Regeneron International Science and Engineering Fair (ISEF)

USAID Science for Development Award
2024 Winners

Global Health and Nutrition

Education and Youth

Climate and Environmental Protection

Working in Crisis and Conflict

17 young scientists
$40,000 in awards
Brilliant **solutions** for development

USA   Zimbabwe   Thailand   India   Turkey   Pakistan

Global Health and Nutrition

1st Place:

Faisal Isam Nabulsi & Michael Xu, USA

SCOMAE: Diagnosing Tuberculosis from Cough Acoustics Using Supervised Contrastive Masked AutoEncoders
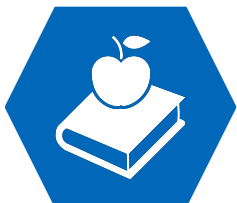
2nd Place:

Siriarpha Panturaporn & Siripapha Panturaporn, Thailand

Alternative Organic Sanitary Pads From Plant Fibers Enhanced with Gooseberry Extract Coating

3rd Place:

Jackson Wilson, USA

DengueScreen: A Novel Computer Vision-Based Diagnostic Alternative for Dengue Fever Prioritizing Efficiency, Cost-Effectiveness, and Accuracy

Education and Youth

1st Place:

Abhishek Amit Shah, USA

AuralStudio: A Multisensory Development Environment With a Novel, Bytecode-Compiled Programming Language

2nd Place:

Maya Shah, USA

Prevention of Gun Violence Through the Buffering Effects of Intellectual Humility in Traumatized Psychopaths

3rd Place:

Nira Goyal, USA

A Review of the Use and Promotability of Mental Health Apps by Teenagers

Climate and Environmental Protection

1st Place:

Kshemaahna Nagi, India

A New Cost-effective Adsorbent Device for Civic Remediation to Reduce Lead, Copper and Cadmium in Surface Water Runoff
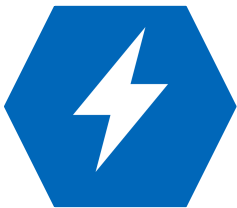
2nd Place:

Ruvarashe Moyo, Zimbabwe

A Low Cost and High Performance Xylem-Activated Carbon Filter Water Purification Device: A Novel Approach to the Global Clean Water Crisis

3rd Place:

Haaris Masood & Haon Kim, Pakistan

Leveraging Electrochemistry and Light Scattering to Improve Air Quality Detection

Working in Crisis and Conflict

1st Place:

Sierra Anne Sun, USA

Differential Empathy, Social Dominance Orientation, and the Limitations of Social Science Research

2nd Place:

Burak Eren Demir, Muhammet Basar Ozcan & Salih Celik, Turkey

A Mesh Network-Integrated Multi-Robot Team With Electronic Nose for Human Detection Under Rubble in Post-Disaster Scenarios

3rd Place:

Meenakshi Nair, USA

Urban Slum Detection and Mapping: Semantic Segmentation on VHR Satellite Imagery

Regeneron International Science and Engineering Fair (ISEF) Winners
USAID Science for Development Award

Global Health and Nutrition

USAID FROM THE AMERICAN PEOPLE

Regeneron International Science and Engineering Fair (ISEF) Winners
USAID Science for Development Award

1st Place

Faisal Isam Nabulsi & Michael Xu

USA

SCOMAE: Diagnosing Tuberculosis From Cough Acoustics Using Supervised COntrastive Masked AutoEncoders

Abstract: Tuberculosis (TB), a leading cause of infectious disease death worldwide, disproportionately affects lower-and-middle-income countries (LMICs). When diagnosed early, TB is very curable, but when left undiagnosed for long periods of time, it can be deadly to the patient and spread throughout the community. Especially in LMICs, current diagnostic methods are slow, resource-intensive, and inaccessible, resulting in the prolific spread of TB within the host and within communities. In order to eradicate TB and ameliorate health disparities, more accessible and scalable diagnostic methods must be introduced. Cough, the most common symptom of TB, exhibits unique acoustic characteristics that vary across different respiratory diseases, suggesting potential for diagnosis based on cough sounds. Previous attempts to develop a machine learning-based algorithm to detect TB from cough audio have largely been unsuccessful due to limited availability of labeled data. In this work, we design and implement a novel self-supervised learning architecture optimized for TB detection from cough sounds, combining Masked Autoencoders and Supervised Contrastive Learning. We pretrain our network on a vast corpus of audio data and then fine-tune it on a dataset of labeled cough recordings from TB patients. Evaluated on a public benchmark, our model achieved an area under the receiver operating characteristic curve (AUROC) of 0.843 on the task of TB detection from cough sounds, outperforming all published techniques to the best of our knowledge. This breakthrough not only sets a new standard for cough-based TB diagnosis, but also marks a significant stride towards the global eradication of TB.

Please note that all abstracts are written by the pre-college student of the winning project and to preserve the integrity of their work, the language has not been modified.

Global Health and Nutrition

2nd Place
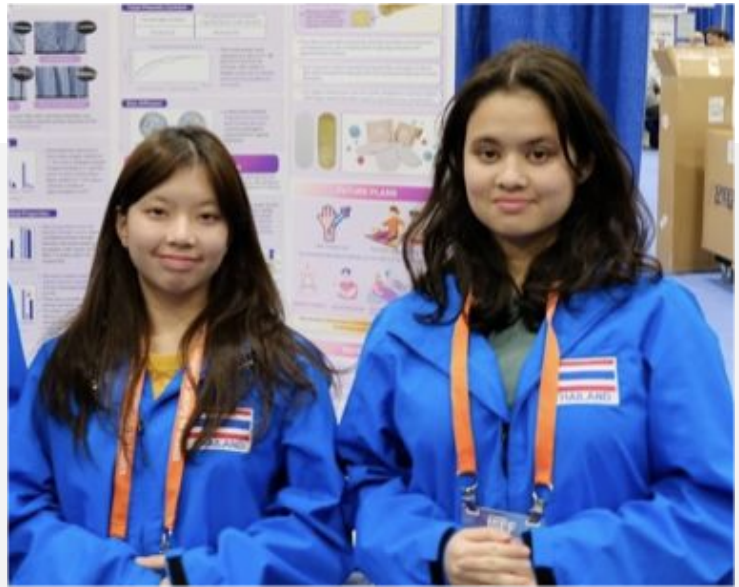
Siriarpha Panturaporn & Siripapha Panturaporn

Thailand

Alternative Organic Sanitary Pads From Plant Fibers Enhanced with Gooseberry Extract Coating

Abstract: Sanitary pads are critical for effective menstruation management, especially in developing countries where access to high-quality menstrual hygiene products is commonly limited. In these areas, the use of inferior sanitary products frequently leads to health problems, such as vaginal infections. Additionally, most available options are made from synthetic polymers that are non-biodegradable and detrimental to the environment. To tackle these challenges, we developed organic sanitary pads using fermented plant fibers derived from pineapple leaves (Ananas comosus L.), banana sheaths (Musa sapientum L.), hemp stems (Cannabis sativa L.), and paper mulberry (Broussonetia papyrifera L.). These fibers are treated with Actinomycetes and Aspergillus sp. to facilitate the degradation of recalcitrant lignocellulose through the action of lignocellulolytic enzymes. Post-treatment analysis revealed that banana and paper mulberry fibers demonstrated favorable physical and mechanical properties for fluid absorption. To produce organic sanitary pads, we incorporated a crude gooseberry extract as a top coating on a 0.20 mm thick woven layer of banana fiber, which effectively inhibited Staphylococcus aureus and Candida albicans, common pathogens responsible for vaginal infections. The middle layer of the pad features a 0.60 mm thick absorbent core made from paper mulberry sheets, and the base layer is waterproof bioplastic. Furthermore, our organic sanitary pads meet the ISO standards for sanitary napkins, achieving an optimal absorbent capacity, absorption time, and pH level. This development provides a sustainable alternative to conventional synthetic products, potentially expanding to broader applications and offering an environmentally friendly solution with widespread usability.

Winner Spotlight: Siriarpha & Siripapha Panturaporn

Siriarpha and Siripapha Panturaporn, twelfth-grade students from Chiang Mai, Thailand, are sisters united by their passion for science, community service, and advocacy. Siriarpha, who leads her school's Mental Health Awareness Club, is deeply committed to promoting mental well-being among teenagers. **"Winning the USAID Science for Development Award has fueled my passion to study and work towards making a positive impact on society, particularly in advancing opportunities for women," Siriarpha shares.** Siripapha, equally dedicated to the sciences, is an active member of the school's science club, where she engages in rigorous experimentation and research. Beyond academics, she volunteers her artistic talents to bring joy to young children by decorating primary schools with colorful murals. **"Through rigorous experimentation and analysis, I am committed to innovating something that can help the world, merging my passion for science with a dedication to advancing human welfare**," Siripapha explains. Both sisters are staunch advocates for environmental conservation and gender equality within their community. Their aspirations lie in the field of biomedical science, where they hope to combine their shared passions to make significant contributions to human welfare and scientific knowledge.

3rd Place

Jackson Wilson

USA

DengueScreen: A Novel Computer Vision-Based Diagnostic Alternative for Dengue Fever Prioritizing Efficiency, Cost-Effectiveness, and Accuracy

Abstract: Dengue (break-bone fever) is an endemic viral infection in more than 100 countries. Each year, approximately 3.9 billion people are at risk. Dengue fever infects 100-400 million of them. It is extremely difficult to diagnose dengue fever in an accurate, low-cost, and efficient manner. Because of this, the number of clinically manifested cases (96 million) is significantly less than the projected 390 million per year. This difference is a strong indication of frequent undiagnosed infections. There is a demonstrable need for additional improved diagnostic tools to fill these gaps. Artificial intelligence-based tools are a powerful alternative, capable of combining the predictive accuracy, accessibility, and cost-effectiveness of the traditional best tools. Specifically, machine learning has been effectively applied to dermatological identification problems, achieving above 99% accuracy in several cases. This study was designed to transfer these effective techniques to a similarly high-performing tool for dengue diagnosis that analyzes smartphone images of cutaneous rashes. Therefore, the researcher evaluated the diagnostic performance of modified ResNet-50, ResNet-18, GoogLeNet, ShuffleNet, and RegNet architectures on a balanced dataset of 300 dermatological images. Performance metrics such as accuracy, precision, recall/sensitivity, specificity, and AUC were analyzed. The highest accuracy was 99.62%, a tie between the ResNet-50 and RegNet architectures. These results demonstrate that neural networks such as the above models can accurately identify dengue fever with a novel combination of efficiency, cost-effectiveness, and distributability. These models have the potential to revolutionize dengue identification, as they can be deployed on a variety of accessible devices.

Education and Youth

Education and Youth

1st Place
Abhishek Amit Shah

USA

AuralStudio: A Multisensory Development Environment With a Novel, Bytecode-Compiled Programming Language

Abstract: According to the World Health Organization, nearly 300 million people worldwide suffer from visual impairments, a number which is only expected to grow in the coming years. In the U.S. alone, nearly 70% of the visually impaired are not currently employed. On the other hand, computer science, which has been enjoying tremendous growth for decades, has largely excluded several disabled groups, the most prominent of which are the visually-impaired. Current development environments and programming languages are simply not accessible enough for the visually-impaired; less than 1% even attempt to learn to code. AuralStudio seeks to solve this issue through the creation of a new programming language and a development environment that: 1) includes a novel, Turing-complete, bytecode interpreter, 2) eliminates the mouse/keyboard, 3) provides multi-sensory feedback with a control pad, 4) highlights code's inherently hierarchical nature with acyclic digraphs, and 5) redesigns error messages for brevity/clarity. AuralStudio is tested on blind and low-vision students at a flagship government school for the blind, and is shown to significantly improve programming times, reduce bugs and provide a far more accessible and immersive development experience overall. Test results indicated no statistically significant difference between development time (from file creation to output) between visually-impaired and sighted students. This project shows that given the right tools, it is possible for the visually-impaired to not only foray into software development, but to be effective, efficient programmers; this work opens several doors for those with impaired vision, and the disabled overall, so that everyone is able to participate in the software revolution.

Winner Spotlight:
Abhishek Shah

Abhishek Shah, a rising senior from Cary, North Carolina, developed AuralStudio, a platform reimagining computer science for the visually impaired. Inspired by his own experiences and through his interaction with visually impaired students, Abhishek realized the difficulties faced by those with permanent visual impairments and was driven to bridge the educational gap in computer science for people with disabilities. Reflecting on his motivation, **Abhishek shared, "I didn't just want to create technology for those with disabilities, but rather to empower them to create technology of their own."** Winning the USAID Science for Development Youth and Education award was a pivotal moment for Abhishek, validating his efforts and amplifying the reach of his project. **"Receiving this award has not only given me confidence in the impact of my work but also provided me with the platform to connect with educators and developers who share a similar vision,"** he said. The recognition has encouraged him to further refine AuralStudio and expand its reach. Abhishek is now focused on conducting additional user interviews and plans to make the programming language open source to build a community focused on improving its design and implementation. With a deep-rooted passion for computer science that began in the fourth grade, Abhishek has explored fields such as app development, machine learning, artificial intelligence, and cyber security. He plans to study a combination of technology and management as an undergraduate next fall, to make a significant impact in the world and continue to develop innovative solutions that address challenges for people with disabilities.

2nd Place

Maya Shah

USA
Prevention of Gun Violence Through the Buffering Effects of Intellectual Humility in Traumatized Psychopaths

Abstract: Gun violence has become a threatening phenomenon that has been affecting the lives of Americans nationwide. Two main traits that show a predisposition towards gun violence are psychopathy and trauma. I focused on the interaction between childhood trauma and psychopathy, and I analyzed how intellectual humility affects this relationship. When looking at the relationship between these two traits, I found that psychopathy had a positive relationship with trauma ($r = 0.75$, $p < 0.001$). This means that there is a highly reactive at-risk population (traumatized psychopaths) that is more likely to use guns for violent purposes. Additionally, a moderation analysis showed that the relationship between trauma and psychopathy was moderated by intellectual humility $F(3, 157) = 74.16$, $p < 0.001$. So, systematically teaching the concepts associated with intellectual humility in schools could decrease the likelihood of traumatized psychopaths committing an act of violence. Additionally, a subscale of intellectual humility had a positive relationship with psychopathy ($r = 0.38$, $p < 0.001$). This means that psychopathic individuals are more likely to change their minds. This indicates that persuasive methods may be used to reason with psychopaths and prevent them from pursuing gun violence. This study utilizes novel relationships to help understand and address those who are prone to gun violence and outlines a proof of concept tool to mitigate gun violence predispositions in at-risk populations.

Winner Spotlight:
Maya Shah
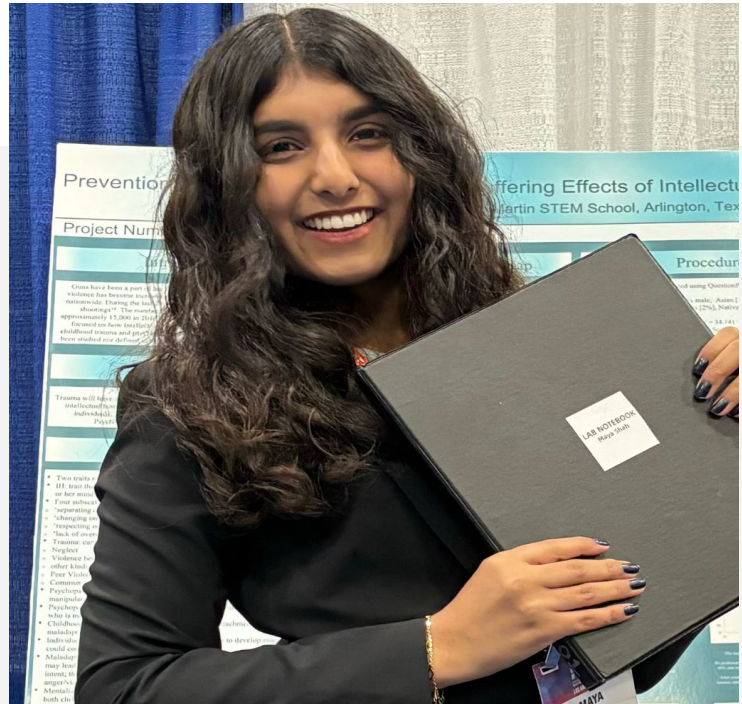
Maya Shah, from Arlington, Texas, is a dedicated advocate for gun violence prevention, driven by personal experiences with two school shootings and numerous lockdowns near her school. Her research focuses on the interplay between psychopathy, trauma, and intellectual humility to understand and mitigate the factors leading to gun violence. Maya discovered that increasing intellectual humility could lower psychopathy in traumatized individuals, thus reducing their predisposition to gun violence. Winning the USAID Science for Development Award recognized her work, highlighting the power of science to address controversial societal issues. She noted the significance of her findings, saying, **"To see that intellectual humility could lower psychopathy in traumatized individuals was a powerful discovery."** Maya plans to use her award funding to make her research open-access and hopes to implement her findings in her school by developing a curriculum that integrates these insights into student-led projects. She emphasized the impact she hopes to make, stating, **"I hope to help move the needle against what has become an epidemic of violence. My research might not solve every school shooting, but I aim to be one of the many solutions that arise for this pressing problem."** Maya's dedication to creating opportunities for young researchers is evident in the research club she revived at her school, fostering a supportive environment for her peers. She hopes her work will inspire others and contribute to solving pressing social issues through scientific inquiry.

Education and Youth

3rd Place
Nira Goyal

USA

A Review of the Use and Promotability of Mental Health Apps by Teenagers

Abstract: Suicide is the second leading cause of death in teens and young adults, emphasizing the urgent need for effective adolescent mental health care. Three hundred seventy-four teenagers assessed the Rose Mental Health app. In addition to providing demographic information, participants rated their likelihood of using and recommending the app on a 1-10 scale, with ten being the highest. The net promoter score based on the results of the survey was 16.04. The likelihood of personal app use significantly influenced the likelihood of recommending it ($p = 2.09 \times 10^{-32}$). Teens who had previously used a mental health app were more likely to recommend the app to a friend ($p = 1.59 \times 10^{-5}$). Gender also played a role, such that females and non-binary individuals were more likely to recommend the app ($p = 0.003585$). Race was not found to be a statistically significant factor regarding how likely teenagers were to recommend the app to a friend or use the app's features, suggesting that mental health app companies do not need to target different racial groups with different techniques. The study highlighted specific features, including mental health articles, personalized content, daily journaling, and questionnaires, to be helpful to teens and drive their preferences. Demonstration of mental health apps increased the likelihood of adoption. These insights underscore the importance of targeted strategies for promoting mental health awareness and care among teens.

Winner Spotlight: Nira Goyal

Nira Goyal, from Palm City, Florida, is a passionate advocate for mental health awareness who has centered her research on the potential of mental health apps to bridge gaps in mental healthcare accessibility. Her groundbreaking project explores teenagers' likelihood of using and recommending mental health apps as an alternative to in-person treatment, addressing the critical issue of mental healthcare shortages and affordability. Winning the USAID Science for Development Award is a monumental achievement for Nira, affirming the significant impact of her work and fueling her aspiration to make a global difference. **"Winning this prestigious award helps give me hope that my project can aid in the efforts to make sure everyone has access to quality mental healthcare,"** she explains. Nira's passion for mental health research was sparked by personal tragedy, having lost two family members to suicide, This experience motivated her to combat the stigma around mential illness by founding Teen Mental Reset, a non-profit dedicated to providing resources and support for teens, creating a safe space for young people to openly discuss mental health, and access the tools they need for their well-being. **"If the stigma around mental illness were not present, they may have been more inclined to seek treatment,"** she reflects. Nira's scientific journey has been profoundly influenced by her mentor, Dr. Erin Rosskopf of the United States Department of Agriculture (USDA), who inspired her to pursue a career in neuroscience and psychology. Nira hopes to become a psychiatrist or neurologist, helping to alleviate the mental healthcare worker shortage and continue her research on mental health treatment techniques. She advises young scientists to persist despite challenges, emphasizing the importance of passion and collaboration in scientific research. **"It is important to push past that feeling and follow your passion,"** she encourages. Nira's plans include examining additional mental health apps to gather more valuable data, which she hopes will contribute to improving mental health accessibility and treatment for teenagers worldwide.

Climate and Environmental Protection

1st Place

Kshemaahna Nagi

India

A New Cost-effective Adsorbent Device for Civic Remediation to Reduce Lead, Copper and Cadmium in Surface Water Runoff

Abstract: The number of annual lead-poisoning fatalities exceeds the combined annual fatalities from car accidents and malaria. Cadmium causes DNA damage. A leading heavy metal exposure source is surface water contamination, lethal to direct consumers and others through biomagnification. To combat this, I devised a 3-part framework. First, major contamination-pathways or 'sources' were identified as runoff from improper battery disposal sites, carwash and maintenance facilities. Composite water sampling of sources and depth-integrated sampling of sinks like lakes from 4 locations across India was conducted. QQQ-ICPMS was used to analyze samples for lead (> 0.01 mg/L), copper (>0.08 mg/L) and cadmium (>0.02mg/L) and grade them based on contaminant levels. Regression and spatiotemporal models enabled identifying sinks at risk. Based on this, I developed a mathematical model to predict lead, copper and cadmium levels in lakes without the expensive, cumbersome and time-consuming process of ICPMS samples testing. Then, potential cost-efficient adsorbents were evaluated on flow rates and coefficient of permittivity using Darcy's Law. The flow volume/time was deduced for standard inlet drains. Adsorption experiments were performed and isotherms constructed. Finally, a layered-adsorbent was constructed using 0.1 M Caustic Soda-treated Rice Husk, kaolinite and Compressed Coconut Fiber structure along with a sensor and a coagulation layer. Carbon-negative rice-stubble biochar reinforced-casing provides structural integrity and increases detention time for adsorption. When placed in surface water inlets, the device reduces Pb and Cd by 95-98% and Cu by 72%. The device costs an average of 14 USD/surface water body (a heavy metal treatment plant costs on average 150000 USD).

2nd Place

Ruvarashe Moyo

Zimbabwe

A Low Cost and High Performance Xylem-Activated Carbon Filter Water Purification Device: A Novel Approach to the Global Clean Water Crisis

Abstract: Globally, over 2 billion people lack access to safe drinking water leading to 3.4 million waterborne deaths yearly. Existing purification methods are often ineffective against both biological and chemical contaminants, or simply too expensive for low-income communities. This research designed an affordable, efficient, and sustainable water filtration device for household use in regions struggling with access to clean water. The device was engineered from a novel xylem-activated carbon filter made by leveraging readily available materials. Orange peels were used to bioengineer a broad-spectrum antimicrobial coating for the xylem filter, while activated carbon was combined with illite from clay soil to create a powerful filter media that has the ability to remove a wide range of chemical and biological contaminants. From laboratory tests, the xylem-activated carbon filter exhibited an exceptional performance removing over 99% of the contaminants tested. Additionally, it had a flow rate of exceeding 1.7L/h, thus, providing over 40 L of clean water daily, easily meeting a family's needs. Inspired by the device's high performance, community workshops were conducted, teaching people how to build these devices, to enable household water purification to be accessible. Over 120 households previously dependent on municipal contaminated water are now using the device, experiencing a drastic improvement in their water quality. This sustainable, low-cost and reliable water filtration device offers a powerful solution to the global clean water crisis and has the potential to enable more than one billion people to have access to water filtration and this could significantly reduce water-borne disease deaths by two million.

Winner Spotlight:
Ruvarashe Moyo

Ruvarashe Moyo, a final-year student from Harare, Zimbabwe, is a passionate advocate for sustainable development who has focused her research on improving water access using locally available materials. Her innovative project, which aims to create an affordable water filtration device for households, addresses the pressing need for safe drinking water in her low-income community. Winning the USAID Science for Development Award is a significant milestone for Ruvarashe, as it validates her work's impact and inspires her to continue making a difference. **"I want this project to inspire people in my community to be more conscious about their health and the water they use,"** she says. Ruvarashe's dedication to science began with a curiosity about the stars and evolved into a commitment to solving real-world problems. Her research journey has not been without challenges, particularly in accessing resources and gaining the technical knowledge needed to refine her device. **"There were times when I doubted whether I could really make an impact, but seeing the difference my work can make keeps me going,"** Ruvarashe reflects. Her plans include partnering with organizations to teach communities how to construct and use her water filtration device, improving its efficacy, and promoting health consciousness regarding water usage. Additionally, Ruvarashe envisions expanding her project beyond her local community, with hopes of adapting her filtration device to suit various environmental conditions in other parts of Zimbabwe and even across Africa. Ruvarashe's journey underscores the importance of local solutions to global issues and the power of young researchers to drive change. **"Every step forward, no matter how small, contributes to a healthier, more sustainable world,"** she concludes, embodying the resilience and vision that fuel her ongoing commitment to science and community development.

Regeneron International Science and Engineering Fair (ISEF) Winners
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Climate and Environmental Protection

3rd Place

Aditya Radhakrishnan

Pakistan
Leveraging Electrochemistry and Light Scattering to Improve Air Quality Detection

Abstract: With an estimated 6.7 million people dying from air pollution annually, and millions of others suffering from illnesses that are either caused or exacerbated by this epidemic, the AQI has become an integral part of our lives, especially for low-income communities that are disproportionately targeted by suboptimal air quality. Yet, with the AQI using 24-hour long averages, distilling too much information into one datapoint, leaving out CO_2 concentrations, and not providing actionable advice, much is left to be desired. The project caters to these shortcomings by instituting the MG-811 sensor, which uses electrochemistry to detect CO_2 concentrations, and the PMS5003, which uses light scattering and is able to differentiate between PM1, PM2.5, and PM10. The sensors are interfaced through the Arduino MEGA board, and an integrated algorithm asks the user two questions. The first one asks the user if they have any respiratory complications, which automatically lowers the thresholds for the values' interpretations; and the second question, which asks the user if they're indoors or outdoors, allows for precision in interpreting CO_2 values. (It is common for CO_2 values to be higher indoors than outdoors). Moreover, AQI monitoring stations are expensive, with some going up to $10,000. Using Arduino circuitry, the project manages to bring the cost down to $85, a massive cost reduction, even when compared to the relatively cost-effective Temtop M2000.
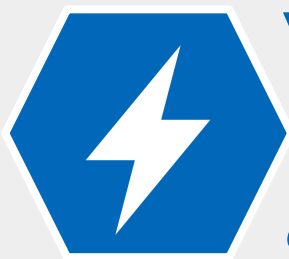
Working in Crisis and Conflict

USAID
FROM THE AMERICAN PEOPLE

1st Place

Sierra Anne Sun

USA

Differential Empathy, Social Dominance Orientation, and the Limitations of Social Science Research

Abstract: Previous research suggests people exhibit an "empathy gap": they feel more empathy for members of their group than for outsiders. I explored whether the empathy gap exists in racial and partisan contexts and how it translates into real-world action (donations). Survey takers were recruited from two platforms. Rather than the expected empathy gap, Platform 1 survey takers exhibited a statistically-significant reverse empathy gap (N=418, p=.0009), with white survey takers expressing more empathy for Black than white scenario protagonists. In contrast, for the same scenario on Platform 2, survey takers exhibited a statistically-significant empathy gap (N=781, p=.0442), with white survey takers expressing more empathy for white than Black protagonists. These conflicting results are explained by a previously unaccounted-for variable: social dominance orientation (SDO), which measures an individual's preference for hierarchy. Platform 2 survey takers had much higher SDO scores than Platform 1 survey takers. When combining data across platforms (N=1199), low SDO survey takers exhibited a reverse empathy gap and high SDO survey takers exhibited an empathy gap; in- vs. out-group-condition moderated the relationship between SDO and empathy (p=.0022). Similarly, both SDO and in- vs. out-group-condition influenced donation amount (p=.1227). Additionally, the relationship between empathy and donation was moderated by both SDO and in- vs. out-group (p=.0199). Partisanship data followed similar trends. These results highlight how hidden differences in population samples can lead to replication failures and even statistically significant, conflicting results. Given significant replication challenges, social science researchers need to account for SDO and similar overlooked factors.

2nd Place

Burak Eren Demir, Muhammet Basar Ozcan & Salih Celik

Turkey

A Mesh Network-Integrated Multi-Robot Team With Electronic Nose for Human Detection Under Rubble in Post-Disaster Scenarios

Abstract: Catastrophic natural phenomena like earthquakes, hurricanes, and tsunamis have caused widespread devastation, resulting in significant loss of life and property damage. In 2023, during the Turkey-Syria Earthquake and Marrakesh-Safi Earthquake, nearly 210.000 people were injured and 65.000 people lost their lives due to the inability to be detected in time under the rubble. Search and rescue teams currently use accosting listening devices and radar units. But these technologies are immobile and difficult to reach because of their high cost. We observed these issues leading to fatalities as individuals. This inspired us to work on this problem. Our project aims to develop a heterogeneous robot team that collaborates to detect people under the rubble in post-disaster scenarios. Each robot type in our team is designed to meet the harsh conditions of the wreckage. We've developed a "station robot" to move on the rubble and carry our operation robots, and smaller robots called "operation robots" to move under the rubble and detect people. Operation robots have microphones to listen to sounds and an "electronic nose" that includes sensor arrays to detect human odors and other metabolic tracers during their biological activities. We've trained a machine-learning model to detect and track these tracers. Also communication and coordination are major problems in search and rescue operations. We've used mesh network topology for continuous and long range communication between our robots. We've developed a desktop application to display data of robots and detected human information to the search and rescue teams. We've tested our project in a real-like debris field. Overall, our project offers a low-cost and innovative solution for search and rescue operations.

3rd Place

Meenakshi Nair

USA

Urban Slum Detection and Mapping: Semantic Segmentation on VHR Satellite Imagery

Abstract: Approximately 1.1 billion people live in slums worldwide today with the number expected to grow by 2 billion in the next 30 years. Slum rehabilitation efforts rely heavily on slum mapping and monitoring. The dynamic nature of slum growth and rapid changes in population emphasize the need for an automated system. Traditional mapping methods are manual and time-consuming. The goal is to contribute to slum rehabilitation by providing a robust segmentation tool for policymakers and urban planners. Existing Artificial Intelligence (AI) models for slum segmentation are restricted by their lack of interpretability and limited generalization across diverse urban contexts. Feature analysis involving interpretable models like SVM, revealed crucial features in slum areas like diverse textures, lack of vegetation, and irregular patterns. I developed a deep learning model using a U-Net architecture and fine tuned the Segment Anything Model (SAM), on over 10,000 slum satellite images and their masks. The U-Net model demonstrated promising performance in both Karachi and Tanzania slums, while the fine-tuned SAM model outperforms U-Net, emphasizing the potential of advanced pre-trained models in addressing the dynamic challenges of urban mapping applications. Results showcase improved precision in slum segmentation with a pixel accuracy of 90.7% (+31.3% from baseline SAM) and 87.1% (+35.9% from baseline SAM) for Karachi and Tanzania respectively with the fine-tuned SAM model. Ultimately, my research provides a crucial tool for informed decision-making in waste management, disaster planning, health initiatives, and other challenges faced by millions living in informal settlements.

Winner Spotlight: Meenakshi Nair

Meenakshi Nair, a rising senior from the Bay Area, California, has made significant strides in urban development with her project on slum detection and mapping using semantic segmentation on Very High Resolution (VHR) satellite imagery. Growing up in Silicon Valley, Meenakshi was immersed in technology from an early age, which sparked her interest in Science, Technology, Engineering, and Mathematics (STEM). Her passion for AI began in seventh grade with a class she took outside of school focused on practical applications, evolving from simple projects to exploring AI's real-world potential. Her journey from coding simple AI projects in her early teens to developing a sophisticated tool for urban slum mapping emphasizes her commitment to using technology for meaningful global impact. Winning the USAID Science for Development Award inspired her to further refine her tool, expand its capabilities, and incorporate more diverse satellite imagery worldwide while showcasing AI's potential in addressing urban challenges. Reflecting on her inspiration, she shares, **"My initial interest was sparked by personal experience during a family visit to Mumbai, where I witnessed the stark contrast between the thriving city and the dire living conditions in slums."** Meenakshi's prior research in AI and image classification, along with mentorship, has been instrumental in developing her ISEF project. She advises aspiring young scientists to maintain a willingness to learn, step out of their comfort zones, stay committed to goals despite challenges, and expand their knowledge through scientific journals. **"I hope my project will inspire other aspiring scientists to use technology to address the social challenges in our world,"** she says. Through her dedication and innovative approach, Meenakshi's project not only provides a critical tool for policymakers but also aims to improve living conditions for millions, showcasing AI's transformative power in urban planning.