



OPUS

College of Engineering

MARQUETTE UNIVERSITY

Electrical and
Computer Engineering

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 2022-2023. 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. 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 methodologies, 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 peek into the real 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

Phillip G. Rose, Roman Electric Co., Inc.

Tony R. Pink, Dynamic Ratings, Inc.

Dr. James Richie, EECE, Opus College of Engineering

Daniel J. Hudetz, EECE, Opus College of Engineering

Timothy Tscheppe, EECE, Opus College of Engineering



ROMAN ELECTRIC CO.





WEB3 PAYMENT ANALYSIS PLATFORM

Team (left to right)

David Titzer, Timothy Tscheppe, Jack Condit,
Ryan Duffy, Nicky Diaz

Faculty Advisor

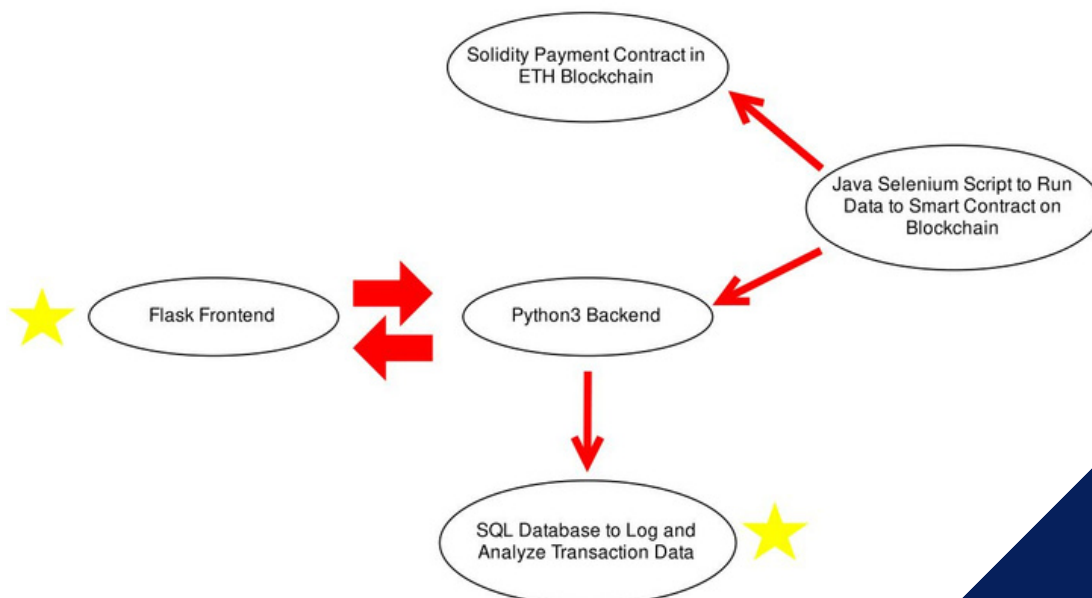
Dr. Richard Povinelli and Dr. Ronald Coutu, Jr.,
EECE, Opus College of Engineering

Sponsor

Timothy Tscheppe, EECE, Opus College of
Engineering

The Web3 Payment Analytics Platform is designed to gather and store data from the Ethereum network. Data is becoming a very valuable resource since everything is moving to be online. One of the untapped markets for data collection is in cryptocurrency. The Web3 Payment Analytics Platform takes user information when transactions are made on the cryptocurrency Ethereum. The data available is the sender address, receiver address, time of transaction, and payment amount. These four data types are the only public information that can be found when looking at the Ethereum block chain that makes them important. A lot of large-name companies are really interested in user data and would pay a lot of money for collected user data. This project is designed as software as a service, it collects data, organizes it and then sells it to companies who desire it. That would allow companies to not worry about the technical details and just get a completed project.

The data collection is completed through a smart contract which is a program that can be added to the Ethereum block chain. To deploy a smart contract onto the actual Ethereum network users must pay a lot of money. Since that wasn't feasible for this project, we designed our project to do it on a test network through a website Remix IDE since it was free. This allowed us to test our smart contract for free and make sure it was functioning without spending any money and making sure our project worked. We created a few programs to get the program to work without any need for inputs beside the first transaction. Our main file created a web-browser based graphic user interface (GUI) that would allow users to input the addresses and transaction amount, that information would then be sent to a program that runs a selenium script that opens Remix IDE and inputs the smart contract and information and runs it on a test network. This returns the addresses, time of transaction, and amounts and then stores it in a database to be distributed at a later point.





EVOLUTION SIMULATOR

Team (left to right)

Daniel J. Hudetz, Miles Danquah, Barry Varley,
Emma Ludwig

Faculty Advisor

Dr. Richard Povinelli, EECE, Opus College of
Engineering

Sponsor

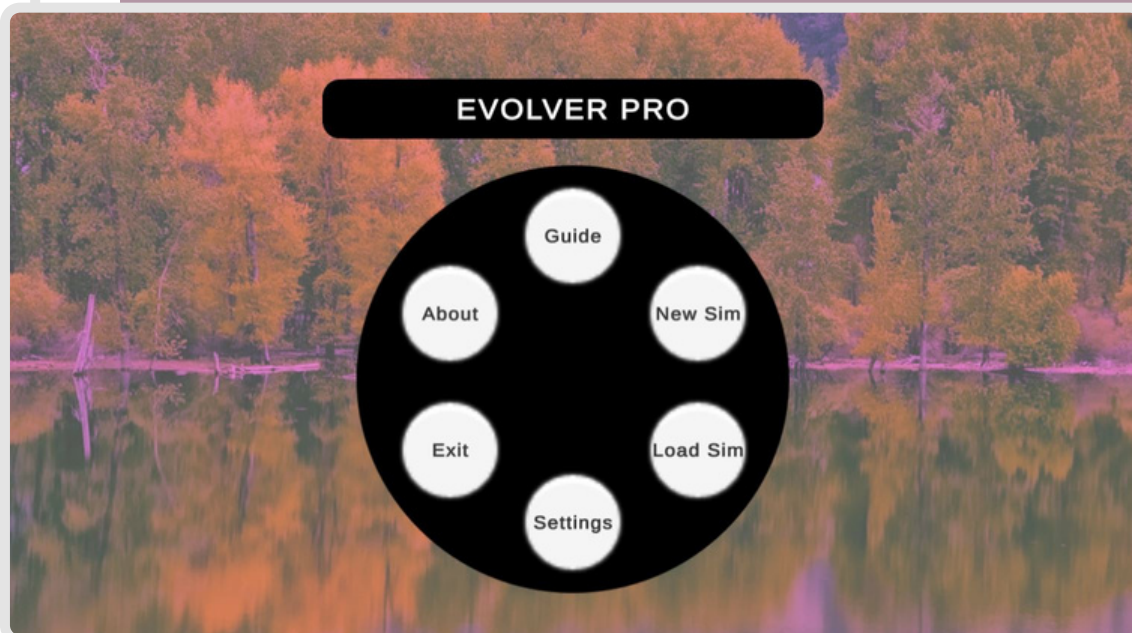
Daniel J. Hudetz, EECE, Opus College of
Engineering

The objective of this project is to develop an evolution simulator, called Evolver Pro, that caters to a diverse range of learners and educators. Evolver Pro is designed to enhance the teaching and learning experience for middle school, high school, and college students in the field of evolutionary biology. It is developed by a team of four developers using Unity and 2D graphics. The simulator offers an interactive and visually appealing platform that demonstrates key evolutionary principles, such as genetic variation, inheritance, mutation, natural selection, and adaptation in real-time. Hence, the aim is not only to provide an accurate visual representation of evolution over extended periods but also to give the simulated organisms control over their behavior via

neural networks. By doing so, the simulator becomes more precise and accessible, enabling learners to easily adjust settings and gain a deeper understanding of the concept of evolution.

The development of a neuro-evolution simulator in Unity has resulted in a highly customizable and accessible platform for simulating evolutionary processes. Using a generalized neural network class, our simulator allows for the creation of organisms that can learn and adapt over time based on their environment.

The use of death and birth events with mutations to the neural network weights has provided an effective method of simulating natural selection in the simulated environment. The survival condition of the simulated

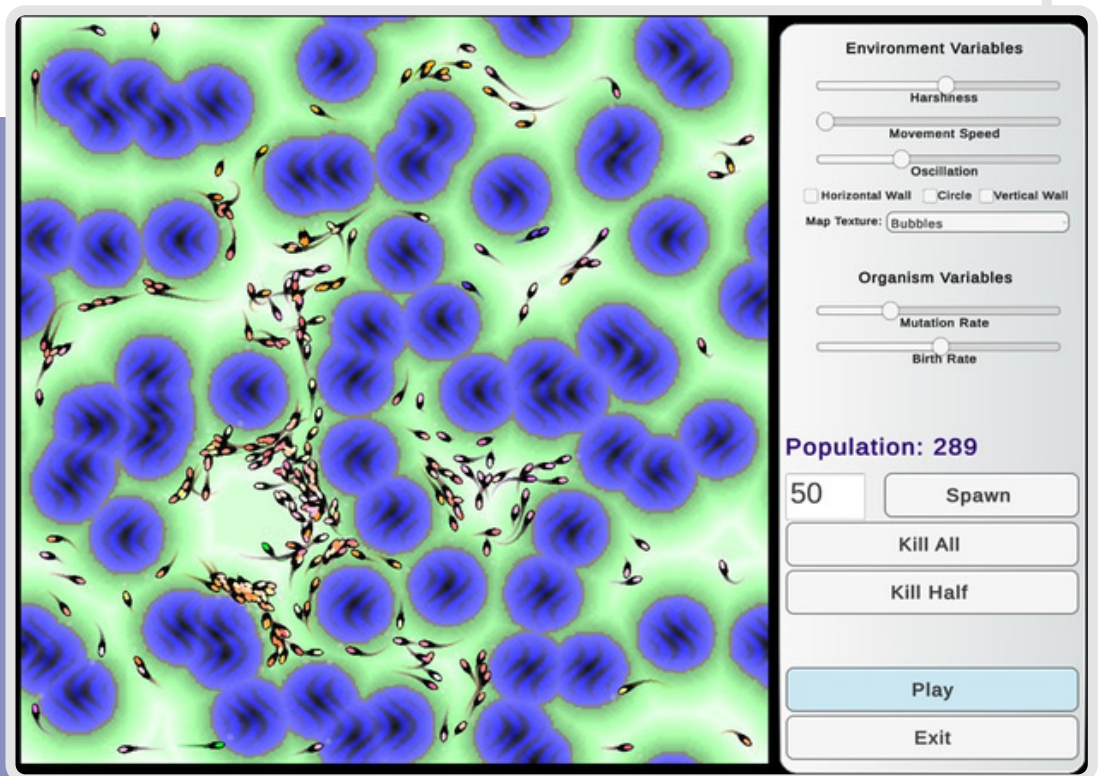


organisms being a 2D scalar map, with input neurons serving as sensors of their environment and output neurons as their speed and target direction, has allowed for a highly interactive and immersive simulation experience.

The results of this simulator in Unity have provided a valuable tool for educators and learners alike to gain a deeper understanding of the concept of evolution. The platform is highly accessible and customizable, with a user-friendly interface and a wide range of features that allow for adjustments to the simulation

settings and parameters.

Overall, the development of a neuro evolution simulator in Unity has provided a valuable contribution to the field of evolutionary biology education, providing a hands-on approach to learning that extends beyond traditional textbook materials. The simulator has the potential to inspire a new generation of learners to explore the fascinating world of evolutionary biology and gain a deeper appreciation for the mechanisms that drive life on Earth.





INTEGRATED SOLAR AND LED TECHNOLOGIES

Team (left to right)	Alex Blum, Jacob Deighton, Liam Maag, Gavin Johnson, Noah Bayer, Jack Wall
Faculty Advisor	Dr. Ronald Coutu, Jr., EECE, Opus College of Engineering
Sponsor	Phillip G. Rose, Roman Electric, Co., Inc.

With the progression of renewable energy technology, such as solar panels, and the growing interest in energy independence, microgrids are being implemented in various applications. The Integrated Solar and LED Technologies project assesses the technical feasibility, efficiency advantages, and economic viability of an entirely direct current (DC) microgrid to power facilities like parking structures, as compared to conventional alternating current (AC) systems. Since solar panels, LEDs, and

batteries are DC in nature, an entirely DC microgrid would offer numerous efficiency benefits compared to AC systems, which experience power losses due to the inefficiencies associated with inverters and rectifiers. Through advancements in power electronics technology, such as DC-DC converters that can handle the various DC voltages in the system, an entirely DC microgrid can be implemented.

After determining the technical feasibility of the DC microgrid in structures like parking



garages, the project shifted towards designing, testing, and comparing AC and DC microgrids. At the Roman Electric facilities, both an AC microgrid and a DC microgrid have been designed and installed to provide additional lighting to the workshop. Both systems utilize solar panels to generate power for charging a battery system. The DC system incorporates a solar charge controller to regulate the power delivered to the batteries, as well as a DC-DC converter to power entirely DC LED lighting fixtures.

On the other hand, the AC system

employs an inverter with a built-in solar charge controller to charge the batteries and supply alternating current power to the AC light fixtures. Through component and system-level testing of both microgrids, the efficiencies of the systems have confirmed the high expectations regarding the energy efficiency benefits of the DC system. As DC technology continues to develop and become more affordable, entirely DC microgrids are expected to become both more energy-efficient and cost-effective than their AC microgrid counterparts.





SCATTERED FIELD MEASUREMENT SYSTEM

Team (left to right)

Melisa Castro, Elise Koenig, Hira Malik,
Paige Munyon, Megan Van Gaal

Faculty Advisor

Dr. James Richie, EECE, Opus College of
Engineering

Sponsor

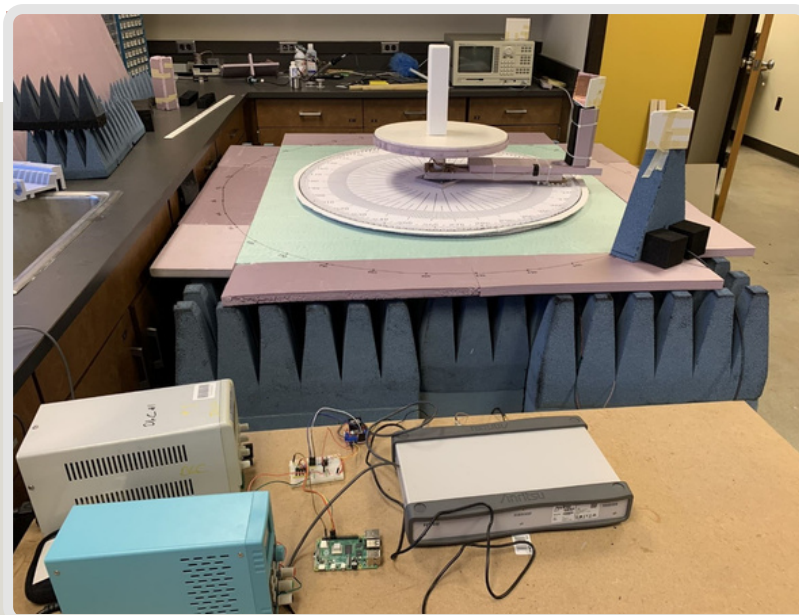
Dr. James Richie, EECE, Opus College of
Engineering

Microwave imaging, a tool often used for medical and commercial purposes, use electromagnetic fields to measure abnormalities within an object. This type of imaging is achieved by using a set of transmit and receive antennas positioned around an unknown object to send electromagnetic waves. An image of the object can then be constructed using the measured scattered fields from the object.

The identified customers, Dr. Richie and Ph.D. candidate Yeasmin Sultana, have started testing and researching the Scattered Field Measurement System using the sampling method. This project was focused on improving upon the work that had been accomplished by the previous E50 team. The purpose of this project is to measure the scattered field of an unknown object. The goal is to obtain a complete data set, including the

fields with and without the object. Ultimately, the customer will be able to determine the object properties by subtracting the data gathered without the object from the data set, including the object.

The scattered field measurement system was divided into several categories, including antennas, antenna mounts, platform structure, motor, and software. The antennas were changed from monopoles to corner reflectors to increase the directivity. The antenna mounts were replaced with a foam pillar and pyramid to improve stability. The diameter was decreased to create a more balanced platform. The amount of current going through the motor was limited to avoid overheating. Lastly, the software was modified to track the location of the transmit antenna and correct motor control errors. A complete data set was successfully obtained and delivered to the customer.





SULFUR HEXAFLUORIDE GAUGE MONITORING SYSTEM

Team (left to right)

Cameron Constabileo, Tom O'Sullivan,
Giovanni Herrera, Vincent Di Castri

Faculty Advisor

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

Sponsor

Tony R. Pink, Dynamic Ratings, Inc.

The objective of this project is to enhance the monitoring of Sulfur Hexafluoride (SF₆) gauges at substations to promptly alert utilities of potential leaks or significant changes in pressure. SF₆ is utilized as an insulating medium to extinguish the arc formed between the moving breaker contacts. Since SF₆ is 23,500 times more effective at trapping infrared radiation than CO₂, it is crucial to closely monitor this gas for leaks given its high environmental impact. To address this issue, we have developed an Internet of Things (IoT) device.

The device consists of a printed circuit board (PCB) enclosed in a plastic housing. It captures an image of the gauge face once every day and can be remotely controlled through a

web interface. The device is capable of collecting and processing data, making it an IoT device. It captures images at the substation where it is located and sends them to an AWS server for processing. An AI algorithm processes the images and records the gauge value. The algorithm is designed to adapt to temperature variations that affect the normal operating pressure of the gas and monitor changes in the gas rate of change to identify potential leaks as quickly as possible.

Initially, the device was designed for use with radial analog pressure gauges on high voltage breakers. However, the principles used in its development could be extended to other types of radial gauges and potentially to any other analog gauge used at a service-operator's substation.



EECE Students Worked on Projects in Other Engineering Departments

Project Department	Project Title	EECE Students
Mechanical Engineering	The Indian Elephant Scarer	Colin D. Dougherty
Mechanical Engineering	Remote Weather Station Information for Boating Applications	Spencer R. Grant
Mechanical Engineering	Affordable Hearing Aid	Micheal J. Donato
Mechanical Engineering	Marquette Aerospace and Robotics Systems (MARS)	Salvador F. Guel, Ian W. Stark, Brian G. Montellano, Alexander Mancilla
Mechanical Engineering	HUSCO PaintBot	Thomas Florian
Mechanical Engineering	Monkey Scarer	Kevin P. Bopp, Nolan H. Greene
Mechanical Engineering	Blood Blender	John J. Mika, Emad A. Khaja
Biomedical Engineering	Redesigned Laparoscopic Handle	Patrick J. Sanders
Biomedical Engineering	Independent Workstation	Noah J. Gumushian
Biomedical Engineering	Adaptive Directional Input Device for Individuals with Disabilities	Luke R. Fiebig

TESTIMONIALS

from Students

"The year-long senior design project helped us apply our knowledge gained through our undergraduate programs and jobs while continuing to learn technical skills, industry-level documentation techniques, and the process of taking a project from start to finish. Through working with Roman Electric, our team worked through common industry-related problems such as order delays and working around personal schedules. I am grateful for the hard work and sacrifices my teammates put towards this project throughout the year, which allowed our project to be successful."

Jack Wall

"Senior design was the experience that prepared me the most for what it would be like to work as an engineer. It helped me refine my communications skills as well as skills related to engineering in general. Senior design allowed me to further understand the safety standards/codes when it comes to working with electricity as well as my role in upholding those standards as an electrical engineer. My experience greatly helped me to understand what it would be like to work as an electrical engineer within the industry."

Liam Maag

"Senior Design was an amazing way to leverage the skills I've developed at Marquette to solve a real-world problem. Giving students the responsibility to operate as a completely autonomous team was a great exercise to prepare us for industry."

Timothy Tscheppe

TESTIMONIALS

from Students

"Senior design proved to be the most invaluable class during my time at Marquette. This course compelled my teammates and me to reflect on our technical understanding, which we had acquired over the past few years, and challenged us to extend our knowledge to develop a marketable solution. Through this experience, we not only gained proficiency in project management, basic supply chain management, risk management, and workplace communication, but we also honed these skills to a level that will undoubtedly assist us in our future careers. Additionally, senior design fostered our ability to think creatively and problem-solve in situations where projects did not progress flawlessly. Tasks such as test redesign, meticulous documentation, and obtaining necessary approvals became essential, exposing us to skills that were previously absent from our curriculum. Overall, senior design provided an effective platform for students to combine their technical knowledge with essential business skills, offering a genuine glimpse into the complexities of completing a design project within an industry setting."

Alex Blum

"Senior Design is exactly what you make of it. Projects vary greatly, so being put on a project that you are excited about is important, but ultimately the quality of the project is up to you and your team and the effort you are willing to put in. It is a great opportunity to finish strong, develop your teamwork skills, and create something truly impressive."

Danny Hudetz

RESEARCH EXPERIENCE for Undergraduates

EECE hosts the Research Experience for Undergraduates (REU-Site) program titled "Hardware, Embedded Software, and Analytics for Environment Quality Monitoring," which is sponsored by National Science Foundation. The program offers a unique chance to delve into innovative research within EECE in collaboration with the departments of Civil Construction and Environmental and Mechanical Engineering. The program lasts for 10 weeks. Upon acceptance into the program, students will:



Summer 2023

- Be matched with faculty mentors and research groups based upon their specified interests and general background
- Contribute to an ongoing research project with faculty and graduate students, and
- Present progress to peers and other interested parties, ranging from informal REU lunch gatherings to formal final presentations.
- Be paid for their involvement

“ I liked the machine learning online tutorial. ”

“ I liked boat tour and the Harley-Davidson Museum! ”

“ I liked working with a PhD student. ”

“ I liked the relationships I was able to form with my adviser and other students. ”



Summer 2021

For more details:



THE 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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Electrical and Computer Engineering
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Publication Date: August 2023

Original Design by: Ecem Kasagga