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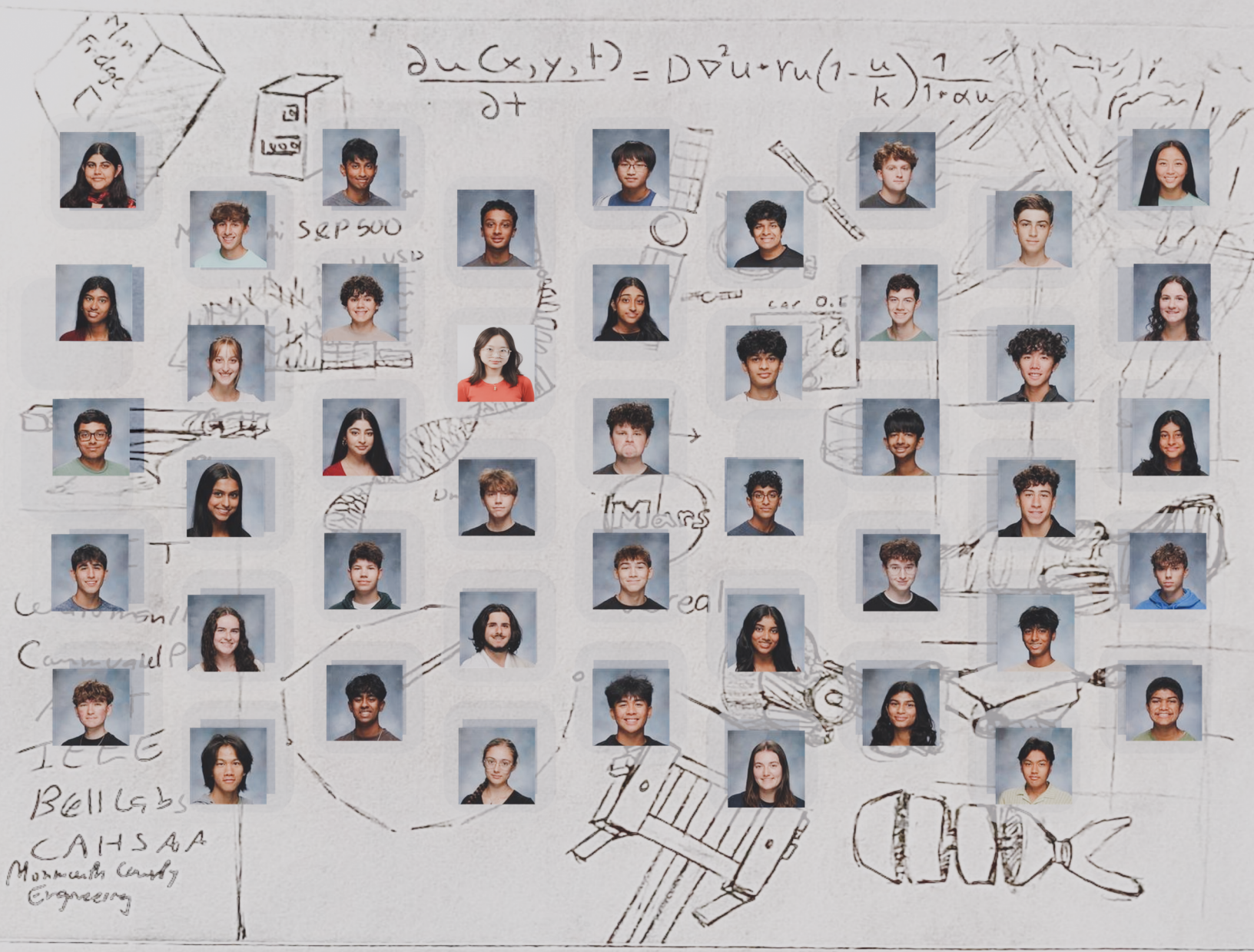

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From the cover: Science & Engineering class of 2026. *Cover image: Rishith Chandra Kilaru and Tushaar Akula.*

Special issue: Science & Engineering Senior Projects and Internships, Semester I, January 28, 2026.

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Senior Projects and Internships
Semester I
January 28, 2026

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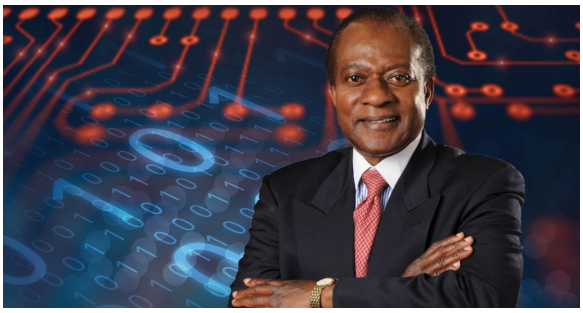

Dr. Victor B. Lawrence is one of the world's foremost telecommunications engineers and inventors, whose innovations form the backbone of modern digital communication. Over more than five decades, his pioneering work has transformed how people connect—advancing the Internet, broadband, and mobile networks, and extending communications across the globe and into space.

At Bell Laboratories, where he rose to Vice President of Advanced Technologies, Dr. Lawrence led breakthroughs in modem design, DSL, ATM, IP switching, and digital audio/video systems. His demonstration of full-duplex data modems over international networks paved the way for global standards and affordable high-speed Internet in the early 1990s—accelerating worldwide connectivity and digital access.

He also guided transformative developments in digital video and secure communications, including HDTV and codecs embedded in consumer electronics. His leadership in modem and fax chipset design enabled secure U.S. government communications, including systems used by the President and senior defense officials. In parallel, his contributions to Sirius Satellite Radio helped establish the satellite infrastructure that brought digital-quality broadcasting to millions and showcased the potential of global space-based networks.

Since the mid-1990s, Dr. Lawrence has championed digital equity through projects expanding high-speed Internet across Africa. His leadership in submarine fiber-optic cable deployment has strengthened digital infrastructure, advancing education, healthcare, and economic opportunity across the continent.

Now a Senior Research Scientist at Stevens Institute of Technology, Dr. Lawrence continues to mentor the next generation of innovators. His honors include the 2024 National Medal of Technology and Innovation, 2023 New Jersey Science & Technology Medal, membership in the National Academy of Engineering, Fellowship in IEEE and Bell Labs, a Primetime Emmy Award, and induction into the National Inventors Hall of Fame.

Dr. Lawrence's legacy is one of inspiring and visionary innovation and enduring global impact.

Math-focused screenreader for accessibility: Internship at IEEE

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Abstract

Mathematics relies heavily on symbolic notation, spatial relationships, and non-linear structures that challenge traditional text-to-speech systems. While screen readers have improved accessibility for reading text, their performance for mathematics remains insufficient due to inconsistent formatting standards, unclear interpretation of mathematical meaning, and a lack of audio representation for visually intuitive math layouts and structures. We were tasked with evaluating current screen reader technologies and developing ideas to improve mathematical accessibility for visually impaired users. Our research involved testing existing screen readers with mathematical symbols, conducting interviews with visually impaired individuals about their experiences accessing mathematical content, and identifying accessibility features that should be included into our website from the initial design phase.

Index Terms

assistive technology, mathematics, screen reader, blind, visually impaired, low vision, Americans with Disabilities Act, ADA, access, mathematical notation, inclusive design, internship, IEEE

Modeling swarm spacecrafts in Python: Internship at Girl in Space Club

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Abstract

Girl in Space Club is a creative technology and human-systems design lab. They design, prototype, and commercialize equipment, tools, and experiences for people navigating future worlds—on Earth and beyond. It was founded by NASA engineer Sabrina Thompson. As part of our mission, we were tasked with creating a full-stack simulation tool that models autonomous spacecraft swarms powered by AI and orbital mechanics. This will be used to demonstrate AI-driven decision-making for a swarm of spacecraft executing orbital maneuvers in response to goals, threats, or mission objectives for both educational and technological purposes. During our presentation, we will present (1) our research involving swarm autonomy rules, their relative motion, and orbital mechanics; (2) how we translated this research into visual representations; and (3) what we plan to implement into our interface in the future for the backend, as well as any issues we encountered.

Index Terms

Girl in Space Club, web design, STEM education, orbital mechanics, Python, swarm control, satellite, simulation, AI, artificial intelligence, swarm autonomy, relative motion, internship

Additions, alterations, rennovations, and rehabilitation at various Monmouth County sites: Internship at Monmouth County Engineering

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Abstract

Monmouth County Engineering's Facilities Section is responsible for the construction, maintenance, and improvement of county-owned buildings and their systems, including mechanical, electrical, plumbing, architectural, hydronic, and heating, ventilation, and air conditioning (HVAC) systems. During my internship with the Facilities Section, I gained hands-on exposure to underlying building systems through site visits and project reviews. My responsibilities included reviewing construction drawings, observing ongoing projects, and tracking project progress across multiple locations. Worksites included the Monmouth County Courthouse, Public Library, Correctional Institution, and various buildings within the Public Works Complex.

Index Terms

Facilities Section, Monmouth County Engineering, heating ventilation and air conditioning, HVAC, mechanical, electrical, plumbing, architecture, hydronics, internship

Creating market activations: Internship at WIT

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Abstract

WIT is a sports marketing company that creates activations, which are marketing events, to promote fan engagement. During our internship at WIT, we learned to use HTML, CSS, JavaScript, and React. Using these tools, we created numerous projects, including a personal website, a Pokémon-based Tic-Tac-Toe game, and an endless runner platformer game. These activations have been pitched to the WIT CTO as potential activations for the future. Our most developed project, the endless runner, involves a point system that increases depending on duration played and number of enemies defeated. Players will compete worldwide for a top spot on the leaderboard, after which prizes will be given to the top three winners.

Index Terms

WIT Sports, HTML, CSS, JS, JavaScript, internship, ReactJS, Bootstrap, web development, game development, sports marketing, endless runner, Pokémon, tic-tac-toe

Development of an internet protocol television (IPTV) application for hotels: Internship at Genesis Global Group

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Abstract

Genesis Global Group is a collection of vertically integrated companies that spans the biotechnology, healthcare, manufacturing, real estate, and hospitality sectors. During my internship, I developed an IPTV hotel television application using Android Studio and simulated a backend server using MySQL. I connected the application to the backend database, gaining experience in frontend and backend development, and understanding how they interact.

Index Terms

Genesis Global Group, internship, frontend, backend, user interface, UI, Android, Kotlin, SQL, IPTV

Speed reduction study: Internship at Monmouth County Engineering, Traffic Safety Division

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Abstract

Civil engineering is a field that focuses on designing, constructing, and maintaining the infrastructure and natural environment that society relies on. Civil engineers have to ensure the safety of all structures and address the concerns of any citizens. Monmouth County Engineering is a public works group that is responsible for the upkeep and development of roads, bridges, traffic signals, and buildings. The Traffic Safety Division focuses primarily on roads, signs, traffic signals, and improving road safety through analysis and design.

This internship has allowed me to learn the daily duties and the responsibilities of civil engineers that keep the road and civilians safe. Throughout my time at Monmouth County Engineering, I was able to witness and partake in a traffic road study that allowed me to understand the process and evaluation of different analyses.

Index Terms

Traffic Safety Division, Monmouth County Engineering, traffic safety, civil engineering, internship, road study

Artificial Intelligence (AI)-based adaptive traffic control system for intersection saturation flow rate and congestion optimization: Internship at CAHSAA AT&T

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Abstract

Intelligent transportation systems have been a topic of major interest throughout the past few decades. Modern adaptive traffic control systems (ATCS) have had consistent development, with individual logic frameworks and architectures developed in order to improve intersection efficiency through adaptive light phase timing. This project focuses on the optimization of saturation flow rate (SFR) for intersections with an ATCS. The model includes a pipeline with a Convolutional Neural Network (CNN) backbone structure for object detection and classification, alongside a Deep Q Network (DQN) based traffic signal phase optimization algorithm. Object detection is implemented at all points of interest at a given intersection, providing congestion data across all lanes used to maximize SFR. This congestion data is processed into a DQN based optimizer algorithm, which dynamically updates phase timings for traffic light states in real time. The system provides an increase in average SFR and reduced congestion within a variety of intersections in ideal conditions over classical fixed timing mechanisms currently in use. This project provides both economical and environmental benefits, alongside reducing average travel time for both civilian and government vehicles.

Index Terms

AT&T, internship, convolutional neural network, artificial intelligence, reinforcement learning, intelligent transportation systems, traffic control, adaptive traffic control, Deep Q network, machine vision, CAHSAA

Slack adoption metrics and analytics at Commvault: Internship at Commvault

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Abstract

Commvault is a cybersecurity company that provides data protection and information management software. During my internship at Commvault, I supported the company's transition from Microsoft Teams to Slack, both of which are used for communication within the organization as well as externally. I did so by automating the extraction of data from the Slack API via time-triggered Azure Function Apps. I worked on cleaning this raw data into tables to support development of a Power BI dashboard, to visually showcase the usage patterns of various Slack tools and functions. This will allow the Business Development team and leadership to quantify impacts or the adoption of Slack within the workspace at Commvault.

Index Terms

Commvault, Power BI, Python, data analysis, Azure, internship

Visualizing sidereal and solar time in honor of Karl Jansky: Internship at IEEE, AT&T, and Bell Labs

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Abstract

In order to understand the significance of any discovery, it is essential to understand the historical context in which it emerged and the shared effort that influenced its development. Bell Labs is an industrial research institution known for foundational advances in communications, physics, and engineering, which provided the environment in which Jansky first identified radio emissions from the Milky Way. This project through the mentorship with IEEE, AT&T Labs, and Bell Labs employs interactive visualizations of time on Mars and Earth on a website, a street clock representation of Mars' sidereal and solar time, and an a novel digital sundial to bring his discoveries to life for a broad public audience. The website uses HTML, JavaScript, and p5.js to model planetary rotation and orbital motion while telling the full story of Karl Jansky's life, discovery process, and contributions to radio astronomy. Designed for installation at the Dr. Robert Woodrow Wilson Park, the Bell Labs Horn Antenna site in Holmdel, the project features a dual-sided clock displaying Mars sidereal time on one side and Mars solar time on the other, allowing viewers to directly compare these two timekeeping systems. In addition, there will be an improved digital sundial, intended to become one of the largest and most accurate of its kind. Overall, the project connects modern science to the historical roots of radio astronomy in a way that is engaging and accessible to all ages.

Index Terms

AT&T, Bell Labs, Karl Jansky, sidereal time, internship

Tracking progress of data backup and restore test cases: Internship at Commvault

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Abstract

Commvault is a cybersecurity company that provides data protection and information management software. Test cases of data backup and recovery provide computer engineers with opportunities to find flaws in current processes and allow them to prevent real disasters from happening. At my internship at Commvault, I learned about the virtualization of operating systems to understand how they safely and securely program processes for data backup and recovery. I was given a test case of data backup and restoration and was tasked to understand its workflow. My overall task was to use Commvault's Python software development kit (SDK) and ProgressTracker module to track its progress, and to retry failed steps rather than restarting the entire operation, saving time and resources by fully automating test case running.

Index Terms

Commvault, test case, data backup and restore, progress tracking, SDK, software development kit, internship

Internship at I House Architecture

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Abstract

Residential architectural design balances client requirements, zoning and setback regulations, and efficient spatial organization within real-world building constraints. In this internship, I designed a single family residence in Wall Township, NJ. The project design consists of a 3-bedroom, 2.5-bath home with approximately 2,000 square feet of living space along with a large garage.

Using AutoCAD Architecture 2013, I produced detailed floor plans and layouts with an open first-floor plan. Key requirements include an island kitchen, hardwood flooring throughout the main living areas, and a primary bedroom with a walk-in closet for both his and hers, freestanding tub, and large shower. This project incorporated research on local zoning and government regulations, including setbacks and lot size requirements specific to Wall Township. Additionally, review of the engineer's report supported an understanding of structural considerations.

This project served as technical training in applying residential planning principles while working within zoning requirements and producing professional architectural designs.

Index Terms

residential architecture, AutoCAD Architecture, floor plan design, zoning regulations, single-family housing, internship

Internship at Watermen LLC

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Abstract

Civil engineering plays a critical role in the planning, construction, and maintenance of infrastructure systems that support residential and commercial development. Watermen LLC is a civil engineering and construction firm specializing in underground utilities, site development, and water and sewer infrastructure projects. The company works closely with municipalities and private developers to ensure projects meet safety standards, environmental regulations, and engineering specifications.

This internship provided me with hands-on experience in the marine and residential side of civil engineering and construction management. During my time at Watermen LLC, I gained exposure to field operations and project coordination, including site inspections, construction documentation, and financial calculations. This experience strengthened my understanding of how engineering plans are implemented in real-world conditions and how collaboration between engineers, contractors, and inspectors is essential for successful infrastructure projects.

Index Terms

civil engineering, construction management, underground utilities, site development, water and sewer infrastructure, field operations, site inspections, construction documentation, financial calculations, municipalities, internship

Analysis of a golf swing

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Abstract

The project focuses on optimizing the golf swing through a physics-based analysis of biomechanics and kinematics. We began studying the fundamental foundations of the golf swing, including the double-pendulum model, which simplifies the motion by transferring energy from the arms (first pendulum) to the wrists and club (second pendulum) to achieve maximum power at impact. To establish a baseline, we recorded our initial swings and compared them to professional golfer Rory McIlroy, analyzing differences in joint angles, limb displacement, and timing using software including Factorial Biomechanics and TrajectoWare. As the comparison highlighted areas for improvement, specifically in swing sequencing and efficient transfers of energy, we applied these targeted adjustments to our swing, allowing for a measurable improvement in efficiency and power. Our final analysis provides a comprehensive, physics-based perspective on optimizing swing output and efficiency, along with new videos of our new and improved swings.

Index Terms

biomechanics, physics, golf, swing kinematics, double-pendulum model, Rory McIlroy, Factorial Biomechanics, TrajectoWare

A computational study of chaos in simplified microbial population models

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Abstract

This project investigates the emergence of nonlinear and chaotic dynamics in microbial population models using purely computational and mathematical approaches. Reaction diffusion systems, logistic growth equations, and Lotka-Volterra style interactions are implemented to study how diffusion, growth rates, carrying capacity, and initial conditions shape population behavior over time. By systematically varying parameters and introducing small perturbations, the model explores sensitivity to initial conditions, bifurcations, and transitions between stable equilibria, oscillations, and irregular dynamics. Numerical simulations generate time series data, phase space plots, and bifurcation diagrams, with chaos quantified using metrics such as Lyapunov exponents. While the current framework is intentionally simplified and limited in its biological realism, it functions as a controlled environment for isolating mathematical mechanisms that produce complex behavior.

Index Terms

dynamical systems, chaos theory, partial differential equation, PDE, diffusion, Lotka-Volterra, simulation, stability, Lyapunov exponent, microbes, ecology, population ecology

A liquidity-driven framework for Micro E-mini NASDAQ-100 Futures (MNQ1)

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Abstract

This project demonstrates the design and evaluation of a rule based trading model for the Micro E-mini Nasdaq-100 (MNQ) futures contract. The model utilizes a multitude of technical confluences, including liquidity sweeps, fair value gaps (FVGs), inverse fair value gaps (iFVGs), breaks of structure, and order blocks, to identify high probability trade entries. Each confluence was individually programmed using TradingView's Pine script, allowing for systematic confirmation directly on price charts. Through the combination of these signals into a single framework, the model reduces impulsive decision making and bias. Backtesting demonstrated an improved clarity in entry timing, more favorable risk-to-reward profiles, and reduced poor decision making. The results emphasize the effectiveness of coding trading concepts into repeatable conditions and highlight the importance of algorithmic trading in intraday futures trading strategies, evident through our 11% increase in win rate compared to manually trading without our tool.

Index Terms

MNQ1, Micro E-mini NASDAQ-100, futures trading, liquidity sweep, Fair Value Gap, FVG, inverse FVG, order block, break of structure, Pine script, TradingView, intraday trading model, intraday analysis, risk management

Reversing gearbox for motorcycle engine-swapped kei trucks

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Abstract

This project details the design and prototyping of a mechanical reversing gearbox for motorcycle engine-swapped ultralight ("kei") trucks. Intended to allow for bidirectional power transmission while maintaining a direct 1:1 input-to-output ratio in both forward and reverse. The system was designed to accommodate high-torque inputs, such as those found in high-performance motorcycles. Using computer-aided design and iterative prototyping through 3D printing, the gearbox features a selectable gear train and a dog clutch-based locking mechanism to constrain carrier motion and ensure reliable engagement between gear states. The design focuses on mechanical simplicity, compactness, and ease of manufacturing while avoiding continuous reverse gearing losses. Future work includes functional testing with high torque and rpm settings against alternative reversing mechanisms and material analysis to determine suitable materials for machined components.

Index Terms

reversing gearbox, power transmission, mechanical design, dog clutch, CAD, 3D printing, automotive, kei truck, motorcycle engine swap

Non-launching mini fridge (NLMF)

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Index Terms

fridge, arduino

Si vis pacem, para ballista

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Abstract

A ballista is an ancient siege weapon, used from 400 BCE to 400 CE, resembling a large crossbow, and typically used during the time of the Ancient Greeks and Romans to hurl large projectiles. They were typically used for long range, high precision sniping. Instead of storing energy in the bending of its limbs like a crossbow, ballistae are powered by two twisted bundles of rope (the skeins). The arms of the ballista are suspended within the skeins, which are wound tight enough to allow the arms to spring forward after they are released from a loaded position. The firing force of a ballista and energy transmitted to the projectile are mainly based on how tightly wound the skeins are, and thus we tested a multitude of ropes using a tensile testing rig consisting of a dynamometer and a chain hoist. The rope would be attached to the aforementioned parts, which would allow us to subsequently find the energy stored in the rope. Throughout this project, we were able to strengthen our CAD and woodworking abilities, whilst also learning about weapons of the time period, specifically through literature like Marsden's *Greek and Roman Artillery: Technical Treatises*, primary sources such as Vitruvius, Hero of Alexandria, and Biton of Macedonia, and contact with medieval reenactors and experimental archaeology enthusiasts from the Society for Creative Anachronism.

Index Terms

ballista, siege weapon, siege engine, ancient Greece, ancient Rome, antiquity, Middle Ages, history, E W Marsden, Vitruvius, Hero of Alexandia, Biton of Macedonia, tensile test, energy, projectile motion, elasticity, elastic energy storage, experimental archaeology, medieval reenactors, Society for Creative Anchronism

Hybrid BiLSTM machine learning with RNAfold-based thermodynamic modeling for RNA secondary structure prediction

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Abstract

RNA secondary structure plays an important role in various biological fields, such as gene regulation, catalysis, and RNA–protein interactions, yet accurate prediction is challenging due to long-range base-pairing and structural complexity. This work presents a hybrid framework that integrates RNAfold's thermodynamic modeling with machine learning to improve RNA secondary structure prediction and interpretability. Using a balanced dataset of approximately 9,700 RNA sequences spanning multiple RNA families ($\approx$ 4.09 million nucleotides), traditional thermodynamic prediction with RNAfold was evaluated alongside a bidirectional long short-term memory (BiLSTM) neural network trained for base-wise pairing prediction. While RNAfold achieved a baseline test accuracy of 0.77, the BiLSTM reached 0.91 accuracy. Building on these results, several hybrid approaches were developed that selectively combine RNAfold and neural predictions, including a base-wise selector, a sequence-level meta-learner, and a Monte Carlo (MC) dropout uncertainty method. The best-performing hybrid model, the MC dropout uncertainty method, achieved a test accuracy of 0.917, outperforming both standalone approaches. This framework has been deployed through an interactive web interface, enabling users to input RNA sequences and compare prediction methods in real-time. To enhance interpretability, predicted structures are converted from dot-bracket notation into annotated visual diagrams depicting the corresponding secondary structure motifs. This study demonstrates that hybrid modeling with uncertainty-aware selection can improve RNA secondary structure prediction while maintaining accessibility and interpretability for later biological analysis.

Index Terms

deep learning, RNA, thermodynamic modeling, ribonucleic acid, secondary structure, BiLSTM neural network, Monte Carlo, machine learning, hybrid, RNAfold

Data forecasting with auto-regressive integrated moving average (ARIMA)

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Index Terms

ARIMA, autoregressive integrated moving average, SARIMA, seasonal autoregressive integrated moving average, data forecasting, job growth

Compact integrated drone payload delivery system

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Abstract

Our project is centered on designing and developing an RC drone that supports a payload system. In this project, the payload consists of lightweight medical supplies intended to be delivered accurately while the drone is airborne. Our project aims at developing a working prototype capable of supporting stable flight and delivering precision with respect to payload. Our approach towards achieving this is through designing a light support mechanism that is ideal and sized for a small base of a quadcopter design. This is through a winch mechanism that is capable of controlled extension and retraction. A winch mechanism was chosen because it allows controlled lowering and retrieval of the payload while airbone, which improves delivery accuracy and safety in confined areas. This has been modeled using CAD design software, and our design has been centered on reducing its weight and having ideal strength that is compatible with a 6-inch drone frame. Alongside our design of the mechanism, we have also mapped out the electric design necessary for our mechanism to operate effectively. This entails a dc motor that supports our mechanism, receiver-transmitter, Arduino, and LiPo battery that operates independently of the drone's electronics. Our design has been informed by factors such as its capacity to operate with a low payload mass, its size corresponding to that of a drone, as well as its capability to perform its operations while sustaining stable flight as it extends and retracts. The project is actively progressing through continuous research and development including assembly, 3D printing, and testing. It's through this work that we aim to show a feasible design of a compact system that also addresses the challenges associated with drones of this size.

Index Terms

drone, flight, mechanics, payload, winch, quadrotor, lightweight medical payload, accurate delivery

Automated car blinds for heat reduction

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Abstract

Research and testing conducted during this project focused on developing and evaluating vehicle window shade systems specifically designed to reduce temperatures in vehicles. We conducted research into materials available in order to evaluate their suitability as window shade systems based on the level of light blockage and durability. During the course of this research project, we collected and evaluated data in order to compare the performance of different materials and to select the best performing materials for further development of the vehicle window shades. Based on our combined engineering and mechanical design knowledge, we created and designed a mechanical system that would allow for the deployment and retraction of the window shade. There are a number of controls that we investigated in order to provide customers with both a reliable and easy to operate window shade system. By going through several iterative design processes and troubleshooting problems along the way, we were able to develop an innovative solution to a significant engineering problem. The mechanism was tested on a 2010 Hyundai Elantra but can be applied to most cars with roof rails.

Index Terms

automotive, solar heating, automation, car blinds, temperature reduction, deployment system, automotive design, data analysis, iterative design, shading, radiative heat transfer, Hyundai Elantra

Interactive hydroponic growth simulator for educational use

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Abstract

This project is a web-based hydroponic simulator created to forecast plant growth in a variety of environmental circumstances. Temperature, electrical conductivity, light intensity, and pH stress, which is the decrease in growth brought on by departures from a plant's ideal pH range, are among the environmental inputs that the simulator uses to model plant growth using the Growth Index equation. The model's main output is an estimated harvest time and growth rate, which enables students to see how environmental changes affect plant development. Sliders allow users to interact with the simulation, allowing for the simultaneous execution of multiple trials and comparisons between different plant species, including kale (*Brassica oleracea*), lettuce (*Latuca sativa*), tomatoes (*Solanum lycopersicum*), and basil (*Ocimum basilicum*). This simulation, which is based on actual hydroponic monitoring systems, helps students develop their intuition about plant growth and sustainable agriculture through experimentation. By enabling students to manipulate environmental variables and analyze system-level responses, the simulator reinforces concepts from AP Biology like homeostasis and experimental design, as well as AP Environmental Science topics including sustainable agriculture, resource management, and human impacts on ecosystems.

Index Terms

hydroponic growth simulator, hydroponics, plant growth, simulation, growth index, environmental modeling, educational tool, interactives, AP Biology, AP Environmental Science, homeostasis, experimental design, sustainable agriculture, resource management, ecosystems, inputs

Fixed-wing aircraft for medical emergencies

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Abstract

Emergency medical situations such as opioid overdoses require immediate intervention, however first responders may be delayed by traffic, distance, or accessibility constraints in suburban areas. This senior project focuses on the design and construction of a small, fixed-wing unmanned aircraft intended to rapidly deliver critical medical supplies, such as naloxone (Narcan) directly to individuals in need. The aircraft is based on the FT Explorer airframe from Flite Test, selected for its flight stability and efficiency. We have built a lightweight payload delivery system utilizing a kirigami-style parachute constructed from polyester sheet to enable controlled and safe deployment of medical supplies. The project prioritizes accurate payload delivery, and low-cost construction, with the goal of demonstrating how unmanned aircraft systems could aid in traditional emergency response and reduce time-to-treatment in life-threatening situations.

Index Terms

fixed wing drone, medical aid aircraft, kirigami parachute, naloxone delivery, Flite Test, FT Explorer

Biomimetic robot: Robofish and printed circuit board (PCB) design project

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Abstract

To humans, the ocean is one of the most vast, mysterious, and threatening parts of the planet. Fish, which are notoriously good swimmers, can change their motion much more quickly and smoothly than human-built machines. With this project we studied the biomechanics of fish swimming in order to design and build a robotic fish that can swim forward, turn, change depths, and utilize a subcarangiform method of swimming. Subcarangiform swimming is used by many types of winter fish off the coast of New Jersey, such as striped bass (*Morone saxatilis*) and white perch (*Morone americana*). Our robotic fish consists of three parts: the head, the body, and the tail. The segmented tail is modeled after the spine of a fish and spans roughly two thirds of its length, modeling which parts of the body are free to undulate in subcarangiform motion. The tail is passively actuated by attaching the first segment to a scotch yoke mechanism located inside the body. To control the direction the fish swims in, we actively actuated the head by attaching it to the body with a servo motor. The pectoral fins are extensions of servo motors, located on both sides of the body, whose main purpose is to adjust the angle of the fish's diving plane. The majority of the fish was 3D modeled using Autodesk Inventor and printed as one piece, except for the head, which was printed separately. The forked caudal fin was modeled on Blender and printed with TPU, while the rest was printed in PLA. The connection between the body and the first segment was wrapped in silicone to prevent water from getting in. Furthermore, we sealed the 3D printed parts to make them waterproof and prevent the electronics inside the body from being compromised.

The second half of the project was to develop in-house manufacturing methods for a CNC machine, the Carvey, to create printed circuit boards. Using Autodesk Fusion to design the schematic, 2D PCB layout, and 3D manufacturing steps, we were able to mill custom printed circuit boards quickly and at lower cost. This enables rapid PCB prototyping, without needing to wait for delivery times associated with online machining services. I designed and milled various test circuits to learn the process, wrote a guide for others to follow, and designed and machined the PCB for the RoboFish.

Ultimately, if the robotic fish's mechanics are successful, we can explore additional applications, such as environmental monitoring, underwater inspection, and marine biology research.

Index Terms

printed circuit board, PCB, CNC milling machine, biomimetic robot, subcarangiform swimming, fish, striped bass, *Morone saxatilis*, white perch, *Morone americana*

Low cost intravenous bag weight monitor

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Abstract

Intravenous (IV) drips are widely used in clinical settings to maintain patient hydration and prevent complications. Although electronic IV pumps provide continuous monitoring, their high cost limits implementation in low-resource hospitals. Our low cost IV bag weight monitor device offers an affordable alternative by detecting when an IV bag reaches a low volume threshold. The device uses a single-point load cell to measure bag weight and triggers a visual LED indicator and audible buzzer when the weight falls below a preset limit. The current prototype uses a simple shelf-style structure to house the Arduino-based circuitry and display the alarm components. Registered nurses have reviewed the current prototype, deeming it a feasible and efficient alternative to more expensive IV pumps. Future work will integrate a microcontroller and a compact 3D-printed encapsulation to improve durability, reduce size, and improve overall usability.

Index Terms

biomedical engineering, ardunio, intravenous, IV

Origami-engineered biopolymer patch for localized nanoparticle delivery in pediatric skin cancer and post-tumor removal therapy: Internship with Cornell University

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Abstract

Children recovering from cancer treatments often develop painful skin lesions that require frequent topical medication, which can be uncomfortable and inconsistent. As part of my internship with Cornell University, I created a moisture-triggered sodium-alginate patch that folds in an origami-like pattern to deliver tannic acid, a natural antioxidant, in a controlled and localized way. Sodium alginate is an inexpensive, biocompatible hydrogel material, and tannic acid, found naturally in green tea, is gentle and soothing on irritated skin, making the combination ideal for pediatric care. The patch's design and crosslinking density were optimized to regulate swelling and diffusion under both physiological (pH 7.4) and wound-like (pH 5.5) conditions. Flat and origami geometries were modeled using Fick's Law of diffusion to study how pH and crosslinking influence release behavior. Data collected over nine time points (0–24 h) were analyzed using ANOVA and kinetic model fitting. The origami design released nearly twice as much tannic acid under physiological conditions as the flat, highly crosslinked design in acidic conditions, with cumulative release values of 78–80% and 39–41%, respectively. Increased surface area and moisture exposure improved diffusion release rates, while tighter crosslinking reduced pore size and slowed release rates. Overall, this work demonstrates that a soft, moisture-responsive hydrogel patch can provide a gentle, low-cost, and effective method for targeted treatment in pediatric skin cancer recovery. Future work will focus on creating physical prototypes and validating diffusion performance experimentally.

Index Terms

origami, drug delivery, therapy, diffusion kinetics, pediatric oncology, pH, biomedical engineering, internship

Index of Authors