CONNECTICUT SCIENCE & ENGINEERING FAIR

77th Annual Fair
March 3-15, 2025

Student Abstracts

CSEF Official Abstract and Certification
2025

Title: Making a Real-Time Water Quality Monitor: An Arduino-Based System for Measuring Water Contamination

Student Name(s): S. Laryea-Adjei, S. Laryea-Adjei, S. Laryea-Adjei

Abstract:

Water contamination is a critical global issue, with around 2.2 billion people lacking access to safe and clean drinking water sources. Bacterial contamination from E. coli and Salmonella poses serious health risks, including infections and potentially fatal cholera. Contrary to popular belief, this issue isn't only prevalent in underdeveloped countries, but also in 40 percent of rivers and 46 percent of lakes here in the United States. Despite the importance of regular water quality testing, high-accuracy equipment remains prohibitively expensive, particularly in lower-income regions. To address this issue, a compact, Arduino-powered water quality testing device was developed to measure parameters such as pH, Oxidation-Reduction Potential (ORP), Electrical Conductivity (EC), Total Dissolved Solids (TDS), and turbidity. The device takes the readings of the sensors and gives a result stating if the water is of good quality or not. The device aims to offer an affordable and portable solution for water quality monitoring. The circuit and 3D prototype were designed using Tinkercad, after which I soldered the required electronic components and constructed the physical prototype with foam cores. I then purchased distilled water and gathered samples from two distinct water sources: Cove Island in Stamford, Connecticut, and Poughkeepsie, New York. After comparing the readings of the device with a store-product water quality tester, the prototype still needs more modifications on some sensors, but overall displayed accurate information. This project has the potential to improve water monitoring practices, especially in resource-limited regions, by providing a user-friendly tool for regular water quality assessments.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

EE CS AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects   ☐ potentially hazardous biological agents
☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes   ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No
4. Is this project a continuation? ☐ Yes   ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No

CSEF Official Abstract and Certification 2025

Word Count: 249

Fair Category: PS

Project Number: 6002

Title: A Stroke of Genius: Applying Smart Wearable Technology to Record and Improve Freestyle Stroke in Competitive Swimmers

Student Name(s): G. Mirgorodskiy

Abstract:

Swimming performance is highly connected to biomechanics, where optimizing stroke technique can lead to significant improvements in speed and efficiency. Traditional methods of analyzing swimming biomechanics, while effective, have been limited by the need for specialized equipment and controlled environments. This study explores the application of commodity smart wearable technology to assess and enhance swimming technique for a wider audience beyond research settings.Using a commercially available smartwatch equipped with multiple sensors, I collected data on a competitive swimmer's arm acceleration, speed, and stroke path. Through data processing, including sensor fusion and position recalibration techniques, I produced detailed visualizations of the swimmer's movements. These visualizations, particularly a 3D reconstruction of the stroke path and arm orientation, provide a comprehensive view of the swimmer's technique. I used two main sensors to reconstruct the path: an accelerometer to compute the watch position in 3D space via double integration, and the angular velocity sensor (gyro) to compute the watch orientation, a crucial step in converting the measured acceleration from the watch coordinate system to the global one. I further demonstrate that the straightforward approach to computing the path greatly suffers from sensor drift and noise. A contribution of this study is in designing several sensor adjustment techniques that make accurate path reconstruction possible. The main one is using a magnet attached to a swimsuit to let the watch's magnetometer detect the accurate arm position once per stroke cycle and adjust the computed position accordingly. Experimental results with the adjustments demonstrate accurate path tracking.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) CS PH MA

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

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☐ Yes ☒ No

Title: Aquaponics and Sustainable Fish Feed: A Comparative Analysis of Tilapia and Bibb Lettuce Growth with Animal, Insect, and Plant-Based Feeds

Student Name(s): B. Shefter

Abstract:

Aquaponics functions by combining aquaculture and hydroponics in a symbiotic relationship whereby waste produced by fish in a controlled aquatic environment fertilizes plants grown in the soilless medium, and plants remove toxins that would otherwise be disposed of as pollutants. While aquaponics can be a sustainable alternative to traditional agriculture and fishing, many closed-loop aquaponic systems rely on animal-based fish food, that typically contains high concentrations of nitrogen and phosphorus. To examine whether alternative insect or plant-based fish food achieves similar levels of growth and cost-effectiveness as animal-based food, juvenile tilapia (n=40) and Bibb lettuce buds (n=48) will be placed in 4 individual aquaponics systems (Tank 1 = traditional fish meal, Tank 2 = black soldier flies, Tank 3 = mealworms, and Tank 4 = spirulina). Plant growth and fish weight will be measured at regular intervals and compared with the cost of a given fish food and a tank's phosphorus and pH output. The relationship between mean growth measurements and fish food type will be analyzed via ANOVA in JMP. Based on existing research on the cost and efficacy of alternative versus animal-based fish food, I hypothesize that Blue Nile Tilapia fed a mealworm diet will grow the fastest over the study period, followed by tilapia fed with traditional fish meal, spirulina fish food, and black soldier fly fish food. Mealworm fish food should represent a sustainable alternative to traditional fish meal and represent a final step to "greening" the aquaponic system.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) PS

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CSEF Official Abstract and Certification
2025

Title: Space Weather and the Aurora: A Study of Solar Wind and Geomagnetic Activity

Student Name(s): M. Smith

Abstract:

My investigation focused on the intricate relationship between space weather and auroral displays, specifically the Northern Lights. I hypothesized that increased solar wind activity and coronal mass ejections (CMEs) would trigger changes in Earth's magnetosphere, resulting in a wider geographical spread of the aurora.

To test this, I gathered real-time space weather data from online sources, including solar wind speed, solar flare occurrences, and the geomagnetic Kp index. Data from October was analyzed, and correlation analysis was used to determine the relationships between solar wind parameters, solar flares, geomagnetic activity, and auroral displays. Visual assessments of auroral images were conducted, comparing them to the corresponding space weather data. A correlation chart was created to visually represent these relationships.

Analysis revealed a strong correlation between solar wind speed and geomagnetic activity. Higher solar wind speeds consistently aligned with elevated Kp values, and CMEs were often followed by enhanced auroral displays. Notably, when solar wind speeds reached 600 km/sec and 700 km/sec, correlating with Kp indexes of 8 and 9, auroral visibility was observed significantly further south than usual.

These findings support my hypothesis that increased solar wind and solar flare activity, coupled with a high Kp index, directly influences auroral displays. Future research could investigate the specific mechanisms of energy transfer from the solar wind to the magnetosphere and the excitation of atmospheric particles. This study underscores the importance of space weather monitoring for understanding and mitigating the potential impacts of solar activity on Earth's technological infrastructure.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   EA   EV

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3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

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☐ Yes   ☒ No

CSEF Official Abstract and Certification 2025

Word Count 269

Fair Category PS

Project Number 6007

Title: Methodical Research of Customized Deep Learning and Large Language Models Integrating Generative AI's Contextual Interfaces: A Case Study in Specialized Crime Detection

Student Name(s): J. Cho

Abstract:

Generative AI's ability to perform personalized and domain-specific tasks is generally achieved through the pretraining of neural networks using specialized data. However, such pretraining steps remain challenging due to irregular datasets, catastrophic forgetting (loss of existing data during training) and static (containment of domain knowledge but may difficult to acquire new). This research introduces a novel method for enhancing server-linked AI language models by integrating customized Deep Learning (DL), speech-to-text (STT), and Large Language Models (LLMs) with generative AI's contextual interfaces, specifically for real-time crime detection and on-device deployment (i.e. Mobile Application)

Autone employs division of labor, where speech-to-text (STT) transcribes real-time speech and custom TensorFlow-based deep learning model classifies non-verbal or paralinguistic audio cues (e.g. glass shattering, distress signals). Additionally, contextual data—such as protocols, procedures, and historical patterns—is integrated to enhance classification. By providing this multimodal data for LLM reasoning—one of the LLM's core strengths—the system effectively "primes" the language model to function as a domain expert, enabling it to assess crime likelihood with real-time accuracy. The system portrayed 86% domain task accuracy, particularly effective when verbal or non-verbal cues were ambiguous. Furthermore, no latency or computational problems were observed. As current academic research aims for unified fully learned end-to-end systems, Autone's rule-based domain enforcement, structured dynamic prompt engineering, and division of labor with AI reasoning is unique and pragmatically effective. Its on-device deployability further makes system a feasible solution for crime detection in real-world compared to many cutting-edge research models remaining largely in labs.

**Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)** CS

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Adaptive Multi-Link Portable Knee Exoskeleton

Student Name(s): D. Shi

Abstract:

Knee disorders are highly prevalent in modern society, affecting people of different ages and activity levels. The design of knee exoskeletons has attracted significant attention. However, there is still room for improvement in terms of high transparency, portability, and adaptability. This paper presents a highly customizable knee exoskeleton device. It utilizes a modular carbon fiber structure and a flexible control system to provide adaptive assistive torque to the knee joint during leg movements. Key innovations include the modular lightweight structure, flexible control system, bearing - based joint design, and detailed modeling and experimental verification. Experimental results show that this exoskeleton can effectively reduce the forces on the knee joint during leg movement, making it a promising rehabilitation and assistive tool. Future work can focus on further optimizing the control algorithms and integrating it with full - lower - limb exoskeletons.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

EE EN

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Consideration of Location-specific Weather and Topographic Datasets to Model Efficient Deployment of Forest Fire Flame Retardants

Student Name(s): I. Pullepu

Abstract:

Wildfires pose a growing threat to communities, ecosystems, and economies, leading to property loss, rising insurance claims, destruction of wildlife habitats, and human casualties. Their rapid spread and unpredictable behavior make efficient suppression strategies essential for minimizing damage. Traditional aerial firefighting relies on manual decision-making, often resulting in inefficient retardant deployment, chemical waste, and delayed containment. This research explores how artificial intelligence (AI) and machine learning (ML) models can optimize flame retardant drop locations and improve suppression accuracy. To validate the AI model's effectiveness, this study cross-referenced predictions with data from the recent Palisades Fire, a wildfire that caused significant structural and environmental damage. Using historical suppression records, real-time fire progression data, and meteorological datasets from MODIS, FIRMS, and USGS LiDAR, the AI system was refined to improve drop accuracy and enhance containment efficiency. The model, trained using neural networks, deep learning, and linear regression, achieved 85-90% accuracy in predicting fire movement and optimizing suppression zones. This research focused on AI model development and simulation testing, providing a proof of concept for real-world applications. Future advancements include integrating AI with firefighting aircraft and autonomous drones to improve real-time decision-making. By leveraging AI-driven suppression strategies and validating predictions against actual wildfire incidents like the Palisades Fire, this project highlights AI's potential to reduce wildfire losses, improve containment efficiency, and revolutionize modern wildfire management.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   CS EV MA

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

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☐ Yes ☒ No

CSEF Official Abstract and Certification 2025

Word Count 258

Fair Category PS

Project Number 6010

Title: Embedding natural language processing within web-based applications to identify real-time risk for depression, anxiety, and suicide among teens

Student Name(s): J. Norful

Abstract:

One in six 10–19-year-olds experience mental health symptoms, an estimated 160 million adolescents/teens diagnosed worldwide. In Connecticut, 49,000 adolescents have depression, half of whom don't receive care, and 8% have anxiety. In 2023, 20% students considered suicide, and 9% had a suicide attempt. Most adolescents/teens don't know how to consult a professional when experiencing symptoms. Identifying and developing novel ways to help adolescents/teens identify mental health symptoms requiring professional care is critical. Advancements in natural language processing (NLP) may enable earlier identification of undiagnosed mental health conditions in real-world settings. The purpose of this project was to apply NLP algorithms that identify mental health risk within a web-based application for adolescents/teens using subjective journaling. This project builds upon my original website by integrating NLP code to assess subjective 2-week journal entries. I deductively identified keywords from American Psychiatric Association's DSM-5 manual, specifically depression, anxiety, and suicide relevant. I integrated SpaCy NLP, and tested whether the NLP algorithms were able to sufficiently identify diagnosis-specific risk through a set of 14 vignettes for each diagnosis and a healthy control. Initially, the NLP was able to give the correct diagnosis for the healthy control vignettes (100% accuracy) but failed to identify anxiety (0%), depression (57%) or suicide (62%). I refined the code with more keywords and yielded 100% accuracy for all diagnoses. This NLP can be embedded in different websites, platforms, or in research aimed at earlier identification of mental health conditions among adolescents/teens in real-world settings.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) CS BC ME

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☒ Yes ☐ No

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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: E.M.E.R.A.L.D. (Environmental Management and Emission Reduction Assistant for Localized Decarbonization)

Student Name(s): T. Bhattacharya

Abstract:

EMERALD aims to combat the confusion and unawareness of homeowners either on their impact on the climate, or how they can minimize this.It reduces the amount of effort necessary for the user to minimize the carbon footprint of their house, office, business etc. and at a larger scale can help lead to a greener planet. It accomplishes this in three steps, 1) collecting the data, 2) pr0cessing the data and 3) presenting the data. To collect the data EMERALD uses IoT sensors for quantitative data points such as electricity and water usage, waste amount, vehicle usage, weather metrics, humidity and temperature and an online form for qualitative data points such as the user's location, building category (apartment, house, office, etc.), number of occupants, number of vehicles, energy and water sources. This data is processed via an Arduino and then sent to the cloud where it is processed via an Artificial Intelligence Recommender algorithm, that is trained on climate data on various of these data points, and ways in which homeowners can minimize their carbon footprint. After the algorithm uses its natural language extension to generate the various remedies for the homeowner to implement, it sends this packet of information from the cloud, to a mobile application on the homeowner's mobile phone, along with the raw data collected by the sensors. All of this information, being neatly presented to the user, allows for easy, cheap and efficient climate solutions ensuring a greener household and with it a greener for us all.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) AT

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Development of Innovative Low-Frequency Sound Absorption Structures Using Advanced Metamaterials

Student Name(s): N. Wang

Abstract:

Low-frequency noise (LFN) poses significant challenges in noise control due to its long wavelengths and ability to penetrate barriers. This study introduces a novel metamaterial-based absorber optimized for low-frequency sound attenuation using a multicoiled structure. The theoretical foundation is established through an equivalent electrical-acoustic circuit representation, leading to the development of an impedance-matching design. The metamaterial's performance is validated using Finite Element Analysis (FEA) simulations incorporating thermoviscous acoustic interactions. The results demonstrate high absorption efficiency at 50 Hz, with a total structure thickness of only 13 mm. A case study on an open duct system confirms that incorporating multiple absorption modules enhances noise reduction, with up to 21 dB attenuation observed. These findings highlight the effectiveness of the proposed metamaterial for compact and efficient low-frequency noise control applications.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

PH EN

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

- [ ] human subjects
- [ ] potentially hazardous biological agents
- [ ] vertebrate animals
- [ ] controlled substances

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification 2025

Word Count
249

Fair Category
PS

Project Number
6013

Title: A Tracking System

Student Name(s): D. Dixon

Abstract:

Tracking systems are important for many reasons including finding lost people/things, wildlife monitoring, law enforcement, emergency support and more. This Tracking System was designed to be an effective communicator. Multiple trials were conducted. The first one was to ensure that the LoRa (long range radio antenna) modules were communicating effectively with the correct wiring and the proper code. The next trial was to ensure that the LoRa and the GPS were aligned. The GPS worked outdoors, away from buildings and forested areas - anything that would interrupt the signal. The GPS coordinates were sent from the sender module via LoRa and received on the receiver module by the second LoRa. Finally, a keypad sent messages from the sender module to the receiver module enabling a buzzer. The keypad was programmed so that certain letters could send HELP, LOST, HURT and SOS (MORSE CODE). The screen displayed the data. The screen also confirmed the signal strength and GPS coordinates. The intent is to alert someone on the receiving end, using the same frequency bandwidth, that someone needed help. This project proved successful because the two Arduinos were able to communicate with each other for up to 946 meters and a maximum signal strength of 98 RSSI. The LoRas were able to send and receive signal data and the keypad enabled the buzzer. The project even though successful, worked for shorter distances than expected. The keypad used was not always reliable. More experimentation needs to be done to increase communication distances.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)
AT EE CS

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- ☐ controlled substances

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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Converting PLA Plastic Water Bottle to 3D Printing Filament

Student Name(s): Z. Sun

Abstract:

This product is called the 3D Printing Filament Extruder. Its goal is to reduce plastic waste and its harmful effects on human health by converting plastic water bottles into usable 3D printing filament. The product consists of four main components:Cutting Section: This part utilizes bearings and screws to efficiently cut the plastic bottles into long strips.Nozzle Section: This is where the plastic strips are heated and transformed into filament.Temperature Controller Section: This part regulates the temperature of the nozzle. Spool Section: This part connects to the spool and is responsible for collecting the extruded filament.To test the optimal temperature, extrusion speed, and the final filament quality, I conducted a total of fifteen experiments. The results concluded that the best filament is produced when the temperature is set to 215°C and the extrusion speed is 7 RPM. Ultimately, I successfully collected 500 grams of transparent 3D printing filament.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   AT EE

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4. Is this project a continuation? ☐ Yes   ☒ No

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☐ Yes   ☒ No

CSEF Official Abstract and Certification
2025

Title: An Investigation into the effects of propeller geometry and surface composition on cavitation rates and decibel transmittance

Student Name(s): N. Krause

Abstract:

More shipping vessels means increased impact on marine animals and ecosystems. Specifically, large shipping propellers rotate through the water, often producing air bubbles that rupture and create sound. This project aimed to determine the optimal blade count and rake angle to decrease cavitation rates, thus reducing sound pollution. Utilizing various propellers and a hydrophone, levels of cavitation were measured and compared across all propellers. Analysis of the results indicate that as rake increases, so does cavitation. The blade that produced the least cavitation at a constant speed proved to be the 4 blade while the 5 blade produced the greatest cavitation.

Technical Disciplines Selected by the Student
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EE ET

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CSEF Official Abstract and Certification
2025

Title: Developing a Wireless, Discreet, Precise, and Painless Piezoelectric Micropump System for Diabetes Patients

Student Name(s): J. Deng

Abstract:

11.8 million Americans are diabetic and require insulin treatment, yet current pumps have many issues. Current hypodermic needles for insulin pumps are painful, which can be solved with painless microneedles. Secondly, there is often occlusion in tubed pumps, which can lead to hyperglycemia; this can be solved by replacing tubing with wireless bluetooth-enabled electronics. Last year's work developed a low-cost, discreet piezoelectric micropump pump chamber with adjustable flow rates that satisfy insulin requirements for diabetics. The purpose of this year's project is to develop the remaining components of the pump system: a painless microneedle patch and wireless bluetooth electronics. The two microneedle designs were hollow and open microchannel microneedles. Stress analysis showed that the hollow microneedle was more mechanically stable. After printing the microneedles, the insertion forces were tested using weights and fake skin; it was found that hollow microneedles could insert 90% of full length with a 0.5N load. The hollow microneedle patch met the criteria of insertion force < 3N and was within the constraint of < 3.5 x 3.5 mm in size. The electronics were dissected from a bluetooth earbud and soldered to a piezoelectric buzzer. The amplitude measured by the oscilloscope was 0.4V. The criteria for the final electronics of the system was a secure connection of 15V with a <$20 cost. Future research includes soldering on a step up transformer to amplify the signal by ~40x.This prototype can reduce pain, improve convenience, and improve the quality of life of over 11 million Americans.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

EN AT ME

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CSEF Official Abstract and Certification
2025

Title: Comparing the Effectiveness of AlCl3-NaCl and Zeolite ZSM-5 Catalysts in the Pyrolysis of HDPE

Student Name(s): W. Bentley

Abstract:

Plastic, high density polyethylene (HDPE) specifically, was invented in the 1950's and rose to popularity quickly due to its high chemical resistance, high tensile strength, and very low water absorption. As plastic continues to grow in use, there still remains no efficient way to dispose of it. Without a feasible solution the majority of plastic is landfilled where it causes substantial harm to the environment causing soil infertility and killing marine life. Pyrolysis is a plastic recycling method where plastic is melted down to reclaim the oil it's made from. Though it holds promise, there are still flaws with pyrolysis that prevent it from being economically viable. Pyrolysis produces large amounts of wax byproduct which is undesirable and expensive to dispose of. Additionally pyrolysis requires high temperatures and doesn't always produce a high enough quantity of oil to justify it as a viable form of recycling. Through the use of AlCl3-NaCl as a catalyst, pyrolysis can be improved upon. Melting small pieces of HDPE sourced from milk cartons and exposed to the AlCl3-NaCl has produced promising results. Results have shown that the catalyst helps dramatically reduce the amount of wax byproduct and increase the oil yield in comparison to traditional catalysts. In trials without a catalyst or with zeolite, a common catalyst, wax was the only product. Trials with AlCl3-NaCl resulted in oil, a stronger flow of vapors, and no wax byproduct. These findings suggest that using AlCl3-NaCl as a catalyst offers a more efficient economical solution for HDPE recycling.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   EN CH EM

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CSEF Official Abstract and Certification
2025

Title: The Compressive Strength and Insulative Qualities of Different Fungal Species within Mycelium-Based Materials

Student Name(s): M. Dunne

Abstract:

In a world trying to move towards a more ecologically sustainable future, construction waste becomes a large obstacle in sustainability. Being responsible for one third of the world's overall waste, finding sustainable alternatives for construction materials becomes more necessary. Mycelium-based materials is one of the many possible alternatives found, and while there are many avenues to take mycelia in relation to construction, this study will focus on its capability as an alternative to polystyrene insulation foam. The aim is to find which out of the chosen species of Pleurotus ostreatus and Trametes versicolor will be a suitable alternative to insulation foam. Taking into consideration growth period and production, the mycelium bricks were put through insulative and compressive tests. From these trials, the study was able to determine which of the two performs the best in either or both categories. Future study is intended to streamline the growing period and to improve the mycelium-based insulation's capabilities.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

MI EN

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☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Facilitated Ethylene Absorption and Freshness Preservation via All-Natural Composite Coated

Student Name(s): N. Jain

Abstract:

The global food waste crisis has reached catastrophic proportions, with 40% of all produce spoiling before reaching consumers, resulting in annual loss of $1 trillion - meanwhile, 828 million people struggle with hunger worldwide. Produce spoilage is caused by ethylene, a plant hormone that accelerates ripening by triggering enzymatic processes that cause texture softening, color changes, and vulnerability to microbial decay. Current ethylene inhibition and oxidation methods are costly, harmful to organisms, and result in uneven maturation. This study introduces novel ethylene-absorbing composite made from activated carbon, ascorbic acid, sodium chloride, and sweet almond oil, which slows ripening while maintaining cost efficiency. The composite's effectiveness was evaluated using Gas Chromatography equipped with Flame Ionization Detection (GC-FID) to measure ethylene concentrations in banana storage chambers, demonstrating 23.5% ethylene accumulation reduction in treated samples. Attenuated Total Reflectance Fourier Transform Infrared (ATR-FTIR) spectroscopy further confirmed ethylene retention, with ethylene-spectral peaks present in exposed samples. Additionally, ATR-FTIR analysis revealed starch-to-sugar conversion was significantly slower in treated bananas, indicating delay in enzymatic breakdown. RGB analysis of bananas showed slower increase in red-to-green (R/G) ratio for treated samples, with 19% difference by Day 9. Scanning Electron Microscopy (SEM) imaging revealed greater structural integrity in treated samples, whereas untreated bananas exhibited fragmentation and pore formation. This composite is 280% more cost-effective than conventional ethylene inhibitors while remaining non-toxic, scalable, and passive. The composite's applicable format results in dramatic ripening reduction and extends produce shelf life by ~25% providing non-hazardous, cost effective, convenient alternative to current preservation technologies.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) EN AT

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4. Is this project a continuation? ☐ Yes ☒ No

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☐ Yes ☒ No

Word Count

197

CSEF Official Abstract and Certification
2025

Fair Category

PS

Project Number

6023

Title: Oxidation of LixMny Electrodes for Gel-Electrolyte Metal Oxide Pseudocapacitors Using Microwave Plasma

Student Name(s): A. Yang

Abstract:

Supercapacitors have great potential in the future of electricity. Traditional methods for the synthesis of metal-oxide based supercapacitors require chemical reactions that are inefficient and produce toxic waste. The study used high energy microwave plasma as a green alternative to these methods. Carbon cloths screen printed with Li^+ and Mn^{2+} salts were treated with different concentrations of Ar and O_2 microwave plasma to form Li_xO_y - Mn_xO_y mixed pseudocapacitors. The areal capacitance of the supercapacitors was measured using cyclic voltammetry (CV) and galvanostatic charge discharge (GCD). Optimal* specific capacitance was achieved with 20 standard cubic centimeters per minute (sccm) flow rate of 100% O_2 plasma at a treatment distance of 7.5 cm. Prolonged exposure to 100% oxygen plasma for 30s appeared to lead to inconsistencies, possibly due to excessive temperature, while 100% argon had poor performance likely due to poor oxidation. It was concluded that 100% oxygen microwave plasma has the potential to replace traditional redox methods of pseudocapacitor synthesis. However, further optimization, such as treatment distance, flow rate, and plasma energy, must be done. The study will also benefit from further analysis of samples, including stability tests and oxide identification.

*in relation to other tested configurations

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

EE CH

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☒ Yes ☐ No

CSEF Official Abstract and Certification
2025

Title: Effects of Increased Temperature and Acidification on Moon Jellyfish (Aurelia Aurita) Reproduction Rates

Student Name(s): R. Rodgers

Abstract:

While rising ocean temperatures and acidification negatively impact a variety of species, there are some species that may thrive under these conditions. Moon jellyfish, Aurelia aurita, a historically ubiquitous species has experienced a growth in its marine boundaries as its populations have expanded polewards and is now present in all but the coldest oceans in the world. This paper examines the effects of increased ocean temperature and ocean acidification on the reproductive rates of A. aurita polyps. The experiment was designed to mimic four conditions: current, warming-only, acidification-only, and future. Conditions were set to replicate current temperature and pH and projected temperature and pH for the year 2100. The results may show that warmer conditions are most conducive to population growth, whereas acidification will act as a limiting factor for jellyfish populations. Additionally, they may show that jellyfish are most likely to bloom under warmer conditions. This reveals that in the short-term, jellyfish populations will rise; however, if acidification accelerates faster than temperature rise then the opposite may occur – jellyfish population growth may decline.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) EA

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

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☐ Yes ☒ No

CSEF Official Abstract and Certification 2025

Word Count 197

Fair Category PS

Project Number 6026

Title: Analyzing GW170817-like Events and Effects on The Uncertainty of Hubble's Constant

Student Name(s): A. Matyszkowicz

Abstract:

Cosmology, the study of the universe's origin, structure, and evolution, often involves determining the Hubble constant (H_0), which describes the rate of cosmic expansion. A persistent discrepancy, called Hubble Tension, arises between early and late universe measurements of H_0. The Planck satellite, which observes the cosmic microwave background (CMB), suggests $H_0 \approx 64.7$ km/s/Mpc(uncertainty ~1), while local measurements from SH_0ES yield $H_0 \approx 73.2$ km/s/Mpc (uncertainty ~0.5). This inconsistency cannot be explained by measurement errors alone, prompting debate over its cause. Gravitational wave (GW) observations offer a new method for constraining H_0. This study investigates how increasing detections of binary neutron star (BNS) mergers improve measurement precision. Using simulated data modeled after GW170817, the first confirmed BNS merger observed by GW observatories LIGO and Virgo, the analysis explores how uncertainty decreases with more detections. Through mode estimation and sampling techniques, results indicate that approximately 60 GW170817-like events are required to achieve an uncertainty of ~1 km/s/Mpc, comparable to Planck's precision. These findings highlight the significance of GW observations in cosmology. With advancements in GW detection technology, they have the potential to resolve the Hubble Tension and refine our understanding of H_0.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) PH

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CSEF Official Abstract and Certification
2025

Title: The Novel Application of Arbuscular Mycorrhizae to improve the vitality of Glycine max

Student Name(s): O. Dueck

Abstract:

Providing a reliable food source to a permanent population on Mars is a substantial horticultural challenge due to the low viability of martian regolith. Arbuscular Mycorrhizae is a symbiotic fungus which penetrates plant root systems and provides extra surface area dedicated to nutrient and water intake. This symbiotic relationship can be used to improve and permit viable horticulture in Martian regolith. It is proposed to supplement martian regolith with Arbuscular Mycorrhizae. This experiment involved soybeans placed into 4 groups; 2 groups in Martian regolith and 2 groups in Earth soil. 1 group in each substrate had 0.5g of AMF inoculant applied, and the other group was not treated. The grow tray used was checked to ensure that there was a similar amount of light and heat applied to each plant. Each plant was given exactly 40 ml of water, with light and heat for 7 hours each day. Data collected has been inconclusive, however trial 1 showed a 200% increase in the regolith treated with AMF, with a 0.33 average growth stage in the untreated regolith, and a 0.67 average growth stage in the treated regolith. This effect has not been able to be replicated in subsequent trials. Future research should involve the analysis of the long-term effects of AMF on soybean growth in martian regolith, into the vegetative and reproductive stages.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

PS EM EN

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☐ Yes ☒ No

CSEF Official Abstract and Certification 2025

Word Count 136

Fair Category PS

Project Number 6029

Title: Creating Prescription Adjustable Glasses to Treat Lazy-Eye

Student Name(s): Y. Ahmed

Abstract:

Children with a lazy-eye or amblyopia often need separate prescriptions for each eye, and prescriptions often need to be changed every year. The objective is to create prescription adjustable glasses with lenses made from a thin stretchy-plastic membrane and glycerine. As glycerine is pumped into the membrane, the concavity of the membrane increases. The more concavity the lens has, the more powerful prescription the lens will have. A '3D Pen' was utilized to create the frame of the 'Prescription Adjustable Eyeglasses'(PAE) virtually from scratch. Upon making the frame, attaching the necessary components, and pushing the glycerine into the plastic membrane; the experiment failed due to there being compromises in the leakproofness of the membrane. The membrane was not as tightly fastened to the frame as previously thought. This resulted in a failed experiment.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) ME EN AT

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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Confirming TESS exoplanet candidates and searching for multi-planetary systems using transit photometry and timing variations

Student Name(s): A. Valji

Abstract:

Determining the habitability of exoplanets, which are planets outside the Solar System, and studying multi-planetary star systems have long been the goals of many astronomers, but first exoplanets must be discovered. The Transiting Exoplanet Survey Satellite (TESS) is a space telescope that searches for exoplanets using the transit method, or the indirect observation of exoplanets via the change in brightness of the star when the planet passes in front. Transit observations can be displayed graphically on a light curve, or brightness over time graph. Once a transit is detected by TESS, the planet is considered to be an exoplanet candidate, but some candidates can turn out to be false positives rather than planets. This study used the Phillips 24" Telescope at the Mt. Lemmon SkyCenter Observatory to perform follow-up transit observations, and then used the open-source software AstroImageJ to create light curves. The existence of exoplanets in the TOI-1858, TOI-1832, and TOI-3856 systems was confirmed. Possible transit timing variations were found in the TOI-1832 system, and a larger unknown object was found in the TOI-3856 system, indicating the potential existence of two multi-planetary systems. Also, the planetary radii of the targets were determined. Confirming candidates, and finding new planets through transit timing variations, allows astronomers to create a list of confirmed exoplanets which can be used to conduct follow-up studies to investigate planetary compositions and orbital architectures of multi-planetary systems. Studying star systems and exoplanets like these gives researchers insight into how our own solar system is different from others.

**Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)**

PH

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☐ Yes   ☒ No

Word Count

248

CSEF Official Abstract and Certification
2025

Fair Category

PS

Project Number

6033

Title: Development of a Fe3O4 (Iron II, III) Nanoparticle based Motor Oil Removal System

Student Name(s): A. Gupta

Abstract:

This project aims to eliminate the destruction that comes with oil spills and the current methods to clean them using nontoxic magnetite nanoparticles. These can safely and efficaciously filter oil-contaminated water. When mixed with oil-polluted water, they adhere to oil due to van der Waals forces (London Dispersion Forces) and repel water because of their nonpolar coatings. Using a magnet, the oil and nanoparticles can be easily and safely removed, decontaminating the water. This project utilizes these principles to create a practical apparatus.

First, I tested the optimal quantity of nanoparticles in a proof-of-concept and settled on a 4:5:25 nanoparticle:oil:water ratio, which yielded a .96 efficiency rate. Significant changes were also visible. After this, I 3D printed a device to perform the removal process. It consists of a compartment for contaminated water and a lid with a hollow rod for mixing. Once nanoparticles are mixed in, a magnet can slide into the mixer to remove the oil. This device makes the process more efficient but less accurate, reaching an efficiency of 1.136. This implies that the device removed small amounts of water with the oil and nanoparticles. However, in real-world applications, this is harmless.

The constructed apparatus can be automated, attached to boats, and driven across contaminated areas, safely cleaning them. Further research could be conducted to reuse nanoparticles and create a more widespread application. Overall, ferrofluid filtration is a superior method of oil removal due to its safety and efficacy.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   EM CH EE

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☐ Yes   ☒ No

Word Count

253

CSEF Official Abstract and Certification
2025

Fair Category

PS

Project Number

6035

Title: Advancing Personalized Seizure Control: A Cutting-Edge Real-Time EEG Feedback System for Precision Adaptive Neurostimulation

Student Name(s): S. Desiraju

Abstract:

Epilepsy affects millions worldwide, with drug-resistant seizures presenting significant challenges. Existing neurostimulation treatments such as responsive neurostimulation (RNS) and vagus nerve stimulation (VNS), lack adaptability to individual brain activity, leading to inconsistent outcomes. This project aims to develop a real-time EEG-based system that classifies seizure types and dynamically optimizes neurostimulation parameters. By leveraging OpenNeuro data and machine learning, this system personalizes treatment, offering a promising advancement in invasive seizure management. The system processes EEG data using bandpass filtering, notch filtering, independent component analysis, and artifact subspace reconstruction to re-move noise. Seizure classification is performed through a hybrid deep learning model integrating Convolutional Neural Networks (CNNs)and Long Short-Term Memory (LSTM) networks. Neurostimulation adjustments are simulated in Python, optimizing frequency parameters using Mean Squared Error (MSE) to minimize deviations from ideal values. When tested on a high-performance computing environment, the system achieved 89% accuracy with a response time of 0.062 milliseconds, accurately identifying seizure patterns and optimizing stimulation parameters within a 10% error margin. On a Raspberry Pi, the model maintained 74% accuracy with an average latency of 0.139 milliseconds, demonstrating feasibility for real time deployment despite computational constraints. These findings suggest that a portable, real time EEG-based neurostimulation system could enhance personalized seizure treatment to better the long-term effect of invasive medical procedures. The ability to implement this technology on lightweight hardware like the Raspberry Pi offers significant potential for at-home seizure monitoring and adaptive neurostimulation, ultimately improving patient outcomes and quality of life.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

EN BC ME

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☐ Yes   ☒ No

CSEF Official Abstract and Certification 2025

Word Count
236

Fair Category
PS

Project Number
6036

Title: The Effects of Using Paints on Outdoor Concrete Surfaces to Lower the Impact of Climate Change on Ground Temperatures

Student Name(s): W. Krishnaswami

Abstract:

Playgrounds, parking lots, and other outdoor surfaces reach dangerously hot temperatures during summer months, and these temperatures will only continue to rise as global warming intensifies. This project tests how different colored paints impact the temperature of concrete under simulated sunlight from a heat lamp. An infrared thermometer was used to measure the temperatures of concrete blocks painted black, grey, white, unpainted, and pool deck cooling paint, every thirty minutes for four hours, under a heat lamp. I predicted that the concrete painted white and painted with the cooling paint would remain the coolest because the color white is known to reflect heat, and the cooling paint is made for the purpose of reflecting heat and keeping the surface cool, and that the concrete painted black would reach the highest temperatures because the color black absorbs heat, and that the unpainted concrete and the grey-painted concrete would be somewhere in between hottest and coolest. The experiment was repeated on three separate days, and the results were consistent. The temperature of the white paint was coolest, and the black paint was hottest, but, contrary to my hypothesis, the cooling paint was ineffective. The problem of overheating outdoor concrete can be mitigated by painting concrete white because the color white does the best job at reflecting and not absorbing heat. Black paint should be avoided on outdoor concrete, and special cooling paint is not worth the purchase.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   EM EV

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CSEF Official Abstract and Certification
2025

Title: Investigating the Relationship Between the Luminosity and the Extent of the [O III] Narrow-Line Region in Nearby Type 2 Seyfert Galaxies

Student Name(s): T. Zhang

Abstract:

Active Galactic Nuclei (AGN) are supermassive black holes that actively accrete matter, emitting radiation that ionizes surrounding gas in the Narrow Line Region (NLR) through photoionization. While this process is well-studied in luminous AGN, its role in low-luminosity active galaxies remains less explored. To investigate the relationship between the luminosity and the extent of the NLR, I use Hubble Space Telescope (HST) narrow-band and continuum imaging of five nearby (<100 Mpc), low-luminosity ($38 < \log L(0.5-2\text{keV}) < 40$ erg/s) AGN. By using SAOImageDS9 and Python to subtract the continuum images from the narrow-band images, I extract [OIII] emission maps to measure NLR luminosities and sizes. When combined with similar AGNs from previous studies, the results show that the extent of [O III] emission scales with luminosity as $R_{[O III]} \sim L_{[O III]}^{0.4}$, slightly shallower than the previously established $R_{[O III]} \sim L_{[O III]}^{0.5}$ relation for higher luminosity objects. This deviation suggests that in low-luminosity AGN, photoionization is not the only mechanism regulating the physical conditions and spatial extent of the NLR, and other processes, such as star formation, also play a role.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) PH

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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: How do Overuse Injuries Affect Sports Performance in Youth Athletes?

Student Name(s): L. Braddock

Abstract:

Increased participation in sports has been linked with an increase in the number of sports-related injuries. Overuse injuries, which are related to inflammation and pain, have proven to be the most common type of sports injury. Overuse injuries in athletic settings are extremely common because sports often require the same repetitive motion, inevitably putting stress on individual locations of the body. Overuse injuries such as these were completely unknown in children until this routine of repetitive sports training became so normalized. Many athletes experience overuse injuries and encounter their setbacks, proving it is an area that requires stressed attention. To examine how overuse injuries affect young athletes, I am conducting a study using two devices which effectively track sports performance. I am using a triaxial WitMotion accelerometer to track running patterns divided into the x, y, and z distribution. In addition, I am using Helios to track hockey players' acceleration, stride speed, agility, and balance. The injured athletes have most likely relearned how to approach different techniques, potentially favoring injured limbs, resulting in overcompensation. The results of this study could help teen athletes better understand the after-effects of overuse injuries and their overall biomechanical movement in running or skating. It is important to consider that even after recovery, compensation can still occur and result in an unequal distribution of force and expelling more load on one side of the body.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) ME BE

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☐ Yes ☒ No

CSEF Official Abstract and Certification 2025

Title: The Future of Wind Energy & Logarithmic Spirals

Student Name(s): M. Davis

Abstract:

My project explores wind energy production by using non traditional spiral shapes. My project focuses on the Fibonacci spiral. The Fibonacci spiral is made up of a sequence of numbers where the sum of each next line is equal to the sum of the past two numbers. I used this pattern to create a Fibonacci turbine to generate wind energy. The question my project answers is whether or not the Fibonacci turbine or other logarithmic spirals should be utilized to generate energy or to prove that they are not worth the effort of producing. I was able to answer this question with my experiments by comparing the Fibonacci turbine to two other turbines that I made. Designing in CAD and using a 3D printer, I made an arithmetic turbine and a mini windmill replica to create an aerodynamic wind shape. The data showed that the Fibonacci turbine generated more RPM than both of my other turbines. To sum up, my project proves that the Fibonacci spiral can be used as a small, affordable, and efficient source of energy collection. At a time when energy costs are skyrocketing out of control for many, especially in Connecticut, the use of a Fibonacci turbine could provide relief to the high costs imposed on energy users.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

AT MA EE

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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Design of a Biomimetic Trap for Spotted Lanternfly using Scent-profiles of Ailanthus altissima

Student Name(s): R. Lu

Abstract:

Since their first sighting in the US in 2014, spotted lanternflies (SLFs) have become a persistent problem in the Northeast, ravaging vineyards and tree farms. Existing SLF lures often attract beneficial wildlife, especially nocturnal bees, and pure methyl salicylate lures are less effective than volatile combinations. A safer, and highly effective lure is needed, and was the focus of this research. This project uses kairomones that are typical of the TOH scent to create a biomimetic, semiochemical lure for SLFs. The four kairomones that were identified through a GC-FID analysis, were beta-caryophyllene (BC), methyl salicylate (MS), linalool (Lin), and Z-3-hexynylacetate (ZHA), where their retention times were verified with comparisons to previous literature, and the NIST11 mass spectral library. Based on the GC-FID relative concentration of each volatile, the same TOH profile was replicated in a HydroMed-D3 polymer at a MS-BC-Lin-ZHA mass ratio of 6.9:2.1:6.6:6.3 in 10g HMed, and 35ml ethanol, to create the allure gel. This gel was manufactured to scale, so that it could cover a 4-foot plastic tube that when dried, would cover the "stand portion" of a new SLF trap mechanism, where both nymph and adult SLF would climb. GC-FID analysis revealed that the SLF Allure Gel Attractant tube TOH simulated-output was 3.1ug-BC, 1.86ug-MS, 0.50ug-Lin, and 0.25μg-ZHA, which was stable for two weeks, post application to the landscape. This combined, 5.71ug of TOH-volatiles far exceeds the 0.7ug output of the real TOH, suggesting that the trap will be effective well beyond the 2-week specification for 100% functionality.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) EN EM AT

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4. Is this project a continuation? ☐ Yes ☒ No

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☐ Yes ☒ No

Title: Nature's Remedy: Understanding the Effects of Urban Tree Cover Inequalities on Human Health

Student Name(s): H. Witharana

Abstract:

This study systematically investigated the potential association between urban tree cover disparities and health effects in Connecticut's seven urban municipalities, a majority of which experienced redlining in the past. The first objective modeled the correlation between percent tree canopy cover (PTCC) and respiratory health conditions. The second objective explored the association between PTCC and mental health conditions. The linear regression models found a negative correlation between the PTCC and three response variables (current asthma crude prevalence, chronic obstructive pulmonary disease crude prevalence, and frequent mental distress). ANOVA results reported statistically significant differences in frequent mental distress across low, medium, and high tree canopy cover levels. Neighborhoods with low tree cover were mostly historically redlined and currently dominated by people of color. Overall, study findings emphasize the benefits of urban trees on physical and mental health of city dwellers.

Technical Disciplines Selected by the Student
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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Using Ant Colony Optimization Algorithms to Generate Artificial Human Genomic Sequences

Student Name(s): A. Haniph

Abstract:

One of the predominating problems facing genomics and bioinformatics researchers are medical privacy laws, protecting the use of human genomes while also limiting researchers' ability to study them and draw statistically accurate conclusions. This proposal will yield large samples of human genomes for researchers to use while respecting medical privacy laws. The Ant and the Anteater model is a modified generative adversarial network (GAN), powered by swarm intelligence, used to generate valid artificial human genomic sequences based on pattern recognition performed on known human genomes. To develop this model, existing AI algorithms were dissected and rebuilt within the R environment. The Ant and the Anteater's modification occurs in the generator AI (the Ants), which is replaced with a novel swarm intelligence model that combines Ant Colony Optimization algorithms with Chaos Game Representation to produce artificial genomes. The discriminator AI (the Anteater) remains an ANN which performs a dual role of checking the viability of a generated genome to exist within the overall human population and the specific population that a genomics researcher may wish to study. The generative algorithm successfully generates an artificial human genome that has a variability and basepair placement that is realistic to existing human genomes. The discriminator will successfully train on both an inputted and reference genomes to produce artificial genomes that are reflective of both. Thus, the Ant and the Anteater model can successfully generate artificial human genomes. It is recommended that future research focus on reducing the model's computational complexity, promoting its use.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

BC CS MA

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects   ☐ potentially hazardous biological agents
☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes   ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Optic Nerve Head is All You Need: Classification and Biomarker Identification in Neurodevelopmental Disorders via Representation Learning for Vasculature Features

Student Name(s): J. Hwang

Abstract:

Neurodevelopmental Disorder (NDD) is an abnormal neurological development that is prevalent across the globe. Among the various types of NDD, Autism Spectrum Disorder (ASD) and Attention Deficit/Hyperactivity Disorder (ADHD) are the most common. The number of NDD patients increases each year, spotlighting the importance of the NDD diagnosis system. Early detection is especially crucial in NDD patients since the disorder cannot be reversed or properly treated once the patient exceeds the age of 5. However, the current diagnosis methods for each NDD heavily depends on parental questionnaires and doctor's examinations, neither of them relying on an objective diagnosis method. Such diagnosis causes fatal errors, potentially putting borderline patients with mild symptoms in a vulnerable position. In response, previous researches have been conducted to find an objective biomarker, suggesting the optic nerve area as a potential biomarker, and implemented a deep learning system for diagnosis method. Despite their efforts, the studies contained several flaws in their study intentions: rather than focusing on the medical drive, the studies focused on improving the accuracy of their deep learning models. This study improves upon the previous study by proposing an improved automated diagnosis system that uses fundus image to detect ASD and categorize ADHD into severity category. The results clearly demonstrated that the proposed approach is superior than the previous state-of-the-art methods by achieving the accuracy of 95.21% and 91.00% in ASD and ADHD screening respectively.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) EN ME AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects   ☐ potentially hazardous biological agents
☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification 2025

Word Count: 230

Fair Category: PS

Project Number: 6045

Title: Evaluating the Effectiveness of Natural Antioxidants in Slowing Food Oxidation and Extending Shelf Life

Student Name(s): K. Bui

Abstract:

Oxidation significantly impacts food quality, leading to discoloration, texture degradation, and reduced shelf life. It is wasteful and it costs money, using natural foods that already have those natural antioxidants would benefit from the antioxidants used in this experiment. This experiment investigates the effectiveness of natural antioxidants: Vitamin C, Vitamin E, and Green Tea Extract in slowing oxidation in food products. The study examines their impact on the oxidation process of apples and avocados by analyzing the pH levels, moisture retention, and color over a one week period. Each type of fruit was divided into four groups: a control group (no antioxidants) and three experimental groups treated with varying amounts (0.50, 1, and 2 mL) of each antioxidant. The fruits were stored at 4.4 degrees Celsius and the data was collected daily, weighing the masses and obtaining the pH with a pH strip. A t-test was conducted to compare the final masses across the different groups. Based on previous research on the internet, the findings suggest that Vitamin C is the most effective antioxidant when delaying oxidation, particularly in apples and avocados. The lower pH level of Vitamin C helps inhibit oxidative damage. The Green Tea Extract showed moderate effectiveness, while the Vitamin E exhibited the least impact. The results indicated that natural antioxidants can be applied in food preservation strategies to extend shelf life and reduce food waste.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) CH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

- [ ] human subjects
- [ ] potentially hazardous biological agents
- [ ] vertebrate animals
- [ ] controlled substances

2. Student independently performed all procedures as outlined in this abstract. [X] Yes [ ] No

3. This project was conducted at a Registered Research Institution. [ ] Yes [X] No

4. Is this project a continuation? [ ] Yes [X] No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

[ ] Yes [X] No

CSEF Official Abstract and Certification
2025

Title: Research on Autoimmune Disease Spectrometer (RAD-Spec): A Machine Learning-Based Application for Improving Accessibility to Research on Autoimmunity

Student Name(s): V. Makarov

Abstract:

It's estimated between 5% to 10% of the global population suffer from some type of autoimmune disease (AD), but despite this prevalence, the general research effort into finding a cure for their symptoms and underlying causes has been very disorganized. For this reason, many in the field see part of the solution as being a public database of indexed scholarly work that researchers, doctors, and patients can use to stay updated on advancements and discoveries. While organizing this literature would be very time consuming if done by hand, machine-learning can automate this task. One candidate that stands out is Bidirectional Encoder Representations from Transformers (BERT), a relatively lightweight Large Language Model (LLM) which has widely proven to be effective at text classification tasks, especially if pretrained on a domain-specific corpus. This study automates the process of organizing research publications on autoimmunity by outlining an original, comprehensive labeling system and developing BERT models which exhibit industry standard accuracy (>85%) and precision/recall (70% to 90%) that can now be used to classify unstructured data. To determine the ideal BERT model for each task, side-by-side comparisons of BioBERT, ClinicalBERT, and BlueBERT – three notable BERT variants which are pretrained on different biomedical corpora – were conducted. Finally, these elements are implemented into a single solution: the Research on Autoimmune Disease Spectrometer (RAD-Spec), a web-app featuring interactive scatterplots (displaying the classified data) that help users explore AD research publications nested under specific labels.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   CS ME

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals   ☐ controlled substances

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3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No

CSEF Official Abstract and Certification
2025

Title: OATNet: A Computational and Mathematical Model of a Novel Neural Network Architecture Utilizing Ternary Weight Decomposition and Element-Wise Methods for Mitigating Computational Complexity

Student Name(s): K. Srikumar

Abstract:

The electricity demand for large language models (LLMs) has skyrocketed, driven by their intensive computational needs. Optimized Arithmetic via Ternary Networks (OATNet) is proposed as a novel neural network architecture for LLMs that uses fewer resources while maintaining performance comparable to current Language Models. The OATNet architecture was mathematically composed and proved as such: It restructures dense layer computations by decomposing the weight matrix into a ternary-valued matrix and a rank-1 magnitude approximation. Sign information is isolated within the ternary matrix, enforcing sparsity via discrete constraints, while the magnitude is represented as the outer product of two independent vectors, reducing the computation to a low-dimensional subspace. This reconfiguration transforms matrix-vector products into scaled element-wise operations and simplified vector additions. To validate the effectiveness of OATNet, model development, and empirical testing were conducted as such: OATNet is tokenized via the WordPiece algorithm (Subword-based tokenization).

The experimental framework in the program JAX optimized forward and backward passes with computational graphs. PyTorch was used for complementary testing with a Transformer stack, enabling gradient tracking, modular layer experimentation, and fine-tuning on benchmark datasets to ensure compatibility and robustness across frameworks. OATNet demonstrated superior efficiency on the WikiText-103 benchmark with validation perplexity of 6.78, a 19.26% improvement over compared LLM models, while requiring only 12.453 Floating Point Operations per second in a token versus the comparisons' mean of 21.302, 41.55% lower. OATNet significantly reduces energy consumption and costs while preserving performance, offering environmental benefits by mitigating computation, and a move toward sustainable Language models.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

MA CS AT

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- ☐ vertebrate animals
- ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Using machine learning models to adjust flow rates of Herschel-Bulkley fluids in Direct Ink Writing 3D printing processes

Student Name(s): J. Storeygard

Abstract:

Direct Ink Writing (DIW) 3D printing enables the printing of complex materials like Herschel-Bulkley (HB) fluids that demonstrate shear-thinning behavior. One challenge in DIW is maintaining consistent flow rates. Feedforward neural networks are machine learning (ML) models that can detect relationships between input parameters, such as nozzle pressure, and output parameters, including flow rates. The purpose of this project was to use ML models to predict and adjust flow rates of HB fluids in Direct Ink Writing (DIW) 3D printing processes. A synthetic dataset with 100,000 instances was generated that included pressure values, fluid characteristics, and flow rates. These values were all based on a spectrum of what would be expected from Herschel-Bulkley fluids in a DIW printer. It was divided into training data to help the model identify patterns, validation data to fine-tune it, and testing data to see how accurately the model could predict flow rates. The model's effectiveness was assessed through mean absolute error which was 1.68, and R^2 which was 0.94. From these values, it can be concluded that the model can effectively predict and adjust the flow rates of HB fluids during DIW. Although this model is still being tested on real DIW printers, the results from this project can be used to increase the consistency of DIW printing and reduce the need for manual fine-tuning of printer parameters.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

EE EN CS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals   ☐ controlled substances

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3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No
4. Is this project a continuation? ☐ Yes   ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Word Count
237

Fair Category
PS

Project Number
6050

Title: Efficiency research of Cellulose Electrospinning and Exploration of Cellulose Nanofiber Applications

Student Name(s): G. Vahey

Abstract:

Electrospinning of cellulose acetate (CA) solution centers around cellulose, the most common biopolymer on the planet. The utilization of cellulose acetate is advantageous for a variety of applications as a biodegradable replacement for materials in both textile and battery technology within anodes and cathodes. The electrical field created by 20-50kv is connected to the spinneret (syringe) and collector, creating a strong electrostatic force that pushes the cellulose acetate solution droplet towards the collector at a flow rate of 5-15 ml/h. The two stock solutions are comprised of 80% acetic acid and 20% water and 80% acetone alongside 10% water and 10% acetic acid, both with a CA wt/v% of 12.5. The testing and development of a low-cost prototype that focuses on industry standard optimal electrospinning conditions has been achieved through this project. The prototype has successfully yielded cellulose acetate fibers and film, with the acetone solution yielding more fibrous structures with better morphological characteristics. The experimentation aims to observe the impacts of conductive and hydrophobic additives to the stock solution that retain biodegradability. Due to the small scale, impedance, and differential voltage present in the fibers when combined with the additives, the true impact has yet to be assessed. The results of this study could provide a scalable and sustainable product as an alternative to heavy metals in batteries and polytetrafluoroethylene in waterproof textiles, increasing usage of renewable biomass resources and lowering environmental impact.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) EN EE AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification 2025

Word Count

258

Fair Category

PS

Project Number

6051

Title: Novel Autonomous Drone Control Framework utilizing Deep Reinforcement Learning

Student Name(s): H. Jin

Abstract:

As autonomous drone technology becomes increasingly prevalent in disaster response, logistics, environmental monitoring, and other fields, the need for scalable, decentralized control systems is growing. Such systems enable drones to operate in tandem and make real-time decisions with minimal human intervention. This research introduces a decentralized control framework that allows drones to process data locally from sensors such as IMU and LiDAR, enabling task execution without relying on centralized systems or GPS. At the framework's core is the TD3 deep reinforcement learning (DRL) algorithm, which offers significant improvements over other models in achieving real-time, continuous control. To the best of this research's knowledge, this is the first work to successfully train the TD3 algorithm on a drone. The inputs to the DRL algorithm are primarily obtained from the onboard flight controller, while its outputs are continuous target velocities and yaw-rates. The algorithm is first trained within the Cosys-AirSim simulation environment and later deployed on a drone to validate its capability for autonomous object detection in real-world scenarios. A key advantage of this approach is its flexibility. The framework's modular subsystems can utilize custom object identification algorithms and allow for tailored flight paths. By defining a set of custom waypoints, the autonomous drone can navigate to specified locations while avoiding obstacles, effectively performing any user-defined task. The system's flexibility was tested by attaching a thermal sensor for fire detection, providing high-resolution infrared imaging to identify hotspots and monitor fire spread in real-time. This integration enables rapid, adaptive responses during fire emergencies.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

EE CS ET

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☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

Word Count

221

CSEF Official Abstract and Certification
2025

Fair Category

PS

Project Number

6052

Title: Utensil Solutions for Tremor Assistance and Neurological Disorders (USTAND)

Student Name(s): R. Albrecht

Abstract:

Tremors are a common side effect of neurological disorders such as Parkinson's Disease and Multiple System Atrophy (MSA), which significantly disrupts daily tasks like eating. MSA tremors involve more cerebellar dysfunction than Parkinson's tremors, categorizing them as postural tremors (Kaindlstorfer 2013). Parkinson's tremors are considered resting tremors, caused by dopaminergic degeneration in the basal ganglia (Dirkx 2022). This project aims to design a utensil grip that reduces the strain associated with tremors, allowing those impacted by tremors to rely less on their caregivers. The project involves creating a utensil grip made entirely with food-safe materials by incorporating an ergonomic design and weight-balancing system. It will result in a design that will improve usability and stability. The process included designing CAD model molds, then 3D printing prototypes. Three different materials were used (silicone caulking, silicone rubber, and hot glue) to accurately represent the model. Testing was not able to occur due to issues with the materials and the mold. In the future, a machine such as an earthquake table will simulate tremors, to test the utensil grip. The model will be evaluated by usability, spillage, and grip comfort. The final design will improve these qualities and ultimately reduce food spillage and strain during use. Future applications include a universal, versatile grip that can attach to various utensils for universal accessibility.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) EN BE ME

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Synthetic Turf Field's Effect on Water Feature

Student Name(s): E. Wright

Abstract:

Synthetic turf fields are made up of rubber often sourced from tires found on cars. These Tires are known to contain various chemicals and toxins, such as arsenic, cadmium, lead, and nickel. These chemicals pose a high health risk to the environment. This has not been sufficiently studied with water bodies. This research aims to investigate the effect of synthetic turf fields, Especially the one located at Tiger Hollow Stadium at Ridgefield High School. This field has a water runoff behind it, known as the Titicus River. The study is conducted in two phases. The first is an in-lab experiment. Turf samples are collected from the field and left undisturbed in distilled water for 4 weeks. After the 4 weeks, the water samples are tested for any presence of toxins. The second experiment takes place near the Titigcus River. Water samples are pulled upstream, and the distances of the water pull are measured. The results of this study will prove that Synthetic turf fields affect the environment around them.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) EV EA EM

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☒ Yes ☐ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

Word Count

259

CSEF Official Abstract and Certification
2025

Fair Category

PS

Project Number

6054

Title: Discovery of Three Debris Disks Near Habitable Planet Candidates Using a Novel Companion SED Subtraction Method

Student Name(s): J. Du

Abstract:

Observations of circumstellar debris disks, formed from collisions between the lingering solid material from planetary formation and evolution, provide great insight into our understanding of planetary system dynamics. Even though the NASA Kepler mission has recently detected over 2000 new exoplanets, only 47 of these have been identified as potentially habitable planet candidates. In addition, around Sun-like stars and habitable planet hosts, circumstellar debris still remains largely unexplored. In my study, I report the detection of circumstellar debris disks around three Kepler stars that show significant infrared (IR) excess (KIC 10452252, KIC 8890150, and KIC 10027247). These three stars also each contain a promising low-mass, terrestrial-sized exoplanet candidate in orbit around them (KOI-8012.01, Kepler-395c, and Kepler-1229b, respectively). I first perform aperture photometry on observations from the Wide-field Infrared Survey Explorer (WISE) to detect IR excess from debris disk dust emission. Then, by fitting spectral energy distributions (SEDs) to thoroughly calibrated Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) and UK Infra-Red Telescope (UKIRT) Hemisphere Survey (UHS) point spread function (PSF) photometry measurements, I rule out companion contribution to IR excess. A robust search of the literature shows that previous research fails to adequately account for this. These discoveries highlight the dynamic, dusty conditions surrounding habitable planet candidates and suggest potential parallels to our solar system. Future work on this subject is straightforward. There is still further investigation to be done on these debris disks, and future studies can apply a similar companion SED subtraction method to confirm debris disk discoveries.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

PH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification 2025

Word Count
241

Fair Category
PS

Project Number
6055

Title: Using Electromagnets to Stabilize Hand Tremors

Student Name(s): A. Stowell

Abstract:

Essential Tremor and Parkinson's are both neurological disorders that result in shaking hands, making day to day tasks difficult. Focusing more directly on Essential Tremor, the disorder affects about 5% of people above the age of 60 and is a widespread issue. This experiment attempts to counteract these tremors using permanent magnets and electromagnets, to counteract the tremor movements. A device was constructed using permanent magnets and electromagnets, controlled by an Arduino Pro Mini and MPU 6050 gyroscope and accelerometer, to push or pull the hand in the opposite direction of the tremor. In order to test the impact of the device, an Archimedean spiral was traced three times freehand and then three times with it on. The papers were then scanned and sent through a program that detects the amount of pixels below a certain color threshold (RGB: 90,90,90) in order to detect the variance from the line. After testing with a person who has Essential Tremor, there was no statistically significant difference between the freehand and device aided drawings ($p > 0.05$). The device had no noticeable effect on the user's accuracy, and there are a few reasons why this could have occurred such as lack of strength from the magnet, lack of experience, or flawed construction. In order to improve the device in this aspect, a redesign of the casing could be beneficial, or the addition of a voltage controller in order to increase the power of the electromagnets.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   EE CS ME

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☒ human subjects   ☐ potentially hazardous biological agents
☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes   ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No

CSEF Official Abstract and Certification
2025

Title: Time to Think in Ternary?

Student Name(s): M. Rangwala

Abstract:

This project compared ternary and binary computing system efficiency and energy use. Most of the computer systems used today are binary. These computing systems think in 1 and 0, or on and off respectively. Ternary computing systems think in 0, 1, and 2, or -1, 0, and 1. This project conducted experiments and analysis to test whether this third state makes ternary computing more efficient by comparing binary to ternary multiplications, the number of steps required to complete the multiplications, and the number of digits in the product. The hypothesis was that ternary computing systems are more energy efficient because ternary numbers store more information in fewer digits. The experiments conducted and the analysis in this project supported the hypothesis. For example, the number 20 requires 5 digits to represent it in binary: 10100; but in ternary, it requires only 3 digits: 202. Ternary computers will only have to analyze 3 digits instead of 5, thus saving energy in the process. Complex computing problems will be solved much easier and by using less energy by ternary computers. This project addresses timely concerns of today: energy consumption and the advent of artificial intelligence (AI). Burning fossil fuels lead to emissions that are detrimental to the health of Earth's ecosystems. AI uses a considerable amount of energy, which is one of the bottlenecks in its advancement. Sustainable energy use choices, like switching to ternary, can shape a better future.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   MA CS ET

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: LungSCOPE: A Multimodal Machine Learning-Based Framework for Overall Survival Prediction in Non-Small Cell Lung Cancer

Student Name(s): P. Hayashi

Abstract:

According to the National Cancer Institute, nearly 700,000 people die of cancer in the United States each year. Almost 20% of these deaths come as a result of non-small cell lung cancer (NSCLC), making it the most deadly form of the disease and creating the need for lung-specific therapeutic solutions. When treating an NSCLC patient, an accurate overall survival prediction is imperative for determining the optimal therapeutic strategy. Currently, physicians typically significantly overestimate overall survival. To solve this issue, predictive machine learning has been heavily developed in recent years. However, traditional approaches have typically only utilized unimodal data sources, limiting their ability to predict survival accurately. Furthermore, the few multimodal NSCLC-specific models which exist have mostly utilized deep learning, a promising yet computationally expensive method that has been shown to underperform alternative methods such as gradient boosting in genomic studies. In this project, a novel comprehensive eXtreme Gradient Boosting (XGBoost)-based multimodal machine learning framework for overall survival prediction in NSCLC, LungSCOPE was created. By utilizing 27 clinical features and 9 genomic biomarkers, an XGBoost model was trained and optimized to predict 12, 36, and 60 month overall survival. LungSCOPE achieved an area under receiver operating curve (AUROC) of 0.78, 0.83, and 0.84 at 12, 36, and 60 months respectively, outperforming all previous similar state-of-the-art models. This framework displays immense potential for providing physicians with accurate overall survival, allowing them to determine the optimal personalized treatment for their patients, greatly improving the quality of their lives.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

BC CS EN

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals   ☐ controlled substances

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3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No

4. Is this project a continuation? ☒ Yes ☐ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: The Design and Development of a Smart and Effective Multi-Device Airline Seat Belt Alert System for Preventing Turbulence-Related Injuries Using iOT Technology

Student Name(s): S. Srinivasan

Abstract:

Turbulence, caused by unpredictable air movements, is the leading cause of non-fatal passenger and crew injuries. Research from the University of Reading shows turbulence has increased by 55% over the past 40 years, making turbulence-related injuries more prevalent.

This research aims to develop a practical and effective alert system to reduce turbulence-related injuries. Inspired by car safety measures, the prototype monitors passenger safety by detecting whether they are seated, their seatbelt is fastened, and their seatback is fully upright. If any of these conditions are not met, an overhead light alerts specific to the passenger to comply.

A mobile application was developed to assist pilots and flight attendants in monitoring seat safety in real time. By displaying which seats are not meeting safety requirements, the app allows the crew to address safety issues efficiently. This not only ensures passenger compliance but also emphasizes crew safety by minimizing unnecessary movement during turbulence. The pilot can activate the system when turbulence is detected and deactivate it when conditions stabilize.

Analysis shows that the system effectively enhances in-flight safety, reducing the risk of injuries. Key technologies include Arduino for the hardware, Flutter and Dart for the mobile app, and Firebase for data storage and authentication. The hardware device and the app communicate via Wi-Fi.

This solution is easy to implement and significantly improves passenger safety. Future research will focus on refining and expanding the invention's capabilities.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

AT CS EE

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3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No

CSEF Official Abstract and Certification
2025

Title: Evaluating Market Efficiency Through Deep Learning: A Performative Analysis of LSTM Neural Networks, Actor-Critic Reinforcement Learning Models, and Technical Indicators

Student Name(s): B. Weiss

Abstract:

Stock market inefficiencies provide opportunities for traders to achieve returns above market averages. However, these inefficiencies are quickly exploited, making their identification and practical application challenging. Previous studies have utilized Long Short-Term Memory (LSTM) neural networks for stock price prediction, yet they often face two critical limitations: reliance on normalization methods that incorporate future data, rendering them unsuitable for real-world use, and a focus on prediction accuracy without addressing how these predictions translate into actionable strategies.This study addresses these limitations. It employs a normalization technique that relies solely on historical data, ensuring real-world applicability. Second, it integrates LSTM neural networks with a trading framework to bridge the gap between theoretical predictions and practical decision-making. Additionally, the research explores the comparative effectiveness of conventional and unconventional technical indicators in identifying market inefficiencies. Using EUR/USD data at 15-minute intervals from 2019 to 2024, this study develops a dual-model system consisting of an LSTM-based predictor and a Deep Q-Network (DQN) reinforcement learning agent. The LSTM model forecasts price movements, while the DQN agent translates these predictions into optimized trading decisions. Results indicate that while unconventional and conventional indicators yield comparable predictive performance, integrating reinforcement learning with LSTM-based predictions leads to significant improvements in trading outcomes. The trained model consistently outperforms both successful discretionary traders and even the top-performing hedge funds.By combining technical indicator analysis with actionable trading strategies, this research advances the practical applications of artificial intelligence in finance, providing valuable insights for both academic research and professional trading practices.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

CS MA AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Novel Incorporation of Braided Byssal Threads into Artificial Connective Tissue to Enhance Form and Function with the Use of Biomaterials Produced by Mussels

Student Name(s): S. John

Abstract:

Anterior Cruciate Ligament injuries are common in high-impact sports and often require surgical reconstruction. Current graft options, such as hamstring tendon and bone-patellar tendon-bone grafts, have limitations, including donor site morbidity, prolonged recovery, and potential failure. This study explores byssal threads, naturally produced by mussels, as a component in synthetic ACL grafts due to their unique combination of strength and flexibility. To assess their suitability, key mechanical properties, including tensile strength, elasticity, Young's modulus, fatigue resistance, and failure strain were evaluated. Different structural configurations were tested using 20 byssal threads, arranged in two designs: a braided crisscross configuration and a single-line structure reinforced with superglue nodes. These designs were tested under controlled force application to determine which provided the best combination of strength and elasticity. The braided crisscross structure exhibited superior mechanical performance, with force resistance increasing from 2.67N at 50g to 6.15N at 400g, maintaining greater resistance to elongation. In contrast, the single line structure showed reduced elasticity, with force values increasing from 2.7N at 50g to 5.07N at 270g, demonstrating lower stretchability. These results indicate that structural arrangement significantly influences mechanical properties, with the braided configuration offering improved strength and flexibility. Future applications of this research could lead to stronger, more durable synthetic ACL grafts, better mimicking natural ligament properties. Additionally, these findings may extend to other biomedical applications, such as tendon and ligament repair.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

EN PH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☒ Yes ☐ No

CSEF Official Abstract and Certification
2025

Title: Comparative Growth Analysis of Mycelium in Standard vs. Orange Peel-Enriched Substrates for Production of a Biodegradable Foam as a Polystyrene Substitute

Student Name(s): C. Reynolds

Abstract:

Expanded polystyrene foam (EPS), or Styrofoam, is a universally utilized packaging material because of its impressive strength and protection. The environmental impact of Styrofoam has prompted the search for sustainable alternatives because of its long decomposition period stretching centuries. This study investigates the potential of mycelium-based biofoams as an eco-friendly replacement for Styrofoam, specifically examining the growth and structural properties of the Tiger Sawgill mushroom (Lentinus tigrinus) with orange peel-enhanced substrates. Biofoams were cultivated with varying amounts of orange peels for 10 days in sawdust medium at 27oC, until mature growth was observed. Growth configurations included a control L. tigrinus group (NO), an orange peel enhanced group (O), and a group with double the quantity of incorporated orange peels (O2). Mature fungal growth for each group was separated, and subjected to compression and structural analyses, including scanning electron microscopy (SEM). Results indicated that biofoams with orange peels (Biofoams O and O2) exhibited superior growth uniformity, enhanced structural integrity, and increased cushioning properties compared to the control (Biofoam-NO). SEM analysis confirmed a denser, more organized mycelial network in orange peel-supplemented biofoams, indicating that the orange peels successfully strengthened the biofoam. Compression testing demonstrated that Biofoam-O2 matched Styrofoam in strength while surpassing it in post-compression recovery (80% vs. 78%), indicating its potential for reuse and as a successful replacement. Additionally, the biodegradable nature of the biofoam allows for recycling and composting, reducing long-term waste accumulation. These findings suggest that orange peel-enriched mycelium biofoam is a viable alternative to Styrofoam in packaging applications.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) EN MI

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Smart Screening for Cytochrome P450 Inhibitors: AI Meets Drug Discovery

Student Name(s): A. Gadhachanda

Abstract:

Cytochrome P450 (CYP450) enzymes are essential in drug metabolism, and their inhibition can lead to significant drug-drug interactions, affecting safety and efficacy. Accurate and rapid prediction of CYP450 inhibition is critical for early-stage drug discovery and toxicity assessment, helping to streamline the identification of safer drug candidates. While effective, traditional experimental methods for screening inhibitors are time-consuming and resource-intensive, highlighting the need for efficient computational approaches. In this proof-of-concept study, we develop a machine learning-based approach using the XGBoost algorithm to predict the inhibitory potential of molecules on six major CYP450 isoforms. Separate models were built for each enzyme using molecular descriptors and fingerprint-based features, leveraging publicly available datasets from TDCommons.ai. The models were trained and evaluated to assess their predictive performance, demonstrating the feasibility of AI-driven CYP450 inhibition screening as a rapid and cost-effective alternative to traditional in vitro testing Our findings underscore the potential of AI-driven screening in drug metabolism research, offering a scalable and interpretable solution for identifying CYP450 inhibitors. By integrating this approach into early-stage drug development pipelines, researchers can reduce screening time, optimize lead selection, and mitigate the risk of late-stage failures due to metabolic liabilities. While this study validates the approach's feasibility, future work will focus on refining models with experimental datasets to enhance real-world applicability and further support safer drug development.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

CS BC AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects   ☐ potentially hazardous biological agents

☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes   ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No

Word Count

202

CSEF Official Abstract and Certification
2025

Fair Category

PS

Project Number

6066

Title: Dusting and Lifting Fingerprints

Student Name(s): A. Juarez Chincilla

Abstract:

Since fingerprints never change, they are considered to be one of most important tools in forensic investigations (Crime Museum, 2024). Fingerprints on soft surfaces such as soap and wax, and fingerprints on hard surfaces that are then classified as latent or patent. This experiment examines how different surfaces affect the quality of the fingerprint. If dusting fingerprints on a nonporous surface, will it come out better than a lifted fingerprint on a porous surface? In this experiment, I analyzed the quality of fingerprints on porous and nonporous surfaces. I dusted latent fingerprints and used tape to lift and preserve the fingerprints. In my experiment, dusting fingerprints on a nonporous surface created better quality fingerprints than a lifted fingerprint on a porous surface. According to Forensic Sources (2013), techniques such as Iodine fuming and Ninhydrin work much better when collecting fingerprints on porous surfaces. This explains why the porous surfaces did not produce good fingerprints due to the technique I used. This research is significant to the forensic science community as it supports the importance of using proper protocols. Future considerations for experiments include testing public surfaces for finger prints and counting the number of full prints on various surfaces using various techniques.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) ME

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Bionic Shoulder Joint Based on Cable Powered Technology

Student Name(s): Y. So

Abstract:

With increasing political tensions leading to many instances of violence, more patients with limb loss around the world face difficulties in their daily lives. Current solutions often weigh a lot, are hard to use, lack freedom of movement, and cater to the wealthy with their exorbitant prices, which is not the majority of amputees. Realizing this, I created a mass-producable, cable-controlled bionic shoulder joint by referencing and mimicking the tendons, muscle groups, skeletal structure and nerves that make up the human shoulder joint. The unique cable mechanism and dual motor-sharing system, reduces the number of motors and optimizes the layout by placing the motors and steering gears away from the frame, dispersing the system's weight amongst the body and preventing the wearer from experiencing weight imbalance. The fork-like structures connected by a cross enables all three degrees of motion while the controller based system allows the product to be more intuitive. Corresponding circuit boards and control codes have also been designed. This product not only contributes to the underdeveloped industry of prosthetics technology, it also can broaden application scopes by being used in industrial and medical settings. Experiments show that this bionic shoulder can perform basic daily tasks and sense pressure to return to its initial position. In subsequent versions, the design will be further optimized by fixing inconsistent cable pulling rates and the amount of stress the shoulder can handle, to improve the overall performance and provide better solutions for patients with limb loss and robotic applications.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) `EN AT EE`

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects   ☐ potentially hazardous biological agents
☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes   ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No

CSEF Official Abstract and Certification
2025

Title: Cycles in the Juggler Sequence

Student Name(s): J. Theodore

Abstract:

In number theory, the juggler sequence is a recursive sequence introduced by Clifford A. Pickover. Pickover conjectured that for any initial value x, the sequence would eventually be equal to 1, where it would stay forever, stuck in what is known as the trivial cycle. Since its proposal, Pickover's Conjecture has been confirmed up to $x = 1,000,000$, but nothing concrete has yet been proven about the juggler sequence's behavior. In this paper, we attempt to prove a lower bound on the length of a non-trivial cycle in the juggler sequence. We do this by examining a potential cycle of length k, and developing lower and upper bounds for the juggler sequence's value after k iterations. We then study when these inequalities are possible.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   MA

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes   ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Word Count
193

Fair Category
PS

Project Number
6071

Title: Projections of Critical Global Warming Thresholds in Connecticut Using Data Analytics

Student Name(s): A. Patel

Abstract:

In today's world climate change is a major threat that affects us in various ways, such as rising temperatures, extreme weather events, rising sea levels, and greenhouse gas emissions. Therefore, this research hopes to create a model that is able to predict these changes up to 2050 under different scenarios. In order to create the model I used historical data and applied regression analysis and scenario analysis using Google Collab and Python libraries. The models will be evaluated based on the Mean Squared Error and R^2 error. MSE measures the average squared difference between predicted and actual values, indicating the model's accuracy, while R^2 shows how well the model's predictions explain the variability of the actual data. After I analyzed the results and provided recommendations for policymakers and how to improve the sustainability of Connecticut, this research not only aims to contribute to the scientific understanding of climate change impacts at a regional level but also seeks to raise awareness and inspire proactive measures within the state. By highlighting the potential future scenarios and their implications, the study hopes to drive informed decision-making and foster a more sustainable future for Connecticut.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   EV EM

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes   ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☒ Yes   ☐ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Fair Category

PS

Project Number

6072

Title: Energy Production From a Homemade Hydrogen Cell

Student Name(s): W. Speight, T. Liskov, T. Liskov

Abstract:

Modern technology constantly demands more energy. This increased demand has a detrimental effect on ecological threats like global warming. The world needs a new clean energy source that can meet the increased energy needs. Hydrogen fuel cells are more efficient at producing energy than gasoline, while producing net zero emissions. A hydrogen fuel cell was built, and output was measured. The testing concluded that hydrogen energy was 3.49% more energy efficient than gasoline by volume. Further research would focus on improving the efficiency of the hydrogen fuel cell.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

AT ET

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals   ☐ controlled substances

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3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No

CSEF Official Abstract and Certification
2025

Title: Increasing Chlorophyll Production:

Microcystis synchronous culturing with Lyngbya: An effort to increase Photosynthetic

Student Name(s): S. McGovern, S. McGovern, S. McGovern

Abstract:

The purpose of this project was to increase the photosynthetic rate in Microcystis by increasing its pigmentation production. It was hypothesized that growing a Lyngbya culture alongside a Microcystis culture would increase pigmentation production and rate of photosynthesis due to the efficient nitrogen fixating capabilities of Lyngbya. Increasing availability of nitrates may increase pigmentation as Microcystis is not a nitrogen-fixing cyanobacteria. Three erlenmeyer flasks were used. One containing Lyngbya grown by itself (Control 1), another containing Microcystis grown by itself (Control 2), and the final containing both grown together. The Microcystis and Lyngbya co-culture produced up to 17.77% oxygen and up to 994 ppm for carbon dioxide, with the Lyngbya culture producing up to 17.70% oxygen and up to 852 ppm for carbon dioxide, and the Microcystis culture producing up to 17.91% oxygen and up to 803 ppm for carbon dioxide. These results signified that there was no significant increase in oxygen production caused by the co-culturing of the cyanobacteria but rather a decrease in carbon dioxide input.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

EA MI

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☐ vertebrate animals   ☐ controlled substances

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3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No

CSEF Official Abstract and Certification
2025

Title: Exploring Antibiotic Effects on Wolbachia-Based Mosquito-Borne Disease Control

Student Name(s): E. Muir

Abstract:

Mosquito-borne diseases, such as dengue and Zika, pose a significant global health threat. Wolbachia, an endosymbiotic bacterium, has been introduced into mosquito populations as a biological control method to reduce disease transmission. However, environmental antibiotic exposure may compromise the stability and efficacy of Wolbachia in mosquito hosts. This study aims to investigate the impact of tetracycline and doxycycline on Wolbachia-infected Aedes aegypti populations. Laboratory experiments will expose Wolbachia-infected mosquitoes to varying antibiotic concentrations, and molecular analysis will measure Wolbachia stability through PCR and gel electrophoresis. By assessing mosquito survival rates and bacterial persistence, this research seeks to determine whether antibiotic exposure diminishes Wolbachia ability to establish and sustain infections in mosquito populations. Understanding these effects is critical for developing effective Wolbachia-based vector control strategies in environments with high antibiotic pollution.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

BI CB

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☒ Yes ☐ No

CSEF Official Abstract and Certification
2025

Title: Soil Nutrient Tester with Rotating Strip Holder for Multi-Day Analysis

Student Name(s): J. Liu

Abstract:

Soil nutrient imbalance significantly affects agricultural and environmental health, yet it continues to be challenging for gardeners and farmers to accurately track soil quality over time. Current soil assessment methods typically involve frequent user intervention, resulting in testing that is expensive, labor-intensive, and potentially inaccurate. These limitations may result in inefficient fertilizer use, lower crop yields, and significant environmental damage due to nutrient runoff. The Soil Nutrient Tester with a Rotating Strip Holder is designed for automated soil quality analysis over multiple days. The device utilizes a modified rotating pill dispenser, while integrating filter papers and chemical testing strips. At programmed intervals, the rotating mechanism releases the filter paper, which is attached to the testing strip, through a weighted mechanism. After making contact with the soil, the device performs a continuous, hands-free monitoring of essential soil parameters, including pH, copper, and lead concentrations. Comparison between expected values from manual methods and values from the Soil Nutrient Tester confirmed low error rates. Percent errors were all under 10% with red (RGB) values at 2.23%, blue at 6.77%, and green at 5.43%. However, hue (HSB) and brightness values were at 9.8% and 8.7% error respectively, indicating minor variations likely due to soil moisture absorption and lighting conditions. This device offers an affordable and accurate alternative to costly electronic testers, enabling accessibility in long-term agricultural monitoring.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) EN EM AT

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3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No

CSEF Official Abstract and Certification 2025

Word Count 161

Fair Category PS

Project Number 6077

Title: CTRQNets & LQNets: Continuous Time Recurrent and Liquid Quantum Neural Networks

Student Name(s): A. Mayorga

Abstract:

Neural networks have continued to gain prevalence in the modern era for their ability to model complex data through pattern recognition and behavior remodeling. However, the static construction of traditional neural networks inhibits dynamic intelligence. This makes them inflexible to temporal changes in data and unfit to capture complex dependencies. With the advent of quantum technology, there has been significant progress in creating quantum algorithms. In recent years, researchers have developed quantum neural networks that leverage the capabilities of qubits to outperform classical networks. However, their current formulation exhibits a static construction limiting the system's dynamic intelligence. To address these weaknesses, we develop a Liquid Quantum Neural Network (LQNet) and a Continuous Time Recurrent Quantum Neural Network (CTRQNet). Both models demonstrate a significant improvement in accuracy compared to existing quantum neural networks (QNNs), achieving accuracy increases as high as 40% on CIFAR 10 through binary classification. We propose LQNets and CTRQNets might shine a light on quantum machine learning's black box.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) CS MA AT

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes   ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No

Word Count

267

CSEF Official Abstract and Certification
2025

Fair Category

PS

Project Number

6078

Title: Recovering the Largest Area Fault-free Rectangle from a Punctured Square

Student Name(s): B. Cha

Abstract:

Given an axis-parallel unit square Q in the plane containing n points, the problem of finding an axis-parallel empty rectangle of maximum area contained in Q is one of the oldest problems in computational geometry. More precisely, we consider the following: Problem. Given S, a set of n points contained in the unit square Q, let f(S) denote the largest area rectangle that does not contain any of the points of S in its interior. Further, let f(n) be the minimum value of f(S) over all sets S of n points in Q. Estimate f(n). It is immediate that f(1) = 1/2. In 2013, Dumitrescu and Jiang determined the values of f(2), f(4), and proved that $(1.25 - o(1))/n \leq f(n) \leq 4/n$.

In this paper we determine f(3) and obtain estimates for f(5) and f(6). We also improve the general estimate by showing that $(1.31 - o(1))/n \leq f(n) \leq 1.91/n$. Our approach consists of two main steps. First, we make use of computers to search for efficient point placements which prevent the existence of large area empty rectangles. Next, we attempt to prove that the point arrangements we identified earlier are indeed optimal. The general upper bound $f(n) \leq 1.91/n$ uses a construction involving the golden ratio and the Fibonacci sequence. We use elements of the theory of continued fractions and geometry of numbers to produce our record construction. Our results are significant as the problem arises in a number of practical situations, such as facility location, manufacturing, and electronic design automation.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

MA CS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No

4. Is this project a continuation? ☒ Yes ☐ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Biodegradable Packaging Materials: Using Polysaccharides Found in Alginate Extract from Marine Macroalgae to Mimic the Structure and Function of Conventional Polymers

Student Name(s): T. Mishra

Abstract:

Single-use plastic makes up around 50% of global plastic waste, presenting a serious environmental challenge. While bioplastics offer a promising alternative, the majority of existing solutions need complex industrial processes and machinery, making it inaccessible to small businesses and individuals. This research project investigates how bioplastic production can be made cheaper and simpler, without compromising effectiveness. The research began with deep analysis of existing solutions, revealing inconsistencies in composition and strength. Iterative testing of different solutions found to be most effective was used to test the impact of different additives on the final texture. The goal was to optimize cost and degradability time. To the core, three things are necessary: A base, a polymer, and a plasticiser. The correct amount of all will ensure a strong but flexible film, whose industrial process was modeled using Agar powder (polymer) and vegetable glycerin(plasticiser). The result of many iterations was a thin sheet, strong and flexible but lacking in elongation rate. The lack of elongation rate can be explained by the fact that agar is a processed edible, lacking some of the raw substances that regular polymer extraction would result in. This project highlights the potential of seaweed based bioplastics as a simpler alternative to traditional plastics. Further research and development in this area could lead to the widespread adoption of bioplastics, helping to reduce plastic pollution and protect our environment.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   EN PS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects   ☐ potentially hazardous biological agents
☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes   ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No

CSEF Official Abstract and Certification 2025

Word Count 248

Fair Category PS

Project Number 6081

Title: Prediction of Low-Pressure Metallization of Metal Hydrides by Ab Initio Simulation

Student Name(s): L. Dozier

Abstract:

The theoretical properties of metallic hydrogen have long been sought after and with the possibility of high-temperature superconductivity, or super fluidity on the horizon, it is no wonder why this material has been at the forefront of material sciences. Despite researchers' best efforts, however, and even up to pressures of 400 GPa, metallic hydrogen is still only theoretical. New research into hydrides at high pressure has helped imagine an alternative route to metallic hydrogen. Building off of the research into SiH_4, LiH_4, and GeH_4 by Feng et al., Vaisynys et al., and Li et al. respectively, and by using hydrides that possess both high chemical precompression and hydrogen-favored bonding, my ab initio research into TiH_4 has predicted it will metalize at approximately 6 GPa. Past research has pointed out the potential error, due to DFT calculation underestimating the band gap, which may suggest that the t3 structure of TiH_4 metalizes at a pressure higher than 6 GPa. However, the transition at 12.5 GPa to the o3 structure, which is predicted to be metallic even at ambient pressures, means even with a large overestimation of the band gap it would be reasonable to suspect TiH_4 would metalize by this transition pressure. At 12.5 GPa TiH_4 has the lowest metallization pressure of any type IV hydride in past research, the closest being 50 GPa for GeH_4. This pressure is achievable in the lab and could pave the way for experimental verification of the covenanted properties of metallic hydrogen.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) CH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification 2025

Word Count
154

Fair Category
PS

Project Number
6083

Title: Comparing the activity of FAST-PETase and Dura-PETase at ambient temperatures

Student Name(s): L. Shah-Gustafsson

Abstract:

The crisis of plastic pollution and the insufficiency of current plastic recycling systems has necessitated the exploration of new recycling technologies. Enzymatic plastic degradation could potentially allow for a more energy- and resource-efficient recycling system, particularly if the enzymes are capable of operating at near-ambient temperatures. In this experiment, I will compare two engineered enzymes, FAST-PETase and Dura-PETase, by assessing the mass loss of 6 mm PET discs and small cubes of PET batting after 6, 12, and 24 hours of degradation. I will obtain enzyme solutions by first inducing protein expression in a liquid bacterial solution, then separating the mixture via centrifugation. Experimental trials will be conducted at three temperatures— room temperature, 35°C, and 50°C. The findings of this study could present a new angle on the search for fast and cost-effective plastic-degrading enzymes and eventually inform the creation of a catalyst suitable for implementation.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)
BI CB

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☒ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification 2025

Word Count
241

Fair Category
PS

Project Number
6085

Title: The Effect of Glycerin on Water Absorptive Capacities of Agar-based Biofilm

Student Name(s): A. Chang

Abstract:

The purpose of this study is to measure water-absorptive capacity of agar-based films and determine if more brittle or flexible bioplastic films result in a greater water absorptive capacity. Water-absorptive capacity is an important attribute of wound dressings as the main function of wound dressings is to absorb excess fluid. To test this, two different agar-based bioplastic films were made by adding varying amounts of glycerin so that one bioplastic film was more flexible while the other was more brittle. The weight of the bioplastic films before submersion in water was taken. Then, the bioplastic films were allowed to soak in water to mimic the absorption of wound fluid. The films were then taken out to be weighed at different time intervals from one to fifteen minutes. The weight of the bioplastic after water absorption was then taken and the amount of water absorbed was calculated. The results demonstrate that bioplastics with a higher composition of glycerin or the flexible films appear to enable a greater absorption of water. The rate of absorption is rapid in both bioplastic films as both films reached their maximum water capacity after 1-3 minutes. In conclusion, the results of this experiment support the hypothesis that the agar films can quickly and efficiently absorb nearly 100% of its weight in water. This data shows a promise for agar-based bioplastic films and for their use in wound dressings to absorb excess fluids.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)
ME

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects   ☐ potentially hazardous biological agents

☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification 2025

Title: A Novel Mantis-Shrimp-Inspired Smart Glove for Stroke Rehabilitation

Student Name(s): J. Liu

Abstract:

This research discusses the design and development of a mantis-shrimp-inspired smart glove targeted at aiding stroke therapy. The glove combines soft and rigid materials in a hybrid exoskeleton system, imitating the dexterity and strength of the human hand through pneumatic actuation and silicone-based constructions. The designing principle of the finger borrows ideas from the bio-structure of the Chitin of mantis shrimp. Mantis shrimp exoskeletons provide a feasible engineering solution to segment silicone fingers while balancing durability and flexibility. The fundamental feature of the device focuses on helping finger motions through regulated inflation and deflation, facilitating rehabilitation in stroke patients with poor dexterity. The glove supports a passive range of motion and active-assisted motion workouts, assisting in the restoration of hand function by facilitating natural finger motions with little force. The performance of the glove in bending and straightening the little and index fingers in wearable and non-wearable situations was investigated. The findings revealed that the portable exoskeleton permits controlled movement via progressive expansion and supports finger bending and extension. Pressure values during expansion indicate strong bending control at 80–90 units in useable conditions. Moreover, the glove demonstrated excellent handling skills, allowing one to softly grasp objects like water bottles and cups—qualities important for rehabilitation activities. High success rates for safe gripping without excessive force indicate the glove's practical use in therapeutic environments. The glove's ability to permit controlled holding and finger mobility presents a potential way of enhancing hand performance in stroke victims.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   EN EE AT

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☐ vertebrate animals   ☐ controlled substances

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CSEF Official Abstract and Certification
2025

Title: Extraction of Cellulose Nanocrystals via Sulfuric Acid Hydrolysis from Post-Consumer Cotton-Elastane Textile Blends with Elastane Recovery

Student Name(s): M. Wies

Abstract:

An estimated 92 million tons of textiles are discarded yearly, contributing to global environmental crisis. Cotton upcycling presents a promising alternative to landfills or incinerators; cotton can be converted into high-value, biodegradable nanocellulose forms with applications across industries. However, the widespread blending of cotton with elastane (spandex) complicates any reuse, as elastane becomes entangled in machinery during traditional recycling. This research develops a scalable, sustainable upcycling pathway for extracting cellulose nanocrystals (CNCs) from post-consumer cotton-elastane textile blends. First, the sample fabric undergoes selective dissolution of elastane using N,N-dimethylacetamide (DMAc). Through filtration, cotton is separated, DMAc is recovered, and elastane fibers are isolated in a form suitable for further recycling. Sulfuric acid hydrolysis is applied to the separated cotton, producing CNC yields of approximately 55%. Dynamic Light Scattering particle size analysis of the CNCs in suspension showed an average hydrodynamic diameter of 60.1nm, which aligns with CNCs from USDA Forest Products Labs. This pathway outperforms an experimental comparison method, where direct sulfuric acid hydrolysis without prior fabric separation yielded fewer CNCs (50.3%), failed to recover elastane, and produced smaller CNCs with an average size of 51.1nm. Based on current commercial facilities, the developed method of pre-separation and subsequent acid hydrolysis can save 1880 kg (about 11,000 t-shirts) of cotton-elastane waste per day. These findings support a scalable and sustainable route for upcycling cotton-elastane blends, which are otherwise challenging to recycle, advancing toward a circular economy.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) EN EM CH

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☐ vertebrate animals   ☒ controlled substances

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: The Effects of Blade Angle, Length and Quantity on Wind Turbine Wattage Output

Student Name(s): N. Lee

Abstract:

As climate change and resource depletion crises continue to concern scientists, a huge rise in renewable energy has come to fruition, including that of solar panels, hydroelectric dams and wind turbines. In the US, wind power production has increased by almost 100x in only 23 years. This project was created to examine how blade angle, length, and quantity affect wattage output. The experiment aimed to determine the most powerful turbine configuration using a factorial testing setup. A wind turbine was constructed, and blades of varying lengths were created. Combinations of one, two, three, and six blades were tested at angles of 15°, 30°, and 45°. The testing indicated 15° degrees was the most effective angle in every single combination of factors, producing 1.32x and 2.44x the power of 30° and 45° blades. As well as that, more and larger blades proved to be superior with six blades producing 5.44x and 2.31x more power than three and two blades, and larger blades produced 1.14x and 2.89x more than medium and shorter blades. Single-bladed turbines produced no measurable power. This study demonstrates a clear correlation of more blade surface area to power output, favoring narrower blade angles for superior efficiency and can provide insights to improve modern wind turbine designs.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

ET EE EM

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3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No

CSEF Official Abstract and Certification
2025

Title: Band-aid Inspired Wearable Hydration Monitor

Student Name(s): E. Liu

Abstract:

97.3 of athletes know that dehydration will lead to worse performances, but the majority of them recognize thirst as the best indicator of dehydration. Yet, research has shown that feeling thirsty signals that you are already severely dehydrated. Because of dehydration it makes players become more prone to injuries like heat stroke and muscle strains, and decreasing performance on and off the field. As an athlete myself, I have seen and experienced this first hand, so I knew I needed to do something about it. Thus, making me create my own real-time hydration monitor, extension of a band-aid, that uses pH, Sodium, and Potassium concentrations to deduce hydration levels. When experimenting, I used buffers 4, 7, and 10 to get data points for pH values (was not able to buy materials in time for potassium and sodium) and their corresponding RGB (Red, Green, Blue) and Hue values, to create a graph and trend line. Hue ($y = 0.0157x+4.9448$, $R^2 = 0.7042$), Green ($y = -0.059+12.705$, $R^2 = 0.9517$), Red ($y = -0.0875x+19.919$, $R^2 = 0.8311$), and Blue ($y = 0.0997+1.1758$, $R^2 = 0.9555$). The most optimal graph was blue, closest to 1. Using the results, you input the values into a table giving you your hydration status and advice on what to do next. For future development, I hope to conduct research on human subjects instead of using buffer solutions.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   EN ME AT

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☐ Yes   ☒ No

CSEF Official Abstract and Certification
2025

Title: See the Future: A Precise Eye Drop Delivery System

Student Name(s): G. Rybaruk, E. Christophy, E. Christophy

Abstract:

Throughout the eye drop delivery system industry, there are issues with inconsistent drop sizes, which can lead to inaccurate dosing and patient difficulties. The prototype eye dropper with a syringe mechanism introduced in this project aims to enhance accessibility, particularly for patients with limited dexterity or vision impairments, by allowing more controlled and precise dispensing. The syringe mechanism allows for consistent drop volume, which can reduce the risk of under- or overdosing. The prototype was compared to a standard eye dropper through a series of controlled experiments. Both systems were used to dispense eye drop solutions into graduated cylinders, with the number of drops needed to reach 1, 2, and 3 milliliters recorded over three trials. The results showed that the traditional eye dropper required an average of 25 drops to reach 1 mL, 27 drops for 2 mL, and 28 drops for 3 mL. In contrast, the syringe-based prototype required only 23 drops for 1 mL, 23 drops for 2 mL, and 24 drops for 3 mL. These findings demonstrated that the syringe mechanism significantly improves drop size consistency and dosing accuracy, supporting the hypothesis that this design enhances precision and ease of use. The prototype offers a more reliable and user-friendly alternative to traditional eye drop delivery systems. Its precise dispensing mechanism not only improves dosing accuracy but also increases patient accessibility and reduces medication waste. Ultimately, this design has the potential to improve the medical field and patient performance with eye drops.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) ME AT EN

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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: The Capacity of Chia Seed Mucilage to Filter Harmful Compounds Out of Water.

Student Name(s): G. Julavits, N. N/A, N. N/A

Abstract:

Mucilage is a soluble, viscous material which acts as a natural filter for various flora. This natural process is proposed to be applied in water filtration. To establish the validity of this proposal, mucilage was extracted from Salvia Hispanica (chia seed) through a modified centrifugal extraction process. Extracted mucilage was frozen or freeze dried for future experimentation. A zinc stock solution (concentration 5600 ppm) was developed to test the efficacy of reconstituted / raw mucilage. This stock solution was introduced to both gel and powder mucilage for 24 hours. XRF analysis demonstrated a 6300 ppm +11.93% and powder demonstrated 6900 ppm +22.81%. This positive uptake indicates the mucilage was successfully able to absorb zinc contaminate. Research on various other metals needs to be conducted, but if mucilage can absorb the tested material, it will become a viable / cost effective alternative to modern filtration systems.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

EM AT EN

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4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Testing the Effectiveness of Different wt% of Platinum Cluster Catalysts Supported by Zeolite or Graphene for Decalin Dehydrogenation

Student Name(s): D. Mathew

Abstract:

While hydrogen fuel cells are a promising alternative to fossil fuels, hydrogen storage and production present several challenges. This study explores this issue by investigating the effectiveness of platinum (Pt) catalysts supported by zeolite and graphene at varying weight percentages (wt%) (0.01, 0.1, 0.5, and 1.0) in decalin dehydrogenation, a reaction that should theoretically produce 5 moles of hydrogen per mole of decalin. The research hypothesized that 0.5 wt% Pt would yield optimal reaction efficiency. Catalysts were prepared using an impregnation method, followed by reduction in H_2 (10 vol% H_2/Ar) at 473 K for 2 hours. The dehydrogenation reaction itself took place in a batch reactor. Conversion efficiency was assessed using nuclear magnetic resonance (NMR) spectroscopy, with computational modeling being used to further visualize Pt cluster structures on graphene, providing insight into the catalyst's atomic arrangement. Results of the 0.5 and 1.0 wt% trials for zeolite seem to support the hypothesis, with 0.5 wt% having significantly higher intensity than 1.0 wt%. This indicates the amount of Pt affects the intensity of the products from decalin dehydrogenation, with a moderate wt% seeming to have a higher concentration than a large wt%. Computational models visualized Pt clusters on graphene, affirming the catalyst's structural integrity. These findings emphasize the importance of optimizing Pt cluster size and support structure to enhance hydrogen production. Further research should focus on refining computational models and exploring alternative catalyst compositions to improve hydrogen yield.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) CH EN

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3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification 2025

Word Count: 250

Fair Category: PS

Project Number: 6094

Title: Acetinox: In-Situ Acetylene-Based Nitrification Inhibitor To Reduce Soil-N loss in Cereal Crops

Student Name(s): S. Rajan

Abstract:

Cereals, which produce grains, cannot fix nitrogen (N), a key nutrient for growth. Thus, farmers largely rely on synthetic nitrogen fertilizers (SNFs). SNFs contribute to greenhouse gas emissions (GHGs). This occurs because ammonium (NH_4^+-N), the initial form of urea fertilizer, is oxidized by bacteria into nitrate-nitrogen (NO_3-N), which is poorly retained in the soil and washes away. Nitrification inhibitors (NIs) work by blocking the conversion of NH_4^+ to NO_3^-, allowing plants to absorb nitrogen in the form of ammonium. However, research has shown that current NIs are highly ineffective. Acetylene showed promise as a ligand in inhibiting microbial nitrification. In order to test acetylene, soil and cereal crops were collected from a farmer, where one soil and a plant had the treatment of acetylene and ammonium, while the other soil and plant sample only had ammonium and served as the control. My results prove acetylene's effectiveness as an inhibitor. I found that acetylene had a 60% inhibition rate over the 56 day trial period, and showed signs of continuing beyond the research time-frame. In addition, I observed a NUE of 73.1% compared to the control's 42.1%. The plants utilized in this experiment showed positive effects as well, with cereal root weight increasing substantially (46%). In order to mitigate risks accompanied with application of acetylene, activated carbon was tested and found to have a high affinity with acetylene. This highlights both the environmental, and industrial potential of acetylene, cutting down costs and saving time, energy, and fertilizer.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   EM EA PS

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☐ vertebrate animals   ☒ controlled substances

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3. This project was conducted at a Registered Research Institution. ☒ Yes   ☐ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No

CSEF Official Abstract and Certification
2025

Word Count
222

Fair Category
PS

Project Number
6095

Title: Comprehensive Assessment for Executive Dysfunction (CAED): A gamified, tablet-based clinical evaluation tool for patients with Traumatic Brain Injury

Student Name(s): V. Scutari

Abstract:

Each year, over one million people in the United States suffer from traumatic brain injuries (TBIs), with 230,000 requiring hospitalization and 50,000 ultimately dying. Of those hospitalized, 34% are discharged with TBI-related disabilities, contributing to the estimated 5.3 million Americans living with TBI-induced impairments today. These impairments severely impact patients' ability to perform everyday tasks. Additionally, TBIs can affect anyone, from an average person to a professional athlete. Furthermore, traditional assessment methods for executive dysfunction are not only costly and time-consuming but also prone to human error due to their paper-and-pencil or verbal nature, limiting their effectiveness in frequent evaluations. This work herein presents the Comprehensive Assessment for Executive Dysfunction (CAED), a mobile, tablet-based, gamified tool designed to overcome these challenges. By integrating gaming elements with clinical evaluation, CAED offers a more accurate, efficient, and patient-friendly approach to assessing executive dysfunction in TBI patients. CAED features realistic game scenarios that replicate daily activities. Player behavior, timing, and decisions within these scenarios are tracked and when analyzed, provides insights into patients' cognitive function. To date, significant progress has been made in CAED's software architecture and visual design including basic systems and concept art. CAED has the potential to revolutionize neurological assessment and rehabilitation, offering a novel, technology-driven solution to improve care for individuals with TBIs.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) CS BE ME

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No

4. Is this project a continuation? ☐ Yes ☒ No

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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Investigating Aerodynamic In Shapes of Drones

Student Name(s): A. Misini

Abstract:

The purpose of this experiment was to see if more geometric shapes have faster speeds and greater efficiency, while having less drag. This is very important to get a better understanding of how design impacts flight. In many cases, drones are used for important missions like emergency rescue and aiding people and animals. In other cases it is used for preventing wildfires with its quick and speedy movements; it's used for medical and healthcare purposes to help transport medical equipment in secluded areas,where many have a hard time getting medical treatment. As for my procedure, I flew the drone in a 5 meter range under 1 minute to get consistent data for each drone. As for efficiency I used the current voltage and the efficiency equation to get my efficiency results. While I used the drag equation to figure out the drag force acting on the object since I wasn't sure how to use the wind tunnel. The results were somewhat accurate and supported the hypothesis with triangular and teardrop showing faster speed and greater efficiency. Looking back at this, there were many challenges I faced but I worked really hard to find solutions to those problems. This design concept can be very useful for airplanes, rockets, helicopters and more to create a more efficient innovative vehicle.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   EE AT MA

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3. This project was conducted at a Registered Research Institution. ☒ Yes ☐ No

4. Is this project a continuation? ☒ Yes ☐ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☒ Yes ☐ No

Word Count
249

CSEF Official Abstract and Certification
2025

Fair Category
PS

Project Number
6097

Title: Development of an Affordable Servo-Pneumatic Lower Body Powered Exoskeleton for Mild to Moderate Mobility Impairment

Student Name(s): I. bell

Abstract:

Ambulatory disabilities impairing the movement of affected individuals are the most prominent form of disability globally. The hundreds of millions of affected individuals employ a variety of technologies such as walkers, wheelchairs, etc. to maintain access to their communities and general quality of life. However, said technologies offer forms of movement fundamentally different from that of unimpaired individuals and require subsequently modified terrain/structures that, in spite of efforts, are frequently not present. Exoskeletons support individuals by emulating gait without facing the same limitations as conventional technologies. Yet, Exoskeletons have remained largely unpopular due to a disconnect between current pricing and insurance coverage. To address this, this project's purpose has been to design and construct a proof of concept, inexpensive exoskeleton to aid those with mild to moderate impairment capable of navigating traditionally hostile terrain like stairs. Research began with the consideration of numerous designs of various component types and configurations. The final concept was constructed and includes an air tank affixed to a back-brace and polycarbonate sheet, thermoformed around the hips, which supplies air to pneumatic cylinders mounted on the polycarbonate which direct the knee's flexion/extension while two similarly mounted servos rotate the upper leg about the hip joint. Several electronics enabling component functionality and pressure management were affixed on the polycarbonate and tank respectively. Student-made metal features provide structural integrity and enable mechanics. A library enabling easy programming/Bluetooth control was created and the system's capabilities were tested in precision (error $\leq 2.3\%$) and applicability.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)
EE ME AT

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☐ vertebrate animals　　☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

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☐ Yes ☒ No

Word Count
248

CSEF Official Abstract and Certification
2025

Fair Category
PS

Project Number
6098

Title: A Multi-Modal Modular Robotic System: Self-assembly and navigation in complex terrains

Student Name(s): M. Ma

Abstract:

Natural disasters cause immense destruction and death, with search-and-rescue operations facing a lot of challenges in efficiency and accessibility. Traditional methods like human teams, rescue dogs, and drones, often struggle with dangerous environments, exhaustion and certain environmental limitations. This project presents a multi-modal modular robotic system designed to better disaster response by autonomously navigating complex terrains, assembling into larger units for increased functionality, and efficiently locating and assisting survivors by splitting up.

The modular robots I developed are capable of independent movement, docking and detaching from one another, and lifting objects or other robots. A vision-based tracking system using April Tags Allows a computer to track every robot's every move at any time, and using esp32's built in communication protocols, the robots were able to send messages to each other wirelessly at lightning-fast speeds. Three key experiments were conducted to evaluate the system's effectiveness: (1) a PID-controlled movement test to assess turning and movement accuracy, (2) a load test to determine lifting capability, and (3) a combined movement test to analyze coordinated navigation. Results demonstrated that the robots could accurately move, dock, and lift each other, with some challenges in multi-robot movement control.

This technology can possibly revolutionize search-and-rescue missions by providing a scalable system that could reaching survivors in disaster-stricken areas faster and more quicker than current methods. Future improvements could include AI-driven autonomy, better obstacle navigation, and deployment capabilities in even more extreme environments.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

EE CS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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4. Is this project a continuation? ☐ Yes ☒ No

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☐ Yes ☒ No

CSEF Official Abstract and Certification 2025

Title: Next-Generation VTOL Drones: A Breakthrough in Tilt Mechanism and Modular Design for Optimization and Accessibility

Student Name(s): C. Taylor

Abstract:

Drones are widely used in military and civilian applications, with Vertical Takeoff and Landing (VTOL) drones combining the vertical lift capability of multirotor helicopters with the horizontal cruising efficiency of fixed-wing aircraft. However, conventional VTOL drones face energy inefficiency, high production costs, and limited repair or upgrade options. This research presents a newly developed VTOL drone featuring a novel tilt mechanism that allows the same motors to function for both vertical lift and horizontal cruising, eliminating redundant components and significantly improving energy efficiency. Additionally, a fully modular design enhances adaptability, durability, and ease of maintenance. The prototype, weighing approximately 2.6 kg, was constructed at one-fifth the lowest cost of comparable conventional VTOL drones.

A review of peer-reviewed literature as of January 2025 indicates that no previously documented VTOL drone has implemented this tilt mechanism, let alone one that integrates both a modular design and an adaptive tilt system. Computational Fluid Dynamics (CFD) simulations validate aerodynamic efficiency, with an optimal cruise speed of 72 km/hr (45 mph), balancing lift and drag for extended endurance. This speed is comparable to fixed-wing drones while being significantly faster than multirotor drones. CFD calculations estimate a flight time of 105 minutes, comparable with the endurance of fixed-wing drones.

Future advancements will incorporate AI-driven autonomous flight capabilities to enhance real-time decision-making and operational efficiency. This research sets a new benchmark in VTOL drone technology by improving propulsion efficiency, cost-effectiveness, and modular adaptability, paving the way for broader real-world applications.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) ET EE PH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

Word Count

246

CSEF Official Abstract and Certification
2025

Fair Category

PS

Project Number

6100

Title: Exoskeleton for Ankle Rehabilitation: Integrating Real-Time Feedback, Bluetooth Control, and Heat Therapy

Student Name(s): O. FENG

Abstract:

Assistive recovery equipment is essential to the therapeutic process after injuries, facilitating patients' daily life movements. This research project focuses on developing a three-support lower-limb exoskeleton integrating a real-time sole pressure feedback mechanism, a Bluetooth-controlled system, and a heat therapy function to enhance user adaptability and comfort. As traditional exoskeletons may disregard the importance of dynamic user feedback, the proposed exoskeleton aims to address such limitations by incorporating two major mechanisms of functionality: a passive mode that provides adaptive adjustments to gait patterns based on a real-time pressure feedback system and an active mode that allows the user to voluntarily control the movement of their ankle via a Bluetooth-connected device.

The design integrates three electric push rods to ensure structural support, distributing forces evenly across the lower limb. A motorized actuator enables active movement control via Bluetooth, while force-sensitive resistors (FSRs) embedded in the shoe sole provide real-time pressure feedback based on responded motions from the user. The device uses an Arduino-based control system to manage motor actuation, pressure feedback, and heating elements.

Data collection focuses on pressure feedback accuracy, heat therapy efficiency, and user comfort levels. Testing and evaluation were conducted on non-injured volunteers to assess the device's performance under various movement scenarios, ensuring that sensors and thermal controls would operate according to the user's recovery needs.

Ultimately, the project seeks to advance lower-limb assistive technology, contributing to effective gait training and rehabilitation support.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   EE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☒ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☐ Yes ☒ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification 2025

Word Count
233

Fair Category
PS

Project Number
6101

Title: Forest friendly paper z

Student Name(s): C. Simon

Abstract:

Global warming is one of the most pressing matters of our generation. One of the leading factors of global warming is deforestation. Trees are one of the biggest consumers of CO2 and as our rainforests are being cut down, CO2 levels are rising. Deforestation is the result of a number of things, one of which is the lumber and paper manufacturing industry. So for this experiment, I will be able to design an eco-friendly alternative to paper made from trees, in order to find a solution which will be able to aid deforestation. The paper made from the experiment will be able to hold 5 ml of water for at least 30 seconds without tearing. It was found that in order to successfully manufacture these paper prototypes, a bonding agent was required in order to add strength to the bamboo fibers. The success lies in how the fibers are able stick together. In this experiment, the fibers from recycled tissue and cotton fibers were used as a bonding agent. This Experiment was successful resulting in four pieces of paper which were able to hold a minimum of 5ml of water. These bamboo paper prototypes are able to be drawn and written on, and with the right chemical treatments have the possibility to be a successful alternative to paper, which will reduce the amount of deforestation, and therefore help aid with global warming.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) EV EM PS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Developing Autonomous and Adaptive Systems For Space-Exploration Robotics With Neuromorphic Frameworks & Artificial Intelligence

Student Name(s): R. Suren

Abstract:

Space exploration represents humanity's greatest endeavor into unknown environments. However, we face challenges in developing independent, autonomous and adaptive systems as we continue to identify novel regions. Current AI-driven rovers, such as NASA's Perseverance, are constrained by SWaP (size, weight, and power), radiation-resistant hardware performance, and onboard processing limitations for SLAM. This research investigates the potential of neuromorphic frameworks integrating Spiking Neural Networks (SNNs) with reinforcement learning (RL) to enhance power efficiency, adaptability, and radiation robustness for extraterrestrial exploration. Thereby, this novel design improves power consumption, radiation resistance, and robust real-time processing for upcoming rovers. The hierarchical system operates on a Raspberry Pi, leveraging event-driven computation akin to SNNs. Testing procedures included system performance tracking, radiation simulation, and action-space clustering evaluation. Results demonstrated a 30× reduction in CPU time and balanced resource utilization of 11% RAM and CPU, compared to traditional algorithms (RAM: 96.3%, CPU: 6%). t-SNE action-distribution visualizations revealed that SNN-PPO exhibited structured clustering and rapid adaptation, akin to biological learning. Radiation simulation testing confirmed system stability, a key requirement for planetary missions. A Welch's t-test comparing action-space clustering between SNN-PPO and ANN-PPO yielded $t \approx 7$, $p < 0.01$, confirming that SNN-PPO forms significantly more structured policies, reinforcing its advantage in decision-making under uncertainty. These findings highlight the framework's potential for increasing rover efficiency while operating in constrained environments. By demonstrating adaptive and power-efficient AI for space robotics, this work advances the development of compact, autonomous planetary rovers and sets the foundation for next-generation space exploration systems.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) AT CS EE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects   ☐ potentially hazardous biological agents
☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Development of a Three-Dimensional Gravitational Lensing Model: the Effect of Lens Mass, Orientation, and Position on Image Distortion

Student Name(s): C. Lee

Abstract:

Gravitational lensing occurs when a massive celestial object, such as a galaxy cluster, bends spacetime, causing light from a more distant object to bend and distort, similar to how a lens magnifies an image. Numerical models of this effect help astronomers study the universe's structure, dark matter, and galaxy evolution. However, these models typically rely on complex theories, such as Einstein's general relativity or advanced optics, which makes them challenging to develop. Additionally, the developed code may require high computational costs to solve Einstein's field equations. As a result, simpler models that still capture the core physics of gravitational lensing are needed. In this project, we developed a simplified gravitational lensing model using Python, incorporating light deflection angles, Rodrigues' rotational formula, and rotation matrices. We used this model to examine how mass, orientation, and position of the lens affect the distortion of the Einstein ring. Our results revealed that increasing the lens mass enlarges the Einstein ring, tilting the lens makes the ring more elliptical, and displacing the lens causes parts of the ring to be cut off. By adjusting these factors, we replicated the Einstein ring image of LRG 3-757 taken by the Hubble Space Telescope. The ability to manipulate these variables offers insights into how different factors influence the appearance of gravitational lensing. Our new model provides a more efficient and accessible method for studying gravitational lensing, allowing researchers to explore its impact on our understanding of the universe's structure without relying on complex and resource-intensive theories.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

PH CS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes   ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: A Voice-Controlled Robotic Arm for Assisting Complex Surgical Tasks

Student Name(s): D. Maltese

Abstract:

In the U.S., 250,000 people die from medical errors yearly, with over 4,000 from surgery-related accidents. Augmented reality (AR) is being integrated into operating rooms to enhance precision, but AR headsets create challenges, particularly in handling tools like ultrasound probes, which are essential for updating the headset. Surgeons, already managing multiple tasks, struggle with precise probe manipulation, increasing the risk of errors. To reduce these numbers, I developed a voice-controlled robotic arm that functions as an additional hand, reducing multitasking and improving efficiency. The arm was 3D modeled, 3D printed with hard plastic, and powered by Nema23 stepper motors with two-stage epicyclic gearboxes and timing belts for precise movement. Motion control and stability tests demonstrated remarkable success, and further development is enhancing claw movements. This robotic system allows for real-time responsiveness to voice commands, enabling seamless integration with AR headsets and reducing manual workload during surgery. The prototype has been well received by doctors at Weill Cornell Hospital, who recognize its potential to assist surgeons in maintaining focus and precision. By automating key aspects of ultrasound probe handling and other surgical tasks, this innovation could significantly decrease surgical errors and improve patient outcomes. As research progresses, further refinements will ensure greater stability, control, and adaptability in various surgical scenarios. With the successful development of a fully functional robotic arm, this technology has the potential to revolutionize surgery by optimizing AR headset use and providing surgeons with reliable, precise, and intuitive robotic assistance, ultimately enhancing surgical safety and efficiency.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

EE EN AT

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☐ human subjects   ☐ potentially hazardous biological agents
☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes   ☐ No

3. This project was conducted at a Registered Research Institution. ☒ Yes   ☐ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No

CSEF Official Abstract and Certification
2025

Title: Effectiveness of Carbon Fiber Connecting rods in an internal combustion engine

Student Name(s): N. Hoag

Abstract:

This study's goal is to find the effectiveness of Carbon Fiber Connecting rods in an internal combustion engine. To start, a 3d replica was designed on a CAD software to perfectly replicate a connecting rod from the AMC 150 cubic liter engine. This 3d replica was then turned into a mold and 3d printed by an Ender 5 3d printer. Once the mold was printed it was then prepped for the molding process by being cleaned and sprayed with non-stick oil. Chopped carbon fiber was then added to West Systems 2 part epoxy to create a chopped carbon slurry which was then poured into the 3d printed mold. For the curing process a 4000 ml beaker was filled and placed on top of the mold to ensure constant pressure during the drying and hardening process. The mold was then broken open to reveal the forged carbon fiber part. So far I have broken the carbon fiber connecting rod out of its mold. With the carbon fiber connecting rod fully casted my next steps were testing the connecting rod in many different simulated scenarios. These simulations included shear testing and compression testing. These series of tests demonstrated the strength of the connecting rod and ensured its stability and safety before I am able to install it in the engine. After testing was finished it was found that my carbon fiber connecting rod design is not suitable for use inside an internal combustion engine.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

EE EN

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☒ Yes ☐ No

CSEF Official Abstract and Certification
2025

Title: Developing a Machine-Learning Driven Wearable Vest for Early Diagnosis and Management of Chronic Obstructive Pulmonary Disease through Vitals Analysis

Student Name(s): A. Shrivastav

Abstract:

Chronic Obstructive Pulmonary Disease (COPD) is a progressive lung disease characterized by breathing difficulties and poor airflow, affecting millions globally. Current detection methods, like spirometry and imaging, are often expensive, invasive, and inaccessible in low-resource settings. While non-invasive methods exist, they lack affordability and comprehensive monitoring, highlighting the need for a more accessible and effective solution to manage this debilitating disease. The purpose of this project was to develop a cost-effective, non-invasive wearable vest that uses machine learning to detect and manage COPD early through vitals monitoring. Models were trained on health datasets using binary classification algorithms such as Random Forest, XGBoost, and Logistic Regression. The vest was constructed with embedded sensors, circuits, and microcontroller-based integration to analyze data for real-time assessment. Among the machine learning models tested, Random Forest achieved the highest accuracy (100%), outperforming XGBoost (98%), Voting Classifier (97%), LightGBM (96%), and Logistic Regression (91%). Sensor-based vitals monitoring showed high accuracy across most metrics: heart rate (0.6 bpm MAE), respiratory rate (0.4 bpm MAE), and SpO_2 (0.8% MAE), though temperature measurements were less precise (7.0 °C MAE). The vest demonstrated reliable vitals tracking consistent with established studies on sensor-based health monitoring. The findings confirmed that the wearable vest could effectively monitor vitals and support COPD diagnosis, validating the hypothesis. Future research should explore diverse datasets, optimize sensor placement, and test the vest in real-world settings. This innovation has the potential to enhance remote health monitoring and improve COPD management, especially in resource-constrained regions.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) EN BC EE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes   ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No

CSEF Official Abstract and Certification
2025

Title: An Instant Depression Screening Method via Valence and Arousal Prediction from Electroencephalogram (EEG) and Galvanic Skin Response (GSR) Data with Unsupervised Representation Learning

Student Name(s): S. An

Abstract:

Globally, 280 million are suffering from depressive disorders, one of the most common mental disorders referring to long periods of depressed mood that affect life negatively, often leading to suicide. Adolescents are especially vulnerable, with 35% of youth aged 12 to 17 in the United States having major or severe depression. The rate of depression in teenagers has doubled over the past decade, along with the youth suicide rate. Currently, self-report questionnaires such as the Patient Health Questionnaire are utilized to diagnose depression. Self-report questionnaires may be accurate for other population groups that are fully aware of the state of their mental health, and are willing to seek support. However, adolescents do not have the same ability to recognize their symptoms nor answer honestly in school-wide screening tests. In order to solve the aforementioned problem, a method that captures the true emotion without self-reports based on electroencephalogram (EEG) and galvanic skin response (GSR) is proposed. The novel system is composed of representation and transfer learning steps for the extraction of emotion-related features from EEG signals, and a 1D convolutional neural network for extraction in GSR signals. The extracted features are merged and outputted as points on the arousal-valence graph, where emotions can be detected. The proposed model demonstrated exceptional performance. The best MAE was 18.4 when without GSR; 18.8 when without representation learning; 17.2 when without the proposed equation, but improved to 16.4 in the proposed model. Brain anatomy evaluations proved the validity and feasibility of the model's application.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

CS EN BE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

Word Count
171

CSEF Official Abstract and Certification
2025

Fair Category
PS

Project Number
6108

Title: The Effectiveness of an Adaptive Traffic Light Utilizing IoT Technologies

Student Name(s): C. Suy Pineda

Abstract:

Traffic congestion continues to be a significant challenge in urban planning, particularly around high-traffic areas such as school campuses. Traditional traffic light systems, which rely on fixed-time or adaptive controls, often fail to dynamically respond to real-time congestion patterns. This study investigates the effectiveness of a smart traffic light utilizing Internet of Things (IoT) technologies to optimize traffic flow on the Stanwich Road Campus. The proposed system integrates cloud-based algorithms—control/failsafe, Boolean, and genetic—relayed through microcontrollers to autonomously adjust lighting sequences based on live congestion data from embedded sensors and satellite feeds. The traffic light will communicate with a secure cloud network via WiFi, ensuring real-time adaptability. Effectiveness will be evaluated based on response time, accuracy in congestion detection, and overall improvement in traffic flow. The implementation, in collaboration with General Electric's Cocreate microfactory, the City of Stamford's Traffic Division, and the Greenwich Country Day School's Facilities, aims to provide a scalable and sustainable model for smart traffic management on school campuses and beyond.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

ET EE CS

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Developing Autonomous and Sustainable Power Management Systems Using AI, Power Over Fiber, and Metal Cores

Student Name(s): A. Sadhvani

Abstract:

The world needs a new method to store, manage, and distribute energy. Renewable energy cannot be generated on demand, a sustainable and efficient method to store energy is necessary. Energy can be stored in metals, as thermal energy. Energy can be managed using EnergyManageR (RL Model). A neural network (NN) can be used to predict demand for EnergyManageR. Power Over Fiber (POF) can be used to quickly distribute power.

The goal of this project is to use AI, Metal Cores, and POF to efficiently and sustainably manage, store, and distribute energy. To investigate different metals' viability for TES (Thermal Energy Storage), brass, aluminum, and steel were heated to 100°C and cooled in a foam enclosure, cooling was measured, temperatures were predicted using Newton's Law of Cooling and the temperatures were converted to energy using specific heat capacity to calculate energy stored. Steel was able to store the most energy, then brass and aluminum. POF was tested using a physical model and a simulation, cables around 2 Km had 95% efficiency.

EnergyManageR was evaluated by simulating its actions and measuring the error between target and actual energy stored. The Actor-Critic model can tune settings to store the amount of energy required, within 200J. The NNs were evaluated using RMSE loss, the linear NN performed better than a LSTM, it was able to predict demand with an error of 250-380MW. This shows that the combination of AI, metal cores, and POF can be efficiently used to store, distribute, and manage power sustainably.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

ET CS EE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Watt Box: Optimized food waste-to-electricity conversion via methane pyrolysis and hydrogen fuel cells.

Student Name(s): M. Smith, P. Modi

Abstract:

Food waste and renewable energy contribute to approximately 83 million metric tons of U.S. greenhouse gas emissions annually. The Watt Box presents a scalable solution used directly at home, integrating anaerobic digestion to convert food waste into electricity. Using an archaea called Methanobacterium in a controlled environment, food waste decomposes into methane. We tested with decomposition by using pears and bread, measuring methane production and temperature using Arduino sensors. Methane undergoes methane pyrolysis to create hydrogen with a solid carbon byproduct. Hydrogen fuel cells achieve ~60% efficiency converting hydrogen to electricity, the byproduct water. Heat recovery methods enhance the final efficiency to ~63% by lowering the input energy needed. Processing 750 tons of food waste daily nationally would generate 690 GWh/year, meeting 6.3% of U.S. annual energy demand. Compared to composting, which emits methane and CO_2 without energy recovery, the Watt Box captures these gases and transforms them into clean electricity, reducing greenhouse gas emissions by ~6-9%. Initial costs, nationally, are ~$100 million for megaplants that can handle 70 tons/day, strategically placed around the United States using K-means clustering, with recurring annual expenses of ~$40 million. The payback period is ~3 years without government support at current electricity rates. This system's scalability is supported by its ability to be publicly distributed and utilizing existing technologies, providing significant energy savings and environmental benefits. The Watt Box is a superior alternative to conventional methods and a long-term solution to food waste and nonrenewable energy challenges.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   MI CB EE

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects   ☐ potentially hazardous biological agents
☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☒ Yes ☐ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Novel use of Beeswax as an Sustainable Medium to Improve the Efficiency and Scalability of Super-Hydrophobic Sponges in Cleaning up Oceanic Oil Spills

Student Name(s): G. Kapp, M. Lanson

Abstract:

Oil spills are a persistent ecological disaster, contaminating oceans, harming marine animals, and requiring costly, labor-intensive cleanup procedures. Conventional cleanup methods, such as chemical dispersants, in-situ burns, booms, and skimmers, all have severe limitations, including environmental harm and global warming, pollution by synthetic materials, and exorbitant costs. To create a better solution for cleaning up oil spills, the goal of this project was to create a cheap, environmentally friendly hydrophobic sponge that selectively absorbs oil but rejects water. Hydrophobic sponges are generally made from fluorinated chemicals or nanoparticles, which are expensive, toxic, and difficult to manufacture on a large scale. Instead, this project used beeswax and melamine—two affordable and abundant materials—to coat standard sponges, rendering them effective at selective oil absorption. In testing, the sponges proved to be superhydrophobic, with a water contact angle of $162.0 \pm 2.4°$. Additionally, they were more water resistant than synthetic hydrophobic sponges used as a control, which had a water contact angle of $136.7 \pm 1.0°$. In simulated ocean conditions, the experimental sponges absorbed over 10 times their weight in oil, and they absorbed more oil than the synthetic sponges. Although both sponges demonstrated the same reusability, the beeswax sponge was far more structurally integral, resisting over 4 times its weight than the synthetic sponge before 50% deformation. These results highlight a novel, affordable, sustainable, and scalable natural hydrophobic sponge suitable for cleaning up oil in ocean conditions.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

EN EM CH

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects ☐ potentially hazardous biological agents
☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Hydrogel Bandage with Natural Plant Extracts

Student Name(s): K. Camotes, A. Garcia-Martinez, L. Sahar

Abstract:

This experiment aims to create a hydrogel bandage that promotes faster wound healing using Aloe Vera and Calendula oil, which are known for their natural anti-inflammatory, antibacterial, and tissue-repairing properties. The objective is to determine whether this hydrogel reduces bacterial growth more effectively than a regular bandage, primarily protecting the wound, rather than the hydrogel, which accelerates healing processes. The Hydrogel, containing the Aloe Vera and Calendula extracts, was prepared in Petri dishes. Staphylococcus epidermidis, a bacterium linked to wound infections, was cultured in a nutrient broth and applied directly to the hydrogel and control. Multiple hydrogel dishes were incubated at 37°C for two days, while two were left outside at room temperature for five days. Afterward, bacterial growth was measured by analyzing the area covered by bacterial colonies. Bacterial growth was evaluated by placing a 20x20 grid over the samples and calculating the percentage of squares occupied by bacterial colonies. The control consisted of bacteria grown on nutrient agar without the hydrogel to compare bacterial growth. In all trials, the control showed consistent bacterial growth (mean: 48.75%, SD: 61.87%, range: 5%–92.5%, median: 48.75%), whereas the hydrogel samples showed 0% growth (SD: 0.0%, range: 0%, median: 0%). Cohen's $d = 1.11$ indicates a large effect size between the control and hydrogel groups. The Aloe Vera and Calendula hydrogel demonstrated effective antibacterial properties, suggesting it can reduce healing time and infection risk. These results support the potential of natural extracts in developing effective wound dressings.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

ME PS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

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☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes   ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No

CSEF Official Abstract and Certification
2025

Fair Category
PST

Project Number
6504

Title: Is AI Intelligent Enough for STEM Learning?

Student Name(s): S. Moon, R. Esmaili Zaghi

Abstract:

As AI becomes an increasingly popular information source, it's important to evaluate it as a learning source. This project focuses primarily on empirically evaluating the accuracy of AI in high school level STEM subjects compared to human experts. Data was collected by giving short answer National Science Bowl questions (in chemistry, biology, physics, and math) to three free generative AI models (ChatGPT, Claude, and Gemini) in sets of 15 with a consistent prompt. Two sets of easy and two sets of difficult questions were asked of the models. The same question sets were given to teachers of corresponding subjects. The AIs and the teachers were graded out of 30 and for each difficulty level, and the accuracy of the two groups was compared.

The three AI models had an average accuracy rate of 86%. Interestingly, it was observed that AI models performed better when they were prompted to present their chain of thought. Asking the AI to show its "thinking" can benefit the user by increasing the reliability of this tool and making it easier for error identification. The teachers had an average accuracy rate of 61%.

The data from this exploratory research backs the idea that emerging generative AI models are becoming accurate enough to support student learning in STEM. If used correctly, AI can be a powerful tool to help students when teachers aren't available. Studies like this inform conversations around the future integration of Artificial Intelligence into formal education to enhance accessibility and consistency in the curriculum.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   AT CS

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☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: EcoCapsule: A Time and Cost Effective Solution to Desertification

Student Name(s): N. Uppara Allabanda, S. Banerjee

Abstract:

Desertification, the degradation of land in arid and semi-arid areas, is a critical global environmental issue. This project aims to develop an effective, feasible, and scalable solution method to combat desertification via targeted mass-planting in suffering areas. Thus, we engineered the EcoCapsule, a cone-shaped capsule with a flour-based biodegradable shell, containing seed balls. We arrived at the cone shape by employing a physics simulation to determine the optimal shape to have the most stability on descent. The capsules would be deployed in the air via heavy-duty drones. Once the capsule is released, angled fins on the sides would cause the capsule to start rotating mid-fall, which would cause its contents to be spread considerably on impact. Each seed ball contains seeds from two different plant species, nutrient-dense soil, and Alfalfa - a powerful fertilizer that releases nutrients over long periods of time. The plant species used—the creosote bush and desert marigold—were chosen due to their symbiotic relationship, rapid growth, and ability to survive harsh conditions. As they grow, they increase the abundance of nutrients in the soil, reinforce soil structure, and boost ecological resilience. Over time, the deployment of these capsules will help to reduce the rate of desertification and contribute to the restoration of vulnerable ecosystems.To conclude, the EcoCapsule provides a scalable and mass-producible solution to desertification. By improving soil health, increasing biodiversity, and offering a long-term method for ecosystem repair, it holds the potential to prevent further land degradation and restore ecosystems affected by desertification.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   EN EA PS

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects   ☐ potentially hazardous biological agents
☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes   ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

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CSEF Official Abstract and Certification
2025

Title: Energy Absorption Efficiency of Various Crumple Zone Materials in Pendulum Impact Tests on Model Cars

Student Name(s): F. Ramirez Moreno, B. Ramirez Moreno

Abstract:

This experiment evaluated the effectiveness of different materials in absorbing impact energy during simulated vehicle collisions. The study compared the energy absorption capabilities of honeycomb cushion, acoustic sound foam, and LEGOs as crumple zone materials in model cars subjected to pendulum impacts. The hypothesis stated that the honeycomb cushion would provide superior protection to the passenger compartment compared to the other materials. A pendulum apparatus was constructed, and model cars with different crumple zones were subjected to impacts at varying heights of 1.9ft, 2.8 ft, and 4.6 ft. The pendulum's weight, 8 lbs, was used consistently throughout all trials, while the height of the pendulum differed at each trial to calculate G-forces. The final displacement was a subsequent result of the G-forces and the pendulum's weight. Measurements included the car's displacement, crumple zone deformation, and passenger movement. Results indicated that the honeycomb cushion exhibited the greatest displacement, suggesting more efficient energy transfer compared to the acoustic foam and LEGO crumple zones, which showed less displacement. This supports the conclusion that the majority of the energy from the pendulum motion was most effectively transferred through momentum rather than by shock absorption by the car itself. This highlights the potential of honeycomb structures in impact absorption. Limitations included variations in the pendulum's release and potential ground contact. Future studies could explore different honeycomb materials and geometric properties, as well as larger-scale models for real-world applicability. These findings could improve vehicle safety design by optimizing crumple zone materials.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) EN MA

1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

☐ human subjects   ☐ potentially hazardous biological agents
☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: From Light to Life: A Novel Spectroscopic Approach to Classifying Exoplanet Habitability using Machine Learning

Student Name(s): Y. Cho, O. Kotula

Abstract:

Telescopes including Hubble and JWST have contributed to discovering over 5,800 extrasolar planets, yet only 63 are confirmed as habitable, or having temperature, atmospheric, and surface water conditions potentially supporting life. While past studies have used deep learning classifiers to identify the existence of exoplanets using the transit method, the same techniques remain unproven for discerning planets' properties. Artificial intelligence, in other instances, was capable of detecting atmospheres and liquid water on exoplanetary surfaces. A novel approach to the issue rests on using simulated atmospheric spectra to train a machine learning model, using near-infrared light observations recorded by JWST to test the model's validity. NIRSpec data of six exoplanets, including potentially habitable K2-18b and GJ-486b, was reduced procedurally through the Eureka! data analysis pipeline referencing planetary parameters to produce a transmission spectrum. NASA's Planetary Spectrum Generator modeled simulated spectra of real planets, forming a cohesive training dataset for binary classification. Following a normalization process, aimed to exaggerate deviations in brightness, a hybrid LSTM-CNN model was trained to extract distinctive atmospheric features from the simulated spectra and tested on the real spectra. Reaching a height of 83.3% accuracy in testing and 74.4% in training, the model then accurately classified the habitability of all observed exoplanets. The results of this analysis affirm the conclusions of recent studies, suggesting with high confidence that GJ-486b holds stronger prospects of harboring biosignatures and subsequently life. Continuing to employ AI in processing astronomical datasets may yield viable research targets and hasten the pace of future discoveries.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) CS

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☐ vertebrate animals ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Utilizing Electrodeposition for Marine Coastline Protection: A Sustainable Solution to Combat Erosion

Student Name(s): L. O'Donohue, S. Mensi

Abstract:

Erosion serves as a serious risk to coastal communities around the world. Erosion mitigation measures have not progressed past medieval or expensive measures such as seawalls and increased vegetation. This project aims to advance research involving the stabilization of a coastal substrate through electrodeposition. Various substrate combinations were created and the most feasible for study was selected based on consistency and stability. Cubes of the optimal substrate were dried and massed, and currents of 4, 6, and 9 volts were passed through cubes in 1 week intervals. Cubes were then subjected to artificial waves created by an orbital shaker for 20 mins. Results revealed that electrodeposition did significantly strengthen the substrate cubes, with the least erosion occurring on those made using a 6V current.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   EM

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☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes   ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

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☐ Yes   ☒ No

CSEF Official Abstract and Certification
2025

Title: Driving Sustainability: Adopting Biofuel for A Greener Future.

Student Name(s): A. Apeajyei, M. France-Bray

Abstract:

Carbon emissions are a global problem, primarily stemming from gasoline combustion. While petroleum-based fuels generate substantial emissions, biofuel—produced from renewable resources like plants and other wastes—offers a promising alternative for environmental sustainability.

Our research was conducted by interviewing biofuel professionals and offering a public survey to assess people's interest in biofuel. The experiment evaluated comparisons of 3 different fuel types. Additionally, we developed an innovative dual ventilation and purifying system prototype, to mitigate vehicle emissions while exploring biofuel's potential.

Of 47 participants, 80.4% were interested in replacing gasoline with biofuel, and over 50% would consider using hybrid cars with biofuel. The SackEnergy biodiesel was the second most successful in experiments, with monoglycerides at 0.39500%, diglycerides at 0.00452%, and triglycerides at 0.7300%. However, the homemade version was even better, with 0.00% for all components. Normal fuel performed the worst, with monoglycerides at 0.80%, diglycerides at 0.20%, and triglycerides at 0.20%, making it the least eco-friendly option.

Therefore, we intend to use biofuel as a replacement for fossil fuel, hoping to reduce carbon emissions in a renewable way. From our studies, we can conclude that the majority of the people in the study are willing to change their transportation types to support the goal. And from our experimentation, we can see how biofuel performs very well. Our prototype seems very promising in hopes of administering biofuel as well as purifying as much polluted air from the tailpipe as possible.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   ET PS EE

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☐ vertebrate animals   ☐ controlled substances

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3. This project was conducted at a Registered Research Institution. ☒ Yes   ☐ No
4. Is this project a continuation? ☒ Yes   ☐ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☒ Yes   ☐ No

CSEF Official Abstract and Certification 2025

Word Count
138

Fair Category
PST

Project Number
6512

Title: Jeffery: Your Friendly Robotic Assistant!

Student Name(s): A. Klein, J. Peplau, N. Garson

Abstract:

We asked a variety of people of different ages to answer a few of our questions, and the results to a few are below, along with the question itself. It's safe to say a good conclusion would be that people would use this hand to hold things and automate tasks for them, making their life a little

Therefore, programming and robotics help humans with both complex and everyday tasks, while also being more efficient. As a way to teach how to use Jeffery, we'll use two different teaching methods.

The independent method: There will be comments in the code explaining what to do and what to change for the best experience.

The instructor-led method: We will have one of our group members explain how to work the hand while also answering questions you may have along the

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)
EE CS

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2. Student independently performed all procedures as outlined in this abstract. ☒ Yes ☐ No
3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No
4. Is this project a continuation? ☐ Yes ☒ No
5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Waste to Watts

Student Name(s): R. Murali, P. Rajarajan, G. Lippi

Abstract:

Wastewater contamination is of immense environmental and health concern, yet traditional treatment technologies are often inefficient, costly, and unsustainable. This paper discusses the use of Microbial Fuel Cells (MFCs) in sewage treatment plants to the dual advantage of reducing pollution and generating renewable energy. MFCs utilize bacterial metabolism to generate electricity from the decomposition of organic waste. Experimental results confirmed that MFCs achieved up to 80% Chemical Oxygen Demand (COD) removal, 40–75% nitrogen removal, and 30–50% phosphorus removal, significantly improving wastewater treatment efficiency. Voltage output monitoring confirmed plateau voltage at 0.7V per cell, determining reliable electricity generation. MFC performance also differed depending on wastewater conditions, where pollutant loads aligned with voltage output and degradation rates. The research also found that the optimization of electrode materials and microbial communities enhanced MFC efficiency. An MFC-based municipal wastewater treatment system prototype is being developed to attain optimal pollutant removal and electricity production. The research places MFCs at the center as a low-cost, scalable, and environmentally friendly solution in comparison with conventional wastewater treatment technologies.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)   EN MI ET

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☒ Yes ☐ No

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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Green Growth Academy

Student Name(s): D. Perez-Cumba, K. Plazas, M. Trejo

Abstract:

An abandoned golf course located in Woodbridge, CT, has been untouched for many years, and is a controversial topic in the town. Discussions on finding a new purpose for this site (rewilding vs development) has led to different conclusions, however ultimately ended up with the site being left alone. Our objective is to create a design to rewild/repurpose this golf course, including remediating the soil which is currently full of chemicals, pesticides and is an unhealthy ecosystem. If the site is rewilded, then it could be used in multiple ways by the town such as a community garden, farmers market, outdoor classroom and a nature trail. The first step is to test the soil and restore native plant species, while removing invasives. Soil remediation is critical for rehabilitating ecosystems and improving its health. Analyzing soil samples from rewilded and non-rewilded places will focus on soil composition, nutrient levels and microbial activity and is a step into starting the remediation. Planting species that help with contaminated soil such as poplar trees, is also a way to speed up the process of sterilizing the site. Seeing as Woodbridge lacks communal gardens and nature trails, the idea is to use it for the benefit of the community, allowing the opportunity to educate citizens about how rewilding leads to healthy ecosystems, and is a positive for the future of the town.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

EM PS EV

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CSEF Official Abstract and Certification
2025

Title: The Benefits of Designing Base Isolators for Earthquake Proof Structures

Student Name(s): A. Gamble, E. Bermudez

Abstract:

To save lives and reduce damage to buildings, engineers have developed various techniques to make buildings earthquake-resistant. One method involves putting a building's foundation on bearings that allow the whole building to move (technically called a base isolation system). There are several different kinds of earthquake-resistant bearings. The first Earthquake we will be talking about is the 12 January 2010 Mw 7.0 earthquake in the Republic of Haiti caused an estimated 300,000 deaths, displaced more than a million people, and damaged nearly half of all structures in the epicentral area costing about 16.3 billon dollars.

Spring Base isolators do indeed work the best because they are the most effective one. This is because they can deflect significantly under load, which allows them to absorb more energy from vibrations and movements, especially at low frequencies. Spring base isolators are considered more effective because they provide a greater deflection compared to other isolation methods like rubber mounts, allowing for better isolation of low-frequency vibrations by effectively decoupling a structure from the ground movement, particularly during seismic events, thus reducing stress on the building's foundation and minimizing damage potential. For Roller Base Isolators they aren't the best because you cant stop the structure from rolling off either side. At the end of our testing and runnings we were right in our hypothesis as Spring Base Isolators did work the best out of all of the Base Isolators we tried.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) EE EA

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CSEF Official Abstract and Certification
2025

Title: PFOAway: An Eco-Friendly, Affordable PFOA Absorbent & Degradation Tabletop Filter Utilizing Decarboxylation

Student Name(s): A. Shunmugaraja, N. Sathish

Abstract:

PFAS, or perfluoroalkyl and poly-fluoroalkyl substances, are common industrial chemicals [1]. Their molecular structure includes C-F bonds, one of the strongest molecular bonds in organic chemistry [2]. These allow PFAS to have a long half-life, avoiding degradation. Therefore, these chemicals are exposed to humans through many pathways. These chemicals are known carcinogens and cause a variety of ailments, ranging from testicular cancer to kidney ailments [3]. Hence, it's urgent to find a way to minimize their presence.

The main source of PFAS contamination in humans is water. The most prevalent type, and our subsequent focus, is perfluorooctanoic acid (PFOA). We have designed a proven two-step filtration system that is biologically and economically friendly.

To check the legitimacy of our design, we tested them through virtual experimentation. We used ORCA to test our adsorption affinity, finding that our components, GAC and chitosan, bind well chemically. Using the Langmuir Isotherm model, we found that PFOA can bind well with these chemicals, getting a value of 395.11 mg/g. Finally, using Google Colab, we found our treatment mechanism had a 94.49% efficiency of degrading these PFOA molecules. This included Carbon Quantum Dots, Potassium Hydroxide, and the green solvent Cyrene,

Through this process, we have made a breakthrough in PFOA degradation. We found that PFOA could be reduced into fluoride ions, a common mineral in toothpaste. Given the estimated cost of less than $40, our project can be implemented by common water filter companies and be implemented as a much cheaper, reliable staple.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) EM CH EV

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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Alternative Drivetrain System for Better Efficiency in FIRST Tech Challenge Robots

Student Name(s): E. Chu, Y. Kwon

Abstract:

In the high school robotics competition FIRST Tech Challenge, mobile robots utilize drivetrain systems to navigate a field and complete tasks. Compared to the commercially available mecanum drivetrain systems most commonly used for omnidirectional movement, swerve drivetrains, in which modules of wheels use two motors to control each wheel's rotation and spin, are rare. We sought to combine manufactured parts with 3D-printed designs to create a compact swerve module for use in an 18" robot and evaluate its performance in competition. Using Autodesk Fusion 360, we designed a coaxial swerve module, in which the two motors are parallel to one another. All prototyped components and most final components were made using 3D printing and designed around commercially available or manufactured parts. We also developed a code library to control a system of swerve modules in Java using Android Studio and the FTC (FIRST Tech Challenge) SDK.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

AT EE CS

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CSEF Official Abstract and Certification
2025

Title: AI lab assistant, N.A.L.A.

Student Name(s): M. Edmond, Y. siongco, E. Smith

Abstract:

Laboratory notebooks can take up alot of time, time that could be used to further your research or conduct more experiments and perfect your art. We decided to create a solution to this problem: N.A.L.A.

N.A.L.A. stands for Notable Ai Lab assistant. N.A.L.A. is an AI (Artificial Intelligence) lab assistant that records and takes notes on lab activities and converts them into lab notebook format to be printed out and pasted into an official lab notebook. N.A.L.A. is a portable, easy to use, adjustable, maneuvering AI powered camera that can be placed above a conventional lab station to note down what the user is doing, how they are doing it, what the procedure is, the list of materials used, and recommended PPE. N.A.L.A. then documents this information into lab notebook format with the date automatically noted and pasted onto the paper. All changes made after the original paper is produced, (such as corrected mistakes) using N.A.L.A. will also be noted, digitally crossed out, initialized, and dated. the recording will also be available for download at all times so there will always be exact undeniable evidence that it was recorded at such time (and correctly identify when without ways of altering such evidence). N.A.L.A. has the potential to streamline the research and documentation.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project)

AT CS EE

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

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☐ Yes ☒ No

CSEF Official Abstract and Certification
2025

Title: Analyzing the Efficiency of Hydro-Electric Power

Student Name(s): K. Passaro, R. Salthouse

Abstract:

One of the main causes of pollution and climate change is fossil fuels. Cleaner and more sustainable energy sources are required to solve this problem. One possible option is hydroelectric power, which uses the energy of flowing water to create electricity.

The goal of our project is to examine the effectiveness of hydroelectric power and look at methods to increase it. We can strive toward a future driven by renewable energy by comprehending the operation of hydroelectric power and its possible drawbacks. To test this, three water wheels of different masses were created and speed was calculated through measuring the distance of the paper clip attached to a string as part of the testing station and the time it took for the paper clip to wind up.

This experiment investigated the relationship between the mass of a water wheel and its speed (potential energy) when water flows over it. The hypothesis predicted that decresing the mass of the water wheel would result in increased speed. However, the results demonstrated the opposite: as the mass of the water wheel incresed, its speed significantly also increased. This outcome might suggest that factors other than mass, like inertia or the force of the water flow, play a large role in determining the speed of a water wheel. Future research could explore these factors in greater detail to gain a more in-depth understanding of water wheel energy output and how they can help with more sustainable power.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) EA EV EM

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3. This project was conducted at a Registered Research Institution. ☐ Yes ☒ No

4. Is this project a continuation? ☐ Yes ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes ☒ No

CSEF Official Abstract and Certification 2025

Word Count
158

Fair Category
PST

Project Number
6525

Title: Exploring Airfoil Shapes and Generating LIft

Student Name(s): G. Andino, B. Reis

Abstract:

The following experiment was conducted to research the correlation of airfoil shapes and the generation of lift. An airfoil is a curved surface that generates lift when air flows over it. The way lift is produced by the airfoil is through Bernoulli's Principle, which states, as the speed of a fluid increases, its pressure decreases; meaning that a faster-moving fluid exerts less pressure than a slower-moving fluid. Through Bernoulli's Principle, we can test which airfoil shapes are the most effective at producing lift. To test this, we will create a wind tunnel and using a food scale, we will measure the weight drops of each airfoil shape to ultimately find which of the three shapes, Flat-bottom, Semi-symmetrical, and Symmetrical provides the most lift. The results support the hypothesis, "If the shape of an airfoil has greater curvature on the top surface compared to the bottom surface, then the generation of lift will be great.

Technical Disciplines Selected by the Student
(Listed in order of relevance to the project) PH AT

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☐ vertebrate animals   ☐ controlled substances

2. Student independently performed all procedures as outlined in this abstract. ☒ Yes   ☐ No

3. This project was conducted at a Registered Research Institution. ☐ Yes   ☒ No

4. Is this project a continuation? ☐ Yes   ☒ No

5. My display board includes photographs/visual depictions of humans (other than myself or my family):

☐ Yes   ☒ No