# CONNECTICUT SCIENCE& ENGINEERING — FAIR—



74th Annual Fair March 7-19, 2022

# Student Abstracts

## Fair Categories

	Life Sciences	Physical Sciences
7 <sup>th</sup> & 8 <sup>th</sup> Grade Team	LT (1001 – 1999)	PT (4001 – 4999)
7 <sup>th</sup> Grade	L7 (2001 – 2499)	P7 (5001 – 5499)
8 <sup>th</sup> Grade	L8 (2501 – 2999)	P8 (5501 – 5999)
High School	LS (3001 – 3499)	PS (6001 – 6499)
High School Team	LST (3501 – 3999)	PST (6501 – 6999)

## **Special Categories**

AT = Applied Technology	EE = Engineering: Electrical & Mechanical
AS = Animal Science	ET = Energy & Transportation
BE = Behavioral & Social Sciences	EV = Environmental Analysis
BI = Biochemistry	EM = Environmental Management
CB = Cellular & Molecular Biology	MA = Mathematical Sciences
CH = Chemistry	ME = Medicine & Health Sciences
CS = Computer Science	MI = Microbiology
EA = Earth Science	PH = Physics & Astronomy
EN = Engineering: Materials & Bioengineering	PS = Plant Science

## Special Category Composites

Biotechnology	AS, BI, CB, EN, ME, MI, PS
Environmental	EV, EM
Engineering	EN, EE
Sustainability	EA, EN, EE, ET, EV, EM

249

Project Number 6001

Title: Can Fuel Cells be a Replacement for The Internal Combustion Motor?

#### Student Name(s): B. England

#### Abstract:

As global warming progresses we are forced to find more sustainable non-fossil fuel energy sources. The hydrogen fuel cell may be a viable replacement for the internal combustion motor in the transportation sector. Hydrogen is the most abundant element in the universe and can be obtained through water electrolysis or PEM (Polymer Electrolyte Membrane) electrolysis. Unlike a lithium-ion battery, a car-sized hydrogen fuel tank can be filled in 3-4 minutes, only weighs about 42kg, and fossils fuels are not required in its production; thus, hydrogen-powered fuel cell vehicles are a potentially a better option for commercial and personal transportation compared to a battery powered car. In the experiment, an electrolyzer was used to produce hydrogen and oxygen. The gasses were then transferred to a hydrogen fuel cell through a system of tubing. The fuel cell in use had a theoretical energy production rate of 0.6 volts. When 2L of distilled water were poured into the electrolyzer powered by 9v the hydrogen fuel cell produced 0.03v. It was found that by adding 6 drops of sulfuric acid to the 2L water and raising the input voltage of the electrolyzer to 15v the fuel cell to produced 0.21v. The max efficiency of this system was 1.3%. In conclusion, this hydrogen fuel cell system was not efficient. The primary obstacle was inefficient production of hydrogen through electrolysis. With further development in production of clean hydrogen the fuel cell may be a viable replacement for the internal combustion engine.

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

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

Project Number 6003

Title: Flexibility with Flying: Replicable and Attatachable Aerial Robot with Multi-Degree-of-Freedom

#### Student Name(s): S. Lu

#### Abstract:

Inspired by the movie Big Hero 6, this project attempts to create an aerial robot with muti-Degree-of-Freedom (DoF) in the air. Like microbots in Big Hero 6, it aims to create a drone that could attach to and perform tasks with replicas. Currently, most drones in the market are quadcopter drones with open propellers, which lose some Degree-of-Freedom, while this robot, created through two ducted fans, could transform shape when attached to replicas of itself. This design allows the drone to increase its Degree-of-Freedom and flexibility in the air. The mechanical design of the drone is mainly made from a thrust rotor module, DoF-Joint Module, two ducted fans, and a Dual-Rotor Gimbal Module. This robot uses Kalman Filters for noise reduction on input data and state position estimates while using PID for balance control. The analysis of the drone is performed through Forward Kinematics, focusing on Kinematic Chains and D-H Convention, and classical Force Analysis. These combined allowed the drone to achieve six DoF in air. The drone could achieve a maximum rotation of 120.73° in the x-direction and 114.22° in the y-direction, and a constant lift allowing the drone to hover in the air both alone and connected with a replica of itself.

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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.  $\Box$  Yes 🛛 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

## 🗌 Yes 🛛 No

Word Count 216

243

Project Number 6004

Title: The Effect of Deep Breathing and Meditation on Practice SAT Scores and Anxiety Levels

#### Student Name(s): S. Aflalo

#### Abstract:

Anxiety is a major issue for high school students when taking standardized tests. Five weeks of training in guided breathing exercises have been evaluated and proven to decrease anxiety levels and increase scores on a practice American College Test (ACT). This investigation studied the effects of a 3-minute deep breathing and meditation video shown immediately before and during each break of a practice SAT test. Potential subjects, students grades 9-11 in Fairfield County, CT, were recruited through school email blast and social media outreach. Twenty-one students registered for the study. Subjects were randomly assigned into each of the two groups. Seven subjects completed the study, 5 in the intervention group and 2 in the control group. Effectiveness was evaluated by comparing prior and current practice SAT test scores and anxiety levels using a self-evaluation on the Westside Test Anxiety Scale. There was no consistent effect on practice SAT scores in the intervention group. When comparing the effect of a 3-minute deep breathing and meditation video to no intervention, there is a very slight decrease in anxiety from first to fourth measurement in the intervention group compared to control (mean average -0.14 vs 0, respectively, on a 5-point scale) in the intervention group. The lack of subjects within the study prohibited a statistical analysis. Given the trend of reduced anxiety with a short and simple intervention, an additional larger study to evaluate the utility of this intervention is justified.

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**X** human subjects

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

Word Count 243 Project Number 6005

 Title:
 Designing and Developing an Affordable Intelligent (Manned/Unmanned) VTOL Aircraft

 for Transportation, Search and Rescue

## Student Name(s): H. Aljafar

#### Abstract:

Drones have been used for a wide variety of purposes including capturing live events, surveying dangerous areas, shooting movies, monitoring wildlife, and use in law enforcement.

The feasibility of designing and manufacturing an autonomous Vertical Takeoff and Landing Aircraft (VTOL aircraft), purposed for search and rescue missions was investigated.

A CAD (Computer-Aided Design) model of the VTOL aircraft was developed using Fusion 360 software. The designed aircraft prototype was then tested using Fusion 360 studies, simulation testing included static stress testing of the aircraft carbon fiber chassis and thermal testing of the motors ( limited capacity motors were chosen to reduce cost ) with the aim to safely transport a 170-pound person.

The fusion 360 simulation testing of the VTOL aircraft was performed with a continuous thermal load of 60 degrees celsius on the motors (heat sink reduced each motor temperature by 6.89 degrees Celsius), a maximum displacement of 2.079 mm on the side arms of the aircraft was reached during stress testing with a maximum thrust of 267.7 pounds (121.44 kg). Stress simulations resulted in an 8 safety score in Fusion 360 which means the created components can withstand up to 7 times the applied load before breaking.

Based on the research, it is feasible to build a homemade VTOL aircraft for search and rescue purposes. The Fusion 360 simulation-tested VTOL aircraft is able to safely carry a 170-pound person. The lifting capacity can be increased by upgrading the motors.

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Word Count 170

Г

Project Number 6008

1/8	
Title:         Track System for Safe and Effective Lifeboat Launches	
Student Name(s): H. Lucian	
Abstract: Lifeboat launches in times of emergency have a high probability of failure instances in which the vessel is at a severe list or has assumed a significan Lifeboats are typically unable to be launched when the ship is at a list (this difficult at lists around 30-35 degrees) because the boats cannot be proper ropes/crains without making contact with the ship at its list. This can be pr lifeboat launches on both the port and starboard sides of the ships and boa particularly in the case of a rapid sinking. The objective is to find ways to implement thin transparent tracks alongside the side of ships and other ma particularly passenger ships, in order for lifeboats to scale upon release. The more lifeboats to be stored on deck or existing lifeboats to be stored more lifeboats to be launched down either side of the ship during an evacuation even of a heavy degree.	e, especially in at deal of damage. s usually becomes ly lowered by roblematic for ts can be scrapped, o successfully urine vessels, his can allow for efficiently, and for involving a list,
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ll that apply):	
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vertebrate animals controlled substances	-
. Student independently performed all procedures as outlined in this abstract	t. 🗙 Yes 🔲 No
. This project was conducted at a Registered Research Institution.	No
Is this project a continuation $2 \square V_{\text{op}} \square N_{\text{op}}$	

- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
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🗙 Yes 🗌 No

#### Ward Count

Word Count 203

## **CSEF Official Abstract and Certification**

Project Number 6009

Title: The use of sodium bicarbonate as a local buffer to decrease ocean acidity to increase larval oyster growth.

#### Student Name(s): K. Carr

#### Abstract:

Ocean acidification impacts larval oysters shell formation through carbonate ion displacement. This displacement leads to higher mortality rates thus presenting a substantial economic/environmental impact to coastal environments. It is proposed to develop a substrate which can be applied in man-made oyster beds to promote an ideal growing environment and reduce ion displacement. To accomplish this, concrete oyster bed frames combined with sodium bicarbonate will form a local buffer within the oyster habitats. The experiments are run through 2 by 4.5 by 1.5 inch porous and non porous concrete brick going through multiple pH, compression strength, and initial contact testing. Through ph. testing concentrations of 20ml or more created substantial ph. increase compared to the controls. Through compression strength testing 40ml was the strongest brick porous or non-porous with a compression strength of 7.313n/cm^2 porous,14.88n/cm^2 non-porous, with the non-porous brick being 103.47% stronger. Further brick testing includes initial water contact/flow demonstrating a steady increase on average of .25 pH/pass stone proving that pH can increase surrounding moving water. With this mixture of concrete future tests of that concrete can be used in an open water scenario and provide a strong growing environment.

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- 3. This project was conducted at a Registered Research Institution. 🗌 Yes 🛛 🗙 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

**Fair Category** 

Project Number

250	PS	6011
Title: Application of Soft Robots in Building Collapse Rescues		
Student Name(s): A. Song		
Abstract: Last June, 98 people died from the Surfside (FL) building collapse. It took to identify the last death. A timely rescue is challenging due to complex str the rubble. Vine robots, a continuum soft robot that uses internal air pressu length, have the potential to go underneath the rubble without being damag research has focused on the steer-ability of the robot, but it lacks specific d optimize the extension speed. The goals of this project include (1) determin the robot length, diameter, or air pressure on extension speed; (2) developin calculate the fastest route to a subject. Robots with different lengths and di with poly tubes and extended by air. The extension speeds of the robots wi passing a tight space (gap) were measured. I found that length and air press difference in speed, but robots with smaller diameters and/or thinner mater speeds. Surprisingly, the speed is greater when passing a gap that is much s robot diameter, probably because passing the gap increases its pressure spec I developed can calculate the fastest route from the entrance to the subject will be incorporated with the robot for its motion control. In conclusion, th design parameters that optimize extension speed. Future work will be on the parameters on steering performance.	more than a ructures under re to grow in ged. Existing esign param- ning the effe- ng a mobile ameters wer th and witho sure hold no ial have grea- smaller than ed. The mol- very quickly e project ide the effects of	month erneath h eters to cts of app to e made out ater the bile app r. This ntified design
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## Yes No

253

Project Number 6013

Title: Optimizing a Portable Vertical Axis Wind Turbine with Improved Construction Methods and Testing of Various Airfoils

#### Student Name(s): B. Lu

#### Abstract:

Wind energy harvesting is a clean alternative to burning fossil fuels. While the current model of horizontal axis wind farms is highly efficient in open, remote areas, the large size of the turbines limits the flexibility of the industry and poses a space issue that makes usage in urban environments very difficult. The study tested the viability of a smaller, foldable vertical axis wind turbine (VAWT) as a potential substitute while evaluating the effect of various airfoils on power output. A novel design was developed focusing on improving the weaknesses of last year's device. A long-term folding mechanism and more balanced gearbox were incorporated, along with a triangular hybrid darrieus design and slots for changing airfoils. Power output was measured at various wind speeds in a one-directional wind channel assembled at home. Each airfoil was tested individually, including traditional and laminar flow models. The Ushaped blade from last year was also tested for control. Three trials were conducted for each blade shape at every wind speed. The results demonstrate a significant average improvement of roughly 95% from last year's model. The two airfoil designs produced statistically similar averages, indicating that the specific airfoil shape was less important at lower wind speeds than initially anticipated. Both airfoils performed slightly better than the control, an improvement of under 10%. The increase justifies widespread application of airfoils in portable VAWTs. However, the structural modifications, which led to decreased damping and more stability, had a significantly larger effect on the overall power output improvement.

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

Word Count

Project Number 6014

Title: On the Casas-Alvero's Conjecture

#### Student Name(s): J. Su

#### Abstract:

As can be easily seen, if a given polynomial is of the form  $a(X-\alpha)^n$ , every derivative of this polynomial has a common factor with this polynomial. Eduardo Casas-Alvero came up with a conjecture which is the reversed form of the above proposition. And in this project, we propose three strategies to attack this problem. The first strategy is to use direct calculations. This method is only efficient when the degree n is less than or equal to 4. The second strategy consists to use Gauss-Lucas theorem to transfer this problem to a combinatorics problem. With this method, we can deal with the case for n no greater than 5. We obtain a general result for all n if a technical condition is assumed. The last strategy is purely algebraic. We use the theory of resultant and Nullstellensatz to reduce this problem to finding common zeros of a given series of multi-variable polynomials. To this ends, we use a mathematical program launched in SageMath to calculate the Gröbner basis of this given series of polynomials and obtain positive answers for Casas-Alvero conjecture up to n=7.

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- 3. This project was conducted at a Registered Research Institution.  $\Box$  Yes X No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
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Fair Category

Project Number 6015

 
 Title:
 Creating a Systematic ESG (Environmental Social Governance) Scoring System using Social Network Analysis and Machine Learning to Influence Company Practices to be More Sustainable

Student Name(s): A. Patel

## Abstract:

Word Count

256

ESG, or Environmental Social Governance, is a widely used metric that measures the sustainability and societal impact of a company's practices. ESG is determined using selfreported corporate filings, meaning companies often portray themselves in an artificially positive light. As a result, ESG evaluation is extremely subjective and inconsistent, and this is an issue since it gives companies mixed signals on what to improve. The purpose of this project is to create a data-driven ESG evaluation system to systematically and holistically analyze the good a company does for society by incorporating social sentiment. To do so, Python web-scrapers were made to collect posts from Wikipedia, Twitter, LinkedIn, Glassdoor, and GoogleNews across all S&P 500 companies. Irrelevant data was filtered using Named Entity Recognition, and the remaining data was cleaned via regex. Next, the Flair NLP algorithm calculated sentiment for each post, which was then averaged and mean-normalized to obtain scores for ESG subcategories. Using these features, machine learning algorithms such as SVR, KNN, XGBoost, Random Forest Regression were trained and calibrated to S&P Global ESG Ratings. The SVR algorithm displayed the strongest results with a mean absolute error of 13% and p-value of 0.021, showing it is well-calibrated to be implemented in a public setting. The student has carried out all parts of the project while the mentor provided guidance. Overall, systemizing ESG can encourage companies to adapt their supply chains and corporate practices to be more sustainable. This can rewire over \$6.1 trillion to more sustainable/ethical initiatives.

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

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- 3. This project was conducted at a Registered Research Institution. 🗌 Yes 🛛 🗙 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

206

Project Number 6016

Title: Finding Gravitationally Lensed Quasars by Analyzing Polar Shapelet Decompositions

#### Student Name(s): I. Prasad

#### Abstract:

Gravitationally lensed quasars are optical mirages in space, formed when the gravitational potential of a foreground galaxy distorts light produced by a background quasar. They have gained much attention over the past four decades due to their rarity and usefulness. Lensed quasar systems serve as laboratories in space, providing information about the distribution of dark matter in distant galaxies, as well as the age, size, and expansion rate of the universe. During this time, astronomers have located most of the large-separation (greater than 1.5 arcsecond separation), easily-identifiable systems, but many small-separation (sub arcsecond separation) systems remain undiscovered. This project attempts to solve this problem by developing an automatic algorithm capable of identifying "quads," or quadruply lensed quasars, from low-resolution sky-survey images. The algorithm applies a polar shapelet decomposition method to 10,000 Dark Energy Survey (DES) extragalactic objects and 2,000 synthetically generated quads to understand which combination of shapelets are unique to lens systems. A probability grid was constructed over shapelet phase-space to quantify the relative likelihood that a given DES object is a lens. By using this approach, my program was able to narrow the number of targets from the original 10,000 to the 10 most likely quad lens candidates.

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

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

## Word Coun

Project Number 6017

 Title:
 Developing a Fully Plant Based Sustainable and Renewable Replacement for a

 Polychloroprene Fabrication

#### Student Name(s): A. Ferraro

#### Abstract:

Polychloroprene produces mass amounts of CO2 emissions in the production cycle. It is proposed: To develop an effaceable, renewable, and sustainable replacement for polychloroprene fabric containing all plant-based materials while incorporating a seaweed component, Chondrus crispus, as an alginate coating alternative to polychloroprene. There are certain characteristics which must be met for the proposed material, such as water absorption, durability, and the ability to be grown in mass quantities. The initial prototype consisted of a hemp and rice straw fiber (HRSF) blend coated with the alginate extract. To establish water absorption insulation, water immersion tests were performed. After testing the HRSF material against polychloroprene, it was found that the HRSF had an average weight difference of 570% and polychloroprene had an average weight difference of 120% between both trials. This demonstrates that the HRSF material had a higher water intake than the polychloroprene. An evolved prototype consisted of hemp coated in the alginate extract which had a hydrophobic powder (lycopodium) infused. To establish waterproofing, water immersion tests were performed. After testing the hemp with a lycopodium infused alginate (aL) material against polychloroprene, the polychloroprene had an average weight difference of 70%, while the aL material had an average weight difference of 600%. As shown through testing, the HRSF prototype produced more positive results of water absorption, compared to the waterproofing aL prototype which absorbed more water than polychloroprene. Further research must be conducted on alternate plant-based seals for the fabric that do not dissolve over long durations of water immersions.

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- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

237

Project Number 6018

Title: How Air Pressure Affects the Efficiency of a Bicycle and the Fuel Economy

#### Student Name(s): N. Mack

#### Abstract:

The overall purpose of this experiment is to prove how the air pressure in mountain bike tires affects the efficiency of the bike, and how that applies to the fuel economy. This experiment can be tested on automobiles and other forms of transportation, but it was better to test with a bicycle because it was practical and easier to determine data with. Experimentation was done on a small street with low traffic because it provided a straight, even surface, which was essential to my project. The bike tires were inflated to different air pressure amounts and it was tested for how long it took for the bike to coast to a stop. It was hoped to prove the correlation that the time it took for the bike to stop increased with the air pressure. After experimentation, it was observed that the data supported the hypothesis and that the times did indeed increase along with the air pressure. These findings were then applied to the general fuel economy and it was concluded that the ideal air pressure for most mountain bikes is around 20 to 25 psi (pounds per square inch). It was also discussed how important it is to have the ideal air pressure in automobile tires. Finally, the creation of a device/app was proposed that would inform and update drivers of their tire pressure and the effect it has on the efficiency of their automobile.

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

174

## **CSEF Official Abstract and Certification**

Fair Category

Project Number 6020

 Title:
 Portable Green Energy Generator and Storage Unit

## Student Name(s): L. Wertalik

## Abstract:

The goal of this project was to build a small portable energy generator that was able to charge rechargeable batteries as a renewable energy source. I used different materials that are easily accessible to build my apparatus. I built an apparatus that is able to collect both solar and wind power. I used different things like a solar light and a hairdryer to test my apparatus. I set up a solar light to feed power into the solar panel that I attached to the battery pack. I used a hairdryer to spin the pinwheel on the motor that was attached to the battery pack to charge it. Both the wind and solar power were able to charge the batteries enough to be used in different devices. For the wind power trials, the average change in amperage between the first and last readings for all of the trials was 1394 maH. For the solar power trials, the average difference in amperage between the first and last reading between all of the trials is 1665 maH.

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171

## **CSEF Official Abstract and Certification**

Project Number 6021

 Title:
 NeRF-UAV: Inexpensive 3-D Reconstruction and View Synthesis Using RGB Camera

 Equipped Drones and Neural Radiance Fields

#### Student Name(s): E. Sun

#### Abstract:

Digitizing and reconstructing objects has always been a goal of computer vision, especially as the Metaverse's influence continues to grow and the transition to digital life begins. However, classical methods of 3-D synthesis require expensive and impractical setups as well as controlled settings, which are inapplicable beyond laboratory settings. This paper proposes a novel deep learning application for aerial reconstruction through optimized Neural Radiance Fields for Unmanned Ariel Vehicles (NeRF-UAV). We then combine classic NeRF with recent developments a Pixel-shuffle Down-sampling (PD) techniques to overcome the low megapixel image resolution for affordable drones and compare our results to traditional photogrammetry and demonstrate superior recovery of both fine color and geometric detail. We also numerically show NeRF-UAV synthesizes more accurate views as compared against generic implementations of NeRF by conducting SSIM and PSNR tests. Finally, we propose an easily up scaleable framework to adapt this technology to swarms. Applications of this technology include the digitization of large/small objects, special effects, 3-D asset generation, and education.

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

Fair Category

Project Number 6022

Title: Combating the Better Than Average Effect in Large Groups by Using Perceived Driving Ability

## Student Name(s): G. Miller

## Abstract:

The better than average effect is a human behavioral trait where a population of people believe that they are better than average. The better than average effect creates several problems in social science studies, especially surveys. This investigation is to research how people feel about their own driving ability and how this relates to the better than average effect. The goal of this project is to find a way to counteract the better than average effect for large groups. In this study we will be comparing the results of the survey to the normal model and determining how different each survey is from the normal model. The survey will be given to students and faculty at my school and it will remain anonymous. There are three different surveys each with six questions and each participant will only take one survey. The first survey will be the control. The second survey will see if adding social incentive will make participants answer more honestly. Literature indicates that having friends in a focus group made people answer more honestly when the better than average effect was present. Survey two will determine if creating a social incentive works like it did in small groups in large scale surveys. The third survey will see if adding a scale on what good drivers looks like will produce more honest results. This project could be important for future social science research especially if better than average effects could create a bias in large scale surveys.

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

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

## 🗌 Yes 🛛 No

Word Count

Fair Category

Project Number 6023

Title: Effectiveness of Different Coastal Erosion Mitigation Structures at Preventing Hydraulic Action

Student Name(s): P. Danise

## Abstract:

The purpose of my experiment was to determine which coastal erosion mitigation structure could retain the most amount of sand from a wave maker. At the beginning of my experiment, I predicted that having the rocks armoring the coastline would the most effective strategy. I tested for different structures along with a control with no structure. Each trial the the sand embankment contained 283.5 grams of sand in a uniform shape. The wave generator was ran for 30 seconds on the other end of the tank and the remaining sand was collected and measured. The control retained 201.3 grams, the 2.75 inch groin 235.3 grams, the 3.75 inch groin 252.3 grams, the tubes 232.5 grams, and the rock armor 266.5 grams. The rocks armoring the coast proved to be the most effective at preventing hydraulic action.

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

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

🗌 Yes 🛛 No

Word Count

ion

Project Number 6024

Title: On the smallest area (n-1)-gon containing a convex n-gon Student Name(s): K. Kwak Abstract: The approximation of convex disks by inscribed and circumscribed polygons is a classical geometric problem whose study is motivated by various applications in robotics and computer-aided design. We consider the following optimization problem: given integers  $3 \le n \le (m-1)$ , find the value or an estimate of  $r(n, m) = max (P \in Pm) min (Q \in Pn, Q \supseteq P)|Q|/|P|$ where P varies in the set Pm of all convex m-gons, and, for a fixed m-gon P, the minimum is taken over all n-gons Q containing P; here  $|\cdot|$  denotes area. It has been proved that r(3,4)=2, and this is the only exact value currently known. In this paper, we prove that every unit area convex pentagon is contained in a convex quadrilateral of the area no greater than  $3/\sqrt{5}$ , and that every unit area convex hexagon is contained in a convex pentagon of area no greater than 7/6. Both results are tight as the case of the regular pentagon (hexagon) shows. In other words,  $r(4,5)=3/\sqrt{5}$  and r(5,6)=7/6. We propose a conjecture regarding the value of r(n-1,n) for  $n \ge 6$ . **Technical Disciplines Selected by the Student** MA CS (Listed in order of relevance to the project) 1. As a part of this research project, the student directly handled, manipulated, or interacted with (check all that apply):

- human subjects
- botentially hazardous biological agents
- vertebrate animals
- controlled substances
- 2. Student independently performed all procedures as outlined in this abstract.  $\square$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution.  $\Box$  Yes  $\boxtimes$  No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

252

Project Number 6025

Title: Developing a Graphical User Interface to Organize Ecommerce Product Attributes

#### Student Name(s): H. Yang

#### Abstract:

Throughout the year, retailers offer various "deals" on products to entice customers. Especially during the pandemic-induced ecommerce boom, deals have become more widespread, with searching for the best deals becoming increasingly difficult. While existing forum communities, such as Slickdeals, consolidate users to a common medium, they are driven by real people to source such deals. Thus, the purpose of this project was to develop a graphical user interface (GUI) using the Python programming language to organize and display product characteristics. Using a previously developed program, data was retrieved from eBay's API with specific attributes filtered. Using PyGuBu, a GUI builder for Python, container frames and widgets were added as a foundation. Then, using Python's Tkinter library for developing GUI's, further customization and functionality were added, such as commands upon user interactions. After prompting a query, results were displayed in a tabular manner using the Tkinter Treeview widget. The PyMySQL library helped establish communications with a MySQL database, where attributes could be stored and accessed. The GUI was tested using simple search queries, such as "iphone", while functionality was measured qualitatively by determining whether specific criteria were met or not. Results showed that all features functioned successfully with products displayed neatly. However, eBay doesn't allow individual developers access to real-time data reflecting their production website. The main implication was to provide deals to a greater audience without the hassle of searching for them and potentially saving the average consumer money. However, it could also benefit retailers by cataloging stock-keeping units.

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

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.  $\boxtimes$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution. 🗌 Yes 🛛 🗙 No
- 4. Is this project a continuation?  $\blacksquare$  Yes  $\square$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

### **CSEF Official Abstract and Certification**

Fair Category

Project Number 6026

Title: Passive Thermal Energy Storage for Air Conditioning Systems Utilizing Phase Change Material

#### Student Name(s): A. Nomani

#### Abstract:

Around 750 billion kWh of energy is used to provide cooling in commercial buildings annually. This energy consumption is also expected to increase approximately ten-fold by the year 2050. Air conditioning (AC) is something that is in very high demand and because it consumes a large amount of energy, this can potentially harm the environment. In addition to the extreme energy consumption of AC units, they are also mainly utilized during the time of day when energy costs the most during peak hours of the day. To help reduce the energy consumption and cost usage of AC units, we designed a heating, ventilation, and air condition (HVAC) system that can passively provide cooling. The main component of our system is phase change material (PCM), which releases and absorbs energy at phase transitions to provide heating and cooling. This provides passive cooling as the PCM can be frozen and when it melts it absorbs heat from its surroundings, producing cold air. We constructed a prototype to hold the PCM and tested it in HVAC systems at three different fan settings: low, medium, and high speed. Low speed produced the most promising results, as it provided cooling for approximately 104 minutes, while medium and high speeds only provided cooling for 80 and 54 minutes, respectively. This system can be utilized to reduce energy consumption of AC users, which can additionally help reduce the cost usage of AC units. Moreover, less energy consumption will produce fewer carbon emissions, thereby mitigating the climate crisis.

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

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

🗌 human	subjects
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potentially hazardous biological agents

vertebrate animals

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

263

## **CSEF Official Abstract and Certification**

Project Number 6027

 
 Title:
 Simple Remediation of Heavy Metal and Fertilizer Runoff Water Contamination via Carbon Nanotube Infused Pinus Strobus Xylem Filtration

Student Name(s): J. Bernstein

#### Abstract:

Runoff from mine waste and fertilizers often causes ion contamination in groundwater. Heavy metal (Pb, Hg, and As) and fertilizer (NO3- and PO43-) ions can pose detrimental health issues when ingested in contaminated water, particularly in regions where water filtration is inadequate. There is a clear need for a simple and accessible water filtration system for these ions, particularly in these regions. Herein, a SWCNT-infused Pinus strobus xylem filtration system was developed, to effectively remove these ion-water contaminants, well below their EPA water action levels (WALs). To measure each contaminant, colorimetric UV-Vis assays were established using respective complex-ion reagents. To fabricate the filtration system, freshly-cut eastern white pine branches were stored/soaked in water, and dried in ethanol prior to use. 1" branch lengths were ultrasonicated in 2mg/ml COOH-functionalized SWCNTs (with 10mg/mg SDBS), to produce  $1.1 k\Omega/cm$  conductivity across the filter diameter. The filter was electrified using a household 9V battery, so that the electrically charged xylem would remove ion contaminants through their interaction with a continuous flow of electrons, trapping them inside of the pit membranes. All contaminants were remediated successfully below their respective EPA WALs. For heavy metals, 1000ppb of mercury, lead, and arsenic were reduced to 1.82, 9.73, and 2.84 ppb, respectively. Nitrate water-contaminant was reduced from 100ppm to 8.34ppm; phosphates were reduced from 1ppm to 0.19ppb. EDS analyses reveal each contaminant in the used xylem filters, further verifying their retention. ATR-FTIR analysis reveal that the filtrates are free of xylem/SWCNT filter components, indicating stability of the filtration system.

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

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.  $\square$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution. 🗌 Yes 🛛 🗙 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

254

Project Number 6028

 Title:
 Electrochromism paired with Finite Difference Time Domain Modeling allows for the

 Successful Prediction of Color Change Achieved by Electrochromic Reactions

#### Student Name(s): G. Krishnan

#### Abstract:

With more than 60% of energy used for energy generation lost, the issue of how to save energy has come to the forefront of research in recent years, particularly as greenhouse gas emissions from wasted energy continue to increase the effects of global warming and climate change. New and innovative approaches are needed to solve this problem; energy saving electrochromic windows fulfill this need. We aimed to improve existing electrochromic windows by designing a more efficient electrochromic coating that can undergo a reversible color change when exposed to smaller magnitudes of positive and negative applied potentials. We ran simulations with varied parameters using the Lumerical modeling software to achieve the best fit between reflectance spectrums generated by simulations and reflectance spectrums obtained from in-person experimentation. Furthermore, additional software was used to acquire an RGB color value from the simulation-generated reflectance spectrums, providing insight into the ideal thicknesses and material combinations necessary to achieve the desired color change. We found that a two-layer model with a top layer of TiCrOx with a thickness of 176 nm and a bottom layer of fluorine-doped SnOx with a thickness of 600 nm allowed for the best fit with the experimental results. Collectively, these novel conditions identified herein lay the groundwork for designing an efficient electrochromic coating and window, a promising solution to a problem that has eluded researchers for years. This, in turn, will allow for an increase in energy savings worldwide, and, most importantly, a decrease in carbon emissions, thereby mitigating climate change.

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

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

🗌 human	subjects
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potentially hazardous biological agents

- vertebrate animals
- Controlled substances
- 2. Student independently performed all procedures as outlined in this abstract.  $\square$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution. 🛛 Yes 🗌 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

253

## **CSEF Official Abstract and Certification**

Project Number 6030

 Title:
 How Raspberry Pi Microcomputers and Computer Vision Artificial Intelligence Can Be

 Utilized to Provide Aid to the Visually Impaired Community

Student Name(s): S. Bhardwaj

#### Abstract:

According to the World Health Organization, an estimated 2.2 million people globally are suffering from a visual impairment or total blindness. Although millions have an inability to see, there is a lack of a practical product on the market which is both cost effective and efficient in assisting the visually impaired population. The Object Detection Universal System Plus (O.D.U.S.+) was designed in order to be that solution, allowing and providing the wearer with freedom and safety in movement, as well as extending their capabilities with Computer Vision Artificial Intelligence. The device was programmed with the programming language Python, and utilized two Raspberry Pi microcomputers, 4 ultrasonic sensors, 4 vibration motors, and a camera. O.D.U.S.+ works by collecting distance data using ultrasonic sensors and parsing it to provide alerts if an object is within 3-feet of the wearer, through 3 methods. These alerts are vibrations created by vibration motors on the glove, with data being received over BLE, or Bluetooth Low Energy, a series of beeps from a buzzer, and a computergenerated voice produced through a text-to-speech program. Furthermore, by using the TensorFlow LITE database, coupled with the programming library, OpenCV, the device can accurately describe objects in front of the wearer, providing an added sense of awareness. Performance tests were done on both the ultrasonic sensors and OpenCV to determine their accuracy. More research and development is needed to expand the functionality of the device, including multiple modes for different applications of the Computer Vision AI for different situations.

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

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.  $\blacksquare$  Yes  $\Box$  No
- 3. This project was conducted at a Registered Research Institution. 🛛 Yes 🗌 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

264

## **CSEF Official Abstract and Certification**

Project Number 6031

 Title:
 Theoretical Modeling and Parameterization of a Novel-Actuator-Based Transtibial

 Pediatric Prosthetic
 Pediatric Prosthetic

#### Student Name(s): A. Bhattamishra

#### Abstract:

Dependability is a key factor for the widespread adoption of powered prosthetics, achievable through longer battery life, lighter weight, and affordability. This presents the need for a highefficiency scalable actuator that provides form-fit-function for pediatric-to-adult prosthetics. Currently, powered prosthetics are built around state-of-the-art electromagnetic motors and gear components that lack scalability and efficiency for mobility. The presented Smart Fluidic Servo Actuator (SFSA) utilized a built-in-design approach, involving every component as an integral part of the mechanism to address these limitations. Last year's proof-of-concept evaluations of the SFSA established the efficacy of a valveless fluidic transmission through the adoption of a novel motor control principle. To establish the capabilities of the SFSA in a transtibial prosthetic, theoretical modeling and parameterization were done during this year. Compensating for the unavailability of pediatric mobility data, empirical studies were conducted that logged the ground-reaction-force of a pediatric subject with a speciallydesigned force-plate and generated joint parameters. The CAD model of the prototype ankle incorporates low-friction graphene-coated pistons and a high-flow programmable displacement pump. All components were designed for additive manufacturing. Theoretical modeling, SolidWorks finite element analysis (FEA), and simulated motion analysis studies showed that the SFSA can generate 50 Nm torque at 5.4 radians/second speed with 120-watt power consumption (40% of the state-of-the-art prosthetic ankle joint). Further work includes design optimization followed by prototype assembly and evaluation. The overarching reach of this work will improve the quality of life for users of all ages.

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

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

**X** human subjects

potentially hazardous biological agents

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

210

## **CSEF Official Abstract and Certification**

Fair Category

Project Number 6032

Title: Flexible mechanical worm based on steering gear

#### Student Name(s): X. Xie

#### Abstract:

In nature, the larvae of moths gain momentum through the deformation of their carapace and can maintain a relatively stable posture in rugged environments such as the ground and tree branches. The purpose of this project is to build a bionic silkworms, with their multi-joint, multi-degree-of-freedom characteristics, moving steadily on rugged surface such as pipelines and ruins. The mechanical silkworm is made up of individual modules, each of which is connect by spring as a flexible connection. The nylon is fixed to the servo arm to stretch the spring and the entire robot is driven by this combination. Arduino is the control board for the whole circuit. In order to move in difference complex terrain, the robot has four different modes: single-section peristaltic, double-section peristaltic, double-section peristaltic with head up, and S shape moving. To test the mobility of the robot, I conducted experiments on different factors including response time of the servo, axle length and surface friction. The conclusion is that the robot reaches its fastest movement in double creep mode with a short axle and a rubber sleeve on the axle surface (to give it high friction), also it is able to cross the obstacles and move on the rough surface.

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

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.  $\blacksquare$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution.  $\Box$  Yes X No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

**CSEF Official Abstract and Certification** 

Project Number 6033

Title: Conducting Semantic Segmentation on Landcover Satellite Imagery through U-Net Architectures

#### Student Name(s): A. Saha

#### Abstract:

Many entities, both public and private, require large amounts of analytical data to pinpoint the optimal areas to build infrastructure, determine rebate programs, and ensure environmental protection. Through the rise of satellite imagery, with terabytes of imagery collected each day, utilizing spatial imagery gives another source of data for entities to use. With such a high amount of data, it's quite laborious to manually analyze each image and gain insights on land cover. In order to quickly and accurately analyze large amounts of data to get land cover insights, I used deep learning methods in order to classify, pixel by pixel, satellite imagery. Through a publicly available dataset of 10,674 512x512 RGB satellite images of Poland, I used transfer learning methods within a U-Net architecture to semantically segment each image, determining whether each pixel represents a building, part of forestry, water, or the background. This U-Net uses transfer methods of MobileNet, EfficientNet, and others to encode the image through a variety of Convolutional Neural Networks. Later, the U-Net uses skip connections provided by the encoder to decode the image into semantically segmented outputs. As a result, this model can accurately predict the composition of an image in terms of four classes: buildings, forestry, water, or background. Further expansion of this project would include expanding the classes analyzed, range of bands (NDVI, Infrared, etc.) to increase the usability of the architecture on more sophisticated satellite imagery.

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

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

237

Project Number 6037

Title: Combating Covid-19 through Programming using Scratch Software

#### Student Name(s): A. Bradley

#### Abstract:

The goal of this project is to provide data on which general scenarios and structured environments are most ideal for avoiding the spread of the transmittable disease Covid-19. I planned to make 3-4 different scenarios where each has a unique combination of objects placed in a set layout. Dots were then randomly scattered about, with one dot in particular acting as the infected individual. A timer was used to track how long it took for every single dot to go from healthy to infected, then eventually recover in each situation. The real-time graph for each individual scenario was represented just below the experimenting field. Where green represented the healthy or vaccinated people (green/yellow-green dots), red represented the infected people (red dots), and blue represented the recovered people (blue dots). In total 4 unique scenarios were created, and in each, different parameters were put in place to simulate how a real-life situation under those specific conditions would pan out to be. All the coding blocks were implemented and modified accordingly and testing at each stage of a new block formation or layout took place. Once the green flag was clicked at the top left, the program and timer would start as the infected dot bounced openly all around, slowly infecting other dots around it once contact was made. All data and observations made during experimentation was collected and written down in a logbook.

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

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

🗌 human si	ubjects
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potentially hazardous biological agents

- vertebrate animals
- Controlled substances
- 2. Student independently performed all procedures as outlined in this abstract.  $\square$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution.  $\Box$  Yes X No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

250

### **CSEF Official Abstract and Certification**

Project Number 6038

 Title:
 Changes in Opioid Prescriptions and Usages Brought by Efforts to Reduce Overdoses: An

 Analysis Using Machine Learning Models

#### Student Name(s): K. Siva

#### Abstract:

The growth in the prescription of highly addictive opioids as pain management medication has led to large-scale misuse and abuse, and has been given the term the Opioid Epidemic. This study aimed to use machine learning models applied to publicly available, de-identified data to analyze the changes in opioid prescriptions over time in order to find a correlation between various factors and overdose-related hospitalization rates. The data used here is from Washington State's Prescription Monitoring Program (PMP), which aims to improve patient care and to stop prescription drug misuse by collecting dispensing records for Schedule II, III, IV, and V drugs. Three independent variables were chosen for their visual correlations, and multiple linear regression models were applied to them: the average daily MME (morphine milligram equivalents) prescribed, the average total MME of doses, and the total number of dispenses. These models were used to predict the hospitalization numbers per quarter, and their resulting accuracy scores indicated the strength of the correlation between the independent and dependent variables. The average daily MME and total dispenses per quarter in combination were shown to have the strongest correlation with the hospitalization rates (92.9%). The MME values had a negative correlation and the measure of the number of dispenses had a positive correlation to the decreasing hospitalization rate. From these results, it can be concluded that the optimum dosage methods should reduce the total number of dispenses while increasing the daily MME values of prescriptions, in conjunction with the CDC's guidelines.

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

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

🗌 human	subjects
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potentially hazardous biological agents

vertebrate animals

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

281

## **CSEF Official Abstract and Certification**

Project Number 6039

 Title:
 Eco-Friendly Remediation of Polycyclic Aromatic Hydrocarbons in Stormwater via

 Magnesium-Infused Calcite Crystal, Supramolecular Hydrogel Scaffolding

Student Name(s): A. Lin

#### Abstract:

Polycyclic aromatic hydrocarbons (PAHs) are commonly found in stormwater runoff due to vehicle usage, oil spillage, and asphalt road material, causing numerous environmental issues when transported throughout ecosystems. For remediation, calcite has been identified as having high absorption capacities of PAHs in water, which is enhanced through inclusion of magnesium within the crystal structure. Unfortunately, magnesium-infused calcite solids are difficult to employ in a PAH-contaminated, free-flowing water system. Instead, this research seeks to embed Mg-infused calcite (5Mg+2:1Ca+2) into an amorphous calcium carbonatepolyacrylic acid hydrogel to fabricate Mg-APH. Mg-APH is then arranged in scaffolds within a water-permeable pouch, creating a system that can remove PAHs from running water, when stretched across a flowing stream or shoreline. As water flows through the filtration device, the hydrogel expands, allowing for enhanced interaction between Mg-calcite and PAHs. In an evaluation of Mg-APH only in air-tight experiments, Mg-APH began remediation of phenanthrene and naphthalene in 30 minutes, at rates of 5.5µg/140µg per gram-Mg-APH with 82%/92% effectiveness rates, respectively, relative to direct placement of Mg-calcite. When 8.3g of Mg-APH was arranged in a 3-compartment pouch, (15cm2 surface-area), and placed in a simulated mid-river arrangement, 0.12mg-Phenanthrene and 4.6mg-Naphthalene were remediated per gram-Mg-APH, in 5 hours against scaled river flow. Increased remediation efficiencies of 16x and 11x, respectively, highlight improvements provided by the scaffold design. Mg-APH was found to be stable, with no structural degradation into running water sources. Once contaminant-saturated, Mg-APH can simply be removed from the waterpermeable pouch and disposed of at an appropriate waste station.

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

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.  $\blacksquare$  Yes  $\Box$  No
- 3. This project was conducted at a Registered Research Institution. 🗌 Yes 🛛 🗙 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

250

Project Number 6040

Title: Biocement Bricks for Negative Emissions: Electrochemical Ocean Carbon Capture

#### Student Name(s): J. Russell

#### Abstract:

Atmospheric concentrations of carbon have increased by over 10% in the past two decades, contributing to the warming effect, which has made 2020 the warmest year on record. Along with reducing anthropogenic emissions, negative emissions technologies must be implemented to mitigate existing carbon. The ocean is the world's biggest carbon sink, having concentrations 120 times higher than the atmosphere. Additionally, ocean acidification caused by carbon dioxide reacting with water endangers the organisms that produce the majority of the world's oxygen. Here, we designed a flow cell for the removal of carbon from the ocean. We flow in ocean water and separate it into two streams, one acidified and one basified, through the use of bipolar membrane electrodialysis, transferring ions from solutions using ion exchange membranes. This model is thermodynamically efficient, leveraging pH and temperature relationships to turn harmful dissolved inorganic carbon into something beneficial: biocement bricks made of insoluble compounds, such as CaCO3. By using a redox couple, such as ferricyanide and ferrocyanide, the cell runs with minimal inputs and minimal voltage losses. Costs and corrosion can be additionally minimized by the use of protective thin-film materials such as TiO2. Machine learning analysis allowed us to rapidly analyze material candidates and their best preparation methods, an additional precaution to ensuring flow cell stability and efficient operation. This project provides both an opportunity for companies that cannot abandon fossil fuels to be carbon-neutral, and an opportunity for the world to become carbon-negative and reduce the damages already done.

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

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.  $\blacksquare$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution. 🛛 Yes 🗌 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

238

Project Number 6041

 Title:
 Modeling Investigation on Amines and Sea-salt Aerosol Interactions to Assess Their

 Potential Climate Impacts
 Potential Climate Impacts

#### Student Name(s): P. Sundararajan

#### Abstract:

Aerosols are solid or liquid particles suspended in air. Sea salt aerosols assist in the formation of clouds and can mitigate the warming trend of the climate. It also can react with sulfuric acid (SA) to release hydrochloric acid (HCl) gas. Amines are derivatives of ammonium typically found in coastal areas. They can react with acids (ex. SA) in aerosols to change their properties. Since HCl is more volatile than SA and closely related to sea salt aerosols, our project aimed to investigate if amines will react with HCl to form amine chloride salts, and if so, at what temperature. We hypothesized that amines will react with HCl and condense on sea salt aerosols at low temperatures. To assess our hypothesis, the Extended AIM Thermodynamic Model (E-AIM) was used to evaluate a chemical system at equilibrium across gas, aqueous, and solid phases. Multiple simulations were conducted on scenarios with constant inorganic concentrations and varying amine concentrations for alkylamines (ex. methylamine and dimethylamine) and polyamines (ex. monoethanolamine and piperazine) from 263.15K to 330K with 50 temperature intervals. We found that alkylamines only condense with HCl at low temperatures (285 K) but polyamines do at moderately higher temperatures (300 K). Our results advance the current understanding on interactions between amines and aerosols and improve current atmospheric models. Our findings also further knowledge on the crucial role of aerosols in cloud formation, light scattering, global radiation balance, and climate change.

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

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

265

Project Number 6042

Title: Controlled Delivery of Sulfoxaflor Pesticide via Cinnamaldehyde-infused Hydrogels

to Reduce Toxicity to Honey and Wild Bee Pollinators

Student Name(s): E. Wallace

#### Abstract:

Sulfoxaflor is a systemic insecticide which acts as a neurotoxin against sap-feeding insects. Unfortunately, its wide-spread use has negatively impacted honey and wild pollinators. Such non-targeted harm emphasizes the need for an innovative pesticide delivery model that can deliver sulfoxaflor systemically, while simultaneously repelling beneficial insects. This research has created such a delivery system, where sulfoxaflor has been embedded in a chitosan-alginate hydrogel, which is then externally-coated with cinnamaldehyde (a natural, low-toxicity bee deterrent), in a SC-Hgel. To model moisture-triggered SC-Hgel dissolution and delivery of sulfoxaflor into soil within a plant bed, 2 through 10 SC-Hgels were separately placed into 10ml containers with 0.5g sawdust (an analytically, non-interfering soil model), and heated at 32oC to simulate summer conditions. ATR-FTIR analyses highlight ~86% release efficiency of sulfoxaflor, which is improved to 96%, after consideration of experimental recovery efficiencies. For concurrent deterrent release, GC-FID analysis suggests a release of  $\sim 20\%$  cinnamaldehyde content, or 1.59mg, in 24 hours, for the 8 SC-Hgels evaluated. When compared to Transform<sup>™</sup> for field application, 4 SC-Hgels are required beneath a single, flowering plant, to reach the suggested, commercial pesticide delivery rate. This same 4 SC-Hgel delivery releases 0.81mg of cinnamaldehyde in 24 hours, which is well below its LC50 concentration for pollinators (7.9mg/24-hours). Application of these newly fabricated SC-Hgels will systemically deliver needed sulfoxaflor to combat sapfeeding insects, while simultaneously outgassing pollinator repellent at safe concentrations, so that these beneficial insects are deterred from visiting the treated, flowering plant, during pesticide release.

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

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.  $\square$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution. 🗌 Yes 🛛 🗙 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

Word Count

Project Number 6043

Title: The solar energy marine garbage recycling boat

Student Name(s): Y. Wan

Abstract:

The purpose of this project is to address the marine pollution caused by garbage and exhaust emissions and to construct a 1:30 model ship made by a boat that collects marine garbage using solar power to generate electricity.

I first constructed the shape for the hull through 3D modeling and then assembled the hull using laser-cut acrylic plates that I bought from Amazon. In the process of assembling the hull, I use hot melt adhesive to glue the gaps of the acrylic plates and divide the hull into four main parts: 1. solar panel 2. main control compartment 3. buoyancy compartment 4. motor compartment.

The movement of the hull is mainly controlled by the Arduino UNO for driving, combined with the APC220 to achieve wireless control function of the motor drive module through the L298N and then regulate the motor for movement. The energy part uses mainly solar panels and uses battery backup power for an emergency. To activate the intelligent cruising function of the ship at sea, and realize the automatic collection of floating garbage to protect the marine ecology. I hope my invention can make a contribution to the protection of the marine environment and improve the marine environment in a real sense.

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

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

🗙 Yes 🗌 No

250

## **CSEF Official Abstract and Certification**

Project Number 6044

Title: Designing and Optimizing a More Efficient and Inexpensive Optical Component for Thermal Cameras

#### Student Name(s): A. Sharonov

#### Abstract:

Thermal cameras are cameras used in various situations to detect infrared radiation. It is typical to use materials like silicon in thermal cameras as 3D structures. However, 2D structures, which are longer than one micron (um) in two dimensions and less than one in another, present greater efficiency in absorbing light in the 7-14 um range. Humans emit the greatest amount of infrared radiation in this range, so it is valuable to absorb light there. A promising material for incorporation into the structure and absorbing infrared is molybdenum trioxide (MoO3). In this project, MoO3 was used in a 2D structure to efficiently absorb light in the 7-14 um range. To do this, a photonic simulator was used to develop models. Various nanostructures such as ribbons, rings, or circles were placed on top of the MoO3 to increase absorption. Additionally, boundary conditions were altered, such as creating repetition of structures in different directions. Other methods of increasing absorption included changing materials and thicknesses of layers. The model that was created showed a high absorption of around 94% at 12 um, and little absorption at other wavelengths. A peak at this wavelength and nowhere else shows that absorption of energy emitted from humans by this model is high, allowing for more efficient detection of humans. Additionally, with the surge in cost of silicon, MoO3 provides an inexpensive alternative. These results indicate promising future use of this model on photodetectors for incorporation into thermal cameras, especially in situations where detecting humans is vital.

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

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

human subjects

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- vertebrate animals
- ☐ controlled substances
- 2. Student independently performed all procedures as outlined in this abstract.  $\square$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution.  $\Box$  Yes X No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):
Word Count 236 Project Number 6045

Title: Marine Debris Collected at Hammonasset Beach State Park Meigs Point.

Student Name(s): J. Walker

### Abstract:

I chose this topic because I have grown up sailing in the Long Island Sound and I have seen more marine debris every year. I believe it is important to preserve the oceans for future generations to be able to experience their beauty.

I hope that local people in the Town of Clinton become more educated about marine debris ending up in our waterways and local beaches and the importance of keeping the ocean clean.

The problem I am answering is how much marine debris washes up on Hammonasset Beach State Park from 01 January 2022 through 28 February 2022?

Once a week I went to Hammonasset Beach State Park Meigs Point at low tide. The length of the beach was 0.42 miles heading in one direction. In order to collect marine debris, I would check in between rocks because that is where all the old fishing lines and gear would wash up.

The investigation concluded by finding 32 lbs of trash on Hammonasset beach over two months. Categories of debris include lost fishing gear (ex. Lost nets, lines, and buoys), plastics, COVID-19 personal protective equipment, and styrofoam. Throughout this experiment, I made an observation that most debris was found at the end of Meigs Point closest to West Rock.

After briefly explaining my project I can conclude that there are different categories of marine debris washing up on Hammonasset Beach State Park Meigs Point.

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

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

potentially hazardous biological agents

- vertebrate animals
- controlled substances
- 2. Student independently performed all procedures as outlined in this abstract.  $\blacksquare$  Yes  $\Box$  No
- 3. This project was conducted at a Registered Research Institution.  $\Box$  Yes X No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

249

# **CSEF Official Abstract and Certification**

Fair Category

Project Number 6046

Title: 3D Print Prosthetic Arm

# Student Name(s): Y. Wang

#### Abstract:

With the development of technology, people can use machinery to make up for the disability of the body. Because the arm is one of the most important organs of the human body, prosthetic arms have naturally become a focus of research. While prosthetic hands for adults have been well researched, there are not many prosthetic hands customized for children, because children have a lot of different characteristics from adults.

This project aims to develop a prosthetic hand that can meet several requirements. Firstly, because the target population of this product is children with arm disabilities, it should be produced at a low cost that even a normal family can afford. Secondly, the functions must be sufficient for daily life. Thirdly, a simple operating system for children is needed.

The final product is a 3D printed prosthetic arm. Based on children's fatigue and low acceptance rate, the weight of the prosthetic arm is reduced and the appearance is designed to be similar to a real human arm. The main control system is a bluetooth remote control. Besides, the additional automatic function ensures that children will not be disturbed by the difficulty of use. This prosthetic arm also has a security mechanism which allows parents to control the arm remotely.

In the experience, the prosthetic arm has the ability to hold a maximum weight of 482g. According to the normal sizes and weight of toys and daily necessities, this grabbing ability is capable of dealing with daily things for a child.

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

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

🗌 human	subjects
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potentially hazardous biological agents

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

223

Project Number 6047

Title: The Effect of a Car's Age on Cabin Noise

### Student Name(s): D. Walker

#### Abstract:

The purpose of my experiment was to determine if the noise level inside a car's cabin becomes louder the older the car is based on the speed of the car. My procedure was to measure the noise level in decibels in five different car cabins varying in age using a sound level meter. I measured the sound level in each car while traveling South on Cow Hill Road, from Silver Birch Lane to Egypt Lane, in Clinton, Connecticut, at 25 mph, and while traveling South on Interstate 95, between exits 63 and 62 in Connecticut, at 65 mph, with either my mom or dad driving the cars. Then, I measured the noise inside the cars when they were idling and turned off. The final step was to compare the data across the different ages of cars. The mean cabin noise in decibels, traveling at 65 mph, for the 2016, 2014, 2011, 2004, 1991 is 67.5, 68.1, 69.1, 70.6, and 74.6 respectively. The linear regression r-squared = 0.95. Age is a good predictor of expected noise in the car (p-value <0.0001 with an alpha of 5%). Based on this evidence, I can conclude that my hypothesis was correct – if the car is older, then the level of noise inside the cabin will be higher because of mechanical wear and tear on the car.

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

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

244

Project Number 6048

Title:An Integrated Alcohol Sensing Device for Cars Comprising of an HX711 Weight Sensor,<br/>SG90 Servo Motor and MQ3 Alcohol Sensor to Prevent Drunk Driving Incidents

Student Name(s): S. Srinivasan

#### Abstract:

In 2019, the annual death toll due to drunk driving was 10,142 in the United States alone. The painful reality is that these deaths were preventable. This prototype aims to address the drunkdriving problem through an integrated alcohol sensing device for cars and comprises both hardware and software components. The system is only activated when the driver's seat is occupied which is supported with an HX711 weight sensor embedded in the car seat. The weight detection sends a signal to a software service built using the Adafruit IO interface. The servo motor SG90 that constantly listens to the service detects the signal and drops the MQ3 Alcohol Sensor from the car ceiling and the MQ3 begins sensing the environment. If a high alcohol concentration is detected, the device sends a text alert via the Twilio service to the specified contact list. For safety reasons, there were no human participants involved instead, different alcohol concentrations were sprayed 1-3 inches away from the sensor so the sensor could analyze the air quality. The spray was used by the designated supervisor. It was determined that values in the 200 range were the baseline for a spray with only water. Diluting the alcohol (43% ABV) with 50% water led to readings in the 350 range. Testing the alcohol that was not diluted led to readings over 500. This unique system has proved effective in alerting the client regarding the environmental situation by alerting based on these values.

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

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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.  $\square$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution. 🗌 Yes 🛛 🗙 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

Word Count 249

Project Number 6049

Title: JARVITS: A Novel Deep Learning IoT Traffic Control System for Real-time Detection and Signal Optimization

### Student Name(s): R. Kim

#### Abstract:

In the status quo, traffic signal control systems operate on predetermined patterns and instructions devised from past data. While this method functions effectively for traffic under normal conditions, it becomes heavily congested and inefficient during busy conditions.

Furthermore, the constant presence of unexpected emergencies renders pre-determined systems ineffectual. By combining traditional traffic controllers with modern technologies like Internet of Things (IoT) devices and computer vision, traffic control systems can be greatly improved. Yet there are currently no systems that can affordably fulfill this task.

By optimizing traffic signal duration, this allows for both a reduction in delay time for vehicles and a reduction of greenhouse gases emitted. Considering the Intergovernmental Panel on Climate Change (IPCC)'s August 2021 report on the current dramatically worsening state of the climate crisis, there is a compelling need for such a traffic control system to optimize throughput and thus greatly reduce vehicle's greenhouse gas emissions.

This research presents a novel deep learning traffic control system, called JARVITS (Just A Rather Very Intelligent Traffic System) that can be used for accurate real-time vehicle detection and signal control. Compared to previous methods, JARVITS offers a complete solution, with a physical vehicle detection algorithm and traffic signal optimizer. This study can largely be divided into two subsections: (1) the IoT traffic control system and (2) traffic control optimization. Lastly, a realistic virtual simulation created using Pygame is used to model traffic conditions and demonstrate that this research effectively improves traffic flow for an intersection.

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

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

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potentially hazardous biological agents

- vertebrate animals
- ☐ controlled substances
- 2. Student independently performed all procedures as outlined in this abstract.  $\blacksquare$  Yes  $\Box$  No
- 3. This project was conducted at a Registered Research Institution. 🗌 Yes 🛛 🗙 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

Fair Category

Project Number 6050

Title: On the machine-learning assisted generation of Alcubierre-like spacetime metrics for use in interstellar faster-than-light travel

### Student Name(s): Y. Song

#### Abstract:

Word Count

161

The Alcubierre metric is a theoretical method by which faster-than-light travel may be achieved in the context of General Relativity. The metric describes a "shell" of spacetime formed by the contraction of spacetime in front and the expansion of spacetime behind. Since there is no limit to the speed at which spacetime itself expands, the shell may be accelerated to any speed, even faster than the speed of light. However, a practical realization of the metric is hindered by its prohibitively high energy requirements, — in its basic form, 100,000 times the mass-energy of the universe. This research discusses progress in modifying the metric to decrease energy requirements via modifying shell parameters, as well as the limitations of such methods. The research then proposes a concept neural network that may be implemented to devise variants of Alcubierre-like spacetime metrics with modified characteristics, reducing total energy requirements considerably, and enabling superluminal interstellar travel in a nearmodern time span.

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

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

251

# **CSEF Official Abstract and Certification**

Project Number 6051

 
 Title:
 Exponential Derivative Identities and Properties to Determine Alternative Methods and Solutions for Calculating and Simplifying Problems and Models

### Student Name(s): P. Chitirala

### Abstract:

The exponential derivative is an operator analogous to the "linear derivative," and its similar definitions, properties, and identities are analyzed, developed, and proved similarly to how the identities and properties of the linear derivative are proved, using alternative approaches to solve those proofs. These proofs will be conducted both in terms of calculus and in terms of real analysis to ensure the truth of the property. These identities include the limit definition of the exponential derivative, the exponential derivatives of fundamental functions such as the exponential function or sinusoidal functions, the relation of the exponential derivative to the linear derivative, the properties of the exponential derivative such as the "product rule," and the introduction and development of the exponential integral and its identities and properties. The applications of the exponential derivative are explored such as calculating the gamma and polygamma relations, linear algebra, applied and theoretical mathematical models, and exponential transformations and independence. The objective of this project is to develop effective methods and procedures to approach a mathematical problem involving products, quotients, exponents, and other high-complexity relations using an operator known as the exponential derivative. The exponential derivative describes the rate of change of a function with respect to its variable as a ratio instead of the difference or slope between function values. For this project, the identities and properties of the exponential derivative relating to all aspects of calculus, in which the linear derivative is involved, will be developed in order to determine those effective methods and procedures.

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

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

🗌 human	subjects
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potentially hazardous biological agents

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

254

Project Number 6052

Title: Developing and Testing Updated Geometric Structures to Model the Optical Properties of

Spirulina, a Helical Photosynthetic Microorganism

Student Name(s): N. Shell

### Abstract:

Arthrospira platensis (Spirulina) is a protein-rich nutrient source whose consumption induces numerous health benefits. The most efficient method to grow Spirulina is using photobioreactors (PBRs), which can optimize growth through monitoring and controlling Spirulina's growing conditions. However, PBRs can be expensive and challenging to use especially on a larger scale. The aim of this project is to form an understanding of the relationship between Spirulina's geometric and optical properties. Coupled with an understanding of how Spirulina's environmental conditions affect its growth, my results can lead to the usage of Spirulina's optical properties to infer its growth conditions. This allows Spirulina organisms to be monitored more effectively and inexpensively. This research project began with the analysis of the factors required to properly represent the structure of a Spirulina trichome. I then created multiple sphere-based and cylinder-based geometric approximations of Spirulina's structure. Following that step, the imaginary indices of refraction of Spirulina were calculated at various wavelengths; wavelengths of interest, corresponding to peaks in the absorption spectra of Spirulina's pigments, were selected. Afterwards, the physics simulation software COMSOL was used to model my various geometric estimations of Spirulina's shape.

Self-written code in Python was developed, using euclidean distance to measure variation between the images generated by the COMSOL simulations. This enabled the determination of which geometric approximation possessed the most similar optical properties to the Spirulina helix.

In the end, stacking volume-equivalent ellipsoids was the most effective representation of Spirulina's geometry, although the stacked disks geometric approximation also yielded promising results.

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

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

🗌 hum	an su	bjects
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potentially hazardous biological agents

vertebrate animals

Controlled substances

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

248

Project Number 6053

**Title:** The Design And Construction Of A Portable Polystyrene Microfluidic Chip For The Point-Of-Care Detection Of Bacteria That Cause Enteric diseases.

### Student Name(s): P. Bazemore

#### Abstract:

Enteric diseases are responsible for 1 out of 9 child deaths and 1.8 million deaths worldwide. Yet, current methods for detecting enteric diseases in drinking water requires the cultivation of a sample in selective media followed by microbial identification based on biochemical, immunological or morphological characteristics. However, this method consumes a lot of materials and is time consuming due to the initial enrichment period of at least 5-7 to identify an isolated colony. As a result, reliable testing for enteric diseases remains inaccessible to many people in developing countries causing thousands of avoidable deaths. The objective of this project is to design and build a portable microfluidic device that costs under \$30 capable of detecting Escherichia coli, a bacteria that commonly causes enteric illnesses. The chip was designed in a computer-aided design(CAD) software system and the designs were engraved onto polystyrene sheets using a CNC machine. Then, the polystyrene sheets were heated causing the material to shrink, creating microfluidic channels from the designs engraved onto it. The microfluidic chip cost \$5 to fabricate which is under the \$30 requirement. Also, the chip is 15 centimeters long and under .4 kilograms. Consequently, it is portable and easy to transport to any location where detection of bacteria that cause enteric diseases is needed. Several chip designs were fabricated and the final design will be used to detect Escherichia coli in a water sample. The chip will be capable of detecting bacteria that cause enteric diseases in water samples.

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

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

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

253

Project Number 6054

 Title:
 Real-Time Motion Tracking System and Data Analytics for Live Insects Using Three-Wheeled Servosphere Robot

### Student Name(s): N. Lee

### Abstract:

Servosphere robots are used as omnidirectional treadmills for tetherless motion tracking, presenting improved accuracy to conventional methods while having numerous practical advantages. An area of interest for motion tracking is in machine learning, where a trained model can determine the traits of an insect, e.g., its species, sex, and health, based on its pathing. Last year's work developed a prototype servosphere tracking system, and this project extends that work with three contributions: 1) enhancing the system using a stronger, compacted design with error-reduced motors, a faster camera, and an optical sensor as well as more efficient multithreaded programming in Python, 2) performing stimulus experiments with seven live, naturally-obtained Lasius niger and Monomorium minimum subjects, and 3) applying collected motion data to machine learning using a convolutional neural network (CNN) classification model. The experimental results demonstrate the effectiveness of the system in tracking live insect motion, having an average experimental error of 3.23mm along an ideal path. Five of the seven subjects are stimulated with 50g of sweetened honey and have a measured average speed of 11.594mm/s. The two control subjects have an average speed of 5.448mm/s, corroborating expected results and demonstrating the system's robustness with innate and stimulated motion. The developed CNN model aims to classify segmented trajectories based on their directions, such as left, right, or straight, and the system-produced trajectories yield a model accuracy of 64%. In the future, the servosphere robot can be applied to other fields such as neuroscience with fluorescent neural behavior analysis.

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

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🗌 human	subjects
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- vertebrate animals
- Controlled substances
- 2. Student independently performed all procedures as outlined in this abstract.  $\square$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution. 🗌 Yes 🛛 🗙 No
- 4. Is this project a continuation?  $\blacksquare$  Yes  $\square$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

245

Fair Category

Project Number 6055

Title: Bird Image Recognition Using Neural Networks

### Student Name(s): L. Lapierre

#### Abstract:

Bird watching is a popular hobby among many but being able to identify birds out in the field or from a picture can be challenging for those with less experience. Apps have been made to combat this issue such as Merlin Bird ID, an app that allows users to upload a photo of a bird and then uses image recognition algorithms to identify the bird. Many of these applications use convolution neural networks(CNNs) which is a branch of machine and deep learning. These networks detect features like lines, edges, or curves in a given image and then make predictions on new images using the features it has detected. The goal of this project is to use the Caltech-UCSD Birds-200-2011 dataset, which has 200 bird species spread across 11,788 images and publicly available code written by Sasank Chilamkurthy that was made for ant and bee identification to create a neural network model that can correctly identify the birds within the dataset at an accuracy of 90% or higher. Changes to specific lines in the code will have to be made to allow it to use the previously mentioned dataset. Currently, after running 3 trials the highest accuracy achieved by the neural network was 88%. This indicates that the network is able to correctly identify the birds in the dataset with reasonable accuracy but still shows room for improvement. Future work will involve changing certain parameters within the code to hopefully increase the accuracy.

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

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.  $\Box$  Yes X No
- 4. Is this project a continuation?  $\boxtimes$  Yes  $\Box$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

Word Count

Project Number 6056

Title: A Wavelet-based Method for Generalizing

Molecular Latent Spaces for Assisted Traversal

Student Name(s): I. Murdock

### Abstract:

Auto-encoders and decoders are becoming more and more prevalent in current cheminformatics applications. In molecular modeling, molecular representations can quickly scale to a point that necessitates simplification or compression. Using a discrete wavelet transform's approximation section, the number of basis vectors needed to represent the majority of a chemical space's detail can be reduced, and this space can thus be more efficiently generalized. For input data, the SMILES molecular representation was used due to its relatively simple nomenclature, combined with one-hot character vectors for efficiency. Using the approximation portion of the discrete wavelet transform, the number of basis vectors needed to represent each character can be reduced by a factor of two. Wavelets allow for the simple transformation and reconstruction of the input data, even if only the approximation section is used, by utilizing a maximizing function. While this novel approach can introduce noise, it allows for simplification of a molecule's mathematical model while preserving most of the latent space properties of a model trained without this method.

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

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

250

Project Number 6057

 Title:
 The Development of an Inexpensive, Simple and Effective Application of Off the Grid

 Solar Disinfection of Potable Water

### Student Name(s): A. Greenberg

#### Abstract:

Less developed countries have a limited amount of clean drinking water to support community needs coupled with a lack of economical/effective ways to treat contaminated water leading to substantial public health issues. This project aims to develop an inexpensive, simple and effective way to produce potable water for use in less developed countries or after natural disasters when the water supply is limited. Solar Disinfection (SODIS) is a method for the disinfection of water using ultraviolet rays (UVA and UVB) from the sun. To enhance this experiment, a mirror and black spray paint will be used to increase the rate of UVA and UVB transmission and amplify the disinfection process. Non-pathogenic Escherichia coli (E.coli) infected water will be used to replicate water that people in developing countries have access to. The pour plate method was used to test effectiveness of the treatment. Threshold criteria establishing UV induced inhibition was any colonies that were larger than 1.53 milliliters is diameter. The bottle with no UV exposure had 10 colonies/cm<sup>2</sup> before treatment and 0 colonies/cm<sup>2</sup> after treatment. The bottle with no modifications but 24 hours of exposure had 15 colonies/cm<sup>2</sup> before treatment and 0 colonies/cm<sup>2</sup> after. Pinpoint colonies were also present after 48 hours for both before and after treatment plates that indicated early stage growth indicative of low cell density. It is concluded that the UV disrupts the DNA sequencing for cell replication and therefore is a suitable method for off the grid solar disinfection.

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

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.  $\square$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution. 🗌 Yes 🛛 🗙 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

Fair Category

Project Number 6058

 Title:
 The Manufacture and Expanded Function of a Locking Container to Eliminate the Distraction of Phones While Driving

Student Name(s): S. Lowder

#### Abstract:

With the rise of technological advances in the 21st century resulting in the popularity of cellular

devices, car accidents, and fatalities associated with distracted driving have become an increasing issue. Additionally, young people are more likely to use their phones compared to older individuals, which makes them a safety concern for their early years as new drivers. To restrain individuals from phones, a prototype for a locking container was developed during freshman year requiring the driver's phone to be stored within the container before driving to prevent attempts of distraction. Afterward, sophomore year focused on manufacturing a 3D model and PCB boards for the project. Then, during junior year, the project was assembled and implemented for use in an automobile. For this year, the focus was on expanding the functionality of the project by patenting the design. The start of patenting was a lengthy process from identifying the type of patent needed, to cross-examining many similar products to ensure the project was unique. In addition, the project then was classified through the CPC (Cooperative Patent Classification) and had claims established for the patent to define the boundaries of the invention. Concerning the purpose of the project, the main implication is to prevent future teen driving-related car crashes involving distractions from their cellular device and to save lives. Other potential implications for this project can be for personal safety for any driver, or as a business policy for the safety of workers for companies such as FedEx or UPS.

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

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

# 🗌 Yes 🛛 No

Word Count

Fair Category

Project Number 6059

 
 Title:
 A Proposal to Use Cost Effective Eco-friendly and Stronger Bricks for Modern Construction

# Student Name(s): Y. Ahmed

# Abstract:

The kilning of bricks, through the combustion of fossil fuels, emits many toxic fumes which are not only harmful to the environment, but harmful to human health and atmospheric health as well. The goal of my project is to investigate traditional ancient eco-friendly brick making methods that could produce bricks stronger than modern bricks, as well as to make them cost efficient. This project will test three brick recipes using traditional ancient materials to determine if they are as strong as modern bricks, as many ancient structures still stand today. Ancient bricks were primarily made of mud and straw, or limestone. From prior knowledge, ancient brick making methods were able to produce bricks that lasted for thousands of years. However, modern bricks are able to last, on average, 300 years. Relative to ancient brick structures still standing today, this is a short amount of time. This led me to the decision of testing ancient bricks to see that they can be stronger than commercial bricks. The intention was to make an eco-friendly, durable, and cost efficient brick. However, It seems the concentrations in which the bricks were made hadn't allowed them to fully clump together. Overall, the variants of bricks made from traditional ancient ingredients were cost efficient and eco-friendly but were unable to meet the commercial bricks' standards of durability, and were quite brittle and chalky, failing the durability test.

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

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

# 🗌 Yes 🛛 No

Word Count

242

# **CSEF Official Abstract and Certification**

Project Number 6060

 Title:
 Increasing Elasticity, Durability, and Function of Wearable PANI-Sense pH Health

 Monitors via a Superhydrophobic, Textile Framework

Student Name(s): M. Minichetti, M. Minichetti

### Abstract:

Current pH sensors fail to be truly wearable while maintaining the necessary sensitivity to varying pH, considering the most recent wearable pH technologies are polyimide film-based (PI). Poor washability and reusability remain challenges in the field of wearables. In this research, a highly durable, water-resistance, and wearable PANI pH Sensor with a Super Hydrophobic coating on a unique textile framework was synthesized. This innovation maximizes the advantages of textile, simultaneously conserving the sensitivity and durability of PI film-based pH sensors. The Super-Hydrophobic SEBS Alkane-Surface-Modified Silver-Nanoparticles ensure washability and repeatability. Moreover, the Voltera Screen Printer enabled small-scale precision making the wearable discrete. The newly fabricated, stretchable, and water-resistant SH-PVA PANI pH sensor demonstrated linear and discernable response per change in pH (3.523mV/pH), with the highly reproducible interpretation of pH from 0-13 (0.5%). With vertical and horizontal stretching & bending the PANI pH response remained within 1.7% of its original performance and 4% change in overall linearity. This represents a measurable improvement over accuracies for current technologies (>5%). The SH-PVA PANI pH sensor resisted 16-36oC water, with <3.3% response accuracy. Additionally, the SH-PVA PANI pH performance, post multiple washes, demonstrates the same response speed, with pH accuracy/reproducibility of  $\sim 1.0\%$ . With regards to the reliability of pH read versus temperature, the PANI pH sensor exhibited only 1.6% negative drift for 0-35oC, which is far less than that currently reported in literature (6.8%).

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

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

207

Project Number 6061

 Title:
 Optimization of the Sleep Cycle by Activation of the Parasympathetic Nervous System

 Using Low-frequency Vibrations and Heart Rate Variability Analysis.

### Student Name(s): R. Kulsakdinun

#### Abstract:

The purpose of this project was to create a wearable device that uses vibrations to increase deep-sleep duration through an increase in parasympathetic activation, measured through HRV (the variation in time between heartbeats). The design of the wearable was a three-step process: wiring the circuit, writing the code, and designing a housing for the electronics. The circuit used a DRV2605L Haptic Driver, which was soldered to an Arduino Nano, to control the vibrating disc. Power was supplied by a 3.7v LiPo battery and a boost converter. The code was written to control the vibration effect and interval by using the DRV2605 library. The housing, which was designed in Fusion 360, had a hole cut out in the bottom for the vibration motor. This hole was surrounded by silicone in order to minimize the noise from the motor's vibrations. A velcro strap was used to attach this housing to the user's wrist. For each participant, an Oura ring was used to record relevant sleep data, including HRV and deep sleep duration, both before and after the use of the device. Analysis indicated a noticeable increase in both average sleep duration and HRV in participants who used the device, with not much change in the control group.

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

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

**X** human subjects

potentially hazardous biological agents

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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.  $\Box$  Yes X No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

258

Project Number 6062

Title: Regenerated Cellulose Fibers and Their Impact on the Environment

### Student Name(s): A. Sasse, A. Sasse

#### Abstract:

Regenerated cellulose fibers such as lyocell, viscose, and many more have become popular choices in the clothing industry. The man-made fibers are made from natural materials and undergo various processes to create a product similar to cotton, but biodegradable. Certain methods used to create fibers impose different environmental impacts.

To find the most sustainable and environmentally friendly regenerated fibers a meta-analysis must be completed that highlights the strengths and weaknesses of all the different fibers. A table was created in order to compare quantitative data such as rates of acidification, impact on global warming, water use, energy use, etc. A separate collection of data occurred that compared qualitative data such as the chemical by-product released, the process used, solvent, etc. Overall, the goal is to look for consistent positive patterns that are backed up by affordable cost and acceptable quality.

Based on previous research, lyocell is hypothesized to be the most eco-friendly fiber because it has a recyclable solvent, shows the lowest numbers in the quantitative chart, and uses a dry jet-wet spinning method when being reconstructed. It is also predicted that many of the plantbased fibers such as viscose and rayon will be eco-friendly fibers but lack in other areas because the processes use more energy and water.

With the knowledge of which regenerated cellulose fibers are the most eco-friendly, consumers will be able to purchase clothes that reduce their environmental footprint. Overall, it's important to know the product you are buying and what kind of quality it's offering.

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

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

human	subjects
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- 3. This project was conducted at a Registered Research Institution.  $\Box$  Yes 🛛 No
- 4. Is this project a continuation?  $\boxtimes$  Yes  $\Box$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

259

### **CSEF Official Abstract and Certification**

Project Number 6063

Title: Utilizing Rooftop Gardens as a Means of Geothermal Cooling and Heating Through Ground to Air Heat Transfer Systems

### Student Name(s): A. King

#### Abstract:

Heating and cooling systems are either incredibly costly to uphold and implement or are large contributors to climate change. Inserting ground-to-air heat transfer systems within rooftop gardens can serve as a potential candidate to offset these issues. According to a study performed in Saudi Arabia, rooftop gardens alone have an insulation effect for the buildings they lie upon (Alhashimi, 2018). If these effects were to be maximized through heat-sync, rooftop gardens could serve as a reliable and safe means of geothermal cooling. To prove the abilities of this system, a model 4'x2'x2' building with a 4'x2'x1' rooftop garden was constructed. A PVC heat exchange was run from outside of the building, through the garden soil, and into the building. Heating testing was performed outside in cold, 4-degree Celsius weather. Over a 2.25-hour period, the model building saw a 2-degree Celsius increase. Cooling testing was performed inside a 27-degree Celsius room. Over a 2-hour span, the model building saw a 2.3-degree Celsius decrease. It is concluded that through experimentation, a large-scale rooftop garden ground-to-air heat transfer system will serve as an effective means of geothermal heating and cooling. It is proposed that experimentation should continue through large-scale gardens where data can more accurately represent fullsized systems. This system will be best applied in urban areas where rooftop gardens are already highly popular. A warm climate setting will be most ideal for this system as its cooling properties are more effective than heating.

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

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

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

Fair Category

Project Number 6064

Title:	Comparing Various Machine Learning Models while Predicting Taxonomy using Codon	
	Combinations	

### Student Name(s): S. Jonnalagadda

#### Abstract:

As we make more advances in the field of bioinformatics, the efficiency of using machine learning with big data becomes more evident. In this project, I compared linear regression and K nearest neighbors models while exploring how codon combination usage can be used to predict taxonomy. The dataset, retrieved from the UCI Machine Learning Repository, consists of 13,028 different organisms and their respective codon combinations, DNAtype, and Kingdom. After an initial accuracy score of 56%, I implemented a more practical approach to preprocessing the data. This included one-hot encoding, a process to convert categorical variables to numerical values. The linear regression model had an final average accuracy of 69% while the KNN model had an average accuracy of 81%.

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

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

# 🗌 Yes 🛛 No

Word Count

Word Count 211 Project Number 6065

Title: A New Hybrid: Harnessing the Power of Friction

Student Name(s): M. Neiss

### Abstract:

Climate Change has the world looking for clean and alternative energy solutions to problems such as global warming. Although there have been many advancements in renewable technology, there have been few steps taken to advance one of the main contributors of pollution: cargo ships.

Over 30 million tons of goods are shipped around the globe daily, and at any given time there are over 50,000 cargo ships crossing the ocean. The purpose of this project is to improve the efficiency of cargo ships through a study exploring an energy harvesting system that collects the energy generated between the hull of a ship and its movement across the water.

In order to understand what a 'clean-energy' system would look like in a cargo ship, research was conducted on different methods of generating electricity through the friction between two objects. What was found was piezoelectric actuator discs --two metal plates with piezoelectric crystals in between--, which might be a viable solution in the conversion of mechanical movements or pressure into electrical energy.

The results of these experiments found that this method was successful in generating small amounts of energy; however, due to limitations of cost, scale, etc., more research is needed to examine the full potential of this form of energy collection.

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

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

247

Project Number 6066

Title: Using an Artificial Neural Network Modelled After the Human Neocortex to Gain a Better Understanding of How the Neocortex Creates New Ideas

### Student Name(s): A. Yun

#### Abstract:

To deal with changing environments, the neocortex of the human brain generates predictions based on its past experiences. However, scientists are still not sure how the neocortex specifically creates new ideas, possibilities, and solutions. One potential solution is to model the neocortex with an artificial neural network. Multiple artificial neural networks exist that can model the generation of new possibilities. However, neuroscientific studies show that the mammalian neocortex uses local and online learning rules, which generative networks do not implement, making them less accurate models of the neocortex. This project aimed to use a neural network that models the human neocortex to better understand how the neocortex can be creative. Under the supervision of my mentor, I used the temporal memory (TM) algorithm of the hierarchical temporal memory framework implemented in Python 2.7. This network adheres to the principles of local and online learning, along with other concepts implemented in the neocortex. I examined ways of generating novel sequences from a TM algorithm that has been trained on sequences of upper case letters. I measured the similarity between the learned and generated sequences using the Levenshtein distance and established a criteria of a Levenshtein distance of at least 2.5. At the conclusion of this project I was able to generate sequences using three different methods, and all methods exceeded the criteria. By using a more accurate model of the neocortex to investigate sequence generation, this project could help us better understand how the neocortex can be creative.

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

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

### **CSEF Official Abstract and Certification**

Fair Category

Project Number 6067

Title: Optimizing Desalinization of Industrial Hypersaline Brine Through Temperature Swing Solvent Extraction

#### Student Name(s): J. Warters

#### Abstract:

Temperature Swing Solvent Extraction (TSSE) is a candidate for desalinization that specializes in purifying hypersaline brine with minimal energy consumption and zero liquid discharge (ZLD). It is proposed that TSSE can be implemented into existing desalination and some industrial systems to mitigate the harmful dispersal of hypersaline brine. Hypersaline brine with salinities around 80 ppt is pumped into marine environments of 35 ppt on average. This poses a substantial risk to the reproduction and survivability of aquatic species and marine ecosystems. It is proposed that disopropylamine (DIPA), an amine solvent, will catalyze within a hypersaline solution initiating salt precipitation at low temperatures above freezing, thereby enabling water extraction post thermal swing phase separation. Repeated extraction trials ascertained the minimum solvent brine ratio to induce desalination to expedite TSSE's candidacy as an efficient and sustainable form of desalinization. An X-ray Fluorescence Spectrometer was used to determine the concentration of sodium chloride. A linear regression analysis was created on the relationship between brine excitation levels and sodium chloride concentration, yielding a correlation of 0.9989. Experimentation revealed that a DIPA volume concentration of 12.5% to 15% does initiate statistically significant desalination of hypersaline brine, both exhibiting p-values of 0.01402 and 0.04452, respectively. Therefore, in temperature swing solvent extraction, a 12.5-15% diisopropylamine catalyst does initiate desalinization from concentrated brine solutions. This expedites developing an optimal system when installed into current industrial and desalination facilities to mitigate or minimize the dispersal of harmful hypersaline brine.

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

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

249

Project Number 6068

Title: Correlation Between Rainfall and Suspended Sediment Levels in the Mill River System

### Student Name(s): C. FitzGerald

#### Abstract:

Human impact on waterways has been a topic of research and social interest dating back to the industrial revolution. The Mill River flows through coastal Connecticut and is the recipient of several point and nonpoint pollution threats, from nitrogenous runoff to waste water discharge. This study was designed to evaluate the severity of this threat as a potential way to model future human impact on local waterways. In an attempt to evaluate possible connections between rainfall in the watershed and changes in local water clarity, six long term sites were chosen from the Mill River, the Quinnipiac River and progression through a gradient of sites out to New Haven Harbor. These sites were visited in a replicate fashion, with surface and bottom water clarity measurements taken and later compared to rainfall data from local weather stations in the days leading up to the field sampling. Preliminary indications show a flushing effect in correlational comparisons between water clarity and bottom water clarity (R2 = 0.776). This, along with ammonia data, seems to indicate signs of moderate rain events posing measurable threats to local waterways. This data should be taken into account, along with similar follow-up studies on multiple temporal and spatial scales to better manage things like allowable waste water discharges during rain events. In addition, future studies should focus on potential impacts to the flow rates within these waterways during rain events as this may be a better proxy for how well the system can rid itself of runoff pollutants.

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

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human subjects

potentially hazardous biological agents

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

228

# **CSEF Official Abstract and Certification**

Project Number 6069

**Title:** Short-term pilot biodegradation analysis of poly (α-pinene methacrylate), poly (myrtenyl methacrylate), and poly (methyl methacrylate) synthesized in supercritical carbon dioxide.

Student Name(s): E. Rodriguez

#### Abstract:

Though there has been recent progress in developing renewable plastics more suitable for commercial use, there is little emphasis on improving the biodegradation rate of these "greener" plastics. This leads to the development of plastics that are renewable but not biodegradable (or vice versa) that are marketed as "environmentally friendly", yet produce a negative environmental impact. A pilot biodegradation analysis was performed on the plastics poly ( $\alpha$ -pinene methacrylate), poly (myrtenyl methacrylate), and poly (methyl methacrylate), all of which were synthesized in scCO2. Samples of these plastics underwent biodegradation for 10 weeks in the presence of soil. 0.5N KOH solutions were used to absorb the carbon evolved from the plastic via microbial activity, which were then titrated to determine the amount of carbon in each solution. Interestingly, poly (myrtenyl methacrylate) samples evolved less carbon than the control sample, containing only soil, indicating poly (myrtenyl methacrylate) did not biodegrade during the 10-week period. However, poly ( $\alpha$ -pinene methacrylate) and poly (methyl methacrylate) samples evolved similar amounts of carbon, demonstrating similar short-term biodegradation rates. As the plastics poly ( $\alpha$ -pinene methacrylate) and poly (myrtenyl methacrylate) are possible renewable alternatives for poly (methyl methacrylate), this pilot biodegradation analysis illustrated that poly ( $\alpha$ -pinene methacrylate) is more readily biodegradable and thus will have a lesser impact during the endof-life stage than poly (myrtenyl methacrylate) and poly (methyl methacrylate).

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

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

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potentially hazardous biological agents

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

181

# **CSEF Official Abstract and Certification**

Fair Category

Project Number 6070

Title: Prototype of a Cleaning Robot

### Student Name(s): E. Hochberg

#### Abstract:

Learning environments are improved when clean and organized, but students at Greenwich Country Day School are permitted to take dishes outside of the dining hall to eat elsewhere, and often do not bring them back.. Several studies show that robots can have a positive impact on workplaces and learning environments, so I have decided to design a robot that can aid in keeping the school clean. By using the VEX EXP Education Kit, I will be able to build and program a robot that fits the school's needs. In addition to transporting dishes, the robot will have distance sensors and line finder sensors so it can follow a path to the dining hall. The robot will have multiple compartments for different items, such as one for dishes, and one for food scraps. I hope that the school will ultimately be cleaner as a result of my robot, and that people are inspired by my work to design and pursue their own experiments, as GCDS is a relatively new high school and I am one of the first to build a robot.

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

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.  $\Box$  Yes 🛛 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

242

Project Number 6071

Title: Cloud Identification in Mars Daily Global Maps with Deep Learning

### Student Name(s): S. Mengwall

#### Abstract:

Cloud identification on Mars is an important tool for climatology studies, making it possible to analyze the distribution, patterns and variability of clouds both spatially and temporally. Traditionally, cloud data on Mars has been extracted through manual or semi-automated processes which can be time consuming, and currently there is limited spatial and temporal cloud data coverage. In this project I demonstrate the successful use of convolutional neural networks (CNNs) to extract cloud masks from Mars Daily Global Maps (MDGMs) composed from the Mars Color Imager (MARCI) on the Mars Reconnaissance Orbiter (MRO). The fully automated model reports 97% pixel-wise accuracy compared to the testing dataset, and in many occasions the model performs better at extracting the full extent of the cloud compared to the prior semi-automatic technique. I also introduce several image pre- and post-processing techniques to improve the model's performance and usability. The model is configured to provide cloud masks at 0.1° longitude by 0.1° latitude resolution. It also automatically bounds the MDGM by northern and southern polar extents depending on solar longitude. The results suggest that this deep learning model is a useful tool to automatically and quickly extract Martian water ice cloud masks and make it possible to generate cloud mask data across the complete set of MDGMs and future ones. The model and related techniques also have potential extensions to Martian dust storm identification. I will make my code, model, and data publicly available.

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

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

243

# **CSEF Official Abstract and Certification**

Project Number 6072

 
 Title:
 Absorbing High Concentrations of Nitrogen using Biochar as a Preventative Measure to Mitigate the Dinoflagellate Karenia brevis

Student Name(s): K. Farber

#### Abstract:

An increase in the nitrogen concentration around the Gulf of Mexico has led to an increase in the severity of harmful algal blooms, specifically the microorganism Karenia brevis. In order to control the growth of these blooms, mitigation measures must be put in place. In taking a preventative approach, controlling the nitrogen concentration will curb Karenia brevis growth. Biochar is a known nitrate absorbent and is used to mitigate the food source of Karenia brevis therefore creating a limiting factor for growth. Biochar is a type of charcoal created through pyrolyzation, or the process of burning organic material in the absence of oxygen. By developing and testing four different species of wood, the activation properties of the biochar were tested to determine which species, when made into biochar, activates the highest concentration of nitrogen. Mahogany, Birch, Oak and Bamboo were used as experiment variables. Before being placed in the nitrate concentration each batch of Biochar was rinsed in distilled water to expel all natural nitrate. Birch Biochar was the most effective species of wood. The nitrate activation rate of birch biochar is 0.0014 ppm/30mins. The nitrate uptake rate is 0.0000372 micrograms. The activation rate of Birch biochar is faster than the Nitrate uptake rate. This has shown that when the biochar is placed in the Nitrate solution, it will absorb Nitrate faster than Karenia brevis can consume it, making it a promising future tool in the prevention and mitigation of Karenia brevis.

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

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?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

254

Project Number 6073

Title: A novel vascular 3D-printing approach assisted by cardiac single cell transcriptomics

### Student Name(s): Z. Qi

#### Abstract:

Cardiovascular disease is a major public health concern that causes up to 17.9 million deaths each year worldwide. This project targets two types of cardiovascular disease which are coronary artery disease and Marfan syndrome. In the surgical procedures for treating coronary artery disease and Marfan syndrome, it normally requires some forms of artificial or actual human blood vessels. A major issue is that opening up the patient's body to find blood vessels for grafting increases rates of complications, and the existing artificial blood vessels are not specifically designed to the needs of each individual patients. Therefore, the engineering goal of the project is to design and synthesize alternative artificial blood vessel by 3D printing of individualized blood vessels coated with pro-vascularization proteins. To achieve this goal, publicly available vasculature imaging data on the DICOM library database were imported into Mimics 3D reconstruction tool to create a model that can be 3D printed. Polyurethane was selected for final 3D-printing product based on physical properties and biocompatibility, so that the artificial blood vessel is similar to an actual blood vessel. Bioinformatic analysis of recently published single cell and spatial transcriptomic data was employed to generate the candidate extracellular proteins for coating of the 3D-printed blood vessel, including endomucin and actin. Future experiments will be performed on evaluating the endothelial cell survival and morphology on polyurethane-based 3D-printed blood vessel surface coated with (1) endomucin, (2) actin and (3) endomucin and actin. This study has provide novel engineering insight to develop artificial vasculature.

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

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

🗌 human	subjects
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potentially hazardous biological agents

vertebrate animals

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

Controlled substances

223

Project Number 6074

Title: Post FDM 3D Printing Processes to Improve Layer Adhesion.

### Student Name(s): J. Shanks

#### Abstract:

The goal of this experiment was to test what post processes could be used to improve the layer adhesion strength of FDM 3D printed parts. For this experiment, I designed a test part to be 3D printed out of PLA with the same g-code for all 20 parts. 5 parts were used as a control. 5 were put in the oven at PLA's glass transition temperature. 5 were put in a sealed bag then placed in water set at PLA's glass transition temperature. Finally 5 were coated in CA glue and then left to cure for 24 hours. The parts were tested on an Atwood machine with the printed parts secured to the ground and attached to a rope running over a pulley with little friction. A bucket was attached on the other side of the rope and slowly filled with sand until the layers of the test part gave out. After that, the bucket was weighed and the force exerted in newtons was calculated. From testing, it was found that putting the parts in the oven increased the layer strengths of the prints by approximately 63%. However, the water and CA glue parts did not have a noticeable increase in layer strength. This shows that it is possible to increase the layer adhesion strength of 3D printed PLA parts after printing.

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

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.  $\Box$  Yes 🛛 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

Word	Count	

141

# **CSEF Official Abstract and Certification**

Fair Category

Project Number 6075

Title:	Building my own Drone!

Student Name(s): I. Campbell

# Abstract:

Considering the topography of Connecticut to have a dense trail of forest and mountains, and also this whole idea of using drone to deliver parcels, one would like to further look into how the weight of an object affects the speed of the drone and its functionality.

This project when conclude will give drone developers an added knowledge of how to redesign drones to serve their purpose. According to (Sah, 2019) drones, are also known as unmanned aerial vehicles (UAVs), they can improve their way of flying in the way they function; however, drone delivery suffers from short but suffering problems such as limited battery life, and weight carrying constraints.

(Han, Tao, et al., 2021), also mentions how developing drones require high computational resources among other things for these drones to become unmanned devices that can freely move in the air.

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

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

256

Project Number 6076

Title: A Spectroscopic Study of Iron-Based Minerals on Earth and Mars

### Student Name(s): P. Shankar

#### Abstract:

The study of iron-bearing mineralogy of rocks and rock formations is vital for understanding the geological processes on terrestrial planets such as Mars. The composite mineral composition is characterized by aggregates of nanocrystalline Fe-oxides that are specific to geological processes dominant at the time of the formation which is not well understood currently. Furthermore, the morphological, crystallographic, and magnetic properties of those nanophase mineral composites are not well understood using existing theoretical models. By comparing and contrasting the nuclear hyperfine properties of Fe-bearing minerals, both on Earth and Mars, we can gain some insights into mineral formation on early Mars., data obtained by Miniaturized Mossbauer Spectrometer (MIMOS-II) onboard NASA's rover, Spirit, were analyzed using a software, Recoil<sup>©</sup>, to identify the mineral composition by mapping unique magnetic fingerprints- isomer shift, quadrupole splitting, and hyperfine field. The data also showed the presence of nanophase composites in amounts almost twice as much on the crater edges, Sol-74, compared to plain rocky terrain, Sol-34. The contribution of nanophase composites was determined by comparing the sub-spectral areas of the profiles to lab-synthesized magnetite samples, measuring 12nm-200nm. The nanophase and bulk components of the mineral showed an inverse polynomial relation, while the magnetic fields of the hyperfine sites showed a polynomial dependence on the crystal size. The nanophase contribution of both Earth-based and Mars-based magnetite, and well-documented research on nanophase magnetite, indicates active crystal nucleation and growth stages. This offers insights into the potentially active geological processes currently on Mars.

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

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

human	subjects
mannan	Subjects

potentially hazardous biological agents

- vertebrate animals
- Controlled substances
- 2. Student independently performed all procedures as outlined in this abstract.  $\square$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution. 🛛 Yes 🗌 No
- 4. Is this project a continuation?  $\boxtimes$  Yes  $\square$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

233

Project Number 6077

Title: Modular Robotic System for Multipurpose Robots

### Student Name(s): B. Ochs

#### Abstract:

A possible solution to a modular robot was designed and developed. A small scale, 3D printed prototype was built. It uses very similar electronics to a proper, fully-functional robot, but it only has basic functionality as its primary goal is to demonstrate modularity. The modules use a DB15 connector to communicate and share power with the core. To test the effectiveness of this solution, a mock robotic system was constructed. Initially, a core was built to host the core computer and power systems. This core has four DB15 connectors, and therefore should be able to support 4 modules at a time. The modules used to test are realistic and simple; a motor, distance sensor, wheel, light sensor, or any others needed to test certain aspects. These modules will be able to plug into any port on the core and function without problems. The core computer can recognize and control each module's computer from every port. While the robot is powered off, modules can be removed and added. Once powered on, the change is recognized. Success is defined by a continuous and stable stream of data between the core and an attached module via the DB15 connector. The mount is deemed successful if it is easy to operate, but still provides a secure connection. The success of this leads the way for this technology to be implemented into a more complex robotic system.

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

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

potentially hazardous biological agents

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

180

Title: Detection of two host galaxies of 2175 Å quasar dust absorbers

Student Name(s): B. Wang

### Abstract:

I report the discovery of two host galaxies of 2175 Å quasar dust absorbers (2DAs) at around z = 1 using the world's largest ground-based optical telescope, the 10.4-meter Gran Telescopio

CANARIAS (GTC) with the OSIRIS Tunable Filter (RTF). The detection was made through the

traditional PSF subtraction technique, which was verified through a PSF simulation

study. The measured impact parameters for two quasar dust absorber host galaxies are 18.79 kpc and 0.36 kpc with a magnitude of 22.74 and 21.44 AB, respectively. The derived star formation rate is around a few solar masses per year. These measurements show that dust absorbers have much smaller impact parameters than other quasar absorbers such as Mg II absorbers and damped Lyman Alpha absorbers, supporting these absorbers are likely associated with disk components of these distant galaxies. Considering that most of these dust absorbers show high metallicity and dust depletion, these dust absorber galaxies are likely excellent probes to trace the evolution of galaxies like the Milky Way galaxy in the early universe. Details of my analysis and results will be reported.

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

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

Word Count

Title: Introduction to Surreal Numbers: Exploring Real, Infinite and Infinitesimal Values and Their Hackenbush Games

Student Name(s): Y. Wong

### Abstract:

The surreal number system, discovered by John H. Conway and Donald Knuth, contains real, infinite and infinitesimal numbers, forming a totally ordered field. This paper discusses the construction and values of surreal numbers, mainly focusing on infinite ordinals, infinite and infinitesimal surreals, as well as their realizations as Hackenbush games.

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

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.  $\blacksquare$  Yes  $\Box$  No
- 3. This project was conducted at a Registered Research Institution. 🗌 Yes 🛛 🗙 No
- 4. Is this project a continuation?  $\Box$  Yes  $\blacksquare$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

265

Project Number 6080

 
 Title:
 Remediation of Fire-Foam PFAs from Contaminated Water Using an Eco-Friendly and Reusable Water Filtration System

Student Name(s): A. Kleshchelski

### Abstract:

Perfluoroalkyl substances (PFASs) pose numerous health risks, however their continued prevalence in many common goods has caused their contamination of many watersheds. Recently, climate change-induced wildfires have caused an increase in PFAS-use as a fire retardant, where their spray-application into forests has led directly to their runoff into streams, lakes, and rivers. In these waterways, PFAS's persist, and are consumed by fish, and eventually humans. In light of this recent increase in use, a simple and effective method for remediation of PFAS in water is needed. In response, this research culminated in the design of an easy-to-fabricate, and highly-efficient, PFAS filtration system, made from a crowd-shared 3D-print design, and natural, biofriendly filter beds. To begin, carboxylic-acid functionalized (10nm) CdSe quantum dots were first fabricated (adaptation of Liu), and used as the basis for sensitive fluorescence (540nm) measure of perfluoro-octanoic acid (PFOA, the model PFAS), down to ~8ppb. In use, PFOA's in water interrupt the solubility of COOH-CdSe's in water, causing a quenching, or reduction in CdSe solution fluorescence. Separately, the multilayer water filtration system (MW-FS) was designed in TinkerCad to function with a typical 1.5L plastic bottle, 3D printed, and assembled to include 25g (each) of SiO2 and Biochar. In use, the (\$5 as constructed) MWFS reduced 1ppm of PFOA-contaminated water to 1.8ppm in one filtration pass, to as little as 10.7ppb, with 5 filtration-passes. Interpretation and extension of the MW-FS remediation model suggests that ~20 filtrations are necessary to achieve water potability, at the 70ppt EPA Water Action Level.

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

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.  $\square$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution. 🗌 Yes 🛛 🗙 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):
240

Project Number 6081

Title: Developing a Machine Learning Algorithm to Accurately Predict Geomagnetic Storms

### Student Name(s): I. Yan

### Abstract:

Geomagnetic storms, major disturbances of Earth's magnetosphere by solar winds, are catastrophic. They cause severe damage to satellites, power grids, and communication infrastructures. Large scale storms can cause trillions of dollars of damage to satellites, and cause electrical blackouts and internet outages on massive scales that might not be repaired for months, or even years. Early prediction is critical in minimizing the hazards. However, current models either don't predict the global magnitude, or only make predictions within one hour of the occurrence, which is not early enough. Early predictions of geomagnetic storms are extremely challenging. There is a low correlation between current solar measurements and the magnitude of storms three hours later, making it difficult to determine magnitudes from the early solar data. Moreover, higher magnitude storms occur rarely, causing the data to be highly imbalanced, where more severe storms would be ignored. Solar measurements often contain noise or distortion when transmitted by satellites, decreasing the quality of data. This project aimed to predict geomagnetic storms as early as possible, using machine learning of solar patterns occurring before storms. The above challenges were overcome by using techniques including undersampling, feature selection, and combining data from multiple sources. For the first time, these techniques enabled predictions three hours ahead of time at an 82.55% accuracy, which outperforms competing algorithms by ~3\%. Predicting geomagnetic storms accurately in advance will provide a sufficient warning time window for preparation, greatly decreasing the damage caused.

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

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

🗌 human	subjects
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potentially hazardous biological agents

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

### **CSEF Official Abstract and Certification**

Fair Category

Project Number 6082

Title: Biomimetic Removal of Microspheres Water Contaminants, via Calcite-Infused, Corallike Melamine Sponges

## Student Name(s): N. Park

### Abstract:

The detrimental threat microplastics (MPs) have on the environment is well-established. However, their effective and efficient remediation in aquatic environments has yet to be established. This research provides a highly efficient/practical method for the removal of MPs through the creation of an Artificial Coral Sponge (ACS). The ACS was constructed on a 2x2x1.5cm (150µm-pore) melamine sponge, with a PTFE adhesion layer, and CaCO3 for MPcapture. The cubic-shaped ACS removed ~176k-MPs (~93%) in 45 hours, from 0.1mg/ml MP-contaminated fresh or seawater. High MP-concentration, long-term experiments were conducted to examine full capacity of the cubic-ACS. Following 1 week of submersion in 0.5mg/ml MP-contaminated water, SEM analysis highlights MP retention throughout its internal structure, demonstrating that it is not a surface-only remediation device. At full capacity, the ACS can retain 2065k MPs per device. To evaluate ACS reuse properties, a single ACS was used, and reused twice more, in subsequent 0.1mg/ml MP-contaminated water samples. Marginal decline of MP-remediation over 3 "reuses" highlights the ability to reapply the ACS in contaminated water, until its MP-limit is reached. An investigation for optimal ACS shape was conducted. Ellipsoid and cubic shaped devices behaved similarly, further pointing to the internal nature of ACS MP-capture. Finally, prolonged stability studies demonstrate prolonged ACS integrity, as a marine-safe, easy-to-use MP-remediation tool, costing 30¢/tested device, or \$12 for a device that mimics a typical 625cm2 coral. In use, the ACS is simply lowered into MP-contaminated water, left until its MP load is reached, and then simply lifted out for MP recovery.

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

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

🗌 human	subjects
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potentially hazardous biological agents

- vertebrate animals
- ☐ controlled substances
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- 3. This project was conducted at a Registered Research Institution.  $\Box$  Yes  $\boxtimes$  No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

228

## **CSEF Official Abstract and Certification**

Fair Category

Project Number 6083

Title: Neck Injuries in Football

### Student Name(s): C. Loth

### Abstract:

Background:

Athletes, both amateur and professional and of various ages train in their specialty to improve performance, be at the top of their game and to avoid injury. They work with a variety of experts-kinesiology specialists, athletic trainers, physical therapists, sports psychologists, coaches and many others to achieve their goals. In the world of football, studies are emerging about both short and long term effects from head and neck injuries including post-concussion syndromes, ligamentous and muscular neck injuries.

Methods:

Using a query of MEDLINE, PubMed, and various online journals, various articles were reviewed discussing various injury prevention strategies. Basic interview questions to school athletic trainers were compiled for their professional opinion and experience. Letters to the editor, case reviews and book chapters were omitted.

### Results:

A combination of sixteen studies and review articles found evidence to support the hypothesis that strengthening particular muscle groups will help to decrease the incidence of injuries in surrounding areas. This was furthermore supported by discussions with trainers and therapists. This premise can be applied to strengthening exercises in the neck, shoulders and upper back that would decrease the incidence of neck/head injuries in football. Additionally, selective papers reviewed that updated equipment and rules regulating certain contacts will decrease the incidence of injury. Further studies are needed to help delineate specific results of exercise programs that would be most effective.

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

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

human sub	jects
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potentially hazardous biological agents

vertebrate animals

Controlled substances

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

249

### **CSEF Official Abstract and Certification**

Fair Category

Project Number 6085

Title: The Synthesis and Properties of a Novel Polyester Material

### Student Name(s): M. McNulty

### Abstract:

Textile waste is an enormous problem in the fashion industry. One way to address this issue is to find ways of making used materials into "new"; usable material as a way of reducing this waste. This experiment attempted to create a new material from polycotton (a cloth type that is a mixture of polyester and cotton) to partially address this issue. Three experiments were performed: first, a 2-square inch piece of 50/50 polycotton (0.35g) was submerged into 25mL of 12.6-mole sulfuric acid. After 15 minutes of submersion, the cloth was dried overnight, then massed at 0.39g. From the weight gain, it can be concluded that a chemical reaction occurred; something in the sulfuric acid bonded with the cloth, and new material was made. In the second, two 2-square inch pieces of 50/50 polycotton (0.35g) were submerged into 3.0mole sulfuric acid; one for 15 minutes and one for 30 minutes. After they were left to dry overnight, both cloths had the same mass, therefore the molarity of the sulfuric acid needs to be higher for bonding to occur. The last experiment tested the strain of the bonded polycotton vs. the original. Both clothes were hung from a ring stand. Using thin metal wire, 800g worth of weights were hung from each cloth for 5 minutes. The results showed the original cloth was 0.89% longer than before while the bonded cloth was 3.51% longer than before, therefore this new material has more stretch than the original.

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

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

🗌 human	subjects
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potentially hazardous biological agents

vertebrate animals

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

219

### **CSEF Official Abstract and Certification**

Project Number 6086

Title: Accessible Program and System for Accurately Aligning a Star Tracking Mount Using a Camera.

### Student Name(s): S. Staubly

### Abstract:

Astrophotography is a popular hobby involving capturing images of the night sky. One major challenge involves eliminating star trails, which are streaks in images caused by Earth's rotation. To compensate for this, a star tracking mount is used to move the camera along with the stars. To use mounts like these, they must first be aligned precisely with the North Celestial Pole, the exact point where Earth's rotational axis meets the sky. This exploration aims to improve algorithms used by a computer program to calculate the precise location of the North Celestial Pole. The first step in improving alignment accuracy is to implement an accurate star centroiding algorithm. Stars appear in images as a blob of pixels, and locating the exact center is necessary for the accuracy of future calculations. The next step is to develop a method for locating the position of every star in an image. Then, to prove the exact axis of rotation to calculate the position of the axis. The goal of the study is to develop precise algorithms capable of polar aligning a star tracking mount, and incorporate them into a computer program to reduce the prevalence of star trails in astrophotography.

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

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.  $\Box$  Yes 🛛 No
- 4. Is this project a continuation?  $\boxtimes$  Yes  $\Box$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

252

Project Number 6087

Title: Developing an Inductive Stent to Accurately Detect the Occurrence of In-Stent Restenosis

### Student Name(s): P. Bahel

### Abstract:

Approximately 30% of people who are treated with a stent for the narrowing of a valve have in-stent restenosis within 6 months. In-stent restenosis is when the stented area narrows even after the stent is implanted within the body. Typically these go unnoticed until the symptoms of a narrowed valve become severe, sometimes going back to the state before surgery. Therefore, a novel stent is crucial in order to detect when in-stent restenosis is occurring before the condition worsens. In this project, a CAD model of an inductive stent, a stent that has the ability to transmit signals, was created and optimized. To do this, first a traditional stent was created using the Solidworks parts feature. This stent was then simulated and structurally optimized by plotting its Factor of Safety (FOS) plot. This model was then imported into Ansys Electronics Desktop given a layer of gold and assigned an impedance value. This provided the stent's conductance capabilities. A transmitter was then created which took the form of an identical stent with a larger diameter. This stent was given an impedance value. Once simulated, the magnetic field was plotted. Results of the simulation show a successful design as the magnetic field of the transmitter reaches the stent. The implications of this project are that this design can be used in medical devices to accurately transmit signals to doctors when the in-stent restenosis occurs. This removes current risks of waiting until the narrowing worsens before determining that restenosis is occurring.

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

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

# **CSEF Official Abstract and Certification**

Word Count 123 Project Number 6088

**Title:** A Comparison between two local elementary schools: which is better protected against traffic-related noise pollution using environmental noise buffers?

Student Name(s): E. Greenfield

### Abstract:

Research from this experiment consisted of recording the decibel levels in green areas to test the effectiveness of tree lines, shrubbery, etc. on noise pollution, recording the decibel levels surrounding local schools to see how invasive noise is to their environment, and surveying the staff of two local elementary schools to see how traffic-related noise levels affects their lives. The data collected will be analyzed to determine how environmental noise buffers can mitigate exposure to traffic-related noise pollution near elementary schools. The conclusions from this study are that when school staff is in the presence of noise, they feel more anxious. Waddell elementary school also experienced higher noise levels than Keeney as they don't have a noise buffer surrounding the perimeter.

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

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

**X** 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.  $\Box$  Yes X No
- 4. Is this project a continuation?  $\Box$  Yes  $\blacksquare$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

254

Project Number 6089

Title: Analysis of Leading-Edge Droop Flaps on Aerodynamic Lift at Different Angles of Attack

### Student Name(s): T. Tan

### Abstract:

High-lift devices on aircraft are critical to the safety of flight operations, particularly during takeoffs and landings where the aircraft must generate sufficient lift to overcome its weight. The purpose of this study is to compare the effects of leading-edge droop flaps on aerodynamic lift at high and low angles of attack (AoA). Using the POWERUP 4.0 remotecontrolled paper airplane, data was collected from three plane models in four categories each – clean configuration at 0° AoA, at 15° AoA, and dirty configuration (droop flaps extended) at 0° AoA and 15° AoA. In each category, 10 trials were conducted to measure the airborne time after the throttle was reduced from 35% to 7%. After 40 trials with the Invader model, it saw an average increase of 3.498 seconds at 15° AoA with droop flaps, a 116.8% increase compared to without droop flaps. At 0° AoA, the mean difference was 1.738 seconds, a 66.8% increase. At 15° AoA, the Onslaught with droop flaps flew for 1.132 seconds longer on average, a 34.8% increase. However, because the p-values for Onslaught (0° AoA) and Valkyrie are over 0.05, conclusions could not be made from those data. These findings indicate that leading-edge droop flaps increase the airborne time more at higher AoAs, when comparing the same model. Although never implemented, leading-edge devices could have increased the Concorde's operating range since they produce extra lift at subsonic cruise segments and decrease fuel burn, which are crucial for increasing the efficiency of future supersonic aircraft.

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

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

human	subjects
mannan	Subjects

potentially hazardous biological agents

vertebrate animals

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

Controlled substances

250

# **CSEF Official Abstract and Certification**

Fair Category

Project Number 6090

 Title:
 The Optimization of a Ground Collision Avoidance System and Application to Inhibit

 Controlled Flight Into Terrain Accidents For Single Engine Aircraft

Student Name(s): M. Beaudette

### Abstract:

Controlled flight into terrain (CFIT) is an accident in which an airworthy aircraft, under pilot control, is unintentionally flown into the ground, a mountain, a body of water, or an obstacle. CFIT accidents were identified as a cause of 25% of USAF Class A mishaps. Many articles regarding CFIT and GCAS systems highlighted that these did not appear in small aircraft. The systems were only prevalent in commercial-sized aircraft such as the ones offered by Boeing and Airbus. These systems consist of radar, lidar, altitude, synthetic vision systems, and mapping. These commercial systems were used as a starting point. The purpose of this continuation project was to provide an affordable, smaller, easier retrofitted system that also incorporated an accompanying app to provide pilots with important instantaneous flight data in order to decrease CFIT accidents. In conjunction with the physical hardware, the app provided telemetry data from the device. The existing system containing the Arduino, WIFI, and GPS, the device was added onto to include app compatibility. This app included important telemetries such as airspeed, warnings, and altitude. Revisions were made to the system code to support this app. Additionally, hardware updates took place to ensure that the device ran and operated as it should. The app was successful in providing a visual aid for pilots, while also decreasing CFIT accidents through the proven, tested CFIT algorithm. Lastly, this system can be applied to not only planes but adjustments can be made to fit helicopters, ultralight aircraft, and even paramotoring.

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

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

248

### **CSEF Official Abstract and Certification**

Project Number 6091

 Title:
 Designing and Testing an Activated Carbon Cloth Storm Drain Filter to Reduce the

 Prevalence of Phosphates and Nitrates in the Long Island Sound

### Student Name(s): A. Barnett

### Abstract:

Excess amounts of nutrient pollutants enter storm drains and are directly deposited into the Long Island Sound. These pollutants carry harmful levels of nitrates and phosphates, which cause eutrophication and lead to lower dissolved oxygen levels, also known as hypoxia, which kills fish populations and even entire ecosystems. My research completed in 2020-2021 has shown that the carbon cloth filter uniquely decreases both phosphate and nitrate concentrations, rather than one of the factors of nutrient pollution as seen in other filtering materials. The purpose of this year's work is to replicate my previous findings utilizing a finalized innovative, effective, and efficient prototype of my carbon cloth storm drain filter. It is hypothesized that the filter will reduce both nitrate and phosphate levels. Filter effectiveness is determined by measuring the concentration of the pollutants in the simulated and real stormwater runoff before and after the use of the carbon cloth filter. A reduction of 100% of nitrates was seen in one trial, and the average decrease of nitrate was 62%. Phosphate levels also decreased by an average of 73%. The storm drain filter prototype is constructed into two separate parts, one containing a mesh attachment to remove harmful debris, only allowing water to pour through, and a second part that contains the carbon cloth which will filter the contaminated water. Nutrient pollution affects thousands of bodies of water across the world and finding a solution to combat nitrate and phosphate overflow will create healthier water for all marine life.

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

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.  $\square$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution. 🗌 Yes 🛛 🗙 No
- 4. Is this project a continuation?  $\blacksquare$  Yes  $\square$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

248

### **CSEF Official Abstract and Certification**

Project Number 6092

 Title:
 Correlation Between Rainfall and Dissolved Oxygen in Local New Haven Waterways: A

 Predictive Model for Human Impact on this System

Student Name(s): T. Maines

### Abstract:

The Mill River was once an abundant recreational and commercial resource to the New Haven area, but has been declining in water quality for some time now. This is due in part to the pollution threats, both point and nonpoint, that it faces. This study was designed to evaluate possible correlations between rainfall that would wash these pollutants in and dissolved oxygen levels in the waterways. Six sites were selected, and visited in a replicated design to profile both top and bottom oxygen levels for comparison against rainfall in the watershed (24 -48 hours prior to sampling). Preliminary results from this work indicate that rainfall events of as little as 1-2inches in a 48-hour time frame have shown measurable impacts on oxygen levels in the river (R2 = 0.975, R2 = 0.801). These findings are worrisome for marine life in the area as impacted oxygen levels fell to hypoxic levels in this biologically critical estuary. The potential long term impacts of hypoxic conditions on this estuary should be the focus of follow-up studies as it will be a critical piece to manage these nursery habitats. Another suitable follow-up would be to examine the potential connections between heavy rain events and changes in hydrodynamic flow in these rivers as that is known to correlate to dissolved oxygen issues. All of this will better service coastal zone managers who are as determined as ever to return this, and other, systems to the economic and environmental level seen in the past.

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

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

241

Project Number 6501

Title: A Comparative Analysis of Thermal, Solar, and Membrane Desalination

### Student Name(s): R. MacNaughton, M. Yeager

### Abstract:

The objective of this project was a comparative analysis of various desalination methods including membrane, thermal, and solar desalination. All three methods have their own advantages and disadvantages, and this study sought to compile a comprehensive data set for use in identifying the most efficient method for specific situations, especially as the world moves toward more frequent usage of desalination. The proficiency of each method was investigated using variables such as the extent of pretreatment required, initial water quality, and time efficiency. The independent variables included energy required, resulting water quality, and risk to the environment. Brackish water from the Long Island Sound was combined with sea salt and soil to standardize the initial water quality. Each method was successful in desalinating the starting 1 gallon of water to a potable range of turbidity and pH as well as a 0.0 ppt salinity. Thermal distillation resulted in the lowest turbidity and most ideal pH but was not very time or energy efficient. Solar distillation has the advantage of requiring no energy input and resulted in only slightly worse pH and turbidity as compared to thermal distillation however it's inefficiency in terms of time rendered it impractical for use on a small scale. Membrane desalination was extremely quick and used a minimal amount of energy as compared to thermal distillation however the resulting water was significantly more basic compared to the other two techniques and the turbidities were slightly higher as well.

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

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

# **CSEF Official Abstract and Certification**

Word Count 246

Project Number 6502

Title:The Effect of Altering The Material Composition in Ultra High-Performance Concrete<br/>(UHPC) With Regional Materials On Compressive Strength

### Student Name(s): J. Ho, N. Magold

### Abstract:

Ultra High-Performance Concrete (UHPC) is a modified concrete mixture with higher compressive strength and durability than standard concrete. UHPC exhibits stronger performance due to a blend of fine aggregates, cement powder, and water, which form a dense matrix. This study investigates the task of developing cost-efficient and environmentally conscious concrete with regional materials.

The first phase of the investigation created a new UHPC mixture utilizing Holcim IL (10) MS, a cement powder with higher calcium carbonate levels, a cheaper and environmentally friendly material. A control mixture utilizing Holcim II/V was developed conforming to standard UHPC mixtures. Mixtures were poured into cubic molds then left to cure in a controlled environment or a steam curer. Cubes were then tested for ultimate compressive strength at different time intervals after pouring.

When cured in standard conditions, the new mixture had a compressive strength 86% as strong as the control and nearly 7 times stronger than traditional concrete. When cured in a steam curer, the new mixture had a compressive strength 83% as strong as the control and over 8 times stronger than standard concrete. The increase in compressive strength of the new mixture compared to standard concrete allows for infrastructure to be developed with higher peak loads in a cheaper and eco-friendly manner. Increases in compressive strength indicate an increased lifespan of structures. This means that infrastructure can be built to last longer at cost-efficient rates. Ongoing experiments will provide stronger solutions to infrastructure.

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

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.  $\square$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution. 🛛 Yes 🗌 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

249

Project Number 6504

Title: Beyond Sunshine: Optimization of Solar Energy Production Using Automated Robot Control

# Student Name(s): A. Christy, N. Vachhani

### Abstract:

With the threat of global warming, green energy generation has become a lucrative alternative, with one option being solar panels. As a result, the energy industry has sought the use of solar panels despite their relatively low-capacity factor of 24.5%. The capacity factor is determined by comparing actual energy produced by a specified source versus the theoretical maximum energy that could be produced by that source over the same period of time. This low-capacity factor, often expressed as a percentage, is partially caused by the accumulation of particles due to various weather and environmental conditions.

The goal of this experiment was twofold. To identify the energy effect due to the lowcapacity factor, five light sensors were utilized beneath pieces of polycarbonate. These pieces included dirt, leaves, and water, each to simulate the aftermath of weather conditions, such as rain and windstorms. This resulted in an average illuminance decrease of 32% for dirt and debris, and less than 3% decrease for water, when compared to the control case.

To enhance the capacity factor, a computer-controlled automated system was designed and prototyped to read energy outputs, identify anomalies, and command the robotic movement of a device used to clean the panel. Testing of the cleaning procedure showed improvement in illuminance compared to its dirty counterpart, of 20% for dirt and debris, and 5% for water. Future work is focused on integrating our code with weather Application Programming Interfaces (APIs) to reduce unnecessary cleanings when sunlight is low.

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

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

242

Project Number 6505

Title: Piezoelectric Wind Harvesting Electrical Energy Conversion

### Student Name(s): D. Pueschel, J. Watrous

### Abstract:

Piezoelectricity is the act of generating electricity through the application of mechanical energy and pressure to certain crystals and proteins. It is less common, however, for piezoelectrics to be solely taken advantage of for their pure energy harvesting feature.

Over the last 10 years, researchers have hypothesized low-cost and smaller energy harvesting devices through piezoelectricity. A piezoelectric tree is a wind harvesting device that connects a tree-shaped shell with branches that are connected to leaves with piezoelectric generators. Wind applies pressure to the leaves which in turn causes the piezo generators to bend, adding pressure and generating electricity through them.

To test how leaf shape affects the electrical output of the piezo generators, three leaf types with approximately the same surface area were designed in order to measure the power generation. A typical leaf shape, along with a narrow sample and wider sample were tested. Two sizes of piezoelectric generators were also tested. A fan was used to blow air onto the leaves and voltage measurements were made to indicate energy generation.

The results of the investigation showed that there was not much difference between the two sensors and on average the narrow leaf generated 25% more volts than the jagged leaf, while the wider leaf generated 12.5% fewer volts than the jagged leaf. In a world with an exponentially growing sustainable energy market, piezoelectric trees with wider leaf shapes could be a great alternative to other energy harvesting methods.

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

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

potentially hazardous biological agents

- vertebrate animals
- controlled substances
- 2. Student independently performed all procedures as outlined in this abstract.  $\blacksquare$  Yes  $\Box$  No
- 3. This project was conducted at a Registered Research Institution.  $\Box$  Yes 🛛 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

218

# **CSEF Official Abstract and Certification**

Fair Category

Project Number 6507

Title: Turf vs. Grass: The effects of heat

### Student Name(s): A. Galaski , R. Zelaya

### Abstract:

There has been considerable controversy in the past over the use of turf and grass fields, on which is more beneficial to athletes' health, specifically in the tradeoff between heat effects and durability. This project focuses on the effect of heat on samples of grass and turf. These samples were compared to see which sample absorbs more heat: if grass fields do not absorb as much heat as turf, then they are more beneficial to athletes' health. In this experiment, two three-gram samples of turf and grass were placed under a heat lamp for 30 minutes. The temperature of each sample was measured in ten-minute intervals starting at room temperature. The heat lamp was about 4 inches above the samples, and they were placed under in way for even heat distribution. There were 3 trials done and the results of all trials ended with turf being at a higher temperature. The highest temperature the grass sample reached after 30 minutes was 27 C° and the turf reached 32 C°. When the samples were felt to the touch it was clear that turf had a higher temperature than the grass. Based on these results, turf absorbs more heat than grass.

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

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

214

# **CSEF Official Abstract and Certification**

Fair Category

Project Number 6508

Title: I See Vitamin C

### Student Name(s): G. Herrera, A. Aquino

### Abstract:

It is said that all types of juice have different amounts of vitamin C in them. This experiment tried to test three distinct types of juices that contain vitamin C. The investigation when completed will tell which type of juice out of lemon, lime, and orange juices has the most Vitamin C. The process involves using basic laboratory tools such as a burette, Erlenmeyer flask, though a titration of lemon, lime, orange juices, iodine solution, vitamin C powder/ascorbic acid powder, 1% starch, and distilled to accomplish this experience. 10mL of the juice, with the starch being the indicator when reacted for the analysis. It became evident that all trials turned into dark blue colors. Upon further inquiry, the blue eventually turned darker blue. Notably, all three juices used changed color. Lemon juice showed a darker blue color compared to lime and orange juice. The result of the trials with lemon juice turned out to be an average of 312.3 mg (about the weight of ten grains of rice)/mL as reported in the experimental data table. The implication is that lemon juice contains more vitamin C per milliliter. It would be expected that orange juice has the most vitamin C from the research but is not the case as evident in the report.

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

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

221

### **CSEF Official Abstract and Certification**

Fair Category

Project Number 6509

Title:Developing a Research Tool to Help Determine the Risk of Chronic Traumatic<br/>Encephalopathy in Football Players

Student Name(s): G. Lauria, C. Hisler

### Abstract:

Chronic Traumatic Encephalopathy is a progressive illness that is connected to the frequency with which the head receives repetitive trauma. Chronic traumatic encephalopathy (CTE) is found in many football players after they die, and could be the cause of why some players die earlier on in life. However, players cannot be diagnosed with CTE until after an autopsy is performed. Not enough is known about the neuropathology of CTE to be able to develop a tool to diagnose living people with CTE. The purpose of this project is to develop a data collection tool for football players to understand the connection between hits to the head and symptoms that may be associated with CTE. To develop this tool, a survey was created for football players to fill out after their games. Players anonymously recorded their player position, the number of traumatic head injuries, and estimated number of hits to the head during a game and filled out a questionnaire focusing on symptoms that are associated with CTE. The data received from high school football players conveys a weak positive correlation between the self reported number of hits and the number of symptoms associated with head injury. This study will help future researchers further their understanding of CTE and increase awareness among football players of the connection between head injury and CTE.

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

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.  $\square$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution. 🗌 Yes 🛛 🗙 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

182

Project Number 6510

**Title:** The Future of Plastic

## Student Name(s): K. Nieves, J. Calderon

### Abstract:

Plastic, a newly synthetic manufactured and durable material, saw its beginning at the crack of the 20th century. In that era, plastic's durable and long-lasting nature gave hope to plastic, becoming the material of tomorrow, it was to an extent that Everybody's Magazine in 1907, called synthetic chemist work on plastic "miracle workers." Now at the turn of the century, plastic supply has never grown bigger, with hundreds of thousands of plastic bags being used every day. While alternatives for plastic materials, such as paper are frequently used, cutting down trees to replace plastic, causes a completely new host of problems. To see the subsidization of plastic, making bags biodegradable seems like a worthy solution. These bags could lead to future innovation in the quality of their designs, provide an opportunity for users to become more eco-friendly, and thus provide permanent and better solutions to lessen the quantity of plastic used by humans. To this end, the goal of this experiment is to create a biodegradable material to substitute plastic, so to avert the impact of plastic on the environment.

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

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

183

Project Number 6512

Title: Utilization of Recycled Materials as an Efficient Insulator for Power Distribution Lines

### Student Name(s): C. Quinson, C. Choy

### Abstract:

The purpose of this project was to create efficient insulators from recycled materials in an effort to insulate currently uninsulated, high-voltage transmission lines. Potential materials to be used as insulators were researched and selected for study based on high-temperature resistance and durability. Four synthetic candidates were selected: nylon, chlorinated polyethylene, ethylene propylene, and neoprene. It was hypothesized that melting and molding these materials around solid core copper wire would reduce energy loss during transmission from the source at a rate that is comparable or more effective than the current HVDC system which averages a 10-12% loss of energy. Insulators were heated until malleable and then molded to a 12 gauge copper wire independently and in combination. The insulators' efficiency was tested by measuring amperes transmitted through the wire using a multimeter. Results were compared against both a bare 12 gauge copper wire and a 12 gauge copper wire with silicone insulation as controls. Data analysis suggests several of the hybrid materials proved more effective in increasing amperes transmitted, illustrating a reduction of energy loss across the span of the insulated wire.

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

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

216

Project Number 6514

Title: Association between Aggressive Behavior in Purebred and Mixed Breed Canines and Gene Variants

Student Name(s): C. Nemec, G. Pascal, S. Augustine

### Abstract:

In 2017, one in sixty-nine people were bitten by dogs. This sparked our exploration of the genetic roots of aggression and how it correlates to certain breeds of dogs. Previous studies have identified gene variants for dog aggression using genome wide associations. It is hypothesized that differences within DNA amongst certain breeds of dogs are associated with dog aggression. In our study we mined data from Darwin's Ark. We will develop a multiple linear regression model using R studio to see if there is a correlation between mixed vs. purebred, the presence of this chromosome, and if it is homozygous vs heterozygous or neither. The dog aggression score will be the dependent variable while chromosome 18:20272961:A:C is the independent variable. We will then calculate the coefficient of determination to see which variable explains how much the dependent variable is explained by the independent variable. This number needs to be adjusted to account for the high number of variables - this means we'll also have to calculate the "adjusted r squared" which gives a more unbiased estimate. We predict that the mixed breeds will be associated with genetic variants that correlate with aggressive behavior. This research enables us to find a possible explanation behind dog aggression by applying a scientific perspective behind a dog's reactions.

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

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

226

Project Number 6515

Title: Developing Methods to Enable Environmental Recognition for Autonomous Vehicles

### Student Name(s): A. Song, K. Tihaiya, R. Francis

### Abstract:

Vehicle accidents are relatively common and cause significant loss of life throughout the world. While autonomous driving (AD) has been achieved before, improvements are needed before autonomous vehicles (AV) become robust and trustworthy. Developing a vehicle ambient of its environment is critical for implementing autonomous vehicles. In this project, the goal was to create an environment and model vehicles capable of detecting obstacles. From here, these models can be scaled up to life-size vehicles to create safer methods of AD. An environment was created with pipes as guard rails, card boxes as obstacles, and white tape on the ground as road markings. The model car can take in information from its surroundings and make informed decisions about how to proceed. It consists of a modified Traxxas Slash 4x4 Premium Chassis, an Nvidia Jetson TX2 module, VESC 6 MkV, Hokuyo 10X lidar, and a Logitech camera. The car can travel for an extended time by utilizing a LiPO battery, allowing for more tests. It senses its environment through a Hokuyo 10X lidar sensor and a camera. Transfer learning was implemented to detect the obstacles through cameras. ROS (Robot Operating System), a software library for building robot applications, allows the car to interpret and use the data obtained to perform acute decisions. Overall, the model provides an applicable foundation for testing new AD methods safely and efficiently.

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

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.  $\square$  Yes  $\square$  No
- 3. This project was conducted at a Registered Research Institution. 🛛 Yes 🗌 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):

# **CSEF Official Abstract and Certification**

2022

Project Number 6516

Title: Lunar Rover Landing Project

Student Name(s): C. Hart, F. Hopstaken

# Abstract:

Caelan Hart and Fabian Hopstaken

This project will reflect on the present issue of scanning for data on another planet such as Mars safely and efficiently. The project's goal is to create a possible detection mechanism that could provide a safe landing zone for a lunar rover, whilst protecting materials collected and the technology of the rover. It is important to create a simplistic and safe prototype for a lunar rover that can protect cargo. The parameters that must be considered are the atmospheric pressure of a planet such as Mars as well as being able to identify the landscape on other planets when deploying a rover onto the surface of the planet. To accomplish this research of NASA-type models and performing tests on a prototype to help create a basic understanding of the parameters for such a feat. Current results show that the overall atmospheric pressure of Mars is 6.518 millibars or 0.95 psi which can be compared to Earth's sea level psi of 14.7 PSI. The atmosphere of Mars consists of 95% Carbon Dioxide and much less than 1% of Oxygen.

Conclusions include that any planet, such as Mars, is very hostile. A prototype would need to resist the atmospheric pressure of Mars as well as the environment itself in order to protect equipment and the material collected. The implications would allow for future development in lunar modules.

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

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

	human	subjects	S
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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.  $\Box$  Yes 🛛 No
- 4. Is this project a continuation?  $\Box$  Yes  $\boxtimes$  No
- 5. My display board includes photographs/visual depictions of humans (other than myself or my family):