Project ID: 291

Senior Division

Engineering: Electrical, Mechanical, and Robotics

Alex Battikha
Westview High School
Gr. 11

Using Artificial Intelligence and Unmanned Aerial Vehicle for Aid on Environment Remediation

AWARDS:

Grand Award Runner Up #2 - Senior Division Physical Sciences
American Society of Civil Engineers - Senior Division 2nd Place
BIA Cares - Senior Division 2nd Place
Office of Naval Research - Senior Division Winner
CSEF Qualified

Addressing inefficiencies and impracticalities in human involvement and existing aerial methods for environmental remediation and monitoring, a novel unmanned aerial vehicle (UAV) platform was developed. With integrated AI-computational capability and a lightweight frame, the UAV system aims to revolutionize monitoring, prioritizing cost-effectiveness and scalability. The prototype achieves a model precision of 95.6%, setting a new sustainability standard through collaborative learning. Additionally, it proves highly affordable and scalable through a 150% cost-effectiveness improvement over current solutions.

To overcome current limitations, the research highlights the integration of cutting-edge advancements in Artificial Intelligence (AI) and cost-effective AI-accelerated platforms. This integration enhances the system's adaptability across diverse environments while ensuring a user-friendly platform that allows for the creation of collaborative learning models. The innovative approach ensures the UAV system's functionality in various environmental conditions, regardless of identification complexity. By delivering an affordable and highly scalable solution, the proposed UAV system represents a significant advance in environmental risk and damage identification, offering a more efficient and accessible monitoring framework.

Project ID: 292

Senior Division

Engineering: Electrical, Mechanical, and Robotics

Logan Brown

High Tech High North County

Gr. 11

Democratization of Metal Fabrication Through a Novel Electrochemical Machining Process

AWARDS:

Collins Aerospace Fred H. Rohr Science Award
American Society of Mechanical Engineers - Senior Division Winner
CSEF Qualified

Metal parts are the foundation of modern technology. Unfortunately, machining, the primary process used to manufacture metal parts, is difficult and costly, especially for high-strength metals and complex shapes.
To make machining more cost-effective, I created a novel 3-axis CNC machine that utilizes electricity and saltwater to dissolve away material in a process called electrochemical machining (ECM). This process involves no cutting forces, and therefore does not need the same level of strength and rigidity as a conventional CNC machine. Furthermore, the ECM process exhibits no tool wear, allowing tools to be used indefinitely without being replaced, leading to reduced tooling costs. My machine is 10 times cheaper than the least expensive conventional machines.

Since the mechanical properties of the material being machined have no effect on the ECM process, it can make parts out of almost any conductive material, even materials that are extremely difficult or impossible to machine conventionally, like hardened steel, tungsten carbide, and nickel-based superalloys. This process can make use of extremely small tools like needles and wires to make fine parts that would be destroyed by the forces and tool wear involved in other machining processes.

My ECM machine can produce complex parts out of carbon steel with tolerances within 0.2mm. My machine also completely recycles its electrolyte using a novel filter design that costs less than twenty dollars and has no moving parts, which is not possible using existing techniques. This makes the machine more sustainable and environmentally friendly by reducing waste produced.

Project ID: 293
Senior Division
Engineering: Electrical, Mechanical, and Robotics

Khushee Goel
Scripps Ranch High School
Gr. 10

An Intelligent Fire Extinguisher for Outdoor Home Protection

Fires are responsible for significant destruction of property, yet there is a lack of technology for outdoor fire surveillance/management. To combat this problem, I built a robotic system to autonomously identify, target, and extinguish outdoor fires during its early stages of ignition. My design is built with readily available mechanical components/electronics and the computer vision model is open source, such that the product can be made accessible to a large population.

To develop the robotic system, I began by defining the mechanical, electrical, and software subsystems. The software subsystem includes perception, processing, and a feedback loop. Using a Python Jupyter Notebook, I virtually tested a YOLO AI model to measure the computer vision algorithm accuracy. The electrical subsystem consists of a Raspberry Pi, Arduino Uno, and SeeedStudio Relay board, which work to control the sprinkler valves. To develop a sound mechanical design, I practiced the iterative design process. Starting with a custom gimbal prototype, I found that servos were not the optimal design choice, as input for exact positioning was required and error in target alignment was likely. The Rain Bird Premium Impact Sprinkler had a wider range and was a more dynamic design option. Testing the final prototype, smoke/fire was identified with high accuracy, the sprinkler valve was successfully triggered, and the water jet had a range of 15+ feet.

The end product is “An Intelligent Fire Extinguisher for Outdoor Home Protection,” the autonomous robotic system for identifying, targeting, and extinguishing outdoor fires.

Project ID: 294
Senior Division
Engineering: Electrical, Mechanical, and Robotics

Rachit Jaiswal
Del Norte High School
Gr. 11

AI and Robotics: Extracting Plastic from the Ocean

AWARDS:

American Academy of Pediatrics Climate Change and Health Committee – SR Div Honorable Mention

Addressing the challenge of plastic recycling is particularly challenging in remote locations, primarily due to the complexities in recovering plastic for recycling. For instance, the Pacific Garbage Patch, a massive concentration of oceanic plastic waste, has expanded to an area more than twice the size of Texas. This growth demonstrates the pressing need for innovative solutions to efficiently retrieve and recycle plastic in such areas, without severely impacting the surrounding environment and marine life. My plan is to create a robotic arm programmed with an artificial intelligence model based on Tensorflow Keras models and have it detect and move towards different types of plastic bottles while being able to recognize which type of bottle it is holding. Picking up the bottle will need to be done through industrial, water resistant parts, which is why the project's focus is movement towards an object. A hard part of the project is the classification between different bottles due to miniscule differences. The project was successful, with an accuracy of 60% with 20 categories; a 55% increase in detection accuracy. The robotic arm, a gobilda 2 stage viper slide, was able to successfully move towards the bottles. Considering some other alternatives, which include multi-object classification and tend to have lower accuracies for plastic bottles while not categorizing them, this project has provided a newer insight into the potential for Machine Learning in environmental protection.

Project ID: 295

Senior Division

Engineering: Electrical, Mechanical, and Robotics

Sanya Kapoor
Del Norte High School
Gr. 10

Optimization of Energy Consumption at Wastewater Treatment Plants

AWARDS:

American Academy of Pediatrics Climate Change and Health Committee - Senior Division 1st Place
American Society of Civil Engineers - Senior Division 1st Place
San Diego County Water Authority - Senior Division 2nd Place
WateReuse Association - San Diego Society - Winner

Clean drinking water is a worldwide challenge affecting one in three people globally (UNICEF 2019) Freshwater demand continues to grow 7-8%. Access to sources of freshwater is getting even scarce.
Problem with alternate sources of water production like Wastewater treatment and desalination plants is the high cost of production due to heavy energy requirements. This in turn is restricting the widespread adoption of such solutions.

The goal of this project is to explore deep learning techniques to develop a novel computational model for the robust prediction of various setpoints which reduces energy consumption significantly during the Reverse Osmosis (RO) process in the plant. It also alleviates human error which usually leads to significant operational downtime. Nineteen unique data points across Sensor data, Climate data, Time of day, and Hydraulic data were collected from publicly available datasets and weather station records.

A novel technique of predicting efficient setpoints for least energy consumption was verified successfully. Climate and water salinity data has not been used before to predict operational setpoints. Multiple features (internal and external to the treatment plant) were collectively used to increase the strength of predictability, instead of simply relying on outflow feed rate. Various neural network and decision tree models were trained to achieve best possible results. Further optimizations such as early stopping, data augmentation, and K-fold accuracy were performed to reduce bias and improve accuracy.

Project ID: 296

Senior Division

Engineering: Electrical, Mechanical, and Robotics

Angelina Kim
The Bishop's School
Gr. 11

An Autonomous Unmanned Aerial Vehicle (UAV) System for Ocean Hazard Recognition and Rescue: Scout and Rescue UAV Prototypes, Findings, and Next Steps

AWARDS:

Grand Award - Senior Division Physical Sciences – ISEF FINALIST
Armed Forces Communications Electronics Association (AFCEA) Senior Division Winner
Office of Naval Research - Senior Division Winner
Society of Women Engineers - San Diego County Section - Senior Division 1st Place
CSEF Qualified

Autonomous Unmanned Aerial Vehicles (UAVs) have potential to aid lifeguard operations. However, commercial drones employed at select guarded beaches still require the manual lifeguard operation. The purpose of this research was to develop an autonomous UAV system where a scout UAV can accurately detect dangers (rip currents) early and activates a rescue UAV, which shortens the rescue response time by dropping flotation devices and pulling victims to safety. The scout quadcopter was designed, built, and implemented with autonomous flights. The scout drone has wide-range triple radio communication links for control and manual override. Launch procedures and safety protocol were established. Seven ocean scout missions were conducted and collected 11.8k ocean images over 13.4km at San Diego beaches. Image analysis with averaged differential frame displacement vectors was conducted for optical flow: particle image velocimetry was estimated with machine learning, and the resulting wave displacement vectors were used to identify rip currents with a deep neural network. For the rescue coaxial hexacopter, a novel in-arm pitch axis design was designed, built, and tested in flight. The rescue UAV spans 2.0m and weighs 12.3Kg with 44.1Kg total thrust for rescue missions. It can be folded into 1.1m for transportation. The in-arm pitch axis extends pitch angle by more than 65% from conventional end-arm pitch axes. The pitch axis realizes the most pitch angle up to +/-45 degrees with symmetric coaxial actuators when compared to conventional UAVs and has wide roll angle up to +/-180 degrees.

Project ID: 297
Senior Division
Engineering: Electrical, Mechanical, and Robotics

Malik Mansour
Bright Horizon Academy
Gr. 9

Solar Powered River Cleansing Robot

AWARDS:

American Academy of Pediatrics Climate Change and Health Committee – SR Div Honorable Mention
San Diego County Water Authority - Senior Division 3rd Place

The purpose of this project is to engineer a river cleaning robot with advanced sensors, propellers and a innovative system for the floating debris that are causing pollution. By developing a product that efficiently detects, collects, and monitors debris in waterways while being powered by Solar batteries/panels. Through reducing water pollution, improving ecosystem health, and assisting communities dealing with these challenges, the project takes a step forward to cleaning the planet.

After the completion of the prototypes and adjustments to the robot, 5 experiments were done(not including test runs), ranging from tiny falling leaves to tiny plastic and wooden components with small, medium, and big testing areas. After the tests, photos were taken of the before and after for the test 5 tests, and a A photo of the GPS tracker tracking robot's positions on the app, along with observations.

In conclusion, the robot followed the program and navigated successfully to gather debris. It functioned well even without a wall in the water water since it was able to set its own boundaries by modifying the program. Larger areas took a little longer for the robot to cover, The robot collected 95% of the harmful debris. Additionally, a photo was taken of the GPS tracker showing the Robot's positions, Everything was uploaded on a slideshow for the presentation.

Project ID: 298

Senior Division

Engineering: Electrical, Mechanical, and Robotics

Yash Patil

Sage Creek High School

Gr. 11

Enhancing Prosthetic Functionality Through the Use of Compliant Mechanisms and 3D Printing

This study tackles the hard challenges inherent in traditional prosthetics, where limited functionality and exorbitant manufacturing costs present formidable obstacles to widespread accessibility. With approximately 5.4 million individuals worldwide requiring prosthetic devices due to limb loss, the financial burden remains a significant barrier, with costs often exceeding $5,000 for basic prosthetic limbs. Moreover, the intricate nature of prosthetic mechanisms, compounded by moving parts, adds complexity to maintenance and repair processes, further impeding accessibility. In response, this research proposes the development of a 3D printed compliant mechanism as a cost-effective alternative. Leveraging the rapidly advancing capabilities of 3D printing technology, which has seen a 21.5% compound annual growth rate from 2020 to 2022, and the inherent flexibility of compliant mechanisms, the prototype aims to address the shortcomings of conventional prosthetics. By sidestepping the need for costly molds and tooling, 3D printing offers the potential to reduce manufacturing costs by up to 90%, making prosthetic devices more financially attainable for individuals worldwide. The primary objective of this study is to design a prosthetic device that not only mitigates financial barriers but also enhances long-term usability and maintenance efficiency. By eliminating moving parts, the proposed prototype seeks to streamline design iteration processes, enabling quicker adjustments to individual user needs. Through rigorous experimentation and analysis, this research aims to demonstrate the feasibility and efficacy of the 3D printed compliant mechanism as a viable solution for affordable and accessible prosthetics. Ultimately, this innovative approach holds promise for revolutionizing prosthetic technology, ushering in a future where individuals in need of prosthetic limbs can enjoy improved quality of life through cost-effective, customizable, and easily maintainable solutions.

Project ID: 299
Senior Division
Engineering: Electrical, Mechanical, and Robotics

Sherwin Salemi
High Tech High North County
Gr. 11

3D Particle Image Velocimetry Using Scanning Laser Planes and Optical Flow

AWARDS:

CSEF Qualified

Tracking airflow in 3D volumes has many important applications, such as optimizing wing geometry in aerospace or tracking airborne viruses in biology. This is a challenging problem due to the difficulty of capturing precise data from vapor patterns, and interpreting motion from the results. In this project, a rotating laser plane is used to illuminate a vapor-filled volume cross section, which is recorded by a camera. The frames recorded are processed by a computer vision algorithm to detect edges and velocities. The result shows this system is capable of capturing the velocity vector field of airflow over time in 3D with high precision.

Project ID: 300
Senior Division
Engineering: Electrical, Mechanical, and Robotics

Rohin Sood
Del Norte High School
Gr. 11

Differential, Multi-Jointed Robotic Arms with Inverse Kinematical Adaptive PID Control for Telesurgery

Telesurgery, a revolutionary approach to remote medical procedures, holds immense potential for improving healthcare accessibility and delivery. However, existing challenges, such as ensuring precision and safety while mitigating high costs, impede its widespread adoption. This research aims to address these issues by developing a proof-of-concept prototype robotic arm for telesurgery. Our approach focuses on minimizing costs through innovative mechanical design, reducing the dependency on expensive electrical components. The proposed differential, multi-jointed robotic arms incorporate Inverse Kinematical Adaptive PID Control, aiming to enhance precision during surgical procedures. Through this project, I strive to make telesurgery more accessible and economically viable, thereby contributing to the advancement of remote surgical technologies and broadening the reach of quality healthcare.