. Finally, the olefins proceed through another reactor in which they are hydrated with water to form alcohols. The challenge in this process is not the process design – each separation and reaction is relatively simple to achieve. Instead, the conflict comes in trying to balance the economic potential of the products with the costs of ensuring high conversion of reactants and efficient separations. This is particularly relevant for the separation of the two butane isomers present in the wet natural gas source, which is the most difficult to achieve and requires a larger column than the other separation units.

Olefins and Alcohol Production from Wet Natural Gas – Team 2

TEAM MEMBERS:

Azah Fatihah Mohd Nazri
Siti Nur Syifaa Mohd Nordin
Candice Zhang

ADVISERS:

Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description

An abundant supply of low boiling alkanes from a wet natural gas source prompts their conversion to olefins and alcohols, which are purified and sold commercially. We designed a three-step process for year-round operation: a cryogenic separation unit to isolate C1-C3 compounds; an olefin production unit for processing the higher alkanes; and an alcohols production unit for converting the alkenes to their respective alcohols. A cryogenic separation is the process where the required alkanes are separated from the rest of the natural gas. From cryogenic separation, we are able to sell the side product, propane. We then processed these alkanes further in the olefins unit, where a chromium catalyst was used to achieve notable conversions of alkanes to olefins. We divided the olefin products from this unit for sales and for further processing into alcohols. This division scale is made from the economic analysis. Separation train synthesis is a critical step in determining the order of distilled products. We used regeneration steps to minimize the amount of side product accumulated. We applied the unique time element of the process that requires the olefin and alcohol units to produce one product at a time. As a result, material not being processed was stored in holding tanks. The cleanup/shutdown costs are offset by the overall reduction in equipment costs. Final process configurations were tested using models from AspenPlus® simulation software. Finally, we analyzed the overall economics and safety of the plant to ensure feasibility of the project.

CHEMICAL & BIOMOLECULAR ENGINEERING

Water Recycle and Reuse Network Software Development

TEAM MEMBERS:

Ahmad Alahmad
Nurul Nabila Mohd Fauzi
Zach Perlmutter

ADVISERS:

Kenneth Debelak, Associate Professor of Chemical and Biomolecular Engineering

Russell Dunn, Professor of the Practice of Chemical and Biomolecular Engineering

CLIENT:

Vanderbilt University

VANDERBILT UNIVERSITY

Project Description

Due to water scarcity and more stringent environmental regulations, all chemical plants using water and producing wastewater must work toward the most efficient use of water. Most facilities do not allocate their water resources optimally. Our team designed a computer program to provide guidance regarding the optimal allocation of water resources for industrial processes. The software identifies the minimum amount of fresh water necessary, the maximum amount of possible recycled wastewater, and the minimum amount of wastewater discharged. It also will generate helpful visual tools such as material recycle pinch and mass mapping diagrams, which will aid in identifying the water recycle network. We designed the software using Microsoft Excel because it is commonly used and can be easily integrated with other software

CIVIL & ENVIRONMENTAL ENGINEERING

Centennial Park Master Plan

TEAM MEMBERS:

Katherine Lopez
Sonja Davenport
Seung-Hwan Chun
El Mehdi El Hailouch

ADVISER:

Kevin Colvett, P.E.

CLIENT:

CH2M Hill

CH2MHILL

Project Description

Water that falls on and runs through Nashville's Centennial Park today is not being managed well. Recently, the underground source of Cockrill Spring was rediscovered beneath Centennial Park. About 100 years ago it had been capped and piped to the sanitary sewer system where it is then unnecessarily treated at a wastewater treatment plant. Our team, working with CH2M Hill, plans to keep this water on site so that it can be used for irrigation, to fill the park lakes, and to contribute to water features in the park, thereby reducing potable water use.

Overhead view of our project site, Centennial Park.

To prevent water from entering the sewer system, we developed a strategy to excavate Cockrill Spring so that the water flows through a newly constructed channel to a newly designed lake, which will be slightly less than an acre in size. The team has also sized pumps to help the water flow from Lake Katherine to Lake Watauga. Lake Watauga currently has poor circulation, so the team decided to implement artificial circulation via destratification to reduce nutrient loading. Additionally, the team is designing rain gardens, bioswales, permeable pavers and rainwater cisterns to prevent additional stormwater runoff.

S.R. 49 Harpeth River Bridge Design, Cheatham County, Tennessee

TEAM MEMBERS:

Mason Hickman
Muhammad Danial Meli
Allen (Teddy) Weaver

ADVISERS:

David Spinks, P.E.
Eric Slayton, P.E.

CLIENT:

Tennessee Department of Transportation

TDOT

Project Description

The project goal was to redesign the Tennessee S.R. 49 Bridge over Harpeth River and ensure that it is in compliance with regulations prescribed by the National Bridge Inspection Standards (NBIS). The project is part of the Federal Highway Bridge Replacement and Rehabilitation Program. The existing bridge, located in Cheatham County, Tenn., has reached the end of its design life. NBIS determined that the bridge should be redesigned in order to ensure continuous functionality and public safety. The bridge was redesigned according to TDOT's Design Procedures for Hydraulic Structures. The project consisted of a hydraulic analysis and structural design phase. Flood studies and survey data were used to construct a hydraulic model of the Harpeth River, determine flood elevations, calculate bridge scour and design the deck drainage. The structural design includes a traditionally reinforced concrete deck and prestressed concrete girders supported by piers. Design documents were prepared to depict the final design.

Tennessee S.R. 49 Bridge

Turkey Creek Medical Center Expansion Project

TEAM MEMBERS:

Bikang Zhang
Kyra Mohamed Sahari
Alessandra Leon

ADVISER:

Ben Nelson, P.E.

CLIENT:

Stanley D. Lindsey and Associates, Ltd.

Project Description

Turkey Creek Medical Center with the area of the proposed expansion highlighted

Turkey Creek Medical Center in Knoxville, Tenn. is seeking to expand the second floor of their existing medical building to accommodate a growing surgery department. The existing structure is a two-story building composed of an open first floor used as an ambulance drop off area, and a second floor that houses the existing surgery suites. The proposed expansion also will be a two-story building with an open first floor to allow the ambulance drop off area to remain in service following construction. The approximately 4,000-sf addition will be largely comprised of structural steel. Our team was responsible for designing the gravity, lateral, and foundation system for the building in accordance with applicable codes and regulations. The photograph shows Turkey Creek Medical Center with the area of the proposed expansion highlighted. Upon thorough review of the project site, we planned the foundation, floor and roof framing and performed load calculations based on the proper building codes for Knoxville. Subsequently, we determined the preliminary sizes for the beams, girders and columns, followed by an in-depth analysis using Ram Structural System. The final design produced by Ram is checked with the calculated sizes for accuracy.

Opus Electronics Antioch Facility Development Project

TEAM MEMBERS:

Aykut Imer
Adair Cummings
Robert McNeilly

ADVISER:

Mark Mize, P.E.

CLIENT:

Carpenter Wright Engineers, PLLC

Project Description

The project goal is to design the structural aspect of a five-story commercial facility to be located in Antioch, Tenn. The process has been divided into three phases: schematic design, design development and construction drawings. The proposed structure consists of class A office space, classroom training facilities for new employees, and ground level material management and shipping facilities.

The schematic design process consisted of determining and analyzing the building loading demands under gravity, wind and seismic loading as required by the 2006 International Building Code. The primary structural framing and foundation system were determined in compliance with the architectural constraints and serviceability requirements.

The design development phase includes designing the building column grid, the framing layout for a typical floor and roof, and the layout and nature of the building lateral force resisting system. Included in the design are moment frames, which aids analysis of the loading on the building and helps determine the necessary members.

Vanderbilt Steel Bridge Team

TEAM MEMBERS:

Jonathan Getz
Ryanne Hilbert
Michael Thomas
William Pepperman

ADVISER:

Lori Troxel, Associate Professor of the Practice

ASCE student chapter adviser

CLIENT:

Vanderbilt University ASCE

Project Description

The project goal was to design, fabricate, and test a steel bridge that complies with ASCE/AISC Student Steel Bridge Competition rules. The aspects of the project to be optimized included total weight of the bridge, deflection when loaded, and speed at which it could be assembled during competition. Bridge design was completed during the 2012 fall semester using a Pratt truss and unique plate-to-plate connection for the mainspan and cantilever design to accommodate evolving competition rules. This design was optimized for both deflection and weight through multiple test panel trials throughout the semester. The 2013 spring semester task was fabrication—all cutting, drilling and welding was done on-site in the engineering machine shop by the four team members. The project was an educational blend of engineering design principles and the practical experience of addressing unexpected challenges prevalent in construction projects. The bridge was constructed under timed conditions and subsequently weighed and loaded at competition March 15 during the ASCE Southeast Conference in Miami, Fla. Of the 23 teams that attended, it came in third place in lightness and seventh overall.

2013 Steel Bridge Competition

Winterset Woods Land Development

TEAM MEMBERS:

Scott Halperin
Chris Bonaventura
Lydia Husni

ADVISER:

Michael Hunkler, P.E.

CLIENT:

Gresham Smith and Partners

Project Description

The project consists of infrastructure design and construction to support a proposed 233-lot single-family subdivision with an entrance at the intersection of Sunset Road and Briarcliff Drive in Nolensville, Tenn. The developer's land planning consultant provided the layout.

The goals of the project include performing traffic impact studies to determine the effect of the subdivision on the surrounding area, determining the requirement for a left turning lane at the subdivision entrance, designing utility systems, including water and natural gas, in compliance with utility district regulations, designing effective storm water and sanitary sewer systems in compliance with local regulations and site layout, and preparing application packages for grading and for environmental and utility permits.

Concrete Canoe

TEAM MEMBERS:

Samantha Moore
Lauren Johnson
Laura Singleton
Amanda Worthington

ADVISER:

Lori Troxel, Associate Professor of the Practice

ASCE student chapter adviser

CLIENT:

Vanderbilt University ASCE

Project Description

This project requires the development and design of a lightweight concrete mix that will be used to build, and consequently row, a canoe in competition at the ASCE Southeastern Regional Conference. While the specifics within the guidelines change each year, the team must create a unique and innovative mix design that incorporates sustainability as well as a theme. We chose to commemorate the city of Nashville with a canoe named Music Row. To illustrate the theme, highway spheres and guitar picks were used to represent music and the Nashville street known as Music Row, and guitar strings were woven into the reinforcement to help with the tensile strength of the concrete. After four months of development and testing, the team chose a mix with a seven day strength of approximately 2300 psi. Construction began in February. Work continues on the canoe as well as the preparation of a written report and oral presentation for the competition March 14-16 in Miami, Fla.

Canoe team at conference.

Marshall County Hospital Project

TEAM MEMBERS:

Anthony Heath
Mohd Fahmi Roslan
Joseph Newman

ADVISER:

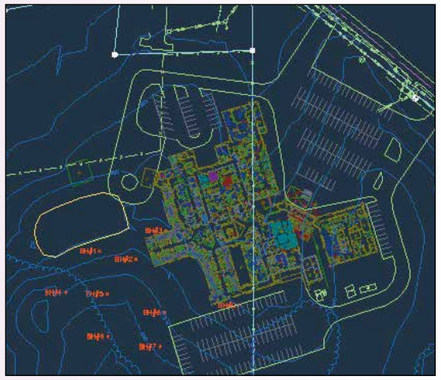
Adam Crunk, P.E.

CLIENT:

Littlejohn Engineering Associates

Project Description

The project goal is to complete a comprehensive civil-site design for a 25-bed hospital located in Benton, Ky. Our team's task was to determine parking and driveway layouts. We received the architectural design to which we attached the proposed parking layouts. Challenges included grading existing land to fit the proposed layout and ensuring that all water would be carried away from the hospital and parking areas. We wanted to minimize the amount of land moved in order to reduce cost while also meeting grading requirements. Storm water detention calculations as well as utility design also will be completed.



Proposed layout for Marshall County Hospital

Augmented Reality Android App

TEAM MEMBERS:

Matthew Lavin
Ryan Robe
Robert Newton
Jacob Logan

ADVISER:

Dave Lane, Director of Development

CLIENT:

Metova

Project Description

Smartphone applications are constantly evolving as more technology is being incorporated into newer versions. With camera views incorporating elements of user interfaces, augmented reality applications are becoming more popular in the world of smartphone applications. The world of apps is constantly changing, and the inability to adapt to changes can ensure the demise of a company dedicated to app development. The project goal is to develop an augmented reality smartphone application framework through the delivery of a business card reader application.

Our team has been able to read information from the camera view using the Tesseract optical character recognition software. We have also been able to incorporate the application programming interface (API) of LinkedIn, the social networking platform used by professionals to help with their business. We are currently implementing the user interface of the application to allow easy use. If time allows, we will implement a SQLite database used to keep track of past scans, allowing the user to find information quite easily.

Clean Hybrid Energy Scalable System

TEAM MEMBERS:

Dan Kish, ChE
Robert Jackson
Muhamad Harun
Alex Huffstutter

ADVISERS:

Mike Myers, Engineer, Vanderbilt's Institute for Software Integrated Systems

Steven Cornelius, President/CEO

CLIENT:

Jet Stream Energy Systems

Project Description

The Clean Hybrid Energy Scalable System (CHESS) is intended to address the intermittent nature of wind and solar power, supplementing those sources with clean, natural gas generation. CHESS integrates commercial off-the-shelf components to create a modular plug-and-play system that is easy to install as a standalone unit or as a retrofit kit to existing systems. CHESS can be scaled and adapted to meet specific user/application demands.

Our team partnered with Jet Stream Energy Systems to develop the first CHESS prototype. Our prototype is a trailer-mounted unit that incorporates a wind turbine, solar panels and an auxiliary generator. The wind and solar units charge a battery bank and are intended to provide the majority of the power for the system, while the auxiliary generator is configured to automatically start and provides supplemental power when there is not enough wind and sun to meet the demand of the system. This design is intended to be deployed for mobile applications, such as providing emergency power after natural disasters.

Our goal is to develop a proof-of-concept that is both inexpensive and reliable. The prototype we constructed will serve as a baseline for the development of further prototypes in the path to commercialization.

CubeSat

TEAM MEMBERS:

Omotoyosi Taiwo
Adilah Ibrahim
Abdul Kamaruzaman
Andrew Snow
Julian White

ADVISER:

Robert Reed, Professor of Electrical Engineering

CLIENT:

Vanderbilt Institute for Space and Defense Electronics

Project Description

When circuits are placed in the environment of space they are exposed to radiation. This can knock off electrons and change voltage levels, resulting in single event upsets that can change a bit from one to zero. Current circuits are designed with shielding against higher levels of radiation, but it is possible that the lower spectrum can also cause errors. Our team will test this hypothesis. The test board will be loaded onto a cube satellite along with other test boards in the hopes of changing the way satellite circuitry is designed. For this project, the major design challenge is taking a prototype test board and shrinking it to the size parameters of the cube satellite while maintaining its functionality.

The challenges associated with functionality of the board include the physical design, connectivity. The board must be able to send results and accept commands from an external communicator adapter. It must also be able to write and read on the SRAM in order to check for single event upsets. And finally, the layout of the board must fit on a 10x10 cm2 space while avoiding areas where other boards will be attached and anchored into the satellite.

Interactive Assistant for Nurses

TEAM MEMBERS:

Ejebagom Ojogbo
Kathryn Battle
Hao Lin Wang
Alok Hota

ADVISERS:

Mitchell Wilkes, Associate Professor of Electrical Engineering and Associate Professor of Computer Engineering

Karen Miller, Director of Clinical Research Operations, MPA, RN

CLIENT:

Vanderbilt University Medical Center

VANDERBILT UNIVERSITY MEDICAL CENTER

Project Description

Nurses rely upon medical supply storage carts to retrieve often used supplies for patients. These carts are generally stocked by various people, and can result in differing contents. Nurses often have difficulty retrieving items if the contents are inconsistent, leading to wasted time searching for supplies. This is critical in an emergency room setting where time is a precious resource.

Our team aims to design a prototype for an intelligent and interactive nurse cart to alleviate this problem. The Interactive Assistant for Nurses (IAN) has an application running on a laptop displaying the contents of the IAN as well as an at-a-glance meter for each item's remaining stock. When nurses select an item for retrieval, the IAN will automatically open the appropriate drawer containing the item.

Each IAN keeps track of its inventory via RFID tags on every item, and has access to a unique database table that records its current stock. When reaching a low stock threshold for an item, the IAN will automatically notify the administrator for restock. Additionally, each IAN will have the ability to record and play back audio notes, making IAN a mobile medical workstation.

Mobilizing Intelligence – Camgian

TEAM MEMBERS:

Devin Brooks
Luke Steensen
Nikhil Goel

ADVISER:

Aniruddah Gokhale, Associate Professor of Computer Science and Associate Professor of Computer Engineering

CLIENT:

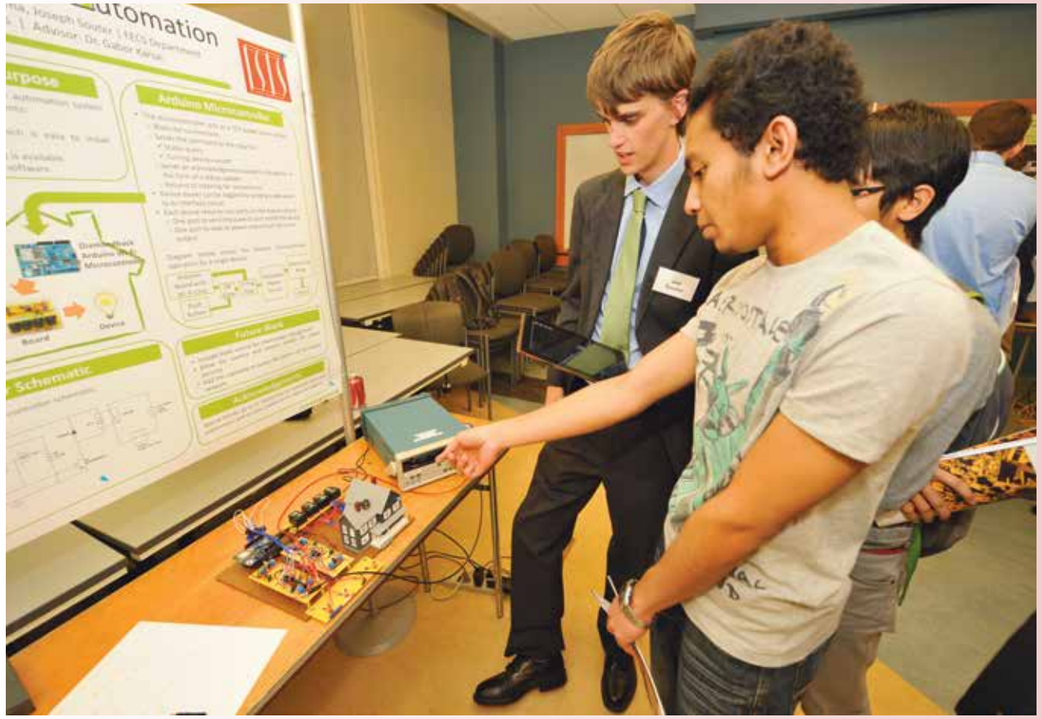
Camgian Microsystems

CAMGIAN microsystems

Project Description

Camgian Microsystems is an information technology and solutions provider headquartered in Starkville, Miss. It was founded in Dec. 2006 by Dr. Gary Butler with a focus on low power microelectronics, sensors, wireless communications and data analysis solutions for large corporations. Today, Camgian has ongoing technology development efforts in areas such as advanced embedded networking technologies and ultralow power integrated circuits. They are supported by organizations such as the Pentagon's Defense Advanced Research Projects Agency and their current intellectual property portfolio includes more than twenty patents in the area of advanced low power semiconductor technologies.

Mobilizing intelligence is a mobile framework that leverages Camgian's current application programming interface to provide applications that work on mobile devices like iPads, iPhones, and Androids. The current implementation in place only allows for their data to be seen on a desktop client. With our design project, we look to mobilize their intelligence by providing this framework in order to support the development of mobile applications.



ELECTRICAL ENGINEERING & COMPUTER SCIENCE

Blade Wear Testing Apparatus for Industrial Cutting

TEAM MEMBERS:

Ryan Mays
Drew Rinella
Mohamad Firdaus Mohamad Izaraee
Randall Kania

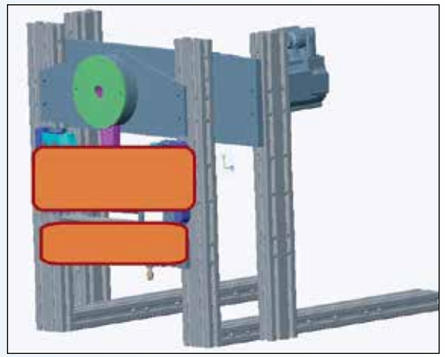
ADVISER:

Peter Goodwin

CLIENT:

Roche Diagnostics

Project Description



CAD diagram of test rig design.

The mass production of modern diabetes test strips requires a long automated assembly line. One step of this process is the cutting of individual test strips from large rolls. Making any experimental change in the production process requires costly down-time of the equipment. Recently the optimality of the cutting blade configuration has been questioned. To test this, a separate mechanism needs to be constructed to run experiments on alternative blade configurations without impacting the main manufacturing line.

The first necessary step was to determine a measurable quantity affected by quality and dulling of the cutting blade. Our research yielded several papers on energy dissipation during cutting as a function of blade performance. Using equipment that we had available, we were able to conduct our own simple experiment to estimate the order of magnitude of energy loss from the cutting of a standard test strip. With this found, the necessary resolution of our instrumentation was known. Designing a small scale model will allow us to develop the software and controls we need. We have found the appropriate parts for the full scale model and are designing housing for them. Integrated with the software, this will be the full scale system.

Vanderbilt Advanced Exhaust Energy Recovery System

TEAM MEMBERS:

Eric Citron
Karl Mecklenborg
John Hamilton
Stephen Jacobson

ADVISER:

Amrutur Anilkumar, Professor of the Practice of Mechanical Engineering

CLIENT:

DENSO

Project Description

***(Clockwise from left)* Intake duct and inline fan; Wind turbine with ogive; Redesigned exhaust stack funnel.**

Our project examines the possibility of energy savings through novel redesign of industrial exhaust stacks. OSHA standards require large industrial facilities to evacuate these buildings at certain rates (CFM). The majority of said facilities achieve these evacuation rates through the use of in-line fans whose exhaust exits through a straight outlet duct. We have redesigned the outlet duct to minimize back-pressure on the fan, as well as installed a turbine at the exit to recapture energy from the flow.

A scaled system of the proposed design has been built and comprehensively tested under the following conditions: baseline, redesigned outlet, installed turbine and installed flow director. Data collection involves measurements of flow velocity (volumetric flux), dynamic pressure, power consumed by the fan and power generated by the turbine. The analyzed data has been extrapolated to the real system to estimate the energy savings and returns on investment, if the design were to be implemented in the industrial context.

Mechanical Design of a Hybrid, Low Aerodynamic Loss Upright Bagless Vacuum Cleaner

TEAM MEMBERS:

McArthur Gill
Tyler Ritrovato
Suzie Ward, ChE
Judson Keel
Aliya Azman
Reny Abdullah
Ahmad Abdul Manan
Clayton Carson

ADVISERS:

Haoxiang Luo, Assistant Professor of Mechanical Engineering

Alok Majumdar, Aerospace Technologist

CLIENTS:

Oreck
NASA

Project Description

Oreck Corporation is a major manufacturer of vacuum cleaners, steam mops, air purifiers and other cleaning products used throughout the United States and Canada. A key priority for Oreck is the development of vacuums that make cleaning simpler, faster and more convenient.

Vanderbilt University has partnered with Oreck to assist in the development of a next generation bagless upright vacuum cleaner. Our design team was tasked to engineer a more efficient internal airflow path, an improved dirt agitation system and a dust compaction system. By developing these systems for potential incorporation into Oreck vacuum cleaners, our team hopes to improve the performance of future products.

In order to approach these three problems, we're also partnering with NASA, using NASA developed computational fluid dynamics (CFD) software to aid in the design process. Through CFD testing the team was able to simulate and optimize various internal airflow path configurations before settling on a final design for construction and experimental testing. CFD testing was also applied to ensure the performance of the dirt agitation system and dust compaction system. By coupling CFD and experimental testing, we were able to produce effective solutions for each of the three initial design challenges.

Aerowing Maintenance Rack

TEAM MEMBERS:

Robert Senseman
Matt McLaughlin
Izzat Mukhlis
Syun Asha'ari

ADVISER:

Jason Valentine, Assistant Professor of Mechanical Engineering

CLIENT:

Aerowing

Project Description

Aerowing specializes in rapid leak detection, rapid sealant removal, rapid curing of sealants and rapid leak verification for commercial and military aircrafts. Aerowing's patented technologies are used to reduce aircraft downtime caused by fuel leaks from multiple days to 12 hours or less. Maintenance on the rapid curing device (RCD), used for the rapid curing of sealants, is difficult and time consuming. Six hoses and two cables must be managed while the rapid curing device is constantly monitored. Our team's task was to develop new maintenance equipment to expedite repair and maintenance operations on the RCD.

The design team designed a maintenance rack to replace the old equipment. Prototyping and computer aided design were used to develop and test different design concepts. The new hardware gives the user the ability to rotate the equipment with two degrees of freedom while maintaining six hoses and two cable connections from external pneumatic and electrical sources. Since the connections are maintained during rotation, the device status may be monitored during the entire maintenance process, making the overall maintenance process significantly more efficient.

Automated Visual Verification of Tablets for Pharmaceutical Industry

TEAM MEMBERS:

Scott Brockmeier
Brian Donelan
Azwan Othman
Noor Azizi Suboh
Baihaqis Bahran, EE

ADVISERS:

Ed Stinnett, President

Lie Tang, Controls System Design

CLIENT:

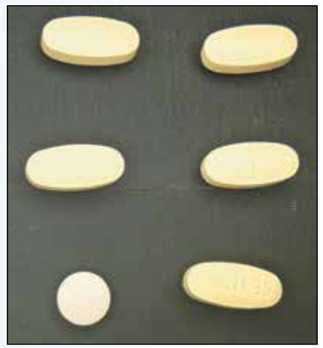
Quality Manufacturing Systems, Incorporated

QMSI

Project Description

Yankees catcher Yogi Berra once quipped: "Sometimes you can see a lot just by looking." In the world of computer vision, however, solutions are usually more complex.

Quality Manufacturing Systems, Incorporated is a leading systems integrator known across the nation for furnishing customers with exceptional industrial automation systems. Last fall, they commissioned our group to solve a challenging computer vision problem. QMSI asked us to develop a system capable of automatically validating the quality of pharmaceutical pills and capsules via digital imaging. With pharmaceutical industry revenues of USD 1.48 trillion annually amidst rapid growth, and mounting regulatory, shareholder and consumer pressures for accurate and efficient quality assurance, such a system signifies a powerful advance for QMSI's clients.



Assorted pills with one anomaly for identification.

Our team developed a multidisciplinary solution, drawing on cutting-edge research in machine vision, statistics, artificial intelligence and image processing to identify defective pills. Iterating through many designs of both software and hardware, the team pushed the envelope of what a computer can do. Technical advances represented by this solution show that engineers are every moment getting closer to robots seeing quite a bit.

Design of an Automated Guided Vehicle Visual Marker Navigation System for Parts Delivery in an Automotive Manufacturing Plant

TEAM MEMBERS:

Nathan Hollis
Sani Sulaiman
Mohammad Adzrin Adzmi
Forrest Wambold

ADVISER:

Robert Webster, Assistant Professor of Mechanical Engineering

CLIENT:

DENSO

DENSO

Project Description

The transport of components in a manufacturing environment is a delicate and vital operation which usually requires great expenditure of manpower and funding. The goal of our project is to help develop a solution for this logistical challenge. Automated Guided Vehicles (AGVs) can replace traditional methods of transportation, but such vehicles need robust and precise navigational systems.

Our team has developed a visual navigation system which circumvents many of the issues plaguing similar systems. The system utilizes a single camera per AGV which detects ceiling based markers and identifies both the relative distance from the AGV to the marker and the unique identification of the marker. The unique based visual navigation system for AGVs is low cost due to its vehicle-centric design, low maintenance due to the elimination of fragile items such as magnetic tape strips, and extremely flexible due to its robust route planning software. Our design uses multiple layers of navigation to ensure accurate and safe vehicle navigation in low light, high noise and high traffic environments. Using open source code and libraries such as OpenCV and AruCo, our team's navigation system can be manufactured in-shop by our contracting company, DENSO International.

Modification of Existing Rotating Beam Fatigue Testing Machine to Utilize Dynamic Loading

TEAM MEMBERS:

Timothy Pondel
C. Jared Schwantz
Mohammad Ab Rakib
Zhiyuan Wang

ADVISER:

Andrew Wereszczak, Ceramic Science and Technology Group

CLIENT:

Oak Ridge National Laboratory

OAK RIDGE National Laboratory

Project Description

Our client's existing rotating beam fatigue testing machine places a reversing bending stress on a material specimen that is being spun axially by the machine's motor. The amount of bending stress is determined by a sliding weight on a cantilevered beam which imparts a force on the load arm that is connected to the specimen. Data is gathered on the material's failure characteristics by plotting the equivalent load on the load arm with the number of rotations it takes for the specimen to fail. This process is repeated numerous times at different loads to gather all of the failure characteristics. Each test can take a considerable amount of time, and a full array of tests to determine failure characteristics may take days, weeks or months.

Specimen loaded for fatigue testing.

The project goal was to modify the existing machine in order to utilize dynamic loading by actuating the weight linearly and continuously along the cantilever beam while stressing the specimen during testing. The corresponding number of rotations to failure is expected to decrease, lowering the amount of time per test. The test results from dynamic loading can then be related to traditional failure outcomes and a mathematical relationship determined.

We accomplished this dynamic loading by adding and implementing a control system that uses a stepper motor to move the weight across the cantilever beam. The stepper motor's operation was scaled according to a time frame given by the user. The rotations to failure and the time frames given could then be compared to rotations to failure and loads from traditional tests.

Design and Optimization of Structural Components of an Aircraft Fuselage

TEAM MEMBERS:

Ryan Russell
Robyn Broniewski
Zulkifli Ahmad

ADVISERS:

Dan Jacob, Director - Nashville Office

Chris Tuttle, Structural Design Engineer

Nathan Greene, Structural Design Engineer

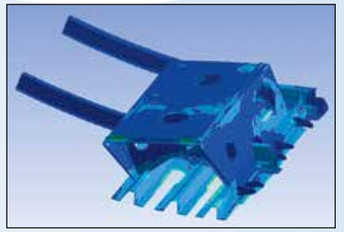
CLIENT:

Spirit Aerosystems

SPIRIT AEROSYSTEMS

Project Description

Based out of Wichita, Kan., Spirit Aerosystems is one of the world's largest suppliers of commercial airplane assemblies and components. Spirit is a major supplier for aerospace companies such as Boeing and Airbus. Currently, they are leading the way in composite construction of aircraft fuselages, wing components, propulsion structures and systems.



Existing Fan Support Bracket Stress Analysis.

A major concern in the aerospace industry is the tradeoff between minimizing the cost and weight of structural components, particularly in new composite aircraft. With the recent advances in finite element analysis software, it has become cheaper and easier to redesign and optimize a part while still meeting the specified design criteria.

Our team's task was to redesign a structural fan bracket of an aircraft fuselage to optimize its cost and weight. This was done by first creating a baseline model of the existing part using our finite element analysis tool, ANSYS. The next step was to redesign the bracket using our modeling tool, Creo, while still meeting all the loading and failure criteria set in ANSYS, creating a design iteration loop. After the bracket was optimized, a manufacturing feasibility study was performed on the fan bracket to compare the price of our newly designed part to the existing competition. The ultimate goal was to redesign this outdated part to bring it up to modern design standards for use in new aircraft.

Rocket-Based Flight Test and Performance Evaluation of a Novel Biohybrid-Fueled Ramjet Engine

TEAM MEMBERS:

Francene Corradetti
Justin Langford
Jason Lee
Brock Smethills
Ryan Thompson
Dexter Watkins

ADVISERS:

Amrutur Anilkumar, Professor of the Practice of Mechanical Engineering

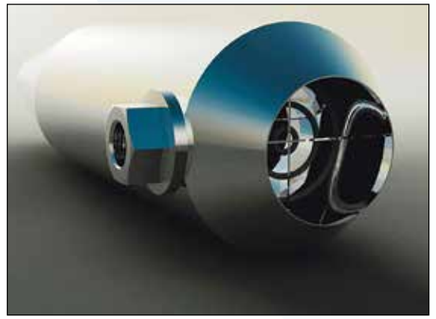
Robin Midgett, Electronics Technician

CLIENT:

NASA

Project Description

Ramjet engines are air breathing engines with no moving parts, which require air compression through high speed flight for combustion and thrust generation. Comprehensive computational fluid dynamics approaches have been used to optimize the design of a ramjet engine to burn biohybrid fuels. The key design features are a short diffuser, concentric turbulator and flameholder, and an extended combustion chamber to optimize pressure rise, fuel mixing, ignition and combustion. Biodiesel mixed with bioethanol serves as the working fuel. Extensive ground-based tests have been used to further optimize the relative placement of the flame holder and the size of the combustion chamber, as well as the right blending ratio of biodiesel and bioethanol. Rocket-based flight test provides parametric extension for testing and evaluation, along with challenges for flame ignition and sustenance. It also establishes rocket as an inexpensive flight vehicle to conduct performance evaluation of biohybrid fueled jet engines. The novel project also raises awareness for the testing and use of biofuels in the aviation sector, as mankind has to plan for the day when renewable fuels are exhausted.



CAD model of our preliminary ramjet design

Development of a Hyperminiaturized, Magnetically Actuated Robot for Visualization Assistance in Transanal Endoscopic Microsurgeries

TEAM MEMBERS:

Kara Boldt
David Cunningham
Syed Muhsin Syed Abdul Hamid
Yen Nguyen

ADVISERS:

Pietro Valdastri, Assistant Professor of Mechanical Engineering

Alan Herline, M.D.

CLIENT:

Vanderbilt Science and Technology of Robotics in Medicine Lab

Project Description

Transanal endoscopic microsurgery is a newly developed surgical procedure aimed at decreasing the invasiveness of colon cancer tumor removal. The surgery itself uses the colon as an entry point, through which robotic "hands" are driven to the tumor to remove it, and sew up the surrounding tissue. Our design team is working to produce a hyperminiaturized two degree of freedom camera device for assistance with visualizing this procedure. The device is anchored and actuated using couplings of multiple rare earth magnets, in both the internal (camera) and external (driving) devices, which allow the camera to rotate to the exact desired position in hopes of reducing operational error caused by insufficient visibility.

The camera and LED lamp are clamped onto the front magnet, which is diametrically dipolar with its external counterpart, and this spur-gear-like setup controls the tilting (up and down) motion of the camera. The housing of this magnet is attached to a pulley system that is connected to the rear of the device, which rotates based on the movement of another pair of diametrically dipolar magnets that control the panning (side-to-side) motion of the camera. The use of magnetic actuation will minimize the device's invasiveness, through greater miniaturization and minimal external physical tethering, while still allowing for the full desired range of motion.

CAD model of the camera device

Implementation of IED Detection Robots for Dynamic Convoy Routing

TEAM MEMBERS:

Taylor Madison
Clair Hernon
James Seduski
Paolo Fu
Sarah Martin, EE

ADVISERS:

Michael Steffen, Systems Engineer

Michael Kariya, Systems Engineer

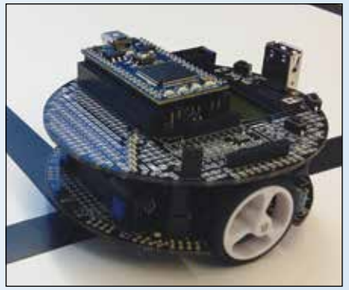
CLIENT:

Northrop Grumman

Project Description

Northrop Grumman is the leading global security company providing innovative systems, products and solutions in unmanned systems, cybersecurity, and logistics to government and commercial customers worldwide. These products have been deployed primarily by the Department of Defense, and are used both beneath the sea and in outer space.

The team was tasked with the implementation of Improvised Explosive Device (IED) detection robots for dynamic routing of a military convoy. The current practices for detecting IEDs are slow and cumbersome. With that in mind, this project creates an autonomous system which can map the fastest route for a convoy through an urban area and subsequently searches the route for IEDs. If an IED is detected along the original route, an alternative route is found and the convoy is diverted to the alternative route. This process is repeated until the convoy reaches its destination.



An IED detection robot displays knowledge of local roads and intersections in order to provide safe navigation to convoys.

Last year's design team created an algorithm which tested search techniques and their efficiencies with a varying number of robots. Our team took that algorithm and employed it in a physical test environment. This process involved choosing a robot and what environment to use while testing, finding a simplified substitution for an IED and corresponding sensing mechanism that would provide the robot with accurate detection, as well as creating a system for dynamic routing of the robot. The project design goals were to produce a robot that could accurately search a test environment for a simulated IED, enable the robot to follow a path searching for IEDs and to reroute the robot to a new path when an IED is detected.

Development of an Inventory Tracking System for All Vehicles Produced in Nissan's Smyrna Plant

TEAM MEMBERS:

Bailie Anne Borchers
Muhammad Hilman Fazli
Nur Aiysha Ghazali
Lester Joshua Primus
Anas Nazreen Bakri

ADVISERS:

John Pionke, Product Quality Analyst

Griffin Knight, Product Quality Analyst

Ashley Gatlin, Manager in Manufacturing Quality

CLIENT:

Nissan North America

Project Description

Nissan North America in Smyrna, Tenn. is a major manufacturer of automobiles for the American market and produces several models of Nissan vehicles at the Smyrna plant. Nissan's highest priority is to produce vehicles that meet the expectations for quality of their customers in all ways.

Our team was asked to establish an inventory tracking system for all vehicles produced at the plant. The fully developed tracking system must include details on: how the vehicles will be tracked, the point at which tracking will begin and end, and the estimated cost to purchase the equipment needed.

By use of radio-frequency identification (RFID) chips and sensors, our group created a systemic plan to insert an automated tracking system to locate specific vehicles in all Nissan parking lots. This will significantly reduce labor costs and increase the productivity of all employees whose task it is to track down lot vehicles. Our group's tracking system plan implements RFID technology for the entire area made up of several Nissan parking lots, which is approximately 0.250 mi2. The system initiates at the end of production line, also known as "final line", and terminates when the Nissan plant sells the vehicle, providing a very technically efficient tracking system.

Development of a System to Utilize Groundwater as the Working Fluid in a Heat Exchanger in Order to Reduce the Cost of a Current System

TEAM MEMBERS:

Rachel Carter
William Redd
Dylan Bulloch
Grant Brennecke
David Gallo

ADVISERS:

Mitchell Lampley, P.E., CEM
Director of Engineering and Technology

Mark Petty, Assistant Vice Chancellor for Plant Operations

CLIENTS:

Trane Corporation
Vanderbilt University
Plant Operations

Project Description

Vanderbilt's Plant Operations provides support and maintenance for buildings across the campus. In addition to building upkeep, Plant Ops also manages services such as electrical, heating and air conditioning and water.

One of Plant Ops current objectives is an alternative to a part of the cooling system for the dorms on Highland Quad and the Blair School of Music. Currently, city water is pumped to the roof and run through cooling towers before being used in the chillers located in the maintenance building. The cooling towers are meant to decrease the thermal load on 000the chillers. Our design task was to investigate the alternative sources of ground water on campus and examine the potential for using this already cooled water to supplement or replace the rooftop coolers. The ground water was discovered in Vanderbilt's recent construction project involving construction of the west garage, which has eight underground floors, and the underground tunnel running from a location near west garage to the central power plant on campus and to the Monroe Carell Jr. Children's Hospital. As part of the study, we examined the financial and physical feasibility of the project.

Design of a Portable Video Booth for Use on Vanderbilt University Campus

TEAM MEMBERS:

Amy Bergeron
Sara Delgado
Fatin Nabilah Jamil
Natashah Maarof

ADVISERS:

Elizabeth Lingo, Director

Amy Wolf, Senior Public Affairs Officer

CLIENTS:

Vanderbilt News and Communication

The Curb Center for Arts, Enterprise and Public Policy

The Curb Creative Campus Initiative

Project Description

The Vanderbilt Story Booth is a highly customizable and mobile video booth designed to collect and share real time, authentic stories and voices. Vanderbilt is the first university to embed a traveling video story booth in the undergraduate campus experience. With a high-definition camera, the booth offers the opportunity to capture high quality video that can convey the "real voice" of students, faculty, staff and the multifaceted nature of Vanderbilt's identity. Throughout the 2012-2013 academic year, Vanderbilt utilized a video booth that was on loan to the university. The loaned story booth traveled across campus and provided opportunities for students, faculty, staff, alumni, visitors, and more to develop and share stories.

Our team was asked to design an improved story booth that is highly portable and can accommodate two people for one-on-one interviews including wheelchair users. Tasks included gathering user feedback from the current story booth, working closely with the project's campus sponsors to address stakeholder requirements, generating several design concepts to present to project advisors and constructing a prototype of the final design. Interviewing experts in various fields was crucial to determine the feasibility of design concepts; those included a paper engineer, a representative from the Video Booth Company, and suppliers of various materials that were considered. Mechanical engineering knowledge from modern manufacturing processes, materials science and CAD modeling were applied to achieve a successful outcome in this project.

MECHANICAL ENGINEERING

Neocortex Medical Application

TEAM MEMBERS:

Ryan Cristal, BME
Brendan Lynch, BME
Spencer Crosswy, CS

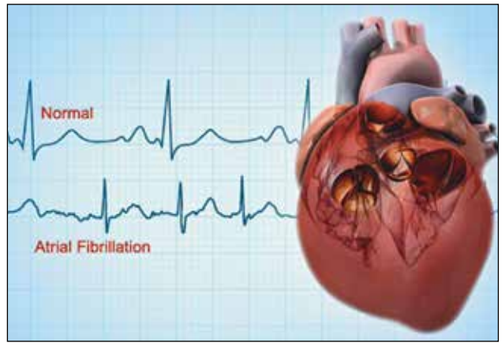
ADVISER:

David Peters, CEO

CLIENT:

Universal Robotics

Project Description



The minor differences in ECG signals between normal and atrial fibrillation-prone hearts are a major reason why automated AF detection has eluded researchers for years.

Atrial fibrillation is an arrhythmia that affects over 2.2 million people in the United States alone. If detected early, this condition can be easily treated with blood thinner or minimally invasive surgery; however, detection of the condition is often made only after patients have been hospitalized for stroke caused by atrial fibrillation. This is, in part, due to the current absence of implemented or marketed software that can analyze professional quality ECG data in real time to make a highly sensitive and specific atrial fibrillation diagnosis. Universal Robotics' initial research has indicated that its proprietary and novel artificial intelligence software, "Neocortex", is able to provide these capabilities, therefore presenting the firm with a strong market opportunity.

Our group has been tasked with creating a business plan for the monetization of this innovative technology with the end goal of obtaining seed financing for the venture. We have capitalized on Universal Robotics' abilities to combine various disciplines and analyze big data in a way that opportunistically positions the firm to gain both initial and growth financing. In addition, the business plan outlines a strategy that will allow Universal Robotics to provide immediate value to clients, while also maintaining a long-term competitive advantage.

Smart Blood Cooler

TEAM MEMBERS:

Jim Mullen, ME
Chris Baker, BME
Walker Hinshaw, BME

ADVISER:

Matthew Walker III, Associate Professor of the Practice of Biomedical Engineering

CLIENT:

Blood Monitoring Solutions

Project Description

Our goal is to create a blood delivery process that reduces red blood cell wastage through the utilization of a temperature feedback system. Due to the high cost of blood units and FDA storage temperature regulations, large scale hospitals can lose hundreds of thousands of dollars in non-expiratory blood wastage each year. Our system aims to help refine the blood delivery process in order to reduce this wastage and save hospitals money.

During this project, we built design requirements around the needs of the Vanderbilt University Medical Center by consulting with doctors, blood bank workers and by observing habits in operating rooms. The cooler is designed around detecting if blood is present, sensing the temperature of each unit, transmitting temperature to the blood bank, alerting the appropriate personnel when blood products are about to exceed a threshold temperature for safe return to refrigeration and designing a mechanism to keep the cooler closed. This method will ensure that we design our system with testable parameters and stakeholder needs in mind. The process will also be iterative, using various checkpoints to ensure we are on the right track.

ENGINEERING MANAGEMENT

Targeting a Disruptive Technology to a Specific Product Segment

TEAM MEMBERS:

Alex Meadow, ES
Fred Eisele, CS
Jonathan Kokot, BME

ADVISER:

Jamie Bailey,
Founder/CEO

CLIENT:

Initial State Technologies

Project Description

The ultimate vision for this creation is to disrupt the diagnostics and verification industry for products that are in the field as well as under development. Consider when your washing machine breaks down. Rather than having a repairman come to your house and work for two hours determining the problem before they can even order replacement parts, imagine them remotely logging into your washing machine, viewing its operation virtually, determining the problem, and arriving at your house with the replacement parts.

The key challenge with Initial State's technology is gaining the momentum for mass adoption. Washing machine manufacturers aren't going to implement the technology just because we say so; they need to be convinced through tangible proof of the technology's effectiveness. To gain the necessary momentum, we decided to enter the open-source electronics prototyping industry. Soon students, engineers, hobbyists, artists and designers will have insight into their creations like never before. They will receive integrated answers to their most perplexing technical questions. They will gain the ability to create increasingly sophisticated devices while employing decreasingly complex instrumentation. Building upon the System-on-Chip that preceded it, the integration of instrumentation onto a single chip permits the next big thing in cyber-physical systems.

Hand Hygiene Sensors

TEAM MEMBERS:

Alec Lafontant, BME
Morgan Hauenstein, BME

ADVISERS:

Jesse Ehrenfeld, M.D.
Jon Wanderer, M.D.

CLIENT:

Vanderbilt University Medical Center, Dept. of Anesthesiology

Project Description

Hospital acquired infection poses a persistent threat to patient safety and is a leading cause of morbidity and mortality. Current data from Vanderbilt University Medical Center reflects that hand hygiene compliance ranges from 60 to 95 percent by department. Current solutions, such as manual observation, are time and resource intensive and have failed to achieve the level of compliance desired.

The integrated sensing system above tracks doorway entry and hand sanitization in order to record and improve hand hygiene compliance.

Our goal is to develop a business plan for a real-time sensing system currently being developed at VUMC that can be used to evaluate usage of alcohol based foam dispensers when entering patient rooms. By tracking room entry and hand hygiene compliance, the effect of interventions, such as an alarm, on compliance rates can be evaluated.

Key commercialization challenges included market competition, cost and reliability. Given the increasing financial pressure on healthcare institutions, the product market is immense but quickly filling with competitors. Thus, product reliability, accuracy and cost are important factors for market success. Inaccurate current standards and unpredictable human behavior make clinical performance rates difficult to determine. However, we have assessed the value of our device and competitors in order to determine our niche market and create a market procurement strategy.

Insight Genetics – QuantiTissue

TEAM MEMBERS:

Andres Arango, BME

ADVISER:

Chris Callaghan,
President and COO

CLIENT:

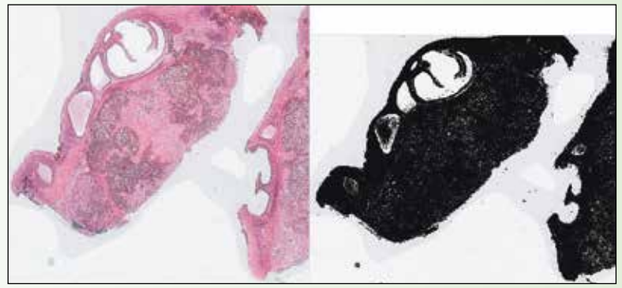
Insight Genetics, Inc.

Project Description

A large percentage of cancer testing returns no distinguishable result due to the poor quality of samples used for testing. These are returned to the ordering hospital with a Quality Not Sufficient (QNS) result. Testing laboratories have reported as many as half of samples from hospitals as QNS, which are a waste of time and money. To address this issue, Insight Genetics is developing QuantiTissue, a laboratory tool to determine the quality of a sample prior to testing.

QuantiTissue will be used to immediately reduce unnecessary testing by prequalifying tissue samples for testing. The device will also provide testing laboratories with a new tool with which to measure the sensitivity of their tests. The key challenges will be proving clinical utility of the device to drive adoption, and create an economic case for a device that will likely reduce testing volume.

Project objectives consist of a market analysis, business model and commercialization strategy for the QuantiTissue device. Items of interest include the economic value and cost of the device for each stakeholder in the cancer care market and how QuantiTissue would complement or disrupt their economics.



QuantiTissue is able to accurately analyze high resolution images of cancerous tissue for their content.

S-RAM Dynamics

TEAM MEMBERS:

Durga Ayyanathan, ES
Brandon Maloney, ES

ADVISER:

Lee Jestings, President

CLIENT:

S-RAM Dynamics

Project Description

The Sanderson Rocker Arm Mechanism (S-RAM) is an elegantly simple mechanism that converts reciprocating to rotary motion, producing high efficiency in both directions without the energy-robbing side forces on the pistons common to crankshaft, swash plate or wobble plate drive mechanisms. The S-RAM drive mechanism can vary piston stroke while maintaining a fixed head clearance, which is not possible with other drive mechanisms. The S-RAM can also be configured with double-ended pistons dramatically increasing power density. It has the potential to be a game changing technology for several applications.

Our capstone project's main focus is on commercializing the S-RAM to enable the HVACR industry to convert from HFC refrigerants to the natural refrigerant of CO2. Our team's focus is on business intelligence and innovation strategies. The main goal is to define the most effective business model. We will address the following: define value proposition, prioritize applications and identify develop path, define market priorities and size, commercialization plan (i.e., licensing or manufacturing or joint venture), identify potential partners and early adopter customers and prepare proforma financials.

Clean Hybrid Energy Scalable System

TEAM MEMBERS:

Daniel Kish, ChE
Stephen Jacobson, ME

ADVISERS:

Stephen Cornelius, President/CEO

John Stevens

CLIENT:

Jet Stream Energy Systems

Project Description

The Clean Hybrid Energy Scalable System (CHESS) is intended to address the intermittent nature of wind and solar power, supplementing those sources with clean, natural gas generation. CHESS integrates commercial off-the-shelf components to create a modular plug-and-play system that is easy to install as a standalone unit or as a retrofit kit to existing systems. CHESS can be scaled and adapted to meet specific user/application demands.

Our team partnered with Jet Stream Energy Systems to develop a commercialization plan for CHESS, focusing on market identification and segmentation, product specification, competitive analysis, and overall opportunity assessment. We're working in parallel with an EECS design team that is constructing the first CHESS prototype.

At this stage, our market focus is on small systems for micro-grid and portable power applications, and those should serve as a launching point into additional applications in commercial and industrial power. There is significant interest in these initial markets for a hybrid system like CHESS that can overcome the challenges of wind and solar energy. The primary obstacle to CHESS right now is developing a customer ready system. Once this is accomplished, Jet Stream Energy Systems has a promising path into the clean energy industry.

ENGINEERING MANAGEMENT

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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 and Translational Research grant (UL1TR000011 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.

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