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Special issue:
Science & Engineering Senior Projects and Internships, Semester I Abstracts

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From the cover: Photo mosaic of the Science & Engineering class of 2025.

Special issue: Science & Engineering Senior Projects and Internships, Semester I, January 28, 2025.

Science & Engineering Learning Center
Senior Projects and Internships
Semester I
January 28, 2025

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Automating IT operations at Commvault using Python and SQL

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Abstract

Modern organizations need efficient IT and streamlined release cycles to scale and stay agile. During my internship at Commvault I helped improve server management and software release processes through automation. I wrote and deployed Python and SQL scripts to address key inefficiencies like monitoring unauthorized access, automated release notifications and log analysis. These automation tools reduced troubleshooting time and human error and improved system reliability and communication between teams. I used industry standard libraries and best practices to ensure the tools were robust and scalable and tested and refined each script before deployment. This hands-on experience deepened my understanding of DevOps and showed me the power of automation in IT workflows. This experience underscored the power of automation in transforming IT workflows, showcasing the practical application of DevOps principles in a professional setting.

Index Terms

Commvault, Python, SQL, IT, internship, automation, DevOps

Automatic malware detection given changes to file systems

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Abstract

When malware gains access to an operating system, it can detrimentally affect it by altering a user's files in different directories. By monitoring whether the number of changes that occur in a specific time interval deviate from user patterns, one can infer the presence of a potential anomaly or piece of malware, prompting a user to take action against it. To automate this detection process, timestamps of directory metadata were collected in a specific time interval and compiled into a Structured Query Language (SQL) database. Once collected, the database is analyzed by an anomaly detection script, which utilizes a statistical model to return potential anomalies by detecting deviations from regular user patterns. Once these potential anomalies are flagged, they are compared with other timestamps to ensure those flagged are neither caused by user or regularly-scheduled patterns.

Index Terms

malware detection, SQL, intenship, Commvault, directory metadata, traffic analysis, deviations, anomalies

Matrix New World Engineering internship

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Abstract

During my internship at Matrix New World Engineering, an engineering firm based in Eatontown, New Jersey, I was able to gain insight in several civil and environmental engineering projects. The firm focuses on environmental services, urban revitalization, and suitable infrastructure, working on a variety of projects across public and private sectors. For the past semester, I spent most of my time focusing on two major projects. The first was the NYC Pier 6 Rehabilitation Program, a reconstruction project located in Brooklyn, New York. I was given the task of finding areas, cross-checking dimensions, and filling out quantities. I also contributed to the actual design of the pier, creating timber caps for retaining walls and other structures. Several of these tasks featured specific functions in CAD such as the hatch feature, which over the course of my internship I learned how to use. The second project was the Garfield New Elementary School, located in Garfield, New Jersey. I went through the process of checking callouts, ensuring they were accurate and consistent with project specifications from the contractors. I verified addresses, dimensions, and other details in order to maintain organization across the details given from contractors and our own details. My internship not only allowed me to improve upon my skills with CAD but also allowed me to develop a more thorough understanding of the step by step process behind large-scale engineering projects. The experience I had there gave me a clearer understanding of the several types of projects that many civil and structural engineers are tasked with on a daily basis.

Index Terms

Matrix New World Engineering, internship, civil engineer, architecture, professional engineer, engineer-in-training, NYC Pier 6 Rehabilitation, Garfield New Elementary School, CAD, structural engineering

Optimizing the fabrication process of microspheres for extended-release drug delivery

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Abstract

In the pharmaceutical industry, many drugs are required to be released over extended periods of time for various applications. Microspheres, microparticles that contain drugs encapsulated by polymers, have special characteristics that make them optimal for these applications. The quality of microspheres is characterized by their physical shape/size and drug encapsulation rates. My goal is to optimize the fabrication process's efficiency and improve the quality of microspheres produced by these techniques by producing microspheres that have an average diameter of about $10\,\mu\mathrm{m}$ to $20\,\mu\mathrm{m}$ and have as high of a drug encapsulation rate as possible.

At my internship in ACON Pharmaceuticals, I'm testing two fabrication techniques: emulsion-evaporation and coacervation. In multiple experiments, I experienced specific issues with the microspheres I created. Some experiments resulted in excess polymer to be formed, resulting in suboptimal shape and size of microspheres. In other experiments, drug crystals were present alongside microspheres, leading to decreased drug loading efficiency. To enhance the results of these techniques, I altered different steps of each technique, including varying drug-to-polymer ratios, purifying drugs, and using different lab equipment. After multiple experiments, I helped find a more optimal procedure to produce microspheres compared to previously used steps.

Index Terms

microsphere, extended release, drug delivery, polymer, emulsion-evaporation, coacervation, internship

Evaluation of DW-MRI neuroimaging data and its application in analyzing the motor outcomes of patients after ischemic stroke at Rutgers NeuREI Lab

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Abstract

The Neurophysiology and Rehabilitation Innovations Lab (NeuREI Lab) at Rutgers School of Health Professions, in collaboration with New Jersey Medical School, aims to enhance the lives of individuals with motor and cognitive disabilities through innovative research in neurophysiology. Led by Dr. Soha Saleh, the lab focuses on using neuroimaging to understand how brain imaging can predict motor recovery in patients who have suffered ischemic strokes. One of the methodologies employed by the lab is diffusion-weighted Magnetic Resonance Imaging (DW-MRI), a non-invasive imaging technique that tracks the movement of water molecules in brain tissues. This approach enables researchers to examine critical neural pathways involved in motor control, such as the corticospinal and reticulospinal tracts.

As a research intern under Dr. Jennifer Gutterman, I developed a categorized database of 57 studies exploring the relationship between DW-MRI methods and motor outcomes in stroke patients. This work examined how changes in specific brain pathways correlate with patients' motor abilities and supports a literature review authored by Dr. Gutterman. Currently, I am collaborating with Mr. Michael Glassen to assess clinical data from the lab, focusing on the evaluation of motor conditions in patients. Both my prior work creating a database of studies and my current project analyzing patient data align with the NeuREI Lab's goals of leveraging neuroimaging to predict motor recovery. Together, these efforts contribute to advancing research methodologies and providing insights for improving rehabilitation outcomes in individuals affected by ischemic strokes.

Index Terms

diffusion-weighted magnetic resonance imaging, MRI, categorized database, literature review, internship, stroke, motor outcome

The Bridges of Monmouth County: Monmouth County Engineering internship

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Abstract

I worked with the bridge and traffic safety department of Monmouth County Engineering. My primary goal was to learn more about county engineering and surveying. I worked on several bridges, taking quantity take-offs (cost estimates), analyzing topography changes (how much the bridge elevation has changed in the past few years), and creating sketches for important elements of certain bridges in an effort to learn more about governmental civil engineering and bridge creation and maintenance.

Index Terms

Bridges of Monmouth County, bridge, traffic safety, Monmouth County Engineering, civil engineer, professional engineer, engineer-in-training, EIT, PE, structural engineering, internship

Schematic analysis and design proposal at Monmouth County Engineering internship

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Abstract

This internship at the Monmouth County Department of Engineering provided valuable insight into project management and client-side processes within the public sector. Responsibilities encompassed handling submittals, Requests for Professional Qualifications (RFPQ), and Requests for Proposals (RFP), offering a comprehensive understanding of procedural workflows. Analysis of past projects facilitated the development of practical knowledge and technical skills in engineering practices. Current contributions include reviewing the Hall of Records facade project and focusing on researching Exterior Insulation and Finish Systems (EIFS) and other materials critical to the redesign. This experience highlights the integration of design, material selection, and project coordination in public infrastructure projects.

Index Terms

schematic, design proposal, request for proposal, RFP, architecture, civil engineering, professional engineer, engineer-in-training, EIT, fundamental of engineering, FE, internship, Monmouth County Engineering, Monmouth County Library

T&M Associates heating, ventilation, and air conditioning (HVAC) internship

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Abstract

T&M Associates is a national engineering firm headquartered in Middletown, New Jersey that specializes in many different fields of engineering. Throughout the past semester, I have had the opportunity to collaborate with Mechanical, Electrical, and Plumbing (MEP) engineers at T&M, working on computer-aided design (CAD) drawings of heating, ventilation, and air conditioning (HVAC) systems. These drawings play a crucial role in the construction process, guiding contractors through the installation of the HVAC systems of a building.

Index Terms

T&M Associates, internship, HVAC, heating, ventilation, and air conditioning, mechanical, electrical, and plumbing, MEP, CAD, professional engineer, engineer-in-training, EIT, piping system, computer aided design

Anomaly detection in Windows Registry hives using machine learning

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Abstract

The importance of malware detection software has increased dramatically with the rise of electronic data sharing and the spread of data theft. During my internship at Commvault, an industry leader in data security and management, I created an algorithm for monitoring Windows Registry hives. The registry serves as a critical database for settings, application preferences, and system parameters, making it a frequent target of malware and malicious activities. By analyzing key-value pairs, structural relationships, and timed patterns within real-world activity on Commvault servers, I established a baseline of normal activity to detect deviations. The system integrates supervised learning models trained on labeled datasets to identify specific types of anomalies, such as trojan horses and worms. Furthermore, the model incorporates real-time logging and notifications to alert the user of potential threats. When run on a simulation of registry tampering and unauthorized key deletions, it achieves an F_1 score of 0.91, which highlights the capability of the system to detect subtle anomalies while minimizing false positives, equipping systems to address emerging threats preemptively.

Index Terms

malware detection, Windows Registry hives, anomaly detection, metadata, Commvault, internship

Automated beach cleaning robot

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Abstract

In order to reduce the need for manual cleaning of beaches, we created an automated beach cleaning robot. To do this we used a machine learning algorithm to detect trash along the shore and an arm to collect the trash. This model was uploaded onto a Raspberry Pi 5. We also used two Arduinos, one to control the movement of the body and one to control the movement of the arm. The arm used servo motors to control the position of the four segments which we 3D printed. We used the Servo.h library in the Arduino to be able to control the motors. Connected to the second Arduino were the motors and ultrasonic sensors. We used four DC motors and treads for the movement of the beach cleaner that were connected to the L293D H-Bridge chip to allow control of forward and backwards motion. We had three ultrasonic sensors that are used to detect objects $1\,\mathrm{m}$ in front. The two Arduinos were connected to the Raspberry Pi, which would give them the information about stopping as well as how far away the trash is for the arm. This information is transferred via the serial port which can be shared by USB connection between the two. In order to determine where to move each segment of the arm we used inverse kinematics which is the process of knowing the end position and calculating the needed angles of the joints. To power everything, we used a $12\,\mathrm{V}$ lithium battery. For the body of the beach cleaner we constructed it out of PVC pipes and plywood to make it light and easy to transport.

Index Terms

robotics, beach, machine vision, environmental remediation, Raspberry Pi, Arduino, servo, h-bridge

AI internship: enhancing AI assistant performance with early exit and cloud offloading

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Abstract

The development of AI assistants such as ChatGPT, Bard, and Copilot has become increasingly important as they are integrated into various applications, ranging from customer service to personal productivity. However, many current AI assistants face processing speed, accuracy, and context understanding limitations, especially when handling complex tasks like image processing or real-time decision-making. These limitations often lead to delays, incorrect predictions, and an overall less efficient user experience. Current models, such as traditional machine learning algorithms, struggle to balance efficiency with accuracy, leading to trade-offs that compromise performance, particularly in mobile and real-time environments where computational resources are constrained. This internship, conducted as part of an AI-focused project with the University of Maryland, aims to address these challenges.

In this project, I focused on improving the performance of an AI assistant by developing an optimized model capable of faster, more accurate predictions while maintaining high levels of contextual understanding. By incorporating advanced architectures such as ResNet18 with early exit mechanisms, I aimed to reduce the time taken for processing tasks, especially when handling images uploaded by users. I tested and implemented cloud offloading techniques to ensure that complex computations are processed in the cloud, offloading tasks from local devices. Additionally, I explored different unlearning strategies to enhance the assistant's adaptability to new data and improve its overall efficiency. The result is a more efficient AI assistant that can handle real-time image processing, adapt to new data inputs, and provide quicker responses, improving the user experience while maintaining high accuracy.

Index Terms

AI assistant, early exit, cloud offloading, unlearning, ResNet18, internship

Ultrasonic device for rapid air bubble removal in automotive coolant systems

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Abstract

The efficiency and longevity of automotive engines are heavily influenced by the proper operation of cooling systems, which can be compromised by the presence of air bubbles. Traditional methods of removing air bubbles, such as system bleeding, are time-consuming and often ineffective. This project introduces an ultrasonic device designed to rapidly and efficiently eliminate air bubbles from automotive coolant systems. Using an LM555 timer chip and push-pull output stage to develop $40\,\mathrm{kHz}$ ultrasound, the device powers a $60\,\mathrm{W}$ ultrasonic transducer that emits sound waves to promote the collapse, coalescence, and release of air bubbles and entrained gasses within the coolant system. Preliminary tests show that this ultrasonic method is faster and more efficient than conventional techniques, while ensuring compatibility with existing automotive systems. The device potentially improves engine efficiency by enhancing coolant flow and reducing the risk of overheating due to trapped air. Potential benefits include faster maintenance, reduced labor costs, and enhanced system performance.

Index Terms

ultrasound, bubbles, automotive, coolant system, degas, feed-and-bleed, fluid system, noncondensable gases, air-intrusion, piping system

Design and implementation of an autonomous robot for the IEEE Micromouse Challenge

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Abstract

We have designed an autonomous maze-solving robot to complete a challenge known as "Micromouse." Micromouse is a competition, led by the Institute of Electrical and Electronic Engineers (IEEE), where teams design small, fully autonomous robots that can navigate and find the optimal path through a maze. Robots may not damage the course or scale it in any way. Five consecutive runs are allowed; mice use one run to traverse, memorize, and process the fastest path through the maze. Then, subsequent runs take the shortest path for maximum speed in solving. The mouse uses IR sensors to detect walls, a flood-fill algorithm to find the optimal path, and a Raspberry Pi for all processing.

Index Terms

micromouse, IEEE, mobile robot, robotics, navigation, optimal search, shortest path, STEM education

Data valuation with Leave-One-Out (LOO) test and Shapley methods

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Abstract

During my fall internship with WIT, I explored methods to value data from progressive profiling questions that I designed. These profiling questions were split into demographic (username, email, country,) behavioral (actions), and psychographic (values, interests, lifestyle) questions. I was to then design a database that recorded estimated values to serve as a base for future progress. After this, I researched data valuation with two tests: Leave-One-Out (LOO) and Shapley. One valued data by essentially finding the least common answer by eliminating all datasets except one to then record the effect the removal had on the distribution. This was efficient in valuing multiple choice answers but was slow and did not accurately affect each removal on the distribution. After making the program, I worked on valuing with Shapley, the marginal contribution each dataset's removal has with respect to another's removal. This yielded more accurate results and eliminated less valuable data at a more successful rate.

Index Terms

data valuation, leave-one-out test, Shapley methods, internship, data science

Multiple neural network system for early congestive heart failure detection

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Abstract

A disease currently found in roughly 6.5 million people under 20 years old, Congestive Heart Failure (CHF) is cardiovascular disease that causes issues with the blood flow of the left ventricle of the heart. CHF is often mistaken for common aches and pains, and due to the inconvenience of testing for it, CHF often goes undetected until the patient is far past any form of treatment. As there is no current cure for CHF, it is best for doctors to find it early, so they can dampen its effects. To provide a more convenient method of diagnosing CHF, while maintaining the accuracy of medical professionals, a stacking neural network system was employed. This system utilized an Artificial Neural Network (ANN) in order to complete a risk factor analysis (where the risk factors were age, anemia, high blood pressure, etc.) as well as a Convolutional Neural Network (CNN) to complete an image analysis of the patient's Magnetic Resonance Imaging (MRI) data. These two neural networks would work in tandem with each other to form an accurate diagnosis of CHF in any given patient.

Index Terms

neural network, congestive heart failure, ANN, artificial neural network, CNN, convolutional neural network, magentic resonance imaging, risk factor analysis, diagnosis, diagnostic AI

Computational solver for studying kingfisher dive dynamics

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Abstract

My research investigates the fluid-structure interactions during kingfisher dives using computational simulations to understand better how they avoid injury. Many species of kingfishers (family Alcedinidae) are plunge-diving birds that dive at high speeds, involving a significant impact against the water free surface, potentially with sufficient force to cause concussions in humans. The behavior appears to have arisen multiple times within the clade. In birds, previous research has examined plunge diving hydrodynamics in gannets (Sulidae), as well as head impacts in woodpeckers (Picidae); however, recent work in kingfishers solely addressed genetic signatures of convergent evolution while neglecting the biomechanics. To address the biomechanics during plunge diving in kingfishers, I focused on computational fluid dynamics (CFD) methods, namely, immersed boundary and overset grid methods.

I initially attempted immersed boundary methods, which overlay a Lagrangian (solid) frame over an Eulerian (fluid) frame to simulate fluid-structure interactions between the bird, fluid, and free surface. Previous research contained little work on the immersed boundary method applied to free surfaces and two-phase flows on complex geometries as experienced when a bird plunge dives. As a result, I shifted to overset grid methods using ANSYS Fluent. In these methods, overlapping/overset grids for solid and fluid and interpolation between the two present an alternative to immersed boundary. ANSYS Fluent also supports the Volume of Fluid (VOF) model, a multiphase model that tracks the interface between fluids. As a first foray into bio-fluid mechanics, my short-term goals included running 2D simulations of bird and other comparison shapes. My long-term goals include data visualization and physics analysis to compare added mass, drag, and other hydrodynamic forces, flow fields, and free-surface movements during the dive, to link shape and form to potentially selective biomechanical factors and the evolution of plunge diving within the kingfishers.

Index Terms

kingfisher, Alcedinidae, biomechanics, computational fluid dynamics, plunge diving, ANSYS, immersed boundary, IBAMR, IB2d, volume-of-fluid, VOF, overset grid

RescueVision: augmented reality solutions for first responders

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Abstract

Natural disasters and emergencies have caused significant casualties annually, posing severe risks to both civilians and first responders. Despite advancements in technology that could help do so, current tools fail to provide the real-time situational awareness and safety enhancements needed in life-threatening scenarios. RescueVision addresses this gap by integrating augmented reality (AR), thermal imaging, and real-time hazard detection into a lightweight, hands-free heads-up display (HUD) for first responders.

The system enhances visibility in smoke-filled or low-visibility environments using infrared and thermal imaging while providing instant environmental data and structural risk analysis. Powered by AT&T FirstNet and cloud-based processing, RescueVision ensures seamless communication and decision-making during high-pressure situations. By equipping firefighters, paramedics, and disaster relief organizations with these tools, RescueVision aims to save lives, improve safety, and optimize firefighter efficiency in critical moments.

Index Terms

augmented reality, heads up display, HUD, first responder, internship, AT&T, FirstNet, cloud-based processing

Algorithms for analyzing risk of aneurysms

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Abstract

Aneurysms are bulges in the blood vessel wall. If they rupture and break, they can cause many harmful effects and even lead to death. The primary causes of aneurysms include high blood pressure, high cholesterol, and genetic disorders. Still, one can never predict the growth of an aneurysm until it has already manifested in the body. There are currently ways to image an aneurysm within a body to confirm the presence of one, but there is no way to predict outright whether or not someone will grow an aneurysm. First, we simulated an aneurysm in real life to learn about the main factors contributing to an aneurysm's growth. We aim to create a program that would analyze whether or not the user is at risk of developing an aneurysm in the future. This will be done by taking different metrics from a database of aneurysm patients and comparing them to data from the user, discerning whether or not the user's data correlates with the patients. At this moment, the SQL query and database are complete but the comparison program is still in the works.

Index Terms

aneurysm, risk factor analysis, detection, SQL

FOREX trading algorithm

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Abstract

Our project is to develop an advanced automated foreign exchange trading system that uses machine learning and sentiment analysis to predict currency movements and execute profitable trades. We combined historical market data with real-time sentiment extracted from global news to provide a framework for making data-driven trading decisions. The core of the model is built using XGBoost, a gradient boosting algorithm, optimized to minimize losing trades while also reducing missed opportunities. Key features of the project include integrating advanced technical indicators such as moving averages, relative strength index, and volatility metrics, along with sentiment scores derived from news analysis. A phased exit strategy and decision matrix for trade signals ensure that trades are optimized to maximize profitability with constantly changing market conditions.

Index Terms

foreign exchange, FOREX, trading, algorithm, currency, news, sentiment analysis, XGBoost, gradient boost, moving average, relative strength index, volatility metrics, optimization

Girl in Space Club internship

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Abstract

Girl in Space Club is a clothing brand established by NASA engineer Sabrina Thompson that produces astronaut-grade and fashion flight suits for the analog astronaut (people who participate in crewed simulated space missions on Earth), female astronaut candidates, and STEM enthusiast communities. Since the corporate mission is to make STEM fun, fashionable, and creative, we were tasked with designing a "Build Your Own Flight Suit" app that enables customers to individualize their flight suits. To develop the website's functionality and aesthetics, we employed the web development languages of HTML, CSS, and JavaScript. The foundation for our website layout and "flow" was based on Ms. Thompson's design philosophy of "putting the user's experience first". During our presentation, we will present the (1) user engagement principles and logic behind our website structure; (2) the evolution of the website's GUI (graphical user interface) and backend code; and (3) a preview of the website. We will also discuss how we intend to measure user engagement with our website to evaluate its effectiveness.

Index Terms

Girl in Space Club, web design, STEM education, flight suit, HTML, CSS, JavaScript, internship, user interface, user experience, UX design

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