OPUS
College of Engineering

MARQUETTE UNIVERSITY

Electrical and
Computer Engineering

2024 SENIOR DESIGN PROJECTS

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

FOREWORD

from the Department Chair

On behalf of the Department of Electrical and Computer Engineering (EECE) in the Opus College of Engineering, I would like to showcase our students' capstone senior-design course for the academic year of 2023-2024. These senior-design projects are a critical component of our students' learning experience as they become transformative engineers. I strongly believe that both education and research can benefit greatly from close partnerships with industry and vice versa. Hence, industry's sponsorship of the projects is key to the success of the projects as well as the completeness of our students' education. The senior-design projects shown in this booklet demonstrate how what is learned in the classroom and laboratories can be put to practice to solve real-world problems. In these industry/faculty sponsored projects, students work together in multi-disciplinary teams, communicate with their sponsors, practice effective project management, and deliver a final product.

As you glance through the projects in this booklet and read through the testimonials by students, you will see evidence of the technical depth and breadth of our electrical engineering and computer engineering programs. The subject matter of the projects and the level of engagement with the sponsors also show our students' commitment to positively impacting our society. This is truly remarkable.

Foremost, I am grateful to our students for their creative work, perseverance, and determination to take these challenging projects to the finish line. I would also like to thank our sponsors who never stop believing in our students. I would also wish to extend special thanks to our faculty advisers for their hard work in planning, designing, and implementing a world-class engineering design experience for our students. Finally, I would like to express my gratitude to our graduate student-assistant, Ms. Ecem Kasagga, for her creative and thorough work in putting this booklet together. Let's make a difference!

Dr. Majeed Hayat
Professor and Department Chair
Electrical and Computer Engineering

OPUS

College of Engineering

Since 1908, Marquette University Opus College of Engineering (OCOE) has been uniquely blending professional engineering preparation with a liberal arts education to provide the world with well-balanced leaders in their profession.

OCOE Mission

Our diverse community of engineering scholars collaborates in transformative learning environments to lead change for the benefit of humanity. We prepare students for fulfilling careers by providing a strong technical and ethical foundation.

We ignite curiosity, encourage student-centered learning, and foster critical thinking by:

- Educating engineering leaders who thrive in innovative, entrepreneurial, and dynamic environments.
- Exploring, discovering new knowledge, and putting research into action.
- Engaging professional and technical communities worldwide.

Accreditation

All undergraduate programs offered by the Marquette University Opus College of Engineering are accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012, 410-347-7700

Marquette University

Founded in 1881 in Milwaukee, Wisconsin, Marquette University has been educating people of faith to be leaders in their professional lives, their communities and in society.

Since the first graduating class of five men were awarded bachelor of arts degrees in the 1880s, Marquette has grown into a modern coed campus of more than 11,000 students who learn and grow through nationally admired undergraduate and professional programs.

ABOUT

Senior Design Projects

All senior electrical and computer engineering students are required to complete this two-semester multidisciplinary course. The course requires students to work on a design project in a team of three to six students. While working on the design project, the students learn and practice current project management methods, including written reports, oral presentations, and developing a working prototype.

Some of these projects are sponsored by our industry partners, giving students an opportunity to see into the industrial world and gain experience and insights into various practices and technologies employed by industry.

As a special note, we would like to thank Dr. Ronald Coutu, Jr., who skillfully and excellently coordinated the Department of Electrical and Computer Engineering senior design projects.

SPONSORS

Tony R. Pink, Dynamic Ratings, Inc.

Dr. Fred Frigo, GE HealthCare & EECE, Opus College of Engineering

Dr. Ronald Coutu, Jr., EECE, Opus College of Engineering

Dr. Priya Deshpande, EECE Opus College of Engineering

Dr. James Richie, EECE, Opus College of Engineering

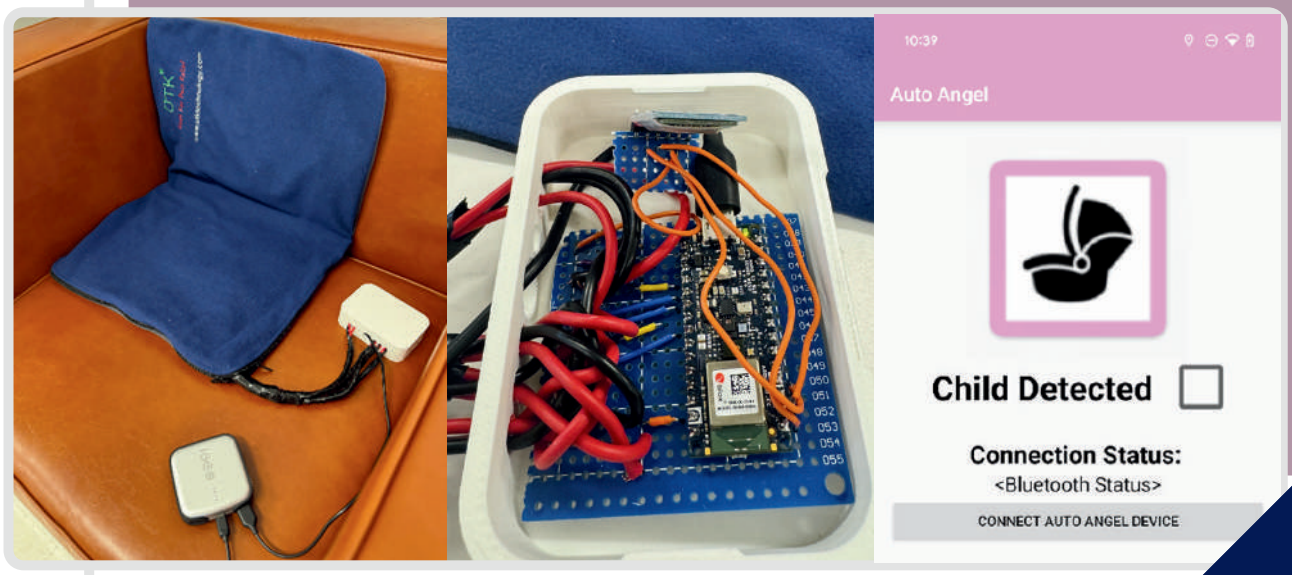
SYSTEM FOR DETECTION OF FORGETTEN CHILDREN IN CARS

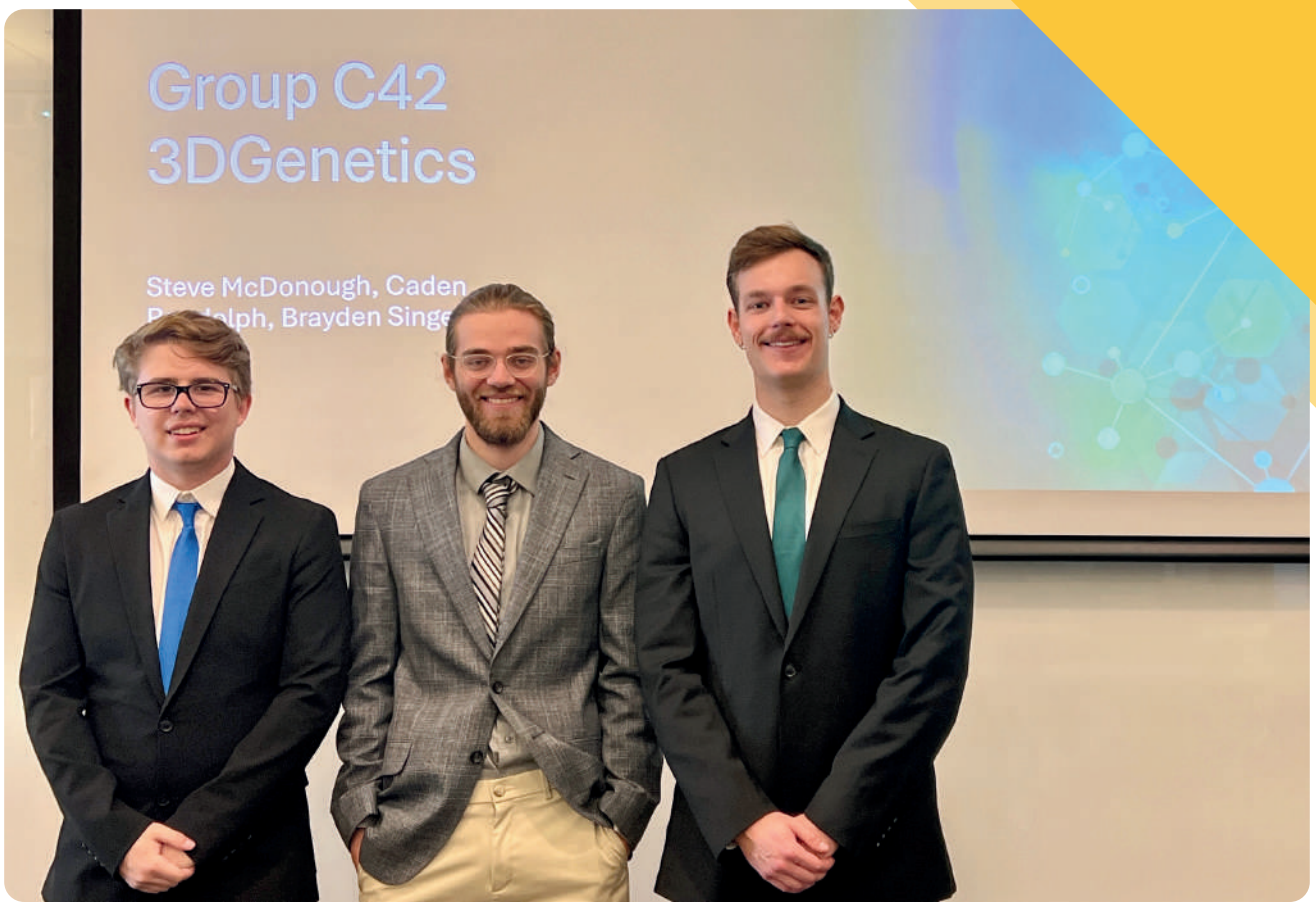
Team (left to right)	Julia Roesler, Mitchell Rouse, Viviana Garcia, Ben Minick, Danny Okerlund
Faculty Advisor	Dr. Cris Ababei, EECE, Opus College of Engineering
Sponsor	Marquette University

Each year, children die or become endangered because they are left unattended in their vehicle by their parent or guardian. Cars in direct sunlight can rapidly increase in temperature, reaching unsafe levels in just over 2 minutes. The purpose of this device is to create a fast and reliable way to elicit a response from the parent or guardian to return to their vehicle and child.

Our final prototype is an additional car seat mat connected to an electronic housing that, using the combination of weight and temperature sensors, is able to accurately notify a Bluetooth-connected device that there is a child sitting in the car seat. The electronic housing contains an HC-05 Bluetooth module and an Arduino Nano BLE that are in constant communication with a connected Android cell phone. When the cell phone reaches a distance where the Bluetooth module can no longer keep a connection, the designed AutoAngel app will know if a child is still detected when the cell phone is disconnected. If a child is detected, an alert will immediately be sent to the cell phone to notify the owner to return to their vehicle. If no child is detected, no alert will be sent to the cell phone, and the owner can proceed with their tasks as normal.

Testing for this device showed that a user was able to turn off their vehicle, exit, and receive a notification that a child was still detected in the vehicle less than 2 minutes from turning off the car to walking a distance where the Bluetooth device disconnects. This creates optimal safety for the child and gives the parent or guardian peace of mind, allowing them to have a backup reminder for additional child safety.

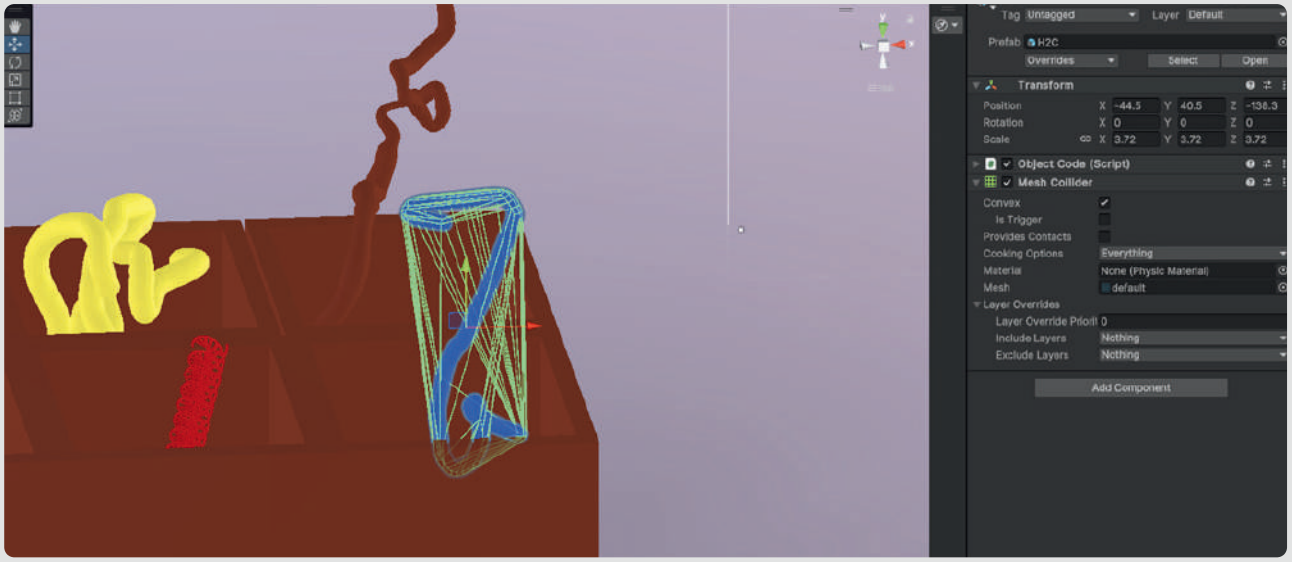




EPIGENETICS LEARNING TOOL

Team (left to right)	Brayden Singer, Caden Randolph, Steve McDonough
Faculty Advisor	Dr. Priya Deshpande, EECE, Opus College of Engineering and Dr. Khadija Makky, Biomedical Sciences
Sponsor	Dr. Priya Deshpande, EECE, Opus College of Engineering

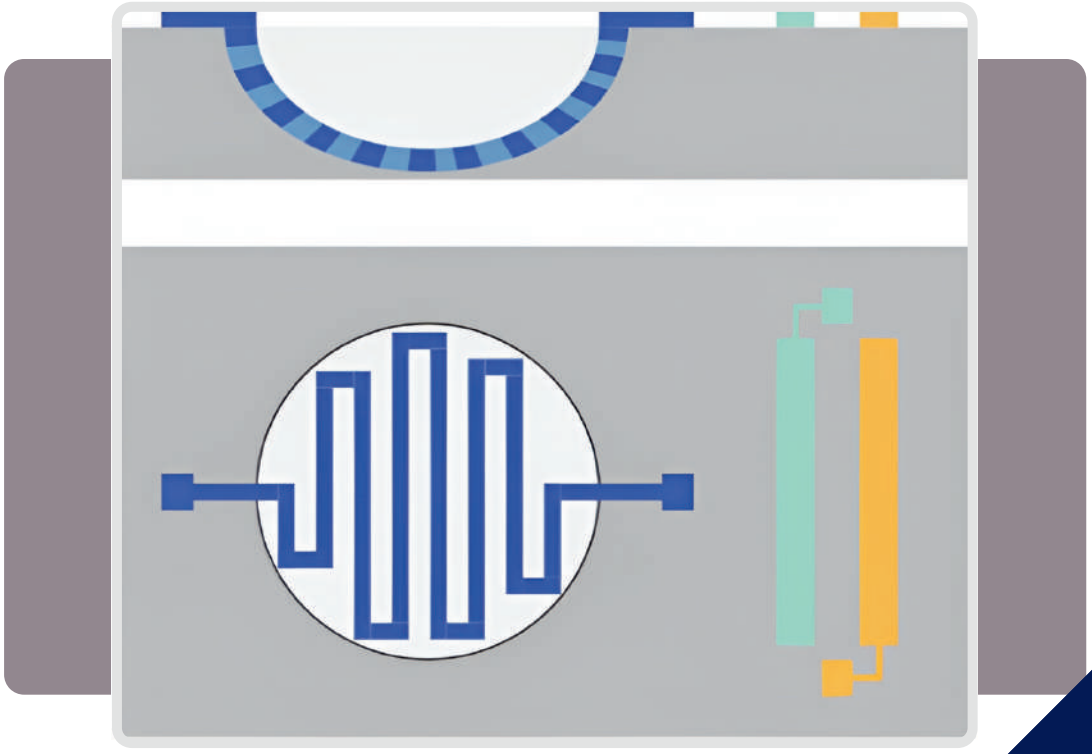
Our team was tasked with developing a learning tool to help struggling students in Marquette's epigenetics classes. To accomplish this, we needed to develop something intuitive, easily accessible, and accurately portray the processes students learn about in their curriculum. To accomplish this, our team decided to use open-source tools like Blender and Unity to develop an application that would resemble a game for students to explore the DNA creation and modification processes they need to know. Blender was used to create the 3-D models to represent the DNA and other molecules that students would interact with within the program, and Unity was used to create the learning environment where students would assemble structures and complete tasks. Our team successfully created this, and received valuable feedback from users on how to improve our product. We were successful in creating accurate models with Blender, as well as creating the learning environment and learning task in Unity. Future senior design teams can push this work even further.



NOVEL, LOW-COST MOISTURE SENSING FOR HOME AND REMOTE AREA USE

Team (left to right)	Mary Bell, Evan Zielke, Aidan Kleinsasser, Patrick McKeever, Samuel Bel
Faculty Advisor	Dr. Ronald Coutu, Jr., EECE, Opus College of Engineering
Sponsor	Dr. Ronald Coutu, Jr., EECE, Opus College of Engineering

Unseen water leaks are among the costliest damages a property owner can experience. Besides their financial impacts, leaks can lead to various health risks. When troubleshooting a plumbing system for leaks, the most common areas to check are open connections to faucets, toilets, showers, dishwashers, and washing machines. Pipes and connections inside walls are difficult to inspect for and prevent leaks. Accessing plumbing inside of walls is costly and invasive. Homeowners would benefit from a monitoring system that can sense leaks inside a wall before water damage builds up in both scale and repair costs. Microelectromechanical systems (MEMS) technology utilizes low-cost integrated fabrication techniques to create mechanical structures at the micron scale. The mechanical stresses these structures experience cause measurable changes in voltage or resistance within the circuit. The purpose of this project was to design and fabricate a prototype of a MEMS sensor that combines the use of a membrane with a piezoresistor that would detect the pressure of water resting on the membrane's surface and two dissimilar metals that would corrode and cause current to flow through them when water is present. A second component of the project was researching how the building codes could be amended to require the retrofitting of this device or its use in new developments to promote commercialization.



GE HEALTHCARE ROBOTIC TESTING

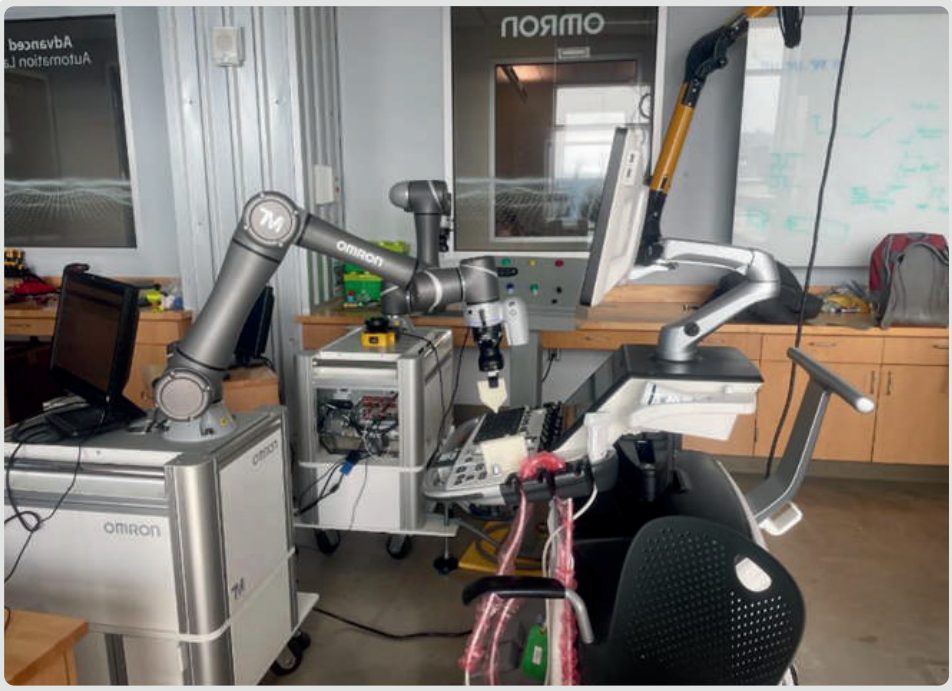
Team (left to right)	Bekkah Scufsa, Jacob Benigni, Rich Lukas, Lauren Bonetti
Faculty Advisor	Dr. Fred Frigo, EECE, Opus College of Engineering
Sponsor	Dr. Fred Frigo, EECE, Opus College of Engineering

Most medical devices support automated testing through a series of scripts that simulate user interactions with the device. However, this testing strategy bypasses the user input device, leaving that part of the system untested. This project aims to address this gap by using an Omron robot to test touch panels, trackballs, hard keys, and other input devices through a robotic mechanism, thereby eliminating the need for human input on a GE Healthcare Ultrasound machine.

The clients for this project are companies like GE Healthcare, which are required to perform rigorous testing of medical devices to ensure quality and reliability in clinical settings. These companies seek innovative mechanisms to improve automated testing coverage, especially in areas that are difficult to test.

The robot chosen for this project is the TM5-900 Omron robot, a high-precision and reliable machine equipped with adaptive mapping and object recognition capabilities. A series of tests were conducted, including the use of the keypad, touch panel, and knobs, to verify the feasibility of the product.

The overall benefit of this improved quality testing is reducing system failures that could occur in healthcare settings, ultimately benefiting both patients and clinical staff.



SECURE COMMUNICATIONS TO THE US POWER GRID

Team (left to right)	Ryan Solveson, Tony Gonzalez, Jose Rovira, Meghan Simutis
Faculty Advisor	Dr. Ronald Coutu, Jr., EECE, Opus College of Engineering
Sponsor	Tony R. Pink, Dynamic Ratings, Inc.

The customer, Dynamic Ratings, needed a replacement chipset for their product, iBridge. This product is designed to deliver data safely and securely from IEDs, RTUs, and cameras with reliability and consistency. The iBridge accomplishes this task by using an inductive coupler to send and transmit signals along existing power lines rather than installing an ethernet cable. The inductive coupler can be easily attached to a wire without breaking that wire's connection. This allows secure data transmission without running or burying a cable between destinations. The chipset that needs to be replaced is now obsolete, and the customer needs a solution that can match, if not enhance, the capability of the iBridge. These chips are responsible for taking the digital signal from the processor, encoding it before transmission, and decoding the received signal.

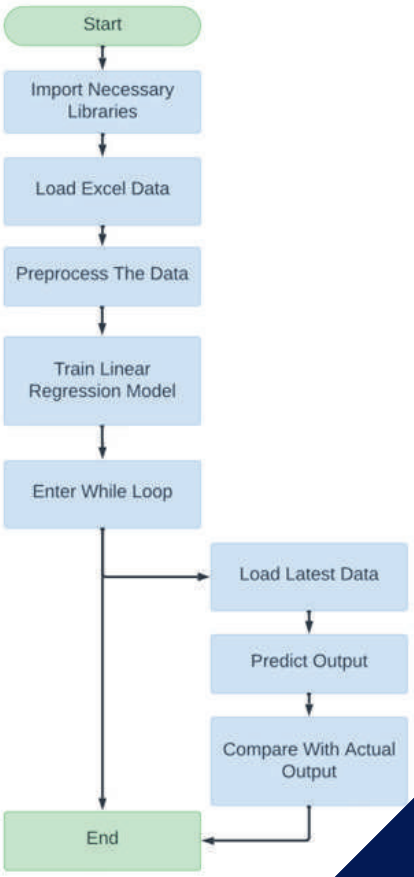
The selected rebuild is from Lumissil Microsystems, which is a home plug device that utilizes the Lumissil chipset. Throughout the semester, it has been modified and adapted to reach the same capabilities as the original iBridge product.

USING AI TO THWART TERRORIST ACTIVITIES AND PROTECT THE US POWER GRID

Team (left to right)	Adolfo S. Villa, Jose Garcia, Calvin Taylor, Evan Dalhoe, Amrit Pal Singh
Faculty Advisor	Dr. Ronald Coutu, Jr., EECE, Opus College of Engineering
Sponsor	Tony R. Pink, Dynamic Ratings, Inc.

Over the years, the United States' power infrastructure has been exposed to numerous attacks. The most common attack is inflicting physical damage to transformer oil tanks present in substations. These physical attacks not only cause companies to lose revenue but also deplete reliable energy provided to populations. While there are no long-term loss prevention procedures, there are ways for companies to temporarily mitigate their losses. Current attempts at preventing power infrastructure attacks include changes in legislation (how attackers are prosecuted), on-site security personnel, and manually preventing further collateral damage (containing oil spills).

The purpose of the project is to develop an artificial intelligence (AI) model that analyzes oil temperature and oil pressure data within a transformer oil tank to detect unwanted changes. For our project to meet declared standards, the AI model must analyze large data sets, generate accurate predictions, compare results in real-time, and notify users of potential complications. To collect usable data for the AI model to use, the group built a physical prototype that simulates a transformer oil tank. In tandem with the tank, the following were used for data collection: a temperature probe, transducer, and a data collection box (E3).



EECE Students Worked on Projects in Other Engineering Departments		
Project Department	**Project Title**	**EECE Students**
Mechanical Engineering	NASA Project	Gabriella Accardi
Mechanical Engineering	NASA Project	Alex Kubik
Mechanical Engineering	NASA Project	Matthew Pauly
Mechanical Engineering	NASA Project	William Pawlowski
Mechanical Engineering	NASA Project	Nathan Timmins
Mechanical Engineering	FASN Mass Customization	George Voight
Mechanical Engineering	*IP Protected*	Chris Toennies
Mechanical Engineering	*IP Protected*	Ben Doyle
Biomedical Engineering	Cost Effective Neonatal Respirator	Ninfa Banda
Biomedical Engineering	Cost Effective Neonatal Respirator	Kamryn Brockman
Biomedical Engineering	All-Terrain Walker or Wheelchair for Improved Access	John Hodges
Biomedical Engineering	All-Terrain Walker or Wheelchair for Improved Access	Will Shanahan

TESTIMONIALS
from Students

“Senior Design at Marquette gave me the opportunity to work between engineering disciplines and emphasized the trial and error necessary for the design process. This experience allowed me and my teammates to get experience in skills outside of the classroom such as project management, collaboration, and risk taking while in conjunction applying the skills we had learned for the past 3 years at Marquette. This class gives students incite on what to expect of an engineering career and helps them prepare for industry in the best way possible.”

Julia Roesler

"My senior design project at Marquette University was an excellent capstone to my electrical engineering degree. It provided a hands-on opportunity to face and overcome real-world engineering challenges, allowing our team to apply and test our skills in a practical environment. This experience was invaluable in preparing us for our careers by simulating the complexities and problem-solving required in the engineering field"

Ryan Solveson

STUDENT ORGANIZATIONS

@MarquetteEECE

Marquette University's Electrical and Computer Engineering Department emphasizes leadership, innovation, teamwork, and service. A keyway for students to embody these values is by getting involved in honor societies and student organizations.

One such organization is Eta Kappa Nu, the honor society of IEEE. It was founded in 1904 at the University of Illinois at Urbana-Champaign as Eta Kappa Nu; merged with IEEE in 2010 to become IEEE-Eta Kappa Nu (IEEE-HKN). Candidates are invited to join based on their academic ranking, and their character and attitude. Eta Kappa Nu is recognized around the globe as the one honor society that represents the highest values of our profession.

This year, three students from senior design projects—John Hodges, Mitchell Rouse, and Kamyrn Brockman—are proud members of IEEE-HKN, exemplifying these values through their work.

Why Join IEEE-Eta Kappa Nu

- Distinguishes you from other students by recognizing your academic achievements.
- Offers leadership opportunities for professional development at both local (Chapter officer) and global (conferences, committees) levels.
- Members receive *The Bridge*, the official IEEE-HKN publication, providing opportunities to submit papers.
- Recognizes members through various awards, including outstanding student, chapter, young professional.

For more details:

IEEE-HKN members, (left to right) Benjamin Bolz, Anthony Esposito, John Hodges, Kamryn Brockman, Dr. James Richie, Anna LoFaro, Mitchell Rouse, Kurt Land, Nicholas Mika

EECE@MARQUETTE

Advantage

The Department of Electrical and Computer Engineering sets itself apart from its peers through a combination of unique features and distinctive opportunities, making it an outstanding choice for aspiring engineers. Here are some of the advantages that EECE provides:

- All courses are taught by faculty members not teaching assistants.
- Students are directly admitted into Electrical and Computer Engineering.
- Students are guaranteed to graduate in four years (or five years with a co-op) if they follow the bulletin.
- Faculty teach students to be an engineer: students graduate knowing how to learn and how to solve problems.
- Both electrical and computer engineering programs have substantial flexibility. They have five electives through a breadth (three courses in different subject areas) and depth (two additional courses in an area of the student's choice) structure. In addition, there are one or two additional electives.
- Substantial hands-on work occurs in most classes, even if not listed as a laboratory course. The EECE Open Laboratory in Engineering Hall is available to students to work on class projects or their own special projects.
- Required laboratory courses in the major rely on the preceding theory courses to allow more in-depth and integrative lab experiences.
- Our co-op program is among the oldest in the country.
- Considerable interaction with Milwaukee industry, including internships, cooperative education, and other employment opportunities.
- Within six months of graduation, nearly 90% of our students have full-time jobs or attend graduate school.
- Considerable undergraduate research opportunities are available in our faculty's laboratories.
  - o Computer Engineering has a strong artificial intelligence (AI) and machine learning (ML) emphasis.
  - o Electrical Engineering has a strong emphasis on power and sensors.

FACULTY Advisors

Hayat, Majeed, Ph.D.

Chair & Professor

Electric-grid analytics for enhanced reliability and resiliency, AI-empowered spectral sensing, signal and image processing, distributed computing systems: modeling, design and optimization, fiber-optic communication: novel avalanche photodiodes.

Ababei, Cris, Ph.D.

Associate Professor

Network-on-chip based multicore processors and datacenters, Embedded systems: aerial/underwater drones, LiDARs in transportation, IoT, FPGAs, reconfigurable computing and parallel computing, Distribution networks and smart buildings, Simulation and optimization of vehicle battery packs, Electronic design automation for VLSI and FPGA circuits.

Coutu, Ronald, Jr., Ph.D.

V. Clayton Lafferty Endowed Chair & Professor

Microelectromechanical systems (MEMS), Advanced microsystems, Device fabrication, Micro-sensors and actuators, Chemical sensors, Smart systems, Micro-electrical contacts for RF MEMS switches, Phase change and metal-insulator-transition materials, Low-cost sensors and actuators, Photovoltaics and energy harvesting.

Deshpande, Priya, Ph.D.

Assistant Professor

Biomedical data integration, Artificial intelligence, Big data analytics, Machine learning, Natural language processing, Databases, Distributed systems, Information retrieval.

EL-Refaie, Ayman, Ph.D.

Werner Endowed Chair & Professor

Electric machine and drives, Power electronics, Power systems, Renewable energy, Hybrid/electrical traction applications, Aerospace applications, Oil and gas applications, Mining applications.

Josse, Fabien, Ph.D.

Professor

Solid state and acoustic wave sensors (chemical sensors, biochemical sensors, biosensors), MEMS devices and sensors, Optical waveguide-based sensors, Smart sensor systems.

Lee, Chung Hoon, Ph.D.

Associate Professor

Micro/Nano scale device fabrication, characterization, and analysis, Ultrasonic/Bio MEMS, Microfluids, Thermal analysis of bio/chemical molecules, Molecular electronics, Thermoelectric material design, fabrication, and analysis, Near-field scanning optical microscopy, Bio/chemical sensors.

Povinelli, Richard, J., Ph.D.

Professor

Machine learning, Signal processing, Dynamical systems and chaos.

Richie, James, Ph.D.

Associate Professor & Associate Chair

Electromagnetic scattering and inverse scattering, Antennas and wave propagation, Numerical techniques in electromagnetics.

Schneider, Susan, Ph.D.

Associate Professor & Director of Undergraduate Studies

Modeling, analysis, estimation, and control of linear and non-linear systems, Applications of control and signal processing to sensor systems, Evaluation of the electrical properties of materials for use as sensors, Educational methods.

Weise, Nathan, Ph.D.

Associate Professor

Power electronics, Power and energy conversion, Electric drives, Vehicular power systems, High voltage direct current converters, Power electronic transformers, Control of renewable energy sources, Control of power electronic systems.

Yaz, Edwin, Ph.D.

Professor

Modeling, analysis, estimation, and control of uncertain and nonlinear systems, Nonlinear and statistical signal processing, Applications of control and signal processing to smart micro- and nano-sensor systems and fault diagnostics, prognostics and self-healing in energy generation, transmission, and utilization systems, Networked control systems.

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BE THE DIFFERENCE.

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