2025

NINETEENTH ANNUAL

UNDERGRADUATE SUMMER RESEARCH PROGRAM

RESEARCH BOOKLET

BORN ANYWHERE Est NYU TANDON 1854 MADE IN BROOKLYN

A Message from the Vice Dean



Peter Voltz
Vice Dean for Academic Affairs

The NYU Tandon School of Engineering's Undergraduate Summer Research Program (UGSRP) offers a unique opportunity for students from NYU Tandon, NYU Abu Dhabi, NYU Shanghai, NYU College of Arts and Science, the NYU Tandon 3+2 Dual Degree Program, and other select institutions to engage in meaningful research over the summer. This program transcends the traditional classroom experience, allowing students to collaborate with faculty mentors, PhD and master's students, and other research staff on cutting-edge projects. Over the course of 10 weeks, students interact with peers from various fields and levels of study, enhancing their knowledge by applying classroom learning to solve practical and contemporary problems, thus preparing them for lifelong learning.

Close interaction with faculty and research staff within the Tandon Areas of Excellence promotes an educational experience that embodies the mission of our community members to engineer creative and smart, connected and secure, sustainable and healthy urban communities. The active participation of faculty and research staff is essential to the success of this program. These project supervisors provide invaluable guidance, helping students learn about research methodologies and best practices in their specific fields. In addition to research, students attend various workshops, lectures, and seminars throughout the summer. A special thanks to Matthew Frenkel, who joined us for yet another year to lead the Student2Scholar (S2S) Series, offering insights on advancing towards scholarship. We also extend our gratitude to all guest speakers who provided students with essential information and resources to ensure their future success. Detailed information about these events and presenters is included later in this booklet.

Financial support from NYU Tandon, faculty research grants, and external donors is essential for the program's continuity. This year marks the 14th anniversary of the Thompson Bartlett (TB) Fellowship, which graciously supported ten female researchers this summer, thanks to Mrs. Dede Bartlett. Her father, Mr. George Juul Thompson, graduated from the Electrical Engineering program at the Polytechnic Institute of Brooklyn in 1930. Our heartfelt thanks go out to Dede for her long-time support of our women participants. Other fellowships include the Tandon Scholars Fellowship, the Visiting Student Fellowship, and a new fellowship from the American Heart Association, featuring exciting projects from NYU Langone faculty. Donors' generous contributions enable us to engage more student researchers and faculty mentors, further enriching this unique summer experience.

This summer, students had the opportunity to participate in both in-person research on campus and remote research from home. While some seminars, workshops, and events were held virtually, we also had in-person events, ensuring that this program mimics the hybrid world that we live in today. The program concluded with a video presentation event where select students were recognized for their outstanding work. The abstracts and posters in this booklet represent the diverse research conducted this summer and celebrate the achievements of our undergraduate researchers.

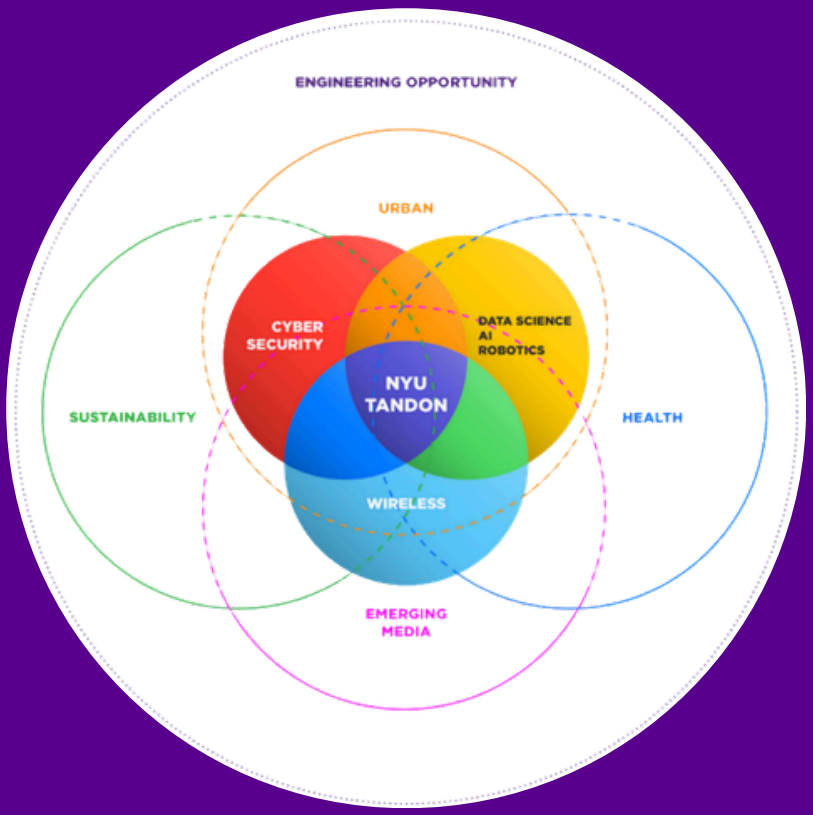
Coordinating this program requires significant effort. Special thanks to Sara-Lee Ramsawak, Assistant Dean of Undergraduate Academics and Global Engagement, who oversees this program and manages booklet production. Since 2013, she has been instrumental in the program's coordination. Adelia Vavilchenkova worked under Sara to compile this year's Research Booklet. Jen Piro, Director of Undergraduate Programs, joined the coordination efforts in 2019, managing student-to-supervisor matching and final project placements. Raffy Orbe worked under Jen on developing and enhancing the application. Kat Arrendondo, Tandon's Manager of Undergraduate Programs, joined in 2022, spearheading the event calendar and creating new engagement opportunities. Mohamed Asran has also provided valuable administrative support since 2024. A huge thank you to the entire team!

Congratulations to all the student researchers who participated in this year's UGSRP. Thank you to the Research Mentors & Staff, Dede Bartlett, Matt Frenkel, our coordinators, and additional guest speakers. I am extremely proud of this program and look forward to many more summers of intellectual and scholarly growth!

Peter J. Voltz

AREAS OF EXCELLENCE

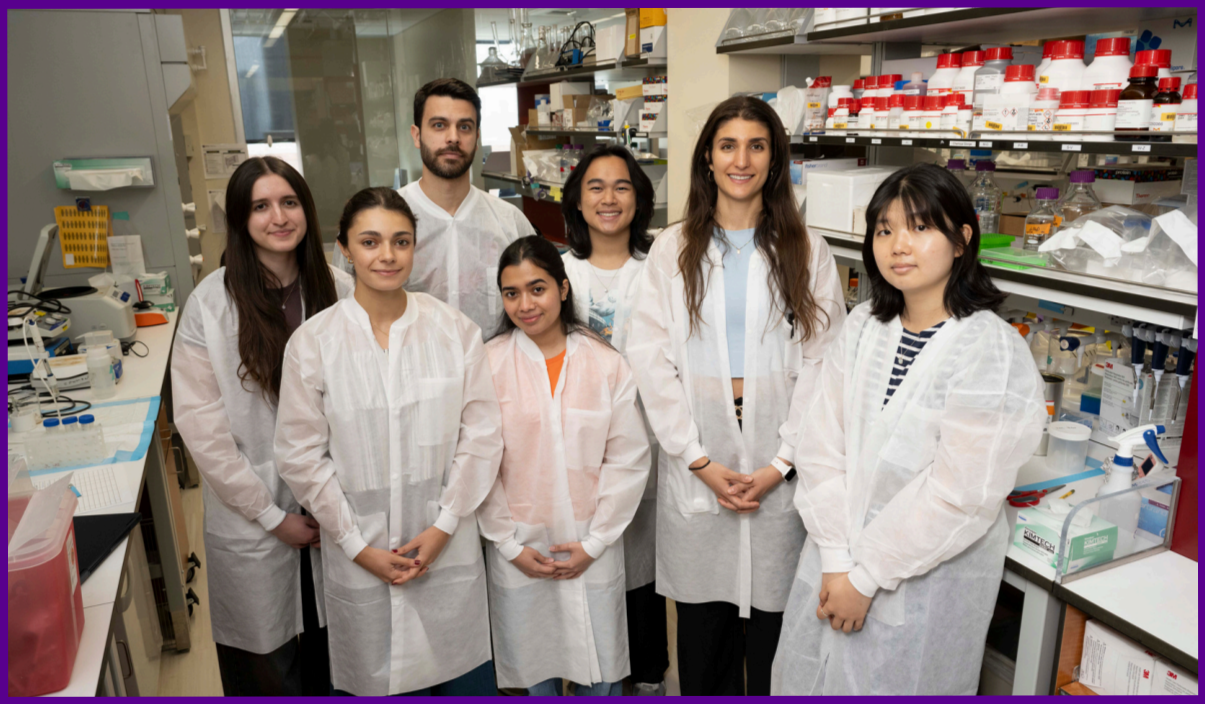
Here at Tandon, our researchers and students work at the bleeding edge of technology — technology that powers cities, enables worldwide communication, fights climate change, and creates new and safer digital worlds. We're building new devices that will revolutionize healthcare, algorithms to help us communicate across the planet, and making more sophisticated & accountable AI systems that bring efficiency and equity to our lives. We're doing so by focusing on fields in vital research areas and the intersections between them. That focus allows us to build upon our rich history, chart a path to a better future for the entire planet, and prove you can be born anywhere, but made right here in Brooklyn.



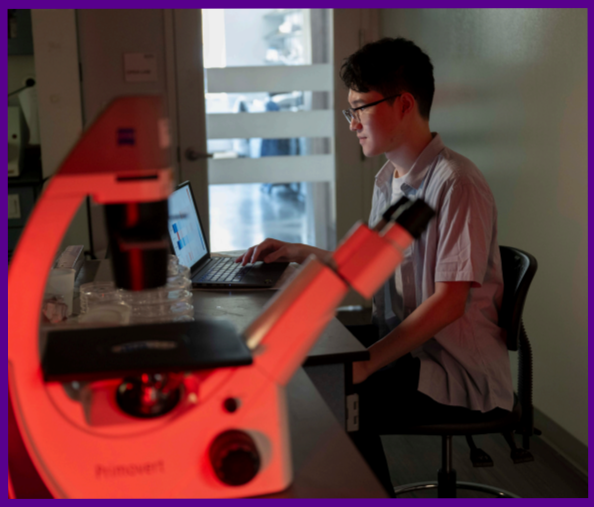
Wireless Data Science/Ai/Robotics Health

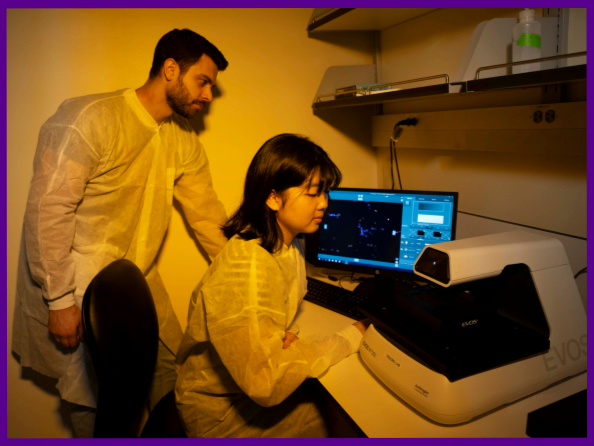
Emerging Media Sustainability Urban Cybersecurity

UGSRP PROGRAM HIGHLIGHTS



Left to Right: Sabriye, Ivan, Tristan, Paula, Reeda, Eleni, and Chaemin





Ivan (left) and Chaemin (right) and doing Live Dead Cell imaging with a microscope



Ivan (right) and Reeda (left) and doing a staining to observe a biomarker of cell senescence in cardiomyocytes



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PROJECT SUPERVISORS & RESEARCH STAFF

Project Supervisors

Alexander Landfair, Andrea Silverman, Augustin Guibaud, Ayaskanta Sahu, Brendan Dolan-Gavitt, Bruce Garetz, Carla Gannis, Cassandra Thiel, Chen Feng, Daniel Neill, Danny Yuxing Huang, David Mugglin, David Truong, Davood Shahrjerdi, Elizabeth Henaff, Fraida Fund, Giuseppe Loianno, Graham Dove, Ingrid Paredes, Irene de Lazaro, Ivan Selesnick, Iwao Teraoka, Jeffrey Hubbell, Jennifer Apell, Jin Montclare, Jin Ryoun Kim, Jonathan Bain, Joo H. Kim, Justin Cappos, Kaan Ozbay, Kat Faculty, Kathleen McDermott, Katsuo Kurabayashi, Kurt Becker, Lisa Hellerstein, Luis Ceferino, Mark Yarmarkovich, Maurizio Porfiri, Miguel Modestino, Nathalie Pinkerton, Nicholas DiZinno, Nikhil Gupta, Nikita Grigoryev, Paola Bardetti, Pavel Kots, Qi Sun, Quanyan Zhu, Rakesh Behera, Ramesh Karri, Rastislav Levicky, Regine Gilbert, Richard A Stein, Rose Faghih, Ryan Hartman, Semiha Ergan, Shivendra Panwar, Takahiro Yabe, Torsten Suel, Weiqiang Chen, Yao Wang, Yong Liu

Research Staff and Additional Mentors

Alma Rocha, Caleb Beckwith, Casey Bloomquist, Dania Muhieddine Orfali, Erica Budina, Fabiana Sofia Ricci, Fan Zuo, Ines Pacheco Figueira, Ivan Pinos, Jiangce Chen, Jingqin Gao, John-Ross Rizzo, Jonathan Sun, Kelechi Ndukwe-Ajala, Megh Bhatt, Michael Napoli, Mo Satt, Nathan Makowski, Nicholas Renner, Nofar Mazuraky, Patrick Zielinski, Pulkita Jain, Rachel Pollard, Raisa Carmen Andeme Ela, Ran Gong, Ricardo Mathison, Sam Bodmer, Sameer Upadhye, Sumanth Dara, Susanna Jaramillo, Tristan Timog, Vidya Raju, Yana Petri, Yaxin Shen, Zilin Bian

CALENDAR OF EVENTS

JUNE 2	PROGRAM ORIENTATION
JUNE 4	WHAT IS RESEARCH? Matthew Frenkel
JUNE 5	LAB LINK-UP: SUMMER RESEARCH SOCIAL
JUNE 6	MICROAGGRESSIONS MODULE
JUNE 11	CRAFTING A RESEARCH ABSTRACT Matthew Frenkel
JUNE 12	TRANSLATING RESEARCH FOR A PUBLIC AUDIENCE Abby Rabinowitz
JUNE 16 - 17	HEADSHOTS
JUNE 18	PROFESSIONALISM: SOFT SKILLS & ENGINEERING RESEARCH Matthew Frenkel
JUNE 23	LABSHOTS
JUNE 25	DESIGNING & PRESENTING RESEARCH POSTER Matthew Frenkel
JUNE 26	STEM GLOBAL AWARDS 101 SESSION Tara Wheelwright
JUNE 26	CLIMB & CONNECT
JULY 1	LABSHOTS
JULY 2	BEGINNERS GUIDE TO DATA VISUALIZATION Fabiha Khalid
JULY 3	REFLECTING TOWARDS A PURPOSE Peter Huu Tran & Zhenwei Lyu
JULY 8	UGSRP VIDEO PRESENTATION SESSION Kat Arredondo
JULY 9	PRINCIPLES OF DATA FINDING Carol Choi
JULY 10	CAREER PLANNING AFTER UNDERGRAD Peter Huu Tran & Zhenwei Lyu
JULY 12	LUNA PARK
JULY 13	MID-PROGRAM EVALUATIONS
JULY 16	INTRO TO RESEARCH DATA MANAGEMENT Nicholas Wolf
JULY 17	NAVIGATING PLAGIARISM IN THE AGE OF AI Jeannie Im
JULY 20	ABSTRACTS SUBMISSION
JULY 21	MEET THE MENTORS: A PHD SOCIAL
JULY 23	DATA VISUALIZATION CLINIC Fabiha Khalid
JULY 24	CONFIDENT COMMUNICATION FOR ENGINEERS Peter Huu Tran & Zhenwei Lyu
JULY 27	NEWS REPORT VIDEO PRESENTATION SUBMISSION
JULY 29	RESEARCH POSTER CLINIC Matthew Frenkel & Dibner Library
JULY 30	BROADWAY SHOW: JOHN PROCTOR IS THE VILLAIN
JULY 31	NSF GRFP SESSION Jamie Lloyd
AUG 1	RESEARCH POSTER SUBMISSION
AUG 6	UGSRP SYMPOSIUM
AUG 6	RECEPTION/POSTER SESSION
AUG 8	EPOSTERBOARDS GALLERY + PEER FEEDBACK SUBMISSIONS
AUG 8	POST-PROGRAM REFLECTION
SEPT 10	ABSTRACT BOOKLET COMPLETED AND PUBLISHED

UGSRP FELLOWSHIPS

American Heart Association (AHA)

New this summer, the AHA Cardiovascular Engineering Fellowship Program is supported by the American Heart Association's institutional award for undergraduate student training. This fellowship provides support for five undergraduate students, offering them the opportunity to engage in cutting-edge cardiovascular engineering research.

Tandon Scholars Fellowship

The Tandon Scholars Fellowship supports high-achieving undergraduates with the potential to become global leaders in innovation, technology, research, and entrepreneurship through the GLASS Scholars Program. This fellowship provides resources, mentorship, and opportunities for upper level GLASS students to engage in cutting-edge research and collaborate with distinguished faculty and industry professionals. It emphasizes developing socially conscious engineering leaders ready to impact society significantly.

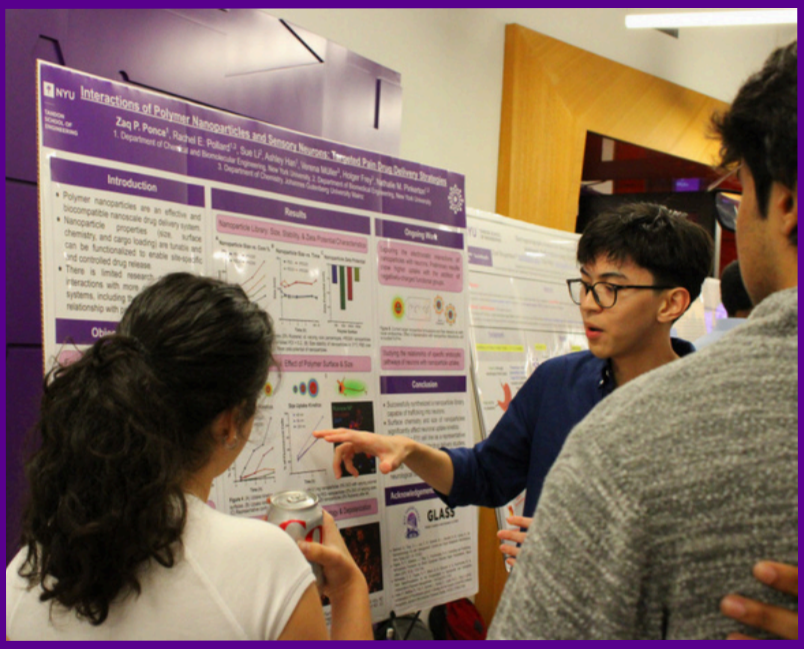
Thompson-Bartlett Fellowship

Established in 2012 and generously supported by Dede Bartlett, the Thompson Bartlett Fellowship funds summer research internships for outstanding women undergraduate students across various majors at NYU Tandon. This includes those majoring in engineering fields, as well as those pursuing STEM-related projects.

Visiting Student Fellowship

The Visiting Student Fellowship provides a unique opportunity for select non-NYU students to participate in research at NYU each year. This fellowship aims to diversify the research community by incorporating students from various institutions and backgrounds. Participants gain access to NYU's cutting-edge research facilities, collaborate with leading scholars, and engage in innovative projects across multiple disciplines.

UGSRP CULMINATING EVENT











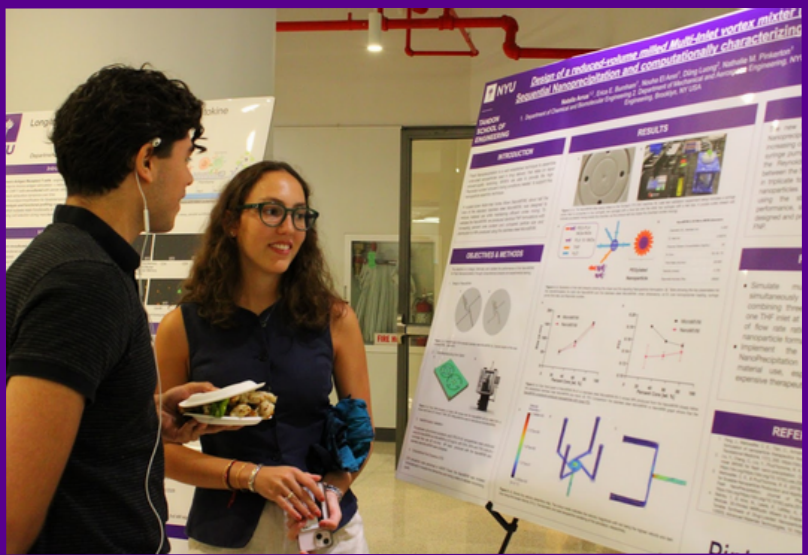


UGSRP CULMINATING EVENT











LAB LINK UP: SUMMER SOCIAL











MEET THE MENTORS: A PHD SOCIAL











CLIMB & CONNECT











LUNA PARK SOCIAL











BROADWAY SHOW SOCIAL











UGSRP VIDEO PRESENTATION WINNERS

Real-World Impact: Anchor Edition

This award honors the most compelling news anchor-style research video that clearly and confidently communicates the real-world or community impact of a student's work. The winning presentation should deliver strong storytelling, polished delivery, and meaningful insights-from a dynamic project introduction to the broader significance of the research.

Honorable Mentions



AI-Driven Structural Optimization: Enhancing Design Efficiency and Performance

Jackson Kollmorgen & Ninad Moharir
***Project Supervisor**: Dzung Luong*



Analyzing the Impact of Congestion Pricing on Urban Mobility Using Data Analytics and AI-Based Computer Vision Techniques

Haoxuan Wang
***Project Supervisor:** Kaan Ozbay*
***Mentor:** Jingqin Gao & Fan Zuo*



Effects of environmental lighting, colors and materials on indoor navigation of persons with visual impairment in virtual reality

Rocell Trinidad
***Project Supervisor:** Maurizio Porfiri*
***Mentor:** Fabiana Sofia Ricci & Michael Napoli*

First Place



Developing an experience sampling app for healthcare research

Mandy Li
***Project Supervisor:** Graham Dove*

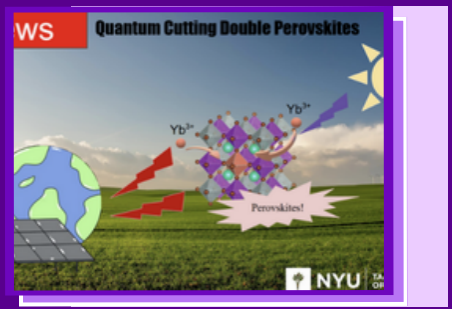
Second Place



Upcycling of waste plastics into valuable lubricants using catalytic slurry reactor

Alice Pan & Aderline Diaz Fernandez
***Project Supervisor:** Pavel Kots*

Third Place



Physical Vapor Deposition and Optical Characterization of Quantum Cutting materials for increasing solar cell efficiencies

Eric Tsang Xu
***Project Supervisor:** Eray Aydil*
***Mentor:** Pulkita Jain*

UGSRP VIDEO PRESENTATION WINNERS

Live from the Lab: Field Reporter Edition

This award honors the most creative and visually engaging field reporter-style research video. It celebrates a student who brings their project to life by taking viewers behind the scenes-showcasing their research process through dynamic visuals, clear storytelling, and a compelling look at discovery in action.

Honorable Mentions



The Epigenetics of Adversity During Prenatal Development and Adult-Onset Diseases

Celia Meunier
Project Supervisor: *Richard Stein*



Bioengineering Lymph node-on a Chip for Modeling Human Adaptive Immune Responses and Vaccine Evaluation (AHA Fellowship Project)

Cristiana Pintea
Project Supervisor: *Weiqiang Chen*
Mentor: *Fanghao Shi*



Decay of microbial contaminants in water treatment and in the environment - environmental engineering

Yashvi Rastogi & Tariro Gurudza
Project Supervisor: *Andrea Silverman*
Mentor: *Alma Rocha*

First Place



16S Metagenomics sequencing studies

Tenzin Kunsel, Anna Huang, Cayden Auyeung, & Marie Toure
Project Supervisor: *Nikita Grigoryev*

Second Place



Visualize noise and air quality data for environmental justice advocacy

Nitsaa Tayal
Project Supervisor: *Graham Dove*

Third Place



Understanding how opportunities for in-person encounters could lead to social interactions in NYC public spaces

Ian Fiterman
Project Supervisor: *Graham Dove*

MENTOR OF THE YEAR AWARD

This award recognizes PhD and Postdoc students who have made a meaningful impact as lab mentors, through research support, guidance, and personal encouragement. Nominated by students, this award honors those who helped make their summer experience truly transformative.



Jiangce Chen



Rachel Pollard



Ran Gong



Alma Rocha

Cybersecurity



Today, our computer systems, services, and devices are more important than ever, and so is keeping them safe. With every aspect of our lives now affected by online systems, NYU Tandon cybersecurity experts are finding the keys to keeping personal data private, power grids impregnable, national defense infrastructure safe from malefactors, and much more.

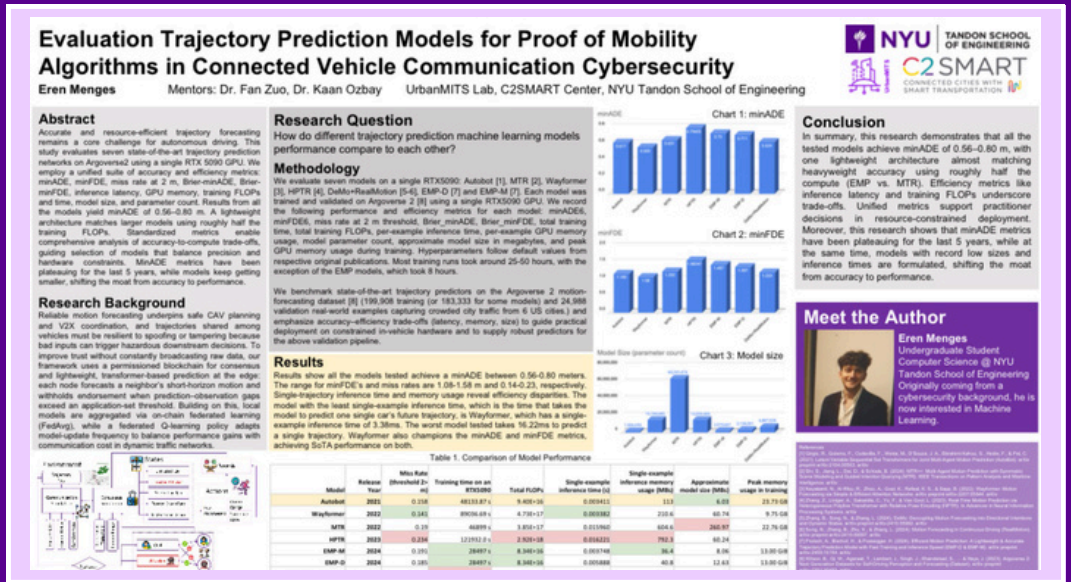
Enhancing Privacy Protection in Connected Vehicle Systems Communication through AI/ML-Driven Multiparty Computation

Accurate vehicle trajectory prediction is critical for the safe and efficient operation of autonomous driving systems. While numerous prediction models have been developed, their performance can vary significantly based on the dataset and environmental context. This study presents a comparative analysis of four prominent trajectory prediction models: Motion Transformer (MTR), Hierarchical Vector Transformer (HiVT), Trajectron++, and a baseline Long Short-Term Memory (LSTM) network. To evaluate the models, we generated a custom vehicle interaction dataset using a SUMO (Simulation of Urban Mobility) traffic simulation. Due to the unique data structure of our simulation output, custom preprocessing scripts were developed for each model to ensure compatibility and proper data ingestion. The models were trained and evaluated on this dataset using standard industry metrics: minimum Average Displacement Error (minADE), which measures the average L2 distance between the predicted and ground truth trajectories, taking the minimum over the K predicted trajectories; minimum Final Displacement Error (minFDE), which measures the L2 distance at the final timestep; and Miss Rate, the percentage of agents whose closest predicted trajectory terminates more than 2 m from the ground-truth final position. The evaluation demonstrated a clear performance hierarchy among the models. MTR consistently achieved the best results, attaining a minADE of X, a minFDE of X, and a Miss Rate of X%. HiVT and Trajectron++ delivered competitive but inferior performance compared to MTR. The baseline LSTM model showed significantly higher error rates, highlighting the advantages of more advanced, context-aware architectures for this task. Our findings indicate that on a controlled, simulation-based dataset, the MTR model provides superior trajectory prediction accuracy. This suggests its architecture is highly effective at capturing the complex dynamics of vehicle interactions. Future work will involve validating these findings on a large-scale, real-world dataset, such as Argoverse 2, to assess the generalizability of these models in more diverse and unpredictable scenarios.

Project Supervisor	*Kaan Ozbay*
Research Areas	*Cybersecurity*
Research Staff	*Fan Zuo, Jingqin Gao*



Eren Menges
Computer Science, B.S.
Fall 2028
NYU Tandon



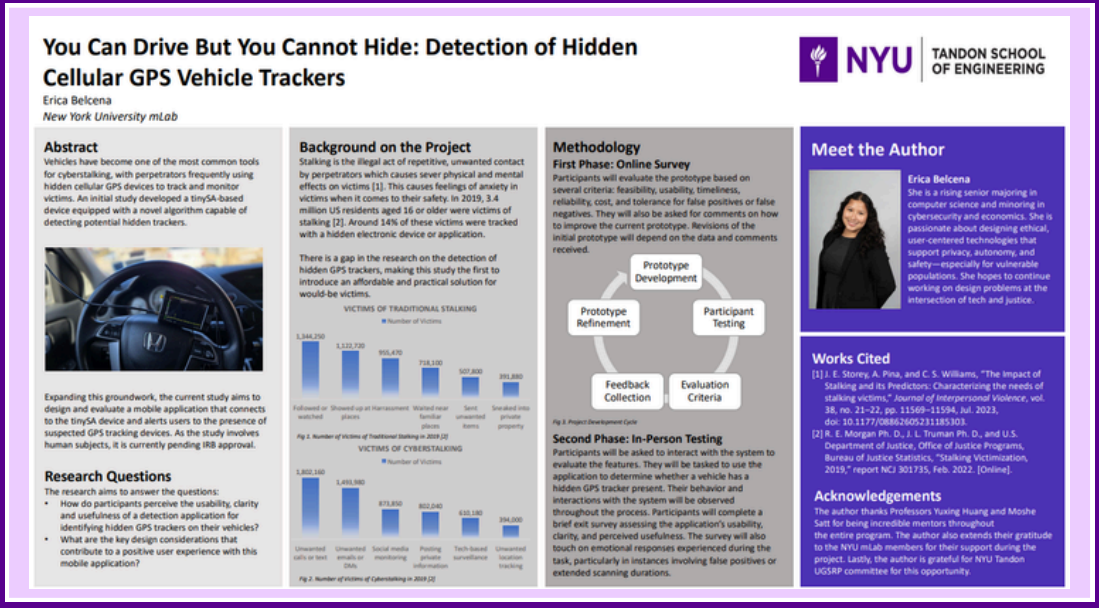
Detection of Hidden 4G/5G Cellular Tracking and Surveillance Devices

Vehicles have become one of the most common tools for cyberstalking, with perpetrators frequently using hidden cellular GPS devices to track and monitor victims. An initial study developed a tinySA-based device equipped with a novel algorithm capable of detecting potential hidden trackers. Expanding this groundwork, the current study aims to design and evaluate a mobile application that connects to the tinySA device and alerts users to the presence of suspected GPS tracking devices. As the study involves human subjects, it is currently pending IRB approval. The research will proceed in two phases. In the first phase, participants will assess the prototype based on feasibility, usability, timeliness, reliability, cost, and tolerance for false positives and false negatives. The prototype will be revised according to the feedback received. The second phase will involve in-person evaluations in real-world conditions to determine the application's performance outside of a controlled environment. The study is expected to result in a fully functional mobile application capable of notifying users when a hidden GPS tracker is detected nearby.

Project Supervisor	*Danny Yuxing Huang*
Research Areas	*Cybersecurity & Wireless*
Research Staff	*Mo Satt*



Erica Belcena
Computer Science, B.S.
Spring 2026
NYU Tandon



You Can Drive But You Cannot Hide: Detection of Hidden Cellular GPS Vehicle Trackers

Erica Belcena
New York University mLab

NYU TANDON SCHOOL OF ENGINEERING

Abstract
Vehicles have become one of the most common tools for cyberstalking, with perpetrators frequently using hidden cellular GPS devices to track and monitor victims. An initial study developed a tinySA-based device equipped with a novel algorithm capable of detecting potential hidden trackers.

Expanding this groundwork, the current study aims to design and evaluate a mobile application that connects to the tinySA device and alerts users to the presence of suspected GPS tracking devices. As the study involves human subjects, it is currently pending IRB approval.

Research Questions
The research aims to answer the questions:
- How do participants perceive the usability, clarity and usefulness of a detection application for identifying hidden GPS trackers on their vehicles?
- What are the key design considerations that contribute to a positive user experience with this mobile application?

Background on the Project
Stalking is the illegal act of repetitive, unwanted contact by perpetrators which causes sever physical and mental effects on victims [1]. This causes feelings of anxiety in victims when it comes to their safety. In 2019, 3.4 million US residents aged 16 or older were victims of stalking [2]. Around 14% of these victims were tracked with a hidden electronic device or application.

There is a gap in the research on the detection of hidden GPS trackers, making this study the first to introduce an affordable and practical solution for would-be victims.

VICTIMS OF TRADITIONAL STALKING
Number of Victims
1,344,250 | 1,122,720 | 955,470 | 718,100 | 507,800 | 391,880
Followed or watched | Showed up at places | Harassment | Waited near familiar places | Sent unwanted items | Sneaked into private property

VICTIMS OF CYBERSTALKING
Number of Victims
1,802,160 | 1,493,980 | 973,850 | 802,040 | 610,180 | 394,000
Unwanted calls or text | Unwanted emails or DMs | Social media monitoring | Posting private information | Tech-based surveillance | Unwanted location tracking

Methodology
First Phase: Online Survey
Participants will evaluate the prototype based on several criteria: feasibility, usability, timeliness, reliability, cost, and tolerance for false positives or false negatives. They will also be asked for comments on how to improve the current prototype. Revisions of the initial prototype will depend on the data and comments received.

Prototype Development → Participant Testing → Evaluation Criteria → Feedback Collection → Prototype Refinement

Second Phase: In-Person Testing
Participants will be asked to interact with the system to evaluate the features. They will be tasked to use the application to determine whether a vehicle has a hidden GPS tracker present. Their behavior and interactions with the system will be observed throughout the process. Participants will complete a brief exit survey assessing the application's usability, clarity, and perceived usefulness. The survey will also touch on emotional responses experienced during the task, particularly in instances involving false positives or extended scanning durations.

Meet the Author
Erica Belcena
She is a rising senior majoring in computer science and minoring in cybersecurity and economics. She is passionate about designing ethical, user-centered technologies that support privacy, autonomy, and safety—especially for vulnerable populations. She hopes to continue working on design problems at the intersection of tech and justice.

Works Cited
[1] J. E. Storey, A. Pina, and C. S. Williams, "The Impact of Stalking and its Predictors: Characterizing the needs of stalking victims," *Journal of Interpersonal Violence*, vol. 38, no. 21–22, pp. 11569–11594, Jul. 2023, doi: 10.1177/08862605231185303.
[2] R. E. Morgan Ph. D., J. L. Truman Ph. D., and U.S. Department of Justice, Office of Justice Programs, Bureau of Justice Statistics, "Stalking Victimization, 2019," report NCJ 301735, Feb. 2022. [Online].

Acknowledgements
The author thanks Professors Yuxing Huang and Moshe Satt for being incredible mentors throughout the entire program. The author also extends their gratitude to the NYU mLab members for their support during the project. Lastly, the author is grateful for NYU Tandon UGSRP committee for this opportunity.

Research in Hardware Systems, LLMs, LLM-based Chip Design, Test, and Validation. Hardware Security

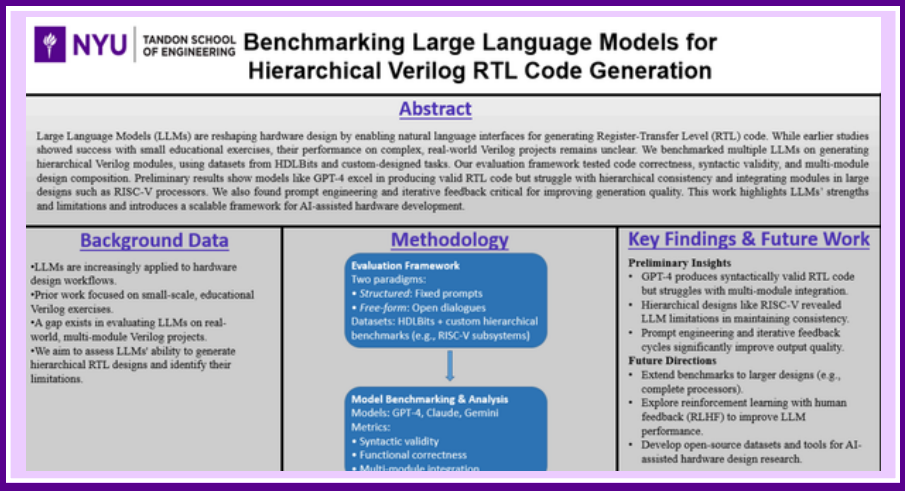
Large Language Models (LLMs) are transforming the landscape of hardware design by enabling natural language interfaces for generating Register-Transfer Level (RTL) code. While prior work has demonstrated LLMs' ability to handle isolated, educational exercises in hardware design, there remains a significant gap in evaluating their performance on complex, real-world Verilog projects. Our research addresses this gap by benchmarking multiple LLMs on the task of generating hierarchical Verilog modules with real-world relevance. We developed a systematic evaluation framework that incorporates both structured and free-form interaction paradigms. Using datasets from HDLBits and custom-designed benchmarks, we assessed models across dimensions such as code correctness, syntactic validity, and their ability to compose multi-module designs. Preliminary results indicate that while state-of-the-art models such as GPT-4 exhibit strong capabilities in generating syntactically valid RTL code, they often struggle with maintaining hierarchical consistency and integrating module-level functionality in large designs like RISC-V processors. Our findings also highlight the importance of prompt engineering and iterative feedback in improving generation quality. This work provides insights into the strengths and limitations of LLMs for hardware design and introduces a scalable framework for future research in AI-assisted hardware development.

Project Supervisor *Ramesh Karri*

Research Areas *Cybersecurity*

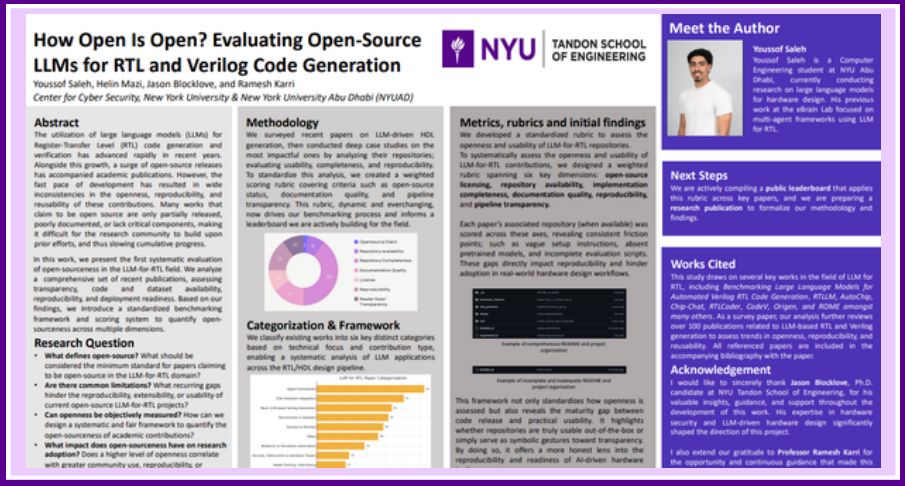


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Securing git repositories with gittuf

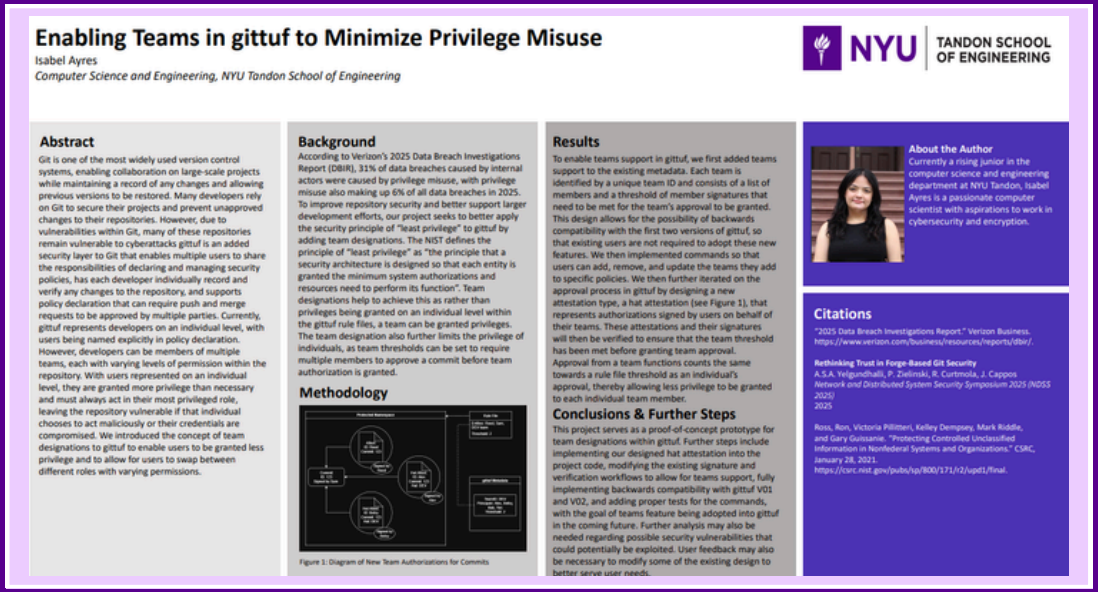
Git is one of the most widely used version control systems, enabling collaboration on large-scale projects while maintaining a record of any changes and allowing previous versions to be restored. Many developers rely on Git to secure their projects and prevent unapproved changes to their repositories. However, due to vulnerabilities within Git, many of these repositories remain vulnerable to cyberattacks. gittuf is an added security layer to Git that enables multiple users to share the responsibilities of declaring and managing security policies, has each developer individually record and verify any changes to the repository, and supports policy declaration that can require push and merge requests to be approved by multiple parties. Currently, gittuf represents developers on an individual level, with users being named explicitly in policy declaration. However, developers can be members of multiple teams, each with varying levels of permission within the repository. With users represented on an individual level, they are forced to either hold multiple keys or must always act in their most privileged role, leaving the repository vulnerable if that individual chooses to act maliciously or their credentials are compromised. We introduced the concept of team designations to gittuf to enable users to act in their least-privileged role. We expanded the existing gittuf metadata to support a team interface, with each team having an ID, a list of team members, and a threshold of member signatures that need to be met for the team's approval to be granted. We also modified the existing signing and verification workflows to support team signatures on commits, enabling users to state what role they are acting within and streamlining the policy declaration process, as entire teams can now be added to a rule at once and any changes to team personnel no longer require the policy declaration to be modified.

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Research Areas	*Cybersecurity*
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Enabling Teams in gittuf to Minimize Privilege Misuse

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Abstract

Git is one of the most widely used version control systems, enabling collaboration on large-scale projects while maintaining a record of any changes and allowing previous versions to be restored. Many developers rely on Git to secure their projects and prevent unapproved changes to their repositories. However, due to vulnerabilities within Git, many of these repositories remain vulnerable to cyberattacks gittuf is an added security layer to Git that enables multiple users to share the responsibilities of declaring and managing security policies, has each developer individually record and verify any changes to the repository, and supports policy declaration that can require push and merge requests to be approved by multiple parties. Currently, gittuf represents developers on an individual level, with users being named explicitly in policy declaration. However, developers can be members of multiple teams, each with varying levels of permission within the repository. With users represented on an individual level, they are forced to either hold multiple keys or must always act in their most privileged role, leaving the repository vulnerable if that individual chooses to act maliciously or their credentials are compromised. We introduced the concept of team designations to gittuf to enable users to be granted less privilege and to allow for users to swap between different roles with varying permissions.

Background

According to Verizon's 2025 Data Breach Investigations Report (DBIR), 31% of data breaches caused by internal actors were caused by privilege misuse, with privilege misuse also making up 6% of all data breaches in 2025. To improve repository security and better support larger development efforts, our project seeks to better apply the security principle of "least privilege" to gittuf by adding team designations. The NIST defines the principle of "least privilege" as "the principle that a security architecture is designed so that each entity is granted the minimum system authorizations and resources need to perform its function". Team designations help to achieve this as rather than privileges being granted on an individual level within the gittuf rule files, a team can be granted privileges. The team designation also further limits the privilege of individuals, as team thresholds can be set to require multiple members to approve a commit before team authorization is granted.

Methodology

Figure 1: Diagram of New Team Authorizations for Commits

Results

To enable teams support in gittuf, we first added teams support to the existing metadata. Each team is identified by a unique team ID and consists of a list of members and a threshold of member signatures that need to be met for the team's approval to be granted. This design allows for the possibility of backwards compatibility with the first two versions of gittuf, so that existing users are not required to adopt these new features. We then implemented commands so that users can add, remove, and update the teams they add to specific policies. We then further iterated on the approval process in gittuf by designing a new attestation type, a hat attestation (see Figure 1), that represents authorizations signed by users on behalf of their teams. These attestations and their signatures will then be verified to ensure that the team threshold has been met before granting team approval. Approval from a team functions counts the same towards a rule file threshold as an individual's approval, thereby allowing less privilege to be granted to each individual team member.

Conclusions & Further Steps

This project serves as a proof-of-concept prototype for team designations within gittuf. Further steps include implementing our designed hat attestation into the project code, modifying the existing signature and verification workflows to allow for teams support, fully implementing backwards compatibility with gittuf V01 and V02, and adding proper tests for the commands, with the goal of teams feature being adopted into gittuf in the coming future. Further analysis may also be needed regarding possible security vulnerabilities that could potentially be exploited. User feedback may also be necessary to modify some of the existing design to better serve user needs.

About the Author

Currently a rising junior in the computer science and engineering department at NYU Tandon, Isabel Ayres is a passionate computer scientist with aspirations to work in cybersecurity and encryption.

Citations

"2025 Data Breach Investigations Report." Verizon Business. https://www.verizon.com/business/resources/reports/dbir/.

Rethinking Trust in Forge-Based Git Security
A.S.A. Velgundhalli, P. Zielinski, R. Curtmola, J. Cappos
Network and Distributed System Security Symposium 2025 (NDSS 2025)
2025

Ross, Ron, Victoria Pillitteri, Kelley Dempsey, Mark Riddle, and Gary Guissanie. "Protecting Controlled Unclassified Information in Nonfederal Systems and Organizations." CSRC, January 28, 2021. https://csrc.nist.gov/pubs/sp/800/171/r2/upd1/final.

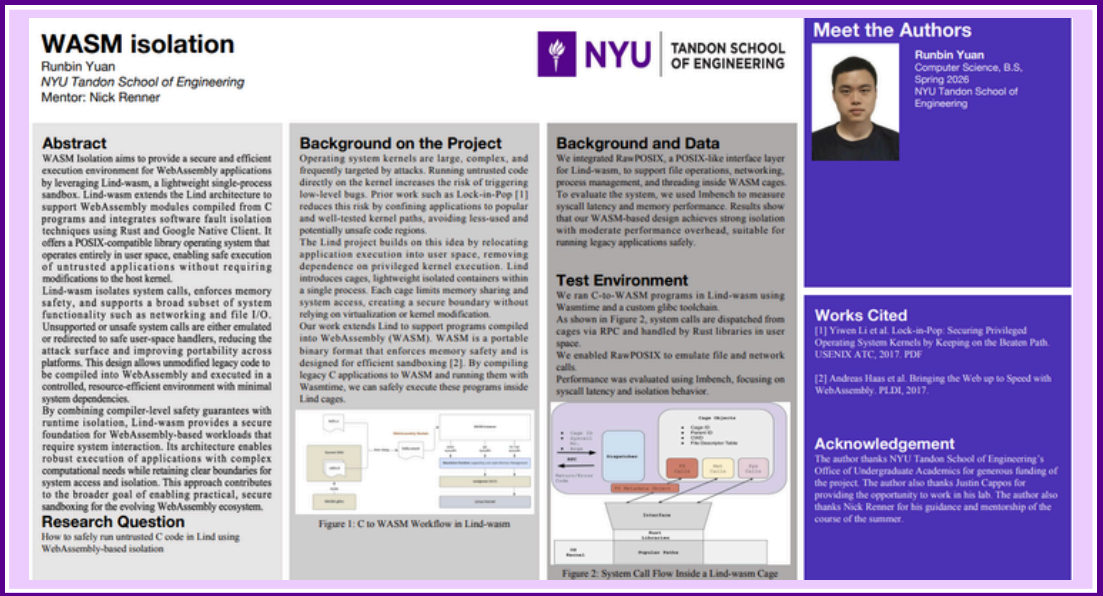
WASM isolation

WASM Isolation aims to provide a secure and efficient execution environment for WebAssembly applications by leveraging Lind-wasm, a lightweight single-process sandbox. Lind-wasm extends the Lind architecture to support WebAssembly modules compiled from C programs and integrates software fault isolation techniques using Rust and Google Native Client. It offers a POSIX-compatible library operating system that operates entirely in user space, enabling safe execution of untrusted applications without requiring modifications to the host kernel. Lind-wasm isolates system calls, enforces memory safety, and supports a broad subset of system functionality such as networking and file I/O. Unsupported or unsafe system calls are either emulated or redirected to safe user-space handlers, reducing the attack surface and improving portability across platforms. This design allows unmodified legacy code to be compiled into WebAssembly and executed in a controlled, resource-efficient environment with minimal system dependencies. By combining compiler-level safety guarantees with runtime isolation, Lind-wasm provides a secure foundation for WebAssembly-based workloads that require system interaction. Its architecture enables robust execution of applications with complex computational needs while retaining clear boundaries for system access and isolation. This approach contributes to the broader goal of enabling practical, secure sandboxing for the evolving WebAssembly ecosystem.

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Research Staff *Nicholas Renner*



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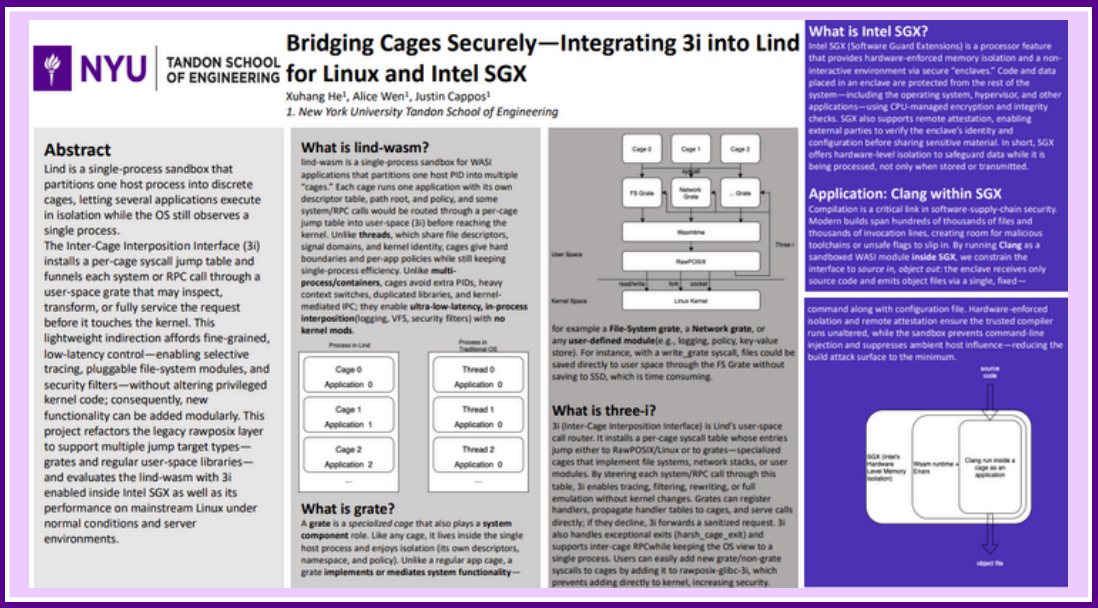
Integrating 3i into Lind for Linux and Intel SGX

Lind is a single-process sandbox that partitions one host process into discrete cages, letting several applications execute in isolation while the OS still observes a single process. The Inter-Cage Interposition Interface (3i) installs a per-cage syscall jump table and funnels each system or RPC call through a user-space grate that may inspect, transform, or fully service the request before it touches the kernel. This lightweight indirection affords fine-grained, low-latency control—enabling selective tracing, pluggable file-system modules, and security filters—without altering privileged kernel code; consequently, new functionality can be added modularly. This project refactors the legacy rawposix layer to support multiple jump target types—grates and regular user-space libraries—and evaluates the lind-wasm with 3i enabled inside Intel SGX as well as its performance on mainstream Linux under normal conditions and server environments.

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NYU TANDON SCHOOL OF ENGINEERING

Bridging Cages Securely—Integrating 3i into Lind for Linux and Intel SGX

Xuhang He[1], Alice Wen[1], Justin Cappos[1]

1. New York University Tandon School of Engineering

Abstract

Lind is a single-process sandbox that partitions one host process into discrete cages, letting several applications execute in isolation while the OS still observes a single process.
The Inter-Cage Interposition Interface (3i) installs a per-cage syscall jump table and funnels each system or RPC call through a user-space grate that may inspect, transform, or fully service the request before it touches the kernel. This lightweight indirection affords fine-grained, low-latency control—enabling selective tracing, pluggable file-system modules, and security filters—without altering privileged kernel code; consequently, new functionality can be added modularly. This project refactors the legacy rawposix layer to support multiple jump target types—grates and regular user-space libraries—and evaluates the lind-wasm with 3i enabled inside Intel SGX as well as its performance on mainstream Linux under normal conditions and server environments.

What is lind-wasm?

lind-wasm is a single-process sandbox for WASI applications that partitions one host PID into multiple "cages." Each cage runs one application with its own descriptor table, path root, and policy, and some system/RPC calls would be routed through a per-cage jump table into user-space (3i) before reaching the kernel. Unlike **threads**, which share file descriptors, signal domains, and kernel identity, cages give hard boundaries and per-app policies while still keeping single-process efficiency. Unlike **multi-process/containers**, cages avoid extra PIDs, heavy context switches, duplicated libraries, and kernel-mediated IPC; they enable **ultra-low-latency, in-process interposition**(logging, VFS, security filters) with **no kernel mods**.

Process in Lind: Cage 0 Application 0; Cage 1 Application 1; Cage 2 Application 2 …

Process in Traditional OS: Thread 0 Application 0; Thread 1 Application 0; Thread 2 Application 0 …

What is grate?

A **grate** is a *specialized cage* that also plays a **system component** role. Like any cage, it lives inside the single host process and enjoys isolation (its own descriptors, namespace, and policy). Unlike a regular app cage, a grate **implements or mediates system functionality**—

for example a **File-System grate**, a **Network grate**, or any **user-defined module**(e.g., logging, policy, key-value store). For instance, with a write_grate syscall, files could be saved directly to user space through the FS Grate without saving to SSD, which is time consuming.

What is three-i?

3i (Inter-Cage Interposition Interface) is Lind's user-space call router. It installs a per-cage syscall table whose entries jump either to RawPOSIX/Linux or to grates—specialized cages that implement file systems, network stacks, or user modules. By steering each system/RPC call through this table, 3i enables tracing, filtering, rewriting, or full emulation without kernel changes. Grates can register handlers, propagate handler tables to cages, and serve calls directly; if they decline, 3i forwards a sanitized request. 3i also handles exceptional exits (harsh_cage_exit) and supports inter-cage RPCwhile keeping the OS view to a single process. Users can easily add new grate/non-grate syscalls to cages by adding it to rawposix-glibc-3i, which prevents adding directly to kernel, increasing security.

What is Intel SGX?

Intel SGX (Software Guard Extensions) is a processor feature that provides hardware-enforced memory isolation and a non-interactive environment via secure "enclaves." Code and data placed in an enclave are protected from the rest of the system—including the operating system, hypervisor, and other applications—using CPU-managed encryption and integrity checks. SGX also supports remote attestation, enabling external parties to verify the enclave's identity and configuration before sharing sensitive material. In short, SGX offers hardware-level isolation to safeguard data while it is being processed, not only when stored or transmitted.

Application: Clang within SGX

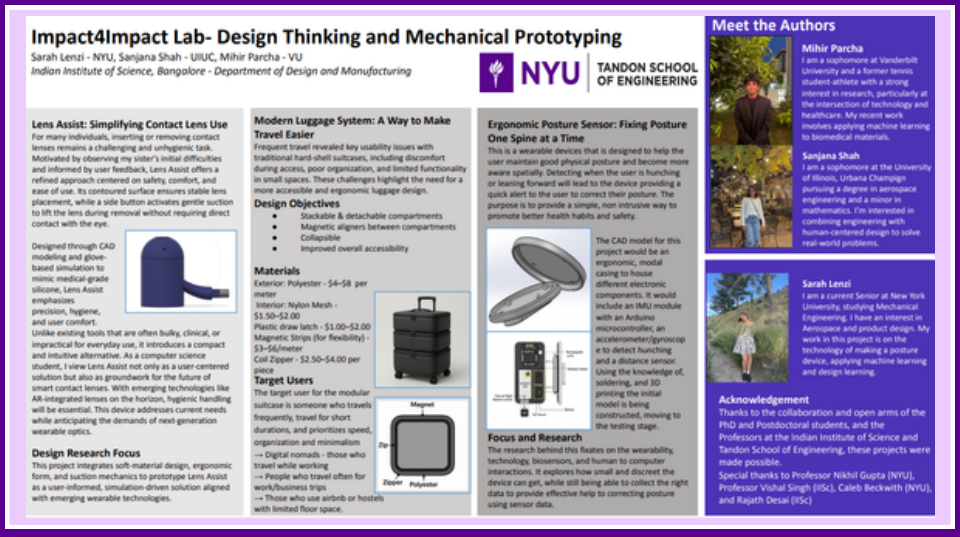
Compilation is a critical link in software-supply-chain security. Modern builds span hundreds of thousands of files and thousands of invocation lines, creating room for malicious toolchains or unsafe flags to slip in. By running **Clang** as a sandboxed WASI module **inside SGX**, we constrain the interface to *source in, object out*: the enclave receives only source code and emits object files via a single, fixed—

command along with configuration file. Hardware-enforced isolation and remote attestation ensure the trusted compiler runs unaltered, while the sandbox prevents command-line injection and suppresses ambient host influence—reducing the build attack surface to the minimum.

USA-India International Research Experience for Students (IRES) in Digital Manufacturing - 2025

This research program applied design thinking and mechanical prototyping to develop three innovative products. Lens Assist was engineered using CAD modeling and SLA 3D printing to create a compact, ergonomic tool enabling safe insertion and removal of contact lenses for individuals with limited dexterity. The modern luggage system was constructed with lightweight polymer composites and aluminum framing, featuring modular compartments, load-distribution testing, and durability analysis to improve mobility and reduce strain. The ergonomic posture sensor integrated MEMS accelerometers, microcontrollers, and a Bluetooth module within a 3D-printed housing to detect spinal alignment and provide real-time feedback. Each prototype advanced through user research, digital simulation, and iterative prototyping, combining materials science, electronics integration, and human-centered design. The program demonstrated how interdisciplinary methods can be used to generate functional, scalable solutions addressing health, mobility, and accessibility challenges.

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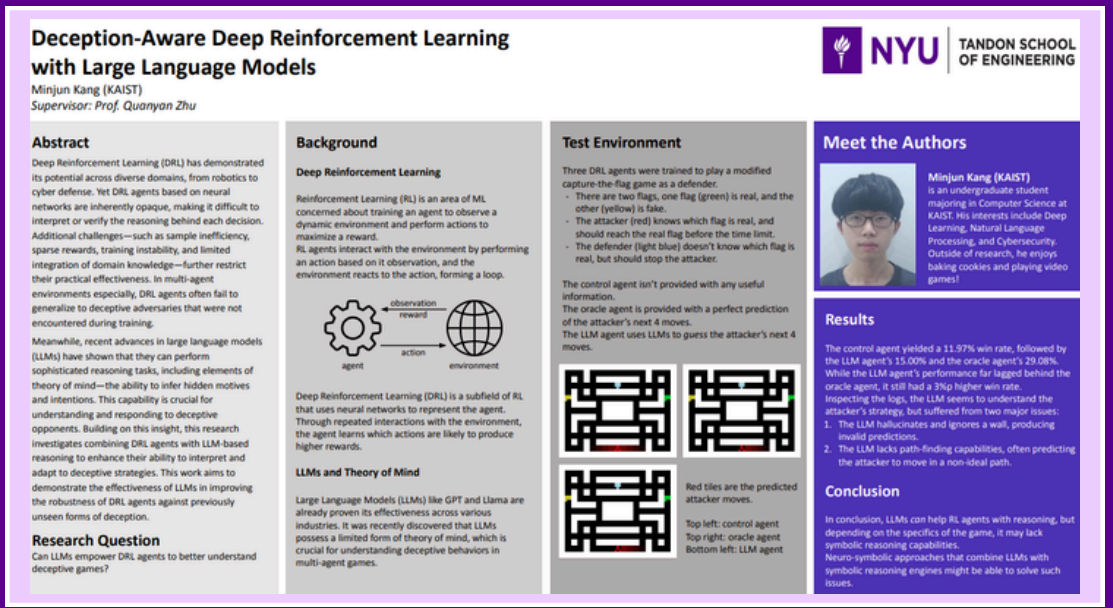
Large Language Models for Network Security

Deep Reinforcement Learning (DRL) has demonstrated its potential across diverse domains, from robotics to cyber defense. Yet DRL agents based on neural networks are inherently opaque, making it difficult to interpret or verify the reasoning behind each decision. Additional challenges—such as sample inefficiency, sparse rewards, training instability, and limited integration of domain knowledge—further restrict their practical effectiveness. In multi-agent environments especially, DRL agents often fail to generalize to deceptive adversaries that were not encountered during training. Meanwhile, recent advances in large language models (LLMs) have shown that they can perform sophisticated reasoning tasks, including elements of theory of mind—the ability to infer hidden motives and intentions. This capability is crucial for understanding and responding to deceptive opponents. Building on this insight, this research investigates combining DRL agents with LLM-based reasoning to enhance their ability to interpret and adapt to deceptive strategies. This work aims to demonstrate the effectiveness of LLMs in improving the robustness of DRL agents against previously unseen forms of deception.

Project Supervisor *Quanyan Zhu*
Research Areas *Cybersecurity*



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Deception-Aware Deep Reinforcement Learning with Large Language Models

Minjun Kang (KAIST)
Supervisor: Prof. Quanyan Zhu

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Abstract

Deep Reinforcement Learning (DRL) has demonstrated its potential across diverse domains, from robotics to cyber defense. Yet DRL agents based on neural networks are inherently opaque, making it difficult to interpret or verify the reasoning behind each decision. Additional challenges—such as sample inefficiency, sparse rewards, training instability, and limited integration of domain knowledge—further restrict their practical effectiveness. In multi-agent environments especially, DRL agents often fail to generalize to deceptive adversaries that were not encountered during training.

Meanwhile, recent advances in large language models (LLMs) have shown that they can perform sophisticated reasoning tasks, including elements of theory of mind—the ability to infer hidden motives and intentions. This capability is crucial for understanding and responding to deceptive opponents. Building on this insight, this research investigates combining DRL agents with LLM-based reasoning to enhance their ability to interpret and adapt to deceptive strategies. This work aims to demonstrate the effectiveness of LLMs in improving the robustness of DRL agents against previously unseen forms of deception.

Research Question

Can LLMs empower DRL agents to better understand deceptive games?

Background

Deep Reinforcement Learning

Reinforcement Learning (RL) is an area of ML concerned about training an agent to observe a dynamic environment and perform actions to maximize a reward.
RL agents interact with the environment by performing an action based on it observation, and the environment reacts to the action, forming a loop.

observation
reward
agent
action
environment

Deep Reinforcement Learning (DRL) is a subfield of RL that uses neural networks to represent the agent. Through repeated interactions with the environment, the agent learns which actions are likely to produce higher rewards.

LLMs and Theory of Mind

Large Language Models (LLMs) like GPT and Llama are already proven its effectiveness across various industries. It was recently discovered that LLMs possess a limited form of theory of mind, which is crucial for understanding deceptive behaviors in multi-agent games.

Test Environment

Three DRL agents were trained to play a modified capture-the-flag game as a defender.
- There are two flags, one flag (green) is real, and the other (yellow) is fake.
- The attacker (red) knows which flag is real, and should reach the real flag before the time limit.
- The defender (light blue) doesn't know which flag is real, but should stop the attacker.

The control agent isn't provided with any useful information.
The oracle agent is provided with a perfect prediction of the attacker's next 4 moves.
The LLM agent uses LLMs to guess the attacker's next 4 moves.

Red tiles are the predicted attacker moves.

Top left: control agent
Top right: oracle agent
Bottom left: LLM agent

Meet the Authors

Minjun Kang (KAIST) is an undergraduate student majoring in Computer Science at KAIST. His interests include Deep Learning, Natural Language Processing, and Cybersecurity. Outside of research, he enjoys baking cookies and playing video games!

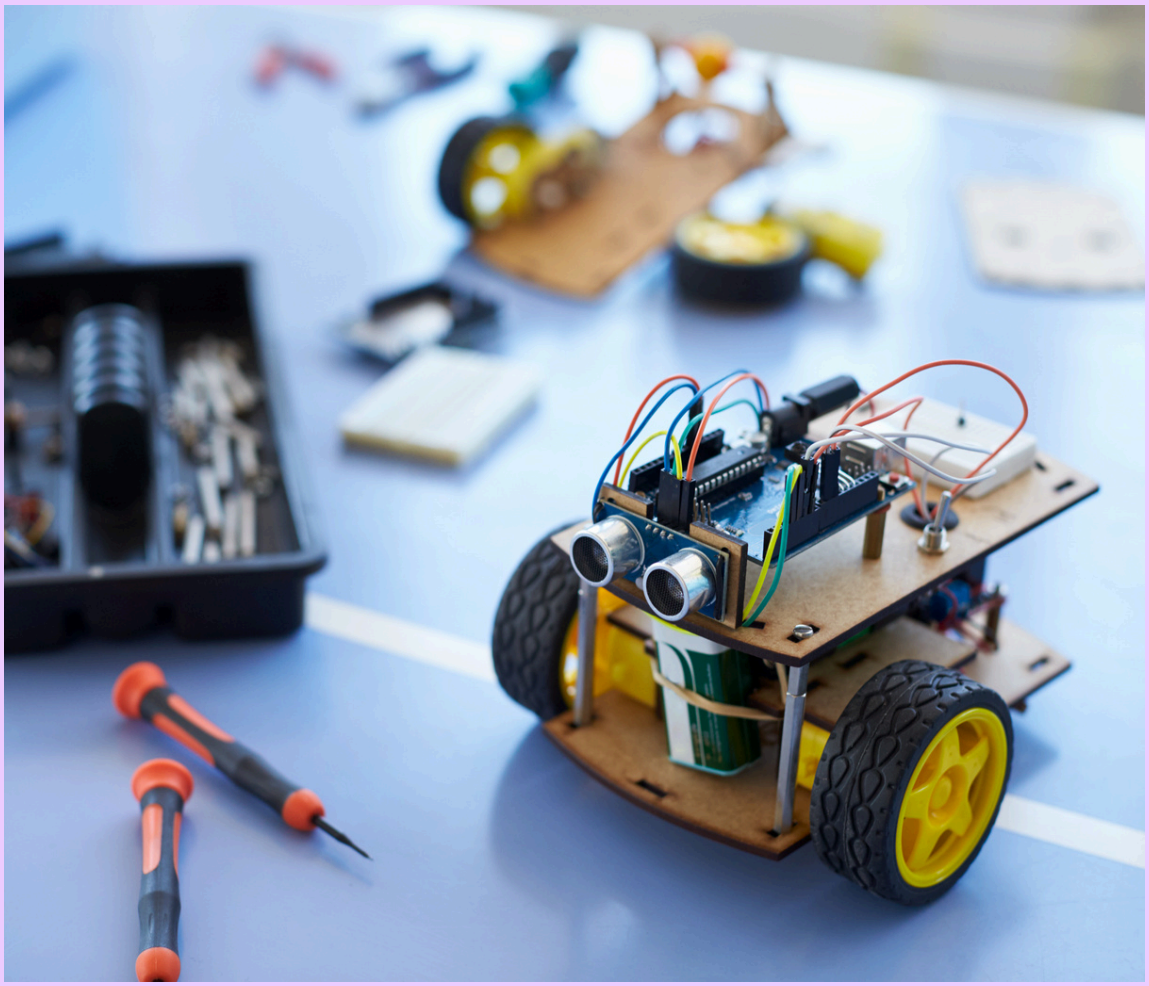
Results

The control agent yielded a 11.97% win rate, followed by the LLM agent's 15.00% and the oracle agent's 29.08%. While the LLM agent's performance far lagged behind the oracle agent, it still had a 3%p higher win rate.
Inspecting the logs, the LLM seems to understand the attacker's strategy, but suffered from two major issues:
1. The LLM hallucinates and ignores a wall, producing invalid predictions.
2. The LLM lacks path-finding capabilities, often predicting the attacker to move in a non-ideal path.

Conclusion

In conclusion, LLMs can help RL agents with reasoning, but depending on the specifics of the game, it may lack symbolic reasoning capabilities.
Neuro-symbolic approaches that combine LLMs with symbolic reasoning engines might be able to solve such issues.

Data Science, AI & Robotics



Three disciplines come together to create the technologies that will define the future. Our AI experts and roboticists are working in concert with our data scientists, who are discovering new ways to analyze, visualize, and use their skills for a common goal: to harness the collective power of data, machine learning techniques, and autonomous systems to address the issues facing the world.

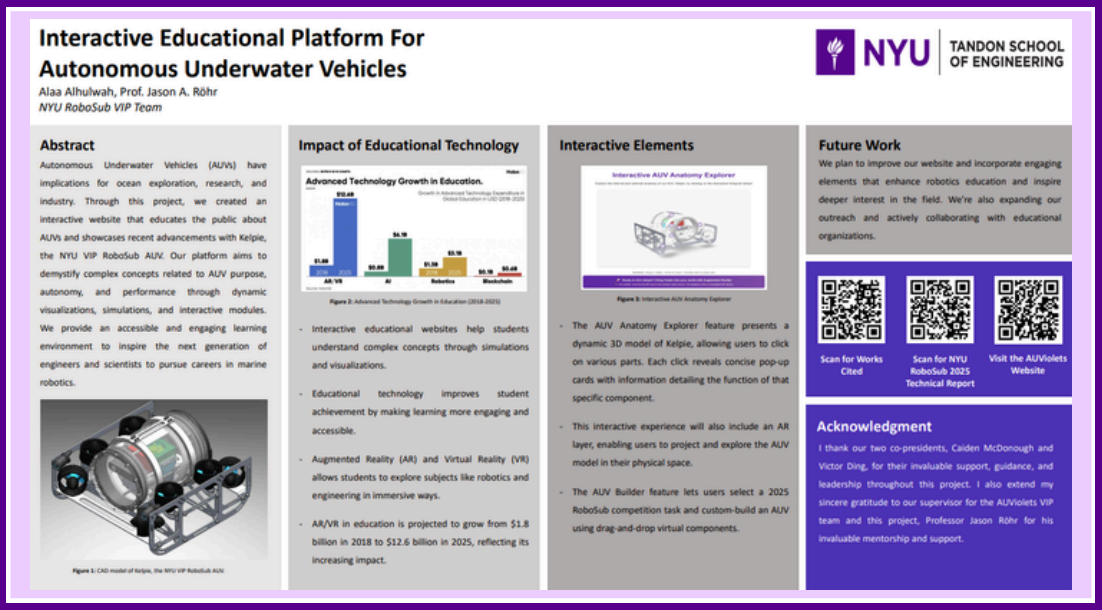
VIP Robotics Project

Autonomous Underwater Vehicles (AUVs) have implications for ocean exploration, research, and industry. Through this project, we created an interactive website that educates the public about AUVs and showcases recent advancements with Kelpie, the NYU VIP RoboSub AUV. Our platform aims to demystify complex concepts related to AUV purpose, autonomy, and performance through dynamic visualizations, simulations, and interactive modules. We provide an accessible and engaging learning environment to inspire the next generation of engineers and scientists to pursue careers in marine robotics.

Project Supervisor *Jason Röhr*
Research Areas *Data Science, AI & Robotics*



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Interactive Educational Platform For Autonomous Underwater Vehicles

Alaa Alhulwah, Prof. Jason A. Röhr
NYU RoboSub VIP Team

NYU TANDON SCHOOL OF ENGINEERING

Abstract

Autonomous Underwater Vehicles (AUVs) have implications for ocean exploration, research, and industry. Through this project, we created an interactive website that educates the public about AUVs and showcases recent advancements with Kelpie, the NYU VIP RoboSub AUV. Our platform aims to demystify complex concepts related to AUV purpose, autonomy, and performance through dynamic visualizations, simulations, and interactive modules. We provide an accessible and engaging learning environment to inspire the next generation of engineers and scientists to pursue careers in marine robotics.

Impact of Educational Technology

Advanced Technology Growth in Education.

- Interactive educational websites help students understand complex concepts through simulations and visualizations.
- Educational technology improves student achievement by making learning more engaging and accessible.
- Augmented Reality (AR) and Virtual Reality (VR) allows students to explore subjects like robotics and engineering in immersive ways.
- AR/VR in education is projected to grow from $1.8 billion in 2018 to $12.6 billion in 2025, reflecting its increasing impact.

Interactive Elements

Interactive AUV Anatomy Explorer

- The AUV Anatomy Explorer feature presents a dynamic 3D model of Kelpie, allowing users to click on various parts. Each click reveals concise pop-up cards with information detailing the function of that specific component.
- This interactive experience will also include an AR layer, enabling users to project and explore the AUV model in their physical space.
- The AUV Builder feature lets users select a 2025 RoboSub competition task and custom-build an AUV using drag-and-drop virtual components.

Future Work

We plan to improve our website and incorporate engaging elements that enhance robotics education and inspire deeper interest in the field. We're also expanding our outreach and actively collaborating with educational organizations.

Scan for Works Cited | Scan for NYU RoboSub 2025 Technical Report | Visit the AUVIolets Website

Acknowledgment

I thank our two co-presidents, Caiden McDonough and Victor Ding, for their invaluable support, guidance, and leadership throughout this project. I also extend my sincere gratitude to our supervisor for the AUVIolets VIP team and this project, Professor Jason Röhr for his invaluable mentorship and support.

Physical AI: an AI Agent in Robotic Applications

This research explores the application of Digital Twin (DT) technology, integrated with NVIDIA Isaac Sim, to enhance the control and performance of robotic arms in automated parcel sorting systems. By creating a high-fidelity virtual replica of the physical robotic arm and its workspace, we leverage real-time simulation, sensor data fusion, and reinforcement learning to optimize object classification, grasping, and placement based on the previous research on robotic arms. Our approach enables predictive maintenance, dynamic path planning, and adaptive manipulation for diverse package types while reducing operational downtime.This research explores the application of Digital Twin (DT) technology, integrated with NVIDIA Isaac Sim, to enhance the control and performance of robotic arms in automated parcel sorting systems. By creating a high-fidelity virtual replica of the physical robotic arm and its workspace, we leverage real-time simulation, sensor data fusion, and reinforcement learning to optimize object classification, grasping, and placement. Our approach enables predictive maintenance, dynamic path planning, and adaptive manipulation for diverse package types while reducing operational downtime.

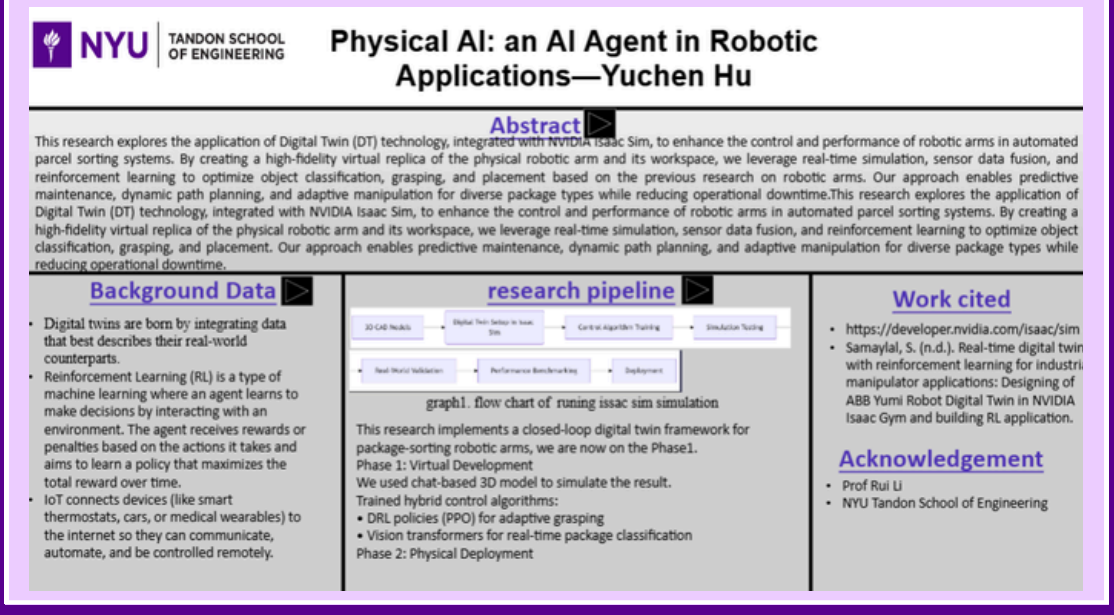
Project Supervisor *Rui Li*

Research Areas *Data Science, AI & Robotics*



Yuchen Hu

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Physical AI: an AI Agent in Robotic Applications

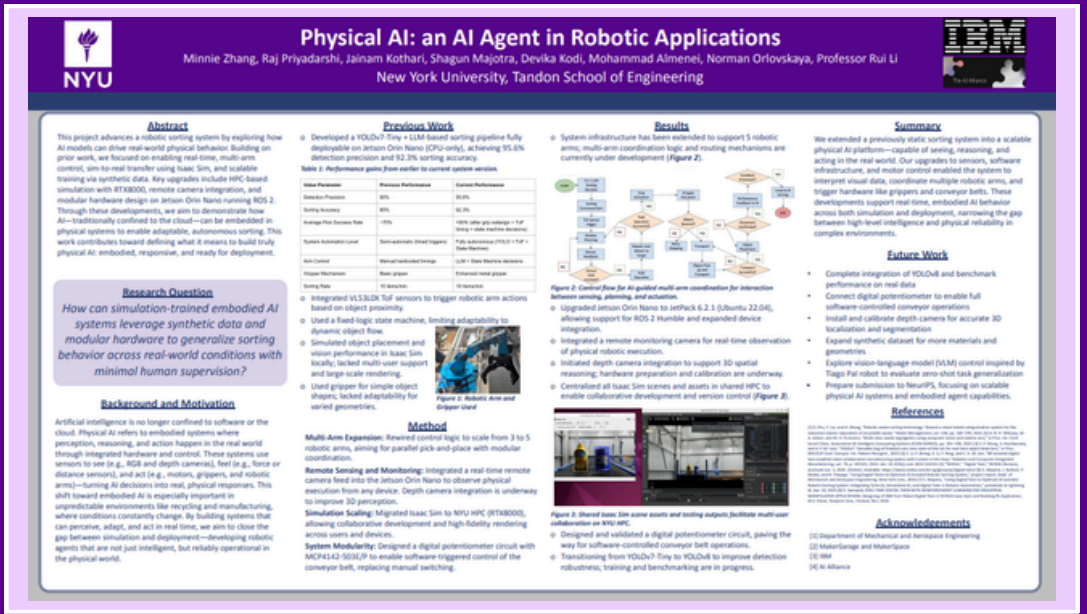
This project explores the development of a robust and scalable robotic waste sorting system powered by digital twins, large language models (LLMs), and computer vision. Building on previous work that integrated YOLOv7-Tiny and GPT-based classification within a simulated Isaac Sim environment, we focused this term on enabling key infrastructure upgrades for future deployment. Progress includes expanding remote control from 3 to 5 robotic arms, replacing the default gripper with a more reliable alternative both in simulation and on hardware, and setting up a remote monitoring camera for real-time observation. We migrated our Isaac Sim scenes to NYU's HPC cluster to support collaborative testing and scene sharing. Meanwhile, we began integrating YOLOv8 and exploring Jetson Nano deployment, alongside initial trials of CAD-to-text workflows for synthetic data generation. Work also began on adding depth camera support and incorporating a physically installed conveyor belt into the full system pipeline. These upgrades lay the groundwork for improved performance, greater adaptability, and eventual full-system autonomy in dynamic real-world environments.

Project Supervisor *Rui Li*

Research Areas *Data Science, AI & Robotics*



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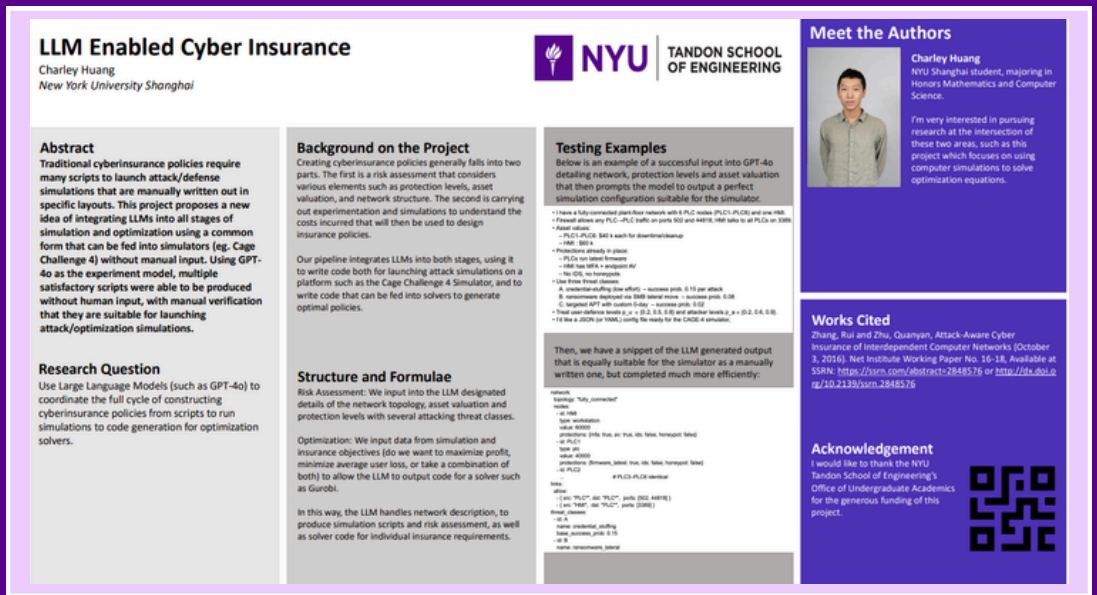
Large Language Models for Multi-Agent Games

Autonomous Underwater Vehicles (AUVs) have implications for ocean exploration, research, and industry. Through this project, we created an interactive website that educates the public about AUVs and showcases recent advancements with Kelpie, the NYU VIP RoboSub AUV. Our platform aims to demystify complex concepts related to AUV purpose, autonomy, and performance through dynamic visualizations, simulations, and interactive modules. We provide an accessible and engaging learning environment to inspire the next generation of engineers and scientists to pursue careers in marine robotics.

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LLM Enabled Cyber Insurance

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Abstract
Traditional cyberinsurance policies require many scripts to launch attack/defense simulations that are manually written out in specific layouts. This project proposes a new idea of integrating LLMs into all stages of simulation and optimization using a common form that can be fed into simulators (eg. Cage Challenge 4) without manual input. Using GPT-4o as the experiment model, multiple satisfactory scripts were able to be produced without human input, with manual verification that they are suitable for launching attack/optimization simulations.

Research Question
Use Large Language Models (such as GPT-4o) to coordinate the full cycle of constructing cyberinsurance policies from scripts to run simulations to code generation for optimization solvers.

Background on the Project
Creating cyberinsurance policies generally falls into two parts. The first is a risk assessment that considers various elements such as protection levels, asset valuation, and network structure. The second is carrying out experimentation and simulations to understand the costs incurred that will then be used to design insurance policies.

Our pipeline integrates LLMs into both stages, using it to write code both for launching attack simulations on a platform such as the Cage Challenge 4 Simulator, and to write code that can be fed into solvers to generate optimal policies.

Structure and Formulae
Risk Assessment: We input into the LLM designated details of the network topology, asset valuation and protection levels with several attacking threat classes.

Optimization: We input data from simulation and insurance objectives (do we want to maximize profit, minimize average user loss, or take a combination of both) to allow the LLM to output code for a solver such as Gurobi.

In this way, the LLM handles network description, to produce simulation scripts and risk assessment, as well as solver code for individual insurance requirements.

Testing Examples
Below is an example of a successful input into GPT-4o detailing network, protection levels and asset valuation that then prompts the model to output a perfect simulation configuration suitable for the simulator.

Then, we have a snippet of the LLM generated output that is equally suitable for the simulator as a manually written one, but completed much more efficiently:

Meet the Authors

Charley Huang
NYU Shanghai student, majoring in Honors Mathematics and Computer Science.

I'm very interested in pursuing research at the intersection of these two areas, such as this project which focuses on using computer simulations to solve optimization equations.

Works Cited
Zhang, Rui and Zhu, Quanyan, Attack-Aware Cyber Insurance of Interdependent Computer Networks (October 3, 2016). Net Institute Working Paper No. 16-18, Available at SSRN: https://ssrn.com/abstract=2848576 or http://dx.doi.org/10.2139/ssrn.2848576

Acknowledgement
I would like to thank the NYU Tandon School of Engineering's Office of Undergraduate Academics for the generous funding of this project.

Design of an Experimental Setup to Understand Social Networks in Ants

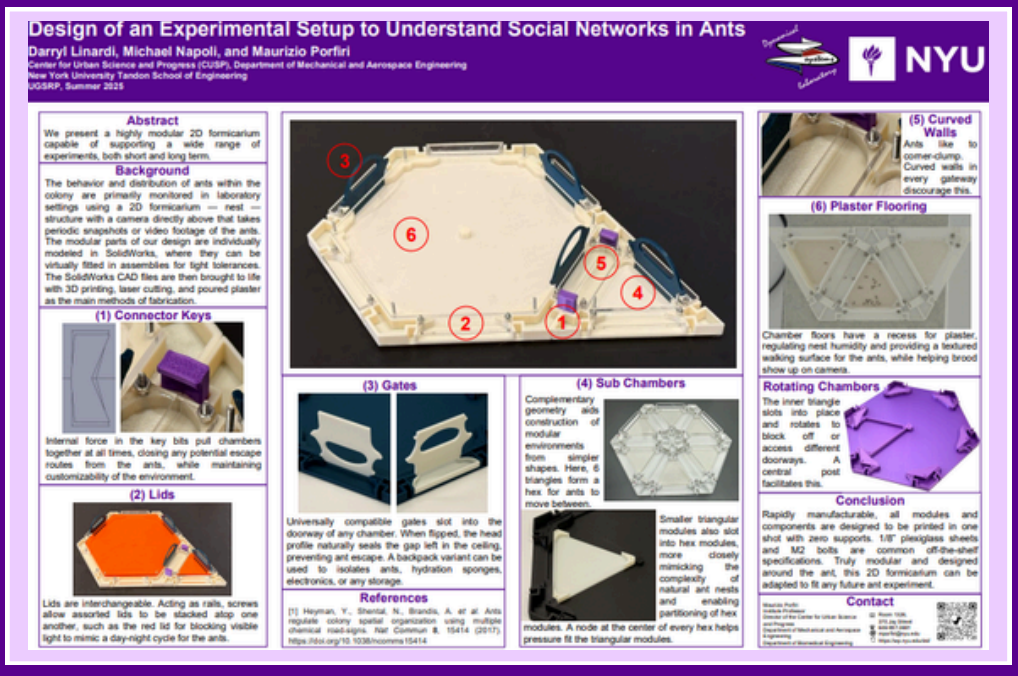
Over the past several decades, research on collective behavior has revealed how colony-level dynamics can emerge from local interactions. Yet, many experimental systems remain limited in scope, often relying on uniform environments that restrict both the scale and complexity of long-term observation. Here, we introduce a highly modular two-dimensional nest system designed to overcome these limitations. The setup combines precision engineering with flexible fabrication methods – including 3D printing, laser cutting, and cast components – to produce tightly fitting, reconfigurable modules. This approach allows for both short- and long-term experiments, while enabling systematic variation of spatial structure and environmental complexity. By integrating continuous video monitoring with interchangeable architectural features, the system supports detailed study of distribution patterns, temporal rhythms, and other facets of collective organization. In doing so, it provides a versatile experimental platform that bridges the gap between constrained laboratory arenas and the broader ecological contexts in which collective behaviors evolve.

Project Supervisor	*Maurizio Porfiri*
Research Areas	*Data Science, AI & Robotics*
Research Staff	*Michael Napoli*



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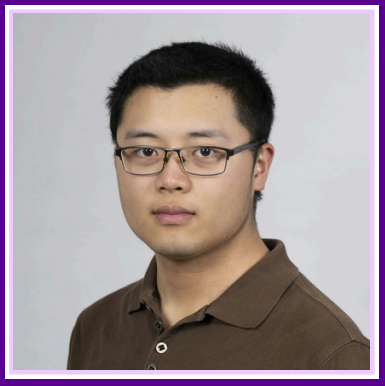


Retrieval-Augmented Generation

Natural Language Generation (NLG) focuses on generating relevant text in response to a provided context, but pure generative models are prone to hallucinations when requiring knowledge outside their training set. Retrieval-Augmented Generation (RAG) combines a retrieval mechanism, designed to surface relevant information from an external source, with the generation module to ground the resulting outputs. This project seeks to explore a novel hybrid retrieval pipeline for RAG systems, using entities extracted from the query as inputs to a traditional sparse retrieval method such as BM25 and fusing the result with the output from a dense retrieval model. When tested on the MS MARCO V2.1 dataset, this novel retrieval pipeline managed similar performance to a standard hybrid retrieval pipeline, while avoiding the costs associated with corpus entity extraction.

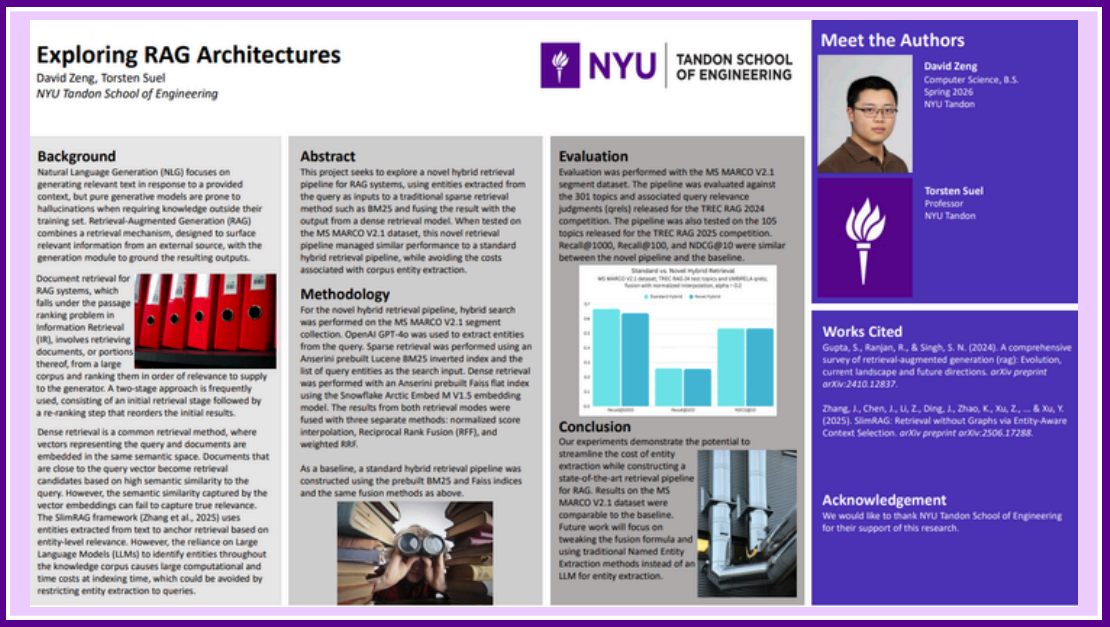
Project Supervisor *Torsten Suel*

Research Areas *Data Science, AI & Robotics*



David Zeng

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Spring 2026
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Improving Approximate Nearest Neighbor Algorithms for High Dimensions

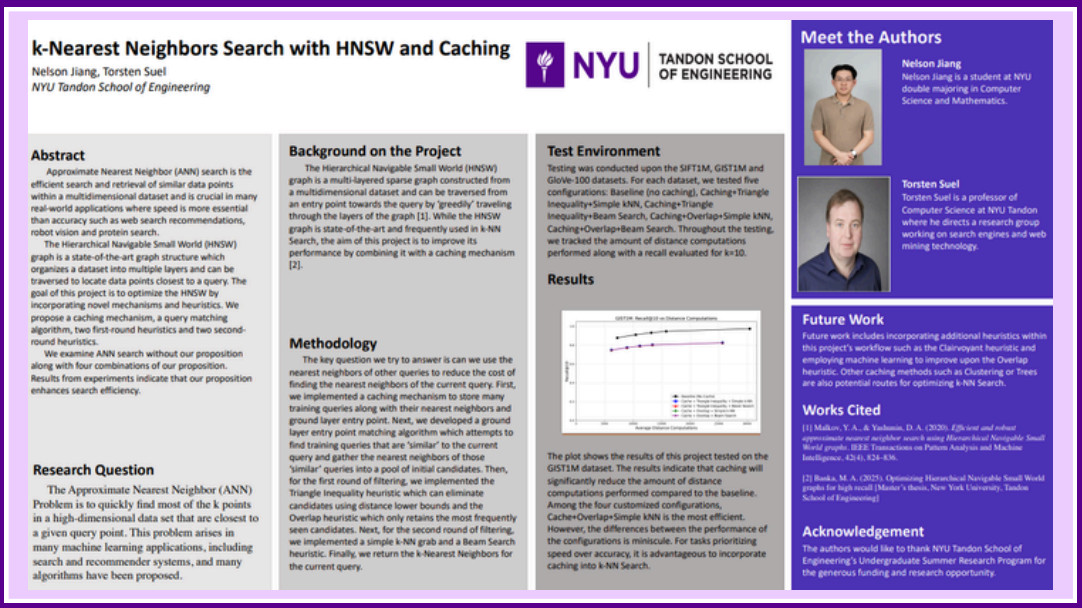
Approximate nearest neighbor search is the efficient search and retrieval of similar data points within a multidimensional dataset and is crucial in many real-world scenarios such as e-commerce recommendations, robotic vision and protein search where speed is more essential than accuracy. The Hierarchical Navigable Small World (HNSW) graph is a state-of-the-art graph structure that organizes a multidimensional dataset into multiple layers with a fixed global entry point which can be used to traverse the graph to search for the datapoint closest to the query. The goal of this project is to optimize the search efficiency by incorporating new mechanisms and heuristics into the original HNSW graph. We propose a caching mechanism, a trail-search-match algorithm, two first-round heuristics and two second-round heuristics. Given a query, the program will initially obtain its trail, which is the set of entry points for the query at each level of the HNSW then peruse the cache for any past ihihhthtilThl trail-search-match algorithm, two first-round heuristics and two second-round heuristics. Given a query, the program will initially obtain its trail, which is the set of entry points for the query at each level of the HNSW then peruse the cache for any past queries which have the same trail. The pool of k-Nearest Neighbors of the discovered past queries will be the current query's initial pool of candidates. For the first round of heuristics, the user is allowed to select either the Triangle Inequality heuristic or the Overlap heuristic to retain the most promising candidates. For the second round of heuristics, the user is allowed to select either a simple k-Nearest Neighbor grab or perform a Beam Search to obtain the predicted solution for the current query. As the query is being processed, the program is also tracking the total amount of distance computations performed. Finally, we store the query, its predicted solution and trail into the caching mechanism.

Project Supervisor *Torsten Suel*

Research Areas *Data Science, AI & Robotics*



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k-Nearest Neighbors Search with HNSW and Caching

Nelson Jiang, Torsten Suel
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Abstract

Approximate Nearest Neighbor (ANN) search is the efficient search and retrieval of similar data points within a multidimensional dataset and is crucial in many real-world applications where speed is more essential than accuracy such as web search recommendations, robot vision and protein search.

The Hierarchical Navigable Small World (HNSW) graph is a state-of-the-art graph structure which organizes a dataset into multiple layers and can be traversed to locate data points closest to a query. The goal of this project is to optimize the HNSW by incorporating novel mechanisms and heuristics. We propose a caching mechanism, a query matching algorithm, two first-round heuristics and two second-round heuristics.

We examine ANN search without our proposition along with four combinations of our proposition. Results from experiments indicate that our proposition enhances search efficiency.

Research Question

The Approximate Nearest Neighbor (ANN) Problem is to quickly find most of the k points in a high-dimensional data set that are closest to a given query point. This problem arises in many machine learning applications, including search and recommender systems, and many algorithms have been proposed.

Background on the Project

The Hierarchical Navigable Small World (HNSW) graph is a multi-layered sparse graph constructed from a multidimensional dataset and can be traversed from an entry point towards the query by 'greedily' traveling through the layers of the graph [1]. While the HNSW graph is state-of-the-art and frequently used in k-NN Search, the aim of this project is to improve its performance by combining it with a caching mechanism [2].

Methodology

The key question we try to answer is can we use the nearest neighbors of other queries to reduce the cost of finding the nearest neighbors of the current query. First, we implemented a caching mechanism to store many training queries along with their nearest neighbors and ground layer entry point. Next, we developed a ground layer entry point matching algorithm which attempts to find training queries that are 'similar' to the current query and gather the nearest neighbors of those 'similar' queries into a pool of initial candidates. Then, for the first round of filtering, we implemented the Triangle Inequality heuristic which can eliminate candidates using distance lower bounds and the Overlap heuristic which only retains the most frequently seen candidates. Next, for the second round of filtering, we implemented a simple k-NN grab and a Beam Search heuristic. Finally, we return the k-Nearest Neighbors for the current query.

Test Environment

Testing was conducted upon the SIFT1M, GIST1M and GloVe-100 datasets. For each dataset, we tested five configurations: Baseline (no caching), Caching+Triangle Inequality+Simple kNN, Caching+Triangle Inequality+Beam Search, Caching+Overlap+Simple kNN, Caching+Overlap+Beam Search. Throughout the testing, we tracked the amount of distance computations performed along with a recall evaluated for k=10.

Results

The plot shows the results of this project tested on the GIST1M dataset. The results indicate that caching will significantly reduce the amount of distance computations performed compared to the baseline. Among the four customized configurations, Cache+Overlap+Simple kNN is the most efficient. However, the differences between the performance of the configurations is miniscule. For tasks prioritizing speed over accuracy, it is advantageous to incorporate caching into k-NN Search.

Meet the Authors

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Nelson Jiang is a student at NYU double majoring in Computer Science and Mathematics.

Torsten Suel
Torsten Suel is a professor of Computer Science at NYU Tandon where he directs a research group working on search engines and web mining technology.

Future Work

Future work includes incorporating additional heuristics within this project's workflow such as the Clairvoyant heuristic and employing machine learning to improve upon the Overlap heuristic. Other caching methods such as Clustering or Trees are also potential routes for optimizing k-NN Search.

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Acknowledgement

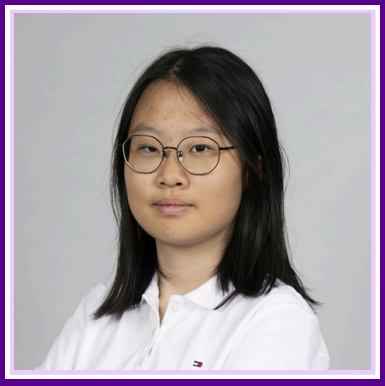
The authors would like to thank NYU Tandon School of Engineering's Undergraduate Summer Research Program for the generous funding and research opportunity.

Sparse Learned Index Structures for Future Search Architectures

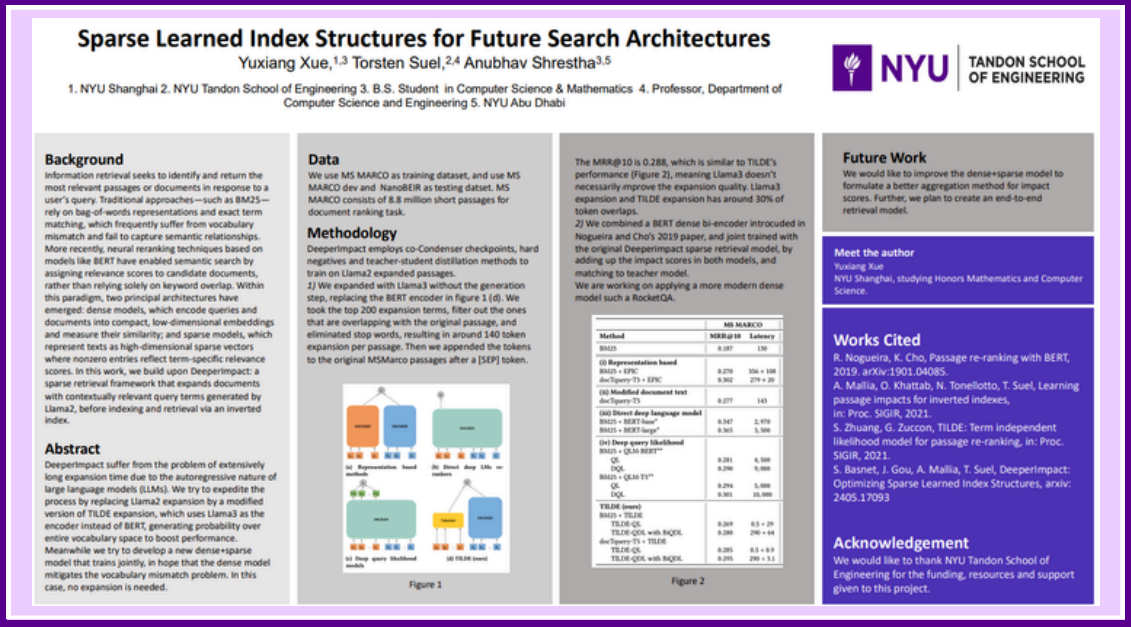
Information retrieval seeks to identify and return the most relevant passages or documents in response to a user's query. To address vocabulary mismatch problem that occur in traditional methods, neural reranking techniques based on models like BERT have enabled semantic search by assigning relevance scores to candidate documents. Within this paradigm, two principal architectures have emerged: dense models, which encode queries and documents into compact, low-dimensional embeddings and measure their similarity; and sparse models, which represent texts as high-dimensional sparse vectors where nonzero entries reflect term-specific relevance scores. In this work, we build upon DeeperImpact, a sparse retrieval framework, by improving the runtime for term generation and incorporating dense + sparse joint training pipeline. Instead of generation by Llama2, we use Llama3 as a decoder only model to predict probability over the entire vocabulary space, greatly reducing expansion time. Meanwhile the added dense model encaptures more semantic information, further mitigating the exact match problem.

Project Supervisor *Torsten Suel*

Research Areas *Data Science, AI & Robotics*



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Sparse Learned Index Structures for Future Search Architectures

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1. NYU Shanghai 2. NYU Tandon School of Engineering 3. B.S. Student in Computer Science & Mathematics 4. Professor, Department of Computer Science and Engineering 5. NYU Abu Dhabi

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Background

Information retrieval seeks to identify and return the most relevant passages or documents in response to a user's query. Traditional approaches—such as BM25—rely on bag-of-words representations and exact term matching, which frequently suffer from vocabulary mismatch and fail to capture semantic relationships. More recently, neural reranking techniques based on models like BERT have enabled semantic search by assigning relevance scores to candidate documents, rather than relying solely on keyword overlap. Within this paradigm, two principal architectures have emerged: dense models, which encode queries and documents into compact, low-dimensional embeddings and measure their similarity; and sparse models, which represent texts as high-dimensional sparse vectors where nonzero entries reflect term-specific relevance scores. In this work, we build upon DeeperImpact: a sparse retrieval framework that expands documents with contextually relevant query terms generated by Llama2, before indexing and retrieval via an inverted index.

Abstract

DeeperImpact suffer from the problem of extensively long expansion time due to the autoregressive nature of large language models (LLMs). We try to expedite the process by replacing Llama2 expansion by a modified version of TILDE expansion, which uses Llama3 as the encoder instead of BERT, generating probability over entire vocabulary space to boost performance. Meanwhile we try to develop a new dense+sparse model that trains jointly, in hope that the dense model mitigates the vocabulary mismatch problem. In this case, no expansion is needed.

Data

We use MS MARCO as training dataset, and use MS MARCO dev and NanoBEIR as testing datset. MS MARCO consists of 8.8 million short passages for document ranking task.

Methodology

DeeperImpact employs co-Condenser checkpoints, hard negatives and teacher-student distillation methods to train on Llama2 expanded passages.
1) We expanded with Llama3 without the generation step, replacing the BERT encoder in figure 1 (d). We took the top 200 expansion terms, filter out the ones that are overlapping with the original passage, and eliminated stop words, resulting in around 140 token expansion per passage. Then we appended the tokens to the original MSMarco passages after a [SEP] token.

Figure 1

The MRR@10 is 0.288, which is similar to TILDE's performance (Figure 2), meaning Llama3 doesn't necessarily improve the expansion quality. Llama3 expansion and TILDE expansion has around 30% of token overlaps.
2) We combined a BERT dense bi-encoder introcuded in Nogueira and Cho's 2019 paper, and joint trained with the original Deeperimpact sparse retrieval model, by adding up the impact scores in both models, and matching to teacher model.
We are working on applying a more modern dense model such a RocketQA.

Method	MS MARCO MRR@10	MS MARCO Latency
BM25	0.187	130
(i) Representation based		
BM25 + EPIC	0.270	356 + 108
docTquery-T5 + EPIC	0.302	279 + 20
(ii) Modified document text		
docTquery-T5	0.277	143
(iii) Direct deep language model		
BM25 + BERT-base*	0.347	2,970
BM25 + BERT-large*	0.365	5,500
(iv) Deep query likelihood		
BM25 + QLM-BERT**		
QL	0.281	4,500
DQL	0.290	9,000
BM25 + QLM-T5**		
QL	0.294	5,000
DQL	0.301	10,000
TILDE (ours)		
BM25 + TILDE		
TILDE-QL	0.269	0.5 + 29
TILDE-QDL with BQDL	0.280	290 + 64
docTquery-T5 + TILDE		
TILDE-QL	0.285	0.5 + 0.9
TILDE-QDL with BQDL	0.295	290 + 3.1

Figure 2

Future Work

We would like to improve the dense+sparse model to formulate a better aggregation method for impact scores. Further, we plan to create an end-to-end retrieval model.

Meet the author

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NYU Shanghai, studying Honors Mathematics and Computer Science.

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S. Basnet, J. Gou, A. Mallia, T. Suel, Deeperimpact: Optimizing Sparse Learned Index Structures, arxiv: 2405.17093

Acknowledgement

We would like to thank NYU Tandon School of Engineering for the funding, resources and support given to this project.

Algorithms for Stochastic Test Ordering Problems

Many situations require performing pre-defined actions sequentially in order to answer a question of interest. For example, a doctor may have a range of medical tests available, each with potential informative value towards some diagnosis; a rescue operation may have a set of possible locations to search to determine the number of survivors that can be saved; a piece of antivirus software analyzing a potentially dangerous program may have numerous sections of code it could test to determine the program's safety. In these types of situations, the question naturally arises: what ordering minimizes the expected number of necessary actions? Mathematically abstracted from a range of distinct but related applications, these situations are classified as stochastic sequence ordering (SSO) problems. Our research focuses on the design of algorithms for SSO problems. We have two criteria for an SSO algorithm, which must be provably met under any possible input: it must run efficiently with respect to the problem's size, and it must produce a strategy which is either exactly or approximately optimal. If an algorithm's ordering is guaranteed to require at most, in expectation, k times the number of actions as the optimal ordering, the algorithm is said to be a k-approximation algorithm. We present an O(log Q)-approximation algorithm for nonadaptively evaluating any discrete function of independent stochastic inputs, where Q is a particular measure of the complexity of the function in question known as its goal value. We apply this result to the problem of evaluating the Coupon Counting Function, obtaining an O(log d)-approximation algorithm, where d is the number of coupons. We generalize this to a closely related but more difficult function, the Coupon Collection Function, to obtain an O(d)-approximation algorithm. We also present a 4-approximation algorithm for evaluating the related Generalized Not-All-Equal function.

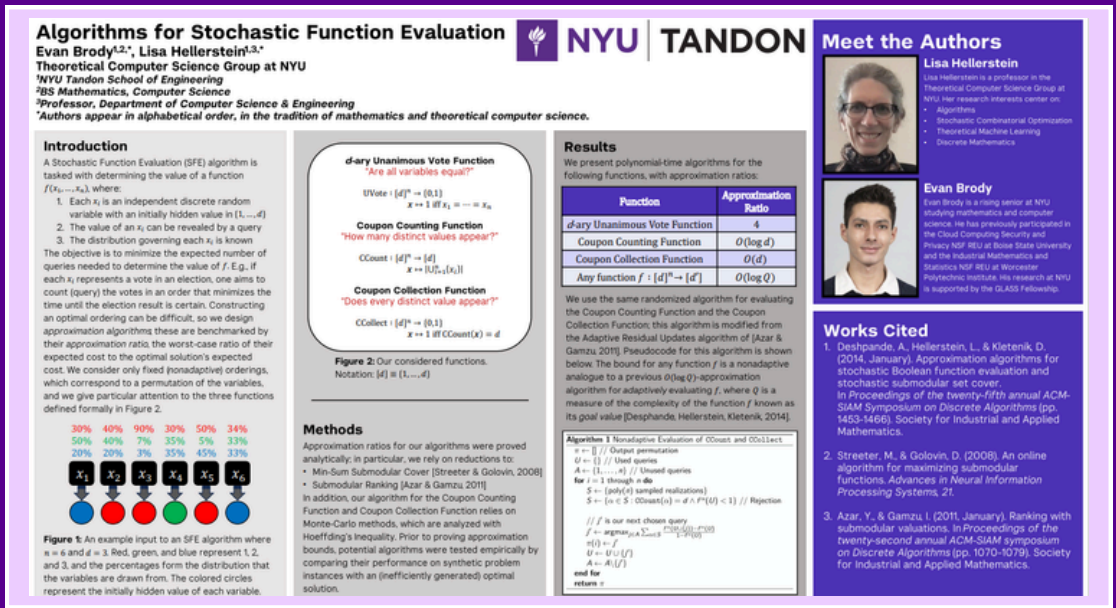
Project Supervisor *Lisa Hellerstein*

Research Areas *Data Science, AI & Robotics*



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Algorithms for Stochastic Function Evaluation

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NYU TANDON

Introduction

A Stochastic Function Evaluation (SFE) algorithm is tasked with determining the value of a function $f(x_1, \ldots, x_n)$, where:

1. Each x_i is an independent discrete random variable with an initially hidden value in $\{1, \ldots, d\}$
2. The value of an x_i can be revealed by a query
3. The distribution governing each x_i is known

The objective is to minimize the expected number of queries needed to determine the value of f. E.g., if each x_i represents a vote in an election, one aims to count (query) the votes in an order that minimizes the time until the election result is certain. Constructing an optimal ordering can be difficult, so we design *approximation algorithms* these are benchmarked by their *approximation ratio*, the worst-case ratio of their expected cost to the optimal solution's expected cost. We consider only fixed (nonadaptive) orderings, which correspond to a permutation of the variables, and we give particular attention to the three functions defined formally in Figure 2.

30% 40% 90% 30% 50% 34%
50% 40% 7% 35% 5% 33%
20% 20% 3% 35% 45% 33%

x_1 x_2 x_3 x_4 x_5 x_6

Figure 1: An example input to an SFE algorithm where $n = 6$ and $d = 3$. Red, green, and blue represent 1, 2, and 3, and the percentages form the distribution that the variables are drawn from. The colored circles represent the initially hidden value of each variable.

d-ary Unanimous Vote Function
"Are all variables equal?"

$$\text{UVote} : [d]^n \to \{0,1\}, \quad \boldsymbol{x} \mapsto 1 \text{ iff } x_1 = \cdots = x_n$$

Coupon Counting Function
"How many distinct values appear?"

$$\text{CCount} : [d]^n \to [d], \quad \boldsymbol{x} \mapsto |\cup_{i=1}^{n} \{x_i\}|$$

Coupon Collection Function
"Does every distinct value appear?"

$$\text{CCollect} : [d]^n \to \{0,1\}, \quad \boldsymbol{x} \mapsto 1 \text{ iff } \text{CCount}(\boldsymbol{x}) = d$$

Figure 2: Our considered functions.
Notation: $[d] \equiv \{1, \ldots, d\}$

Methods

Approximation ratios for our algorithms were proved analytically; in particular, we rely on reductions to:

- Min-Sum Submodular Cover [Streeter & Golovin, 2008]
- Submodular Ranking [Azar & Gamzu 2011]

In addition, our algorithm for the Coupon Counting Function and Coupon Collection Function relies on Monte-Carlo methods, which are analyzed with Hoeffding's Inequality. Prior to proving approximation bounds, potential algorithms were tested empirically by comparing their performance on synthetic problem instances with an (inefficiently generated) optimal solution.

Results

We present polynomial-time algorithms for the following functions, with approximation ratios:

Function	Approximation Ratio
d-ary Unanimous Vote Function	4
Coupon Counting Function	$O(\log d)$
Coupon Collection Function	$O(d)$
Any function $f : [d]^n \to [d']$	$O(\log Q)$

We use the same randomized algorithm for evaluating the Coupon Counting Function and the Coupon Collection Function; this algorithm is modified from the Adaptive Residual Updates algorithm of [Azar & Gamzu 2011]. Pseudocode for this algorithm is shown below. The bound for any function f is a nonadaptive analogue to a previous $\beta(\log Q)$-approximation algorithm for adaptively evaluating f, where Q is a measure of the complexity of the function f known as its *goal value* [Desphande, Hellerstein, Kletenik, 2014].

Algorithm 1 Nonadaptive Evaluation of CCount and CCollect

$\pi \leftarrow []$ // Output permutation
$U \leftarrow \{\}$ // Used queries
$A \leftarrow \{1, \ldots, n\}$ // Unused queries
for $i = 1$ through n **do**
  $S \leftarrow \{\text{poly}(n) \text{ sampled realizations}\}$
  $S \leftarrow \{\alpha \in S : \text{CCount}(\alpha) = d \wedge f^u(U) < 1\}$ // Rejection
  // f is our next chosen query
  $f \leftarrow \text{argmax}_{f \in A} \sum_{\alpha \in S} \frac{f^u(\alpha \cup \{f\}) - f^u(U)}{1 - f^u(U)}$
  $\pi(i) \leftarrow f$
  $U \leftarrow U \cup \{f\}$
  $A \leftarrow A \setminus \{f\}$
end for
return π

Meet the Authors

Lisa Hellerstein

Lisa Hellerstein is a professor in the Theoretical Computer Science Group at NYU. Her research interests center on:

- Algorithms
- Stochastic Combinatorial Optimization
- Theoretical Machine Learning
- Discrete Mathematics

Evan Brody

Evan Brody is a rising senior at NYU studying mathematics and computer science. He has previously participated in the Cloud Computing Security and Privacy NSF REU at Boise State University and the Industrial Mathematics and Statistics NSF REU at Worcester Polytechnic Institute. His research at NYU is supported by the QLASS Fellowship.

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AI-Driven Structural Optimization: Enhancing Design Efficiency and Performance

Git is one of the most widely used version control systems, enabling collaboration on large-scale projects while maintaining a record of any changes and allowing previous versions to be restored. Many developers rely on Git to secure their projects and prevent unapproved changes to their repositories. However, due to vulnerabilities within Git, many of these repositories remain vulnerable to cyberattacks. gittuf is an added security layer to Git that enables multiple users to share the responsibilities of declaring and managing security policies, has each developer individually record and verify any changes to the repository, and supports policy declaration that can require push and merge requests to be approved by multiple parties. Currently, gittuf represents developers on an individual level, with users being named explicitly in policy declaration. However, developers can be members of multiple teams, each with varying levels of permission within the repository. With users represented on an individual level, they are forced to either hold multiple keys or must always act in their most privileged role, leaving the repository vulnerable if that individual chooses to act maliciously or their credentials are compromised. We introduced the concept of team designations to gittuf to enable users to act in their least-privileged role. We expanded the existing gittuf metadata to support a team interface, with each team having an ID, a list of team members, and a threshold of member signatures that need to be met for the team's approval to be granted. We also modified the existing signing and verification workflows to support team signatures on commits, enabling users to state what role they are acting within and streamlining the policy declaration process, as entire teams can now be added to a rule at once and any changes to team personnel no longer require the policy declaration to be modified.

Project Supervisor *Dzung Luong*

Research Areas *Data Science, AI & Robotics*



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AI-Driven Structural Optimization:
Enhancing Design Efficiency and Performance

NYU TANDON SCHOOL OF ENGINEERING

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Abstract

Recent years have seen the advent of new powerful AI programs such as ChatGPT and DeepSeek, large language models (LLMs) that are accessible to individuals and can parse submitted text and respond with appropriate outputs incredibly quickly, generating segments of code, spontaneous writing, or even images in seconds. The rapid development of these tools has had a disruptive effect on many industries, with software tools improving rapidly, and the known viable use-cases expanding constantly.

However, one area in which general purpose LLMs still struggle is in the generation of mathematically defined 3D models, through something known as Computer Aided Design (CAD). Our research identifies the most common issues in LLM CAD generation, and from that information, creates a set of guidelines for LLM prompting dictating both LLM and user behavior that maximizes LLM stability and output in CAD generation.

Background

LLMs such as ChatGPT uses a neural network trained on large datasets of digital information, which allows it to mimic the construction of human generated text. However, as their name suggests, large language models have a far less robust understanding of non-text-based media such as graphical interfaces, which poses a barrier to their usage of traditional CAD programs workflows, which operate graphically, with the user selecting faces, edges, and/or points to apply operation too.

Past research has already attempted to circumvent LLM limitations via creative solutions such as additional encoding/decoding algorithms[1], and specialized training sets[2]. However, challenges persist in the generation of complex shapes. This is because without the ability to operate a graphical interface, the LLM must interface with a CAD program's API, writing code that is then translated into operations. This separation limits the LLMs ability to track and reference what has already been created, preventing the creation of complicated models.

Methods / Results

To increase the accuracy of the LLM CAD generation, a set of training prompts describing 3D models were developed and used to gauge the specific weaknesses and erroneous tendencies of the process. The LLM chosen was DeepSeek due to availability, and initial results. The CAD program chosen was Fusion 360. The Fusion 360 API is well documented and contains many official sample codes, which helped diagnose issues and would later aid in pre-training. The LLM was prompted through each of the training models, and the output was compared to human generated models developed from the same prompts. An example of the initial LLM vs. Human output is shown below.

After these initial tests, the most common modeling errors committed by the LLM were identified and traced back to the LLM's code. Additionally, multiple prompting techniques were trialed on the same training sets, allowing us to gauge the effectiveness of techniques such as explicit mimicry, chain-of-thought prompting, and problem segmentation. From these trials, two documents were produced as guidelines for future LLM CAD work. Firstly, a pre-training module to be uploaded to the LLM consisting of annotated sample code and common errors to promote consistent code generation and combat errors, and secondly a set of user prompt guidelines, stressing the importance of explicit problem segmentation and containing troubleshooting techniques.

From these guidelines, the following drone body was designed entirely through a dialogue with the pre-trained DeepSeek V3 model:

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Robot Energy Consumption: From Electrical to Mechanical

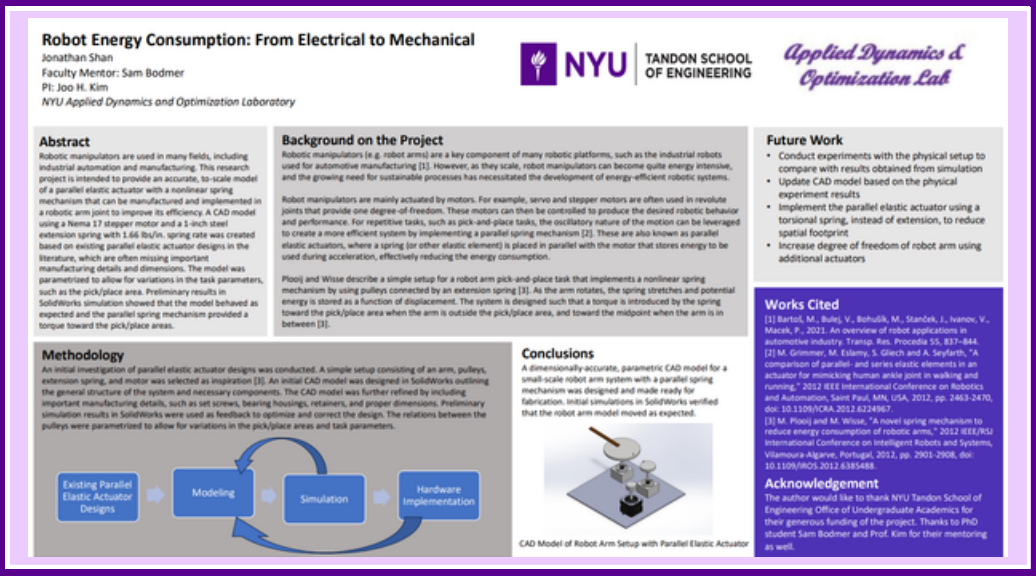
Robotic manipulators are used in various fields, with many applications in industrial automation and manufacturing. As robotic manipulators become more commonly used, more thought must be put towards their energy consumption and efficiency. In the growing demand for more sustainable processes, there have been several approaches to improve the energy-efficiency of robotic arms, such as energy-optimal path-planning and/or optimizing scheduling times. For repetitive tasks, such as a pick-and-place operation, a bottom-up approach can be taken by improving the underlying technology to leverage the oscillatory motion for better energy-savings. This research project is intended to provide an accurate, to-scale model of a parallel elastic actuator with a nonlinear spring mechanism that can be manufactured and implemented in a robotic arm to improve its efficiency. A CAD model using a Nema 17 stepper motor and a 1-inch steel extension spring with 1.66 lbs/in. spring rate was created based on existing parallel elastic actuator designs in the literature, which are often missing important manufacturing details and dimensions, thus limiting their reproducibility and implementation. The model was parametrized to allow for variations in the task parameters, such as the pick/place area. Preliminary results in SolidWorks simulation showed that the model behaved as expected and the parallel spring mechanism provided a torque toward the pick/place areas, reducing the effective energy consumption. In addition, preliminary novel design improvements including the use of a torsional spring are proposed for future work.

Project Supervisor	*Joo H. Kim*
Research Areas	*Data Science, AI & Robotics*
Research Staff	*Sameer Upadhye, Sam Bodmer*



Jonathan Shan

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Spring 2027
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Robot Energy Consumption: From Electrical to Mechanical

Jonathan Shan
Faculty Mentor: Sam Bodmer
PI: Joo H. Kim
NYU Applied Dynamics and Optimization Laboratory

NYU TANDON SCHOOL OF ENGINEERING — Applied Dynamics & Optimization Lab

Abstract

Robotic manipulators are used in many fields, including industrial automation and manufacturing. This research project is intended to provide an accurate, to-scale model of a parallel elastic actuator with a nonlinear spring mechanism that can be manufactured and implemented in a robotic arm joint to improve its efficiency. A CAD model using a Nema 17 stepper motor and a 1-inch steel extension spring with 1.66 lbs/in. spring rate was created based on existing parallel elastic actuator designs in the literature, which are often missing important manufacturing details and dimensions. The model was parametrized to allow for variations in the task parameters, such as the pick/place area. Preliminary results in SolidWorks simulation showed that the model behaved as expected and the parallel spring mechanism provided a torque toward the pick/place areas.

Background on the Project

Robotic manipulators (e.g. robot arms) are a key component of many robotic platforms, such as the industrial robots used for automotive manufacturing [1]. However, as they scale, robot manipulators can become quite energy intensive, and the growing need for sustainable processes has necessitated the development of energy-efficient robotic systems.

Robot manipulators are mainly actuated by motors. For example, servo and stepper motors are often used in revolute joints that provide one degree-of-freedom. These motors can then be controlled to produce the desired robotic behavior and performance. For repetitive tasks, such as pick-and-place tasks, the oscillatory nature of the motion can be leveraged to create a more efficient system by implementing a parallel spring mechanism [2]. These are also known as parallel elastic actuators, where a spring (or other elastic element) is placed in parallel with the motor that stores energy to be used during acceleration, effectively reducing the energy consumption.

Plooij and Wisse describe a simple setup for a robot arm pick-and-place task that implements a nonlinear spring mechanism by using pulleys connected by an extension spring [3]. As the arm rotates, the spring stretches and potential energy is stored as a function of displacement. The system is designed such that a torque is introduced by the spring toward the pick/place area when the arm is outside the pick/place area, and toward the midpoint when the arm is in between [3].

Future Work

- Conduct experiments with the physical setup to compare with results obtained from simulation
- Update CAD model based on the physical experiment results
- Implement the parallel elastic actuator using a torsional spring, instead of extension, to reduce spatial footprint
- Increase degree of freedom of robot arm using additional actuators

Methodology

An initial investigation of parallel elastic actuator designs was conducted. A simple setup consisting of an arm, pulleys, extension spring, and motor was selected as inspiration [3]. An initial CAD model was designed in SolidWorks outlining the general structure of the system and necessary components. The CAD model was further refined by including important manufacturing details, such as set screws, bearing housings, retainers, and proper dimensions. Preliminary simulation results in SolidWorks were used as feedback to optimize and correct the design. The relations between the pulleys were parametrized to allow for variations in the pick/place areas and task parameters.

Existing Parallel Elastic Actuator Designs → Modeling → Simulation → Hardware Implementation

Conclusions

A dimensionally-accurate, parametric CAD model for a small-scale robot arm system with a parallel spring mechanism was designed and made ready for fabrication. Initial simulations in SolidWorks verified that the robot arm model moved as expected.

CAD Model of Robot Arm Setup with Parallel Elastic Actuator

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Acknowledgement

The author would like to thank NYU Tandon School of Engineering Office of Undergraduate Academics for their generous funding of the project. Thanks to PhD student Sam Bodmer and Prof. Kim for their mentoring as well.

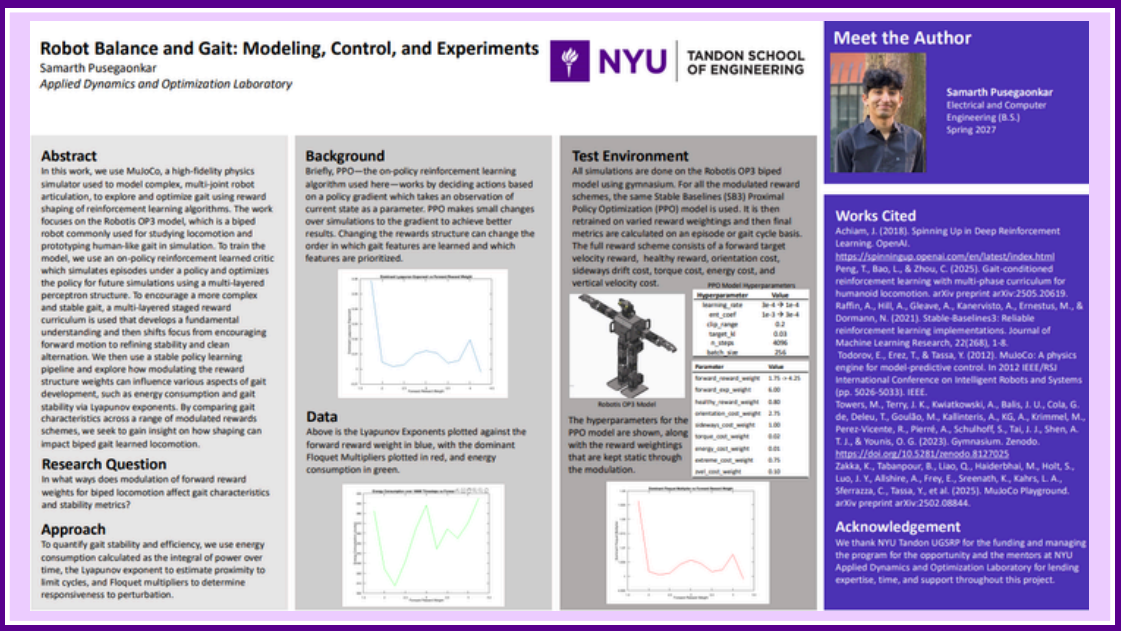
Robot Balance and Gait: Modeling, Control, and Experiments

In this work, we use MuJoCo, a high-fidelity physics simulator used to model complex, multi-joint robot articulation, to explore and optimize gait using reward shaping of reinforcement learning algorithms. The work focuses on the Robotis OP3 model, which is a biped robot commonly used for studying locomotion and prototyping human-like gait in simulation. To train the model, we use an on-policy reinforcement learned critic which simulates episodes under a policy and optimizes the policy for future simulations using a multi-layered perceptron structure. To encourage a more complex and stable gait, a multi-layered staged reward curriculum is used that develops a fundamental understanding and then shifts focus from encouraging forward motion to refining stability and clean alternation. We then use a stable policy learning pipeline and explore how modulating the reward structure weights can influence various aspects of gait development, such as energy consumption and gait stability via Lyapunov exponents. By comparing gait characteristics across a range of modulated rewards schemes, we seek to gain insight on how shaping can impact biped gait learned locomotion.

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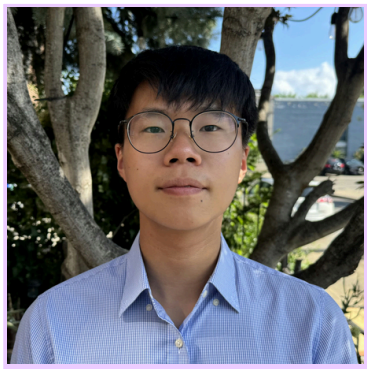


Modeling and improving fairness in criminal justice decisions

Criminal justice systems increasingly employ artificial intelligence as decision-support tools, typically in the form of risk assessment (RA) scores, for judicial sentencing – a process known as "algorithm in the loop" (AITL). While judges' implicit biases can produce disparities across racial, gender, and socioeconomic lines even without algorithmic assistance, AITL theoretically offers a means to identify and correct such biases (Neill). However, emerging research demonstrates that automated decision tools can actually worsen existing disparities or introduce new biases (Neill). This project examines how algorithmic outputs influence judicial decision-making and proposes a novel methodology to nudge judges toward more equitable sentencing. To understand how judges are influenced by RA scores, Vaccaro et al. developed a Bayesian model to learn how the scores impact judges' probability of giving alternative sentencing for defendants with non-violent offenses in the Virginia court system. Through this model, we can quantify, measure, and visualize the probability curve across a range of possible RA scores to determine whether their effects are positive or negative on a defendant's chances of receiving alternative sentencing. Using this probability curve, our novel methodology proposes that we can systematically nudge judges toward fairer decisions by selectively choosing when to withhold or optimize risk assessment scores for protected classes. This process has been shown to decrease disparity and nudge alternative sentencing rates closer to statistical parity.

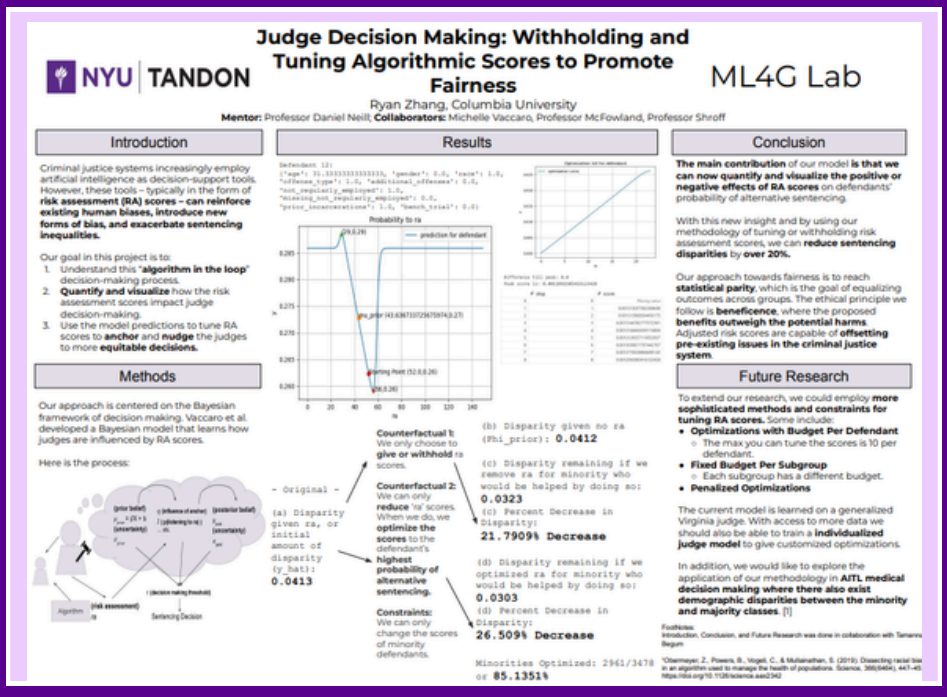
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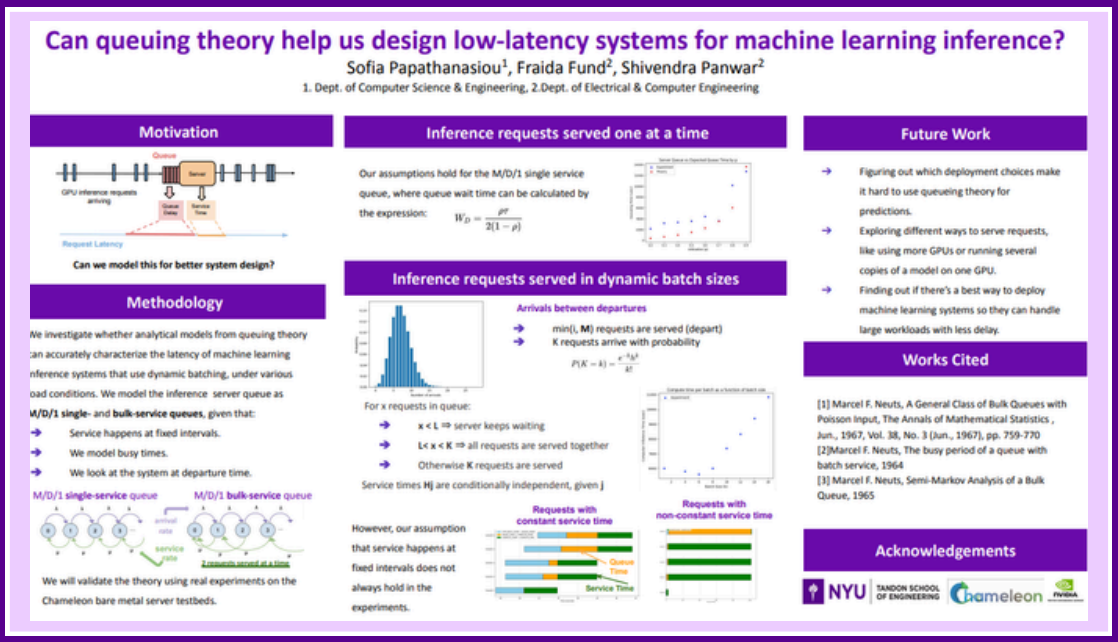
Can queuing theory help us design low-latency systems for machine learning inference?

Users of machine learning systems have little patience when waiting for inference results. Therefore, the designers of these systems need to carefully plan deployments to minimize latency (delay). Unfortunately, it's not always clear how a deployment will respond under realistic heavy load patterns, when inference requests may need to wait in a queue before being served. To address this, we investigate whether analytical models from queuing theory can accurately characterize the latency of machine learning inference systems that use dynamic batching, under various load conditions. We hope our findings will inform future work on scheduling inference jobs and deploying machine learning systems more effectively, ultimately improving performance at scale.

Project Supervisor *Shivendra Panwar & Fraida Fund*
Research Areas *Data Science, AI & Robotics*



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ALCNet: Axis-Separable Convolutions over Attention Tensors for Expressive Text Classification

We introduce ALCNet (Attention-Layer Convolutional Net), a framework for text classification that applies an axis-separable 3D convolutional architecture directly to transformer attention tensors. Spatial patterns, head diversity, and layer depth are processed along separate axes and recombined through residual fusion. Integrated with RoBERTa-large, ALCNet achieves 87.36% validation accuracy on GLUE RTE in 3 epochs. Ablation studies confirm that each axis contributes to accuracy. Branch ablations show that removing the CNN path reduces validation accuracy by 5.4%. The CNN branch consistently outperforms the CLS-only path that corresponds to vanilla RoBERTa-large predictions, demonstrating that attention tensors encode richer signals than are captured by pooled embeddings. To stabilize feature usage, we employ a redesigned head with LayerNorm on concatenated features, branch-dropout, and learnable per-branch gates, mitigating scale bias and encouraging multi-branch utilization. Cross-branch dependence analyses (RV and CCA) further indicate that CNN and statistical features provide complementary expressivity. On a 10k-sample AI vs. human text classification dataset, ALCNet attains a validation AUC of 0.9742 after only 2 epochs, with Nsight profiling confirming GPU efficiency. These results demonstrate that explicitly modeling spatial, head, and layer dimensions of attention tensors reveals structured signals beyond CLS pooling, enabling more expressive text classification.

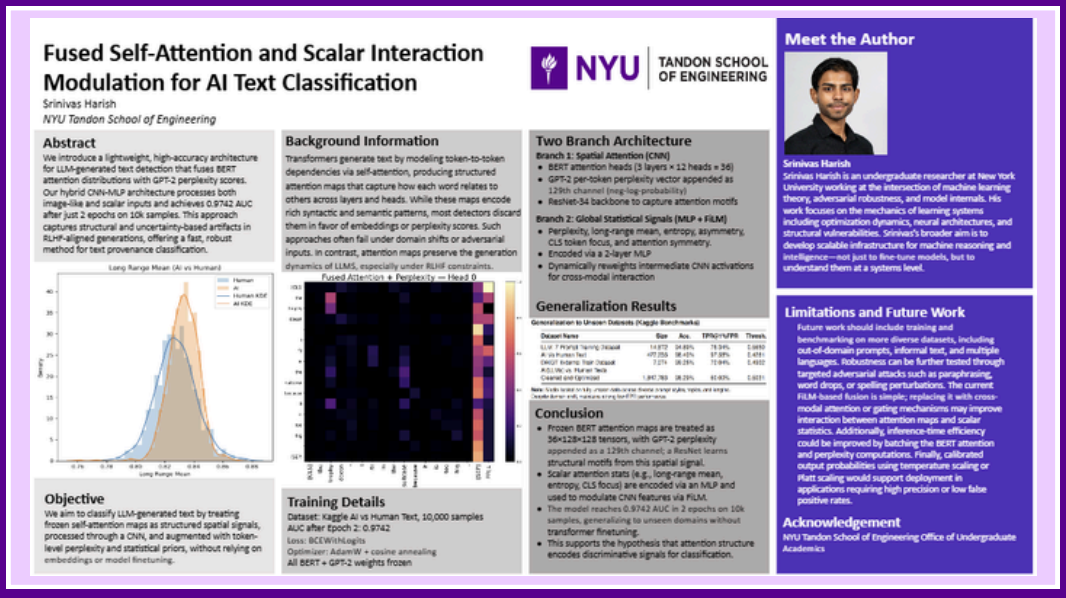
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Examining emerging fire risk in New York City using the FDNY Incident database

Urban fire hazards are rapidly evolving due to emerging technologies, climate change, and increasing urban density. This project analyzes the Fire Department of the City of New York (FDNY) incident database to identify spatio-temporal trends and assess modern threats such as electric vehicle fires, heat-induced ignitions, and risks associated with combustible building materials like cladding. Over 340,000 fire incidents from almost ten years of data were combined with hourly and daily weather data and geolocation metadata. Using Python library tools, the dataset was analyzed to detect temporal patterns in fire counts and intensity by hour, day, month, and weather conditions. We removed baseline alarms to isolate significant fire events and merged the dataset with demographic and building typology information. Preliminary results show that fire intensity and frequency increase during summer months, especially in lower-income and high-density areas. Correlations were found between fire activity and factors such as high temperature, low humidity, and low precipitation. Spatial mapping identified persistent hotspots in neighborhoods with older residential infrastructure and higher population vulnerability. These results emphasize the need for updated building codes, improved firefighter training, and community-specific fire prevention programs. The methodology developed here enables cities to perform comprehensive risk assessments and better allocate resources for fire safety. This project supports evidence-based decision-making to improve urban resilience in the face of emerging fire hazards

Project Supervisor *Augustin Guibaud*

Research Areas *Data Science, AI & Robotics*



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NYU TANDON SCHOOL OF ENGINEERING

Examining emerging fire risk in New York City using the FDNY Incident database

igNYte

Tejas Siddaramaiah[1], Augustin Guibaud[2]

1. Department of Computer Science and Engineering 2. Department of Mechanical and Aerospace Engineering

Background

Urban fires are linked to humidity in summer and dewpoint in winter, with no strong ties to wind, rain, or snow [1]. Traffic slows fire truck response and increases fire-related damages [2]. Dense housing limits fire truck access and raises risk, especially where firefighting knowledge and resources are lacking [3]. A 10% rise in vacant homes increases fire injuries, while more college-educated residents reduces them [4]. Poverty is the strongest fire risk factor, along with family instability, overcrowding, and lack of homeownership [5]. Adults over 50 face higher fire death risk; ages 20–69 are more prone to injury. Men, African Americans, and Native Americans have higher fire death rates [6].

Abstract

Analyzed 340,000+ FDNY fire incidents over 10 years using Python tools with weather, other features.

Fires peak in winter and in low-income, high-density areas. Cold, less humidity and rain increase fire risk.

Findings support better building codes, targeted prevention, and improved firefighter training.

This project analyzes nearly a decade of FDNY fire incident data, over 340,000 events, combined with weather, building type, and demographic data to assess fire risk in New York City. High-intensity fires were concentrated in older, high-density neighborhoods like East New York and Brownsville, while general fire activity clustered near major parks. Winter months and Thanksgiving saw peak incidents. Statistical analysis revealed strong negative correlations between fire activity and humidity, dew point, and temperature, with increased risk during cold, dry conditions. Certain building types, like healthcare facilities, school sites, and condo rentals, had higher fire rates. These insights support targeted safety upgrades and enhanced firefighter training to promote fire prevention and urban resilience.

Methodology

To understand modern fire risks in New York City, we analyzed nearly 340,000 FDNY fire incident records spanning a decade. These were joined with hourly and daily weather datasets and geolocation metadata to examine spatio-temporal fire trends. ZIP code shapefiles from NYC Open Data were merged to spatially map fire frequency, focusing on high-intensity events (alarm level ≥ 2). Geospatial mapping was done using Python's GeoPandas, allowing us to visualize hotspots across neighborhoods (Figure 1). We integrated PLUTO land use data to assess correlations between fire activity and building characteristics such as age, class, and density. A statistical correlation analysis using Pearson and Spearman coefficients on weather data from Visual Crossing revealed links between fire intensity and variables like temperature, humidity, and precipitation. Finally, we corrected for multiple testing using the Bonferroni method and compared fire data with demographic metrics to assess broader urban risk factors. All data cleaning, merging, and analysis were conducted using Pandas, GeoPandas, Seaborn, and Matplotlib in Python.

Results

Spatial mapping revealed that high-intensity fires (alarm level ≥ 2) are concentrated in ZIP codes such as 11207, 11212, and 11208, neighborhoods like East New York and Brownsville, characterized by older infrastructure and higher population density. Surprisingly, hotspot maps also showed large clusters of fires occurring in parks and outdoor recreational zones. Statistical tests found significant negative correlations between both fire intensity and frequency with dew point, humidity, and temperature, with dew point showing the strongest effect ($r = -0.49$ for frequency) (Figure 2). After Bonferroni correction, only the most robust relationships remained significant, confirming that drier, colder weather increases fire risk. Correlations with wind and visibility were weaker but positive. Building code analysis showed that fire risk is not evenly distributed across property types. Institutional, dispensaries, and mixed-use residential structures experience the highest average fire counts. When grouped by designation, buildings marked as asylums and homes, hospitals and health facilities, and religious facilities top the list. This suggests elevated fire risks in buildings with public access and vulnerable occupants. Recreational zones and vacant school lots also ranked unexpectedly high. These results underscore the complex interplay between environmental conditions, building characteristics, and land use, pointing to the need for targeted mitigation strategies in high-risk zones.

Figures

Figure 1: NYC fire heat map

Figure 2: Linear regression between dew and fire count

References

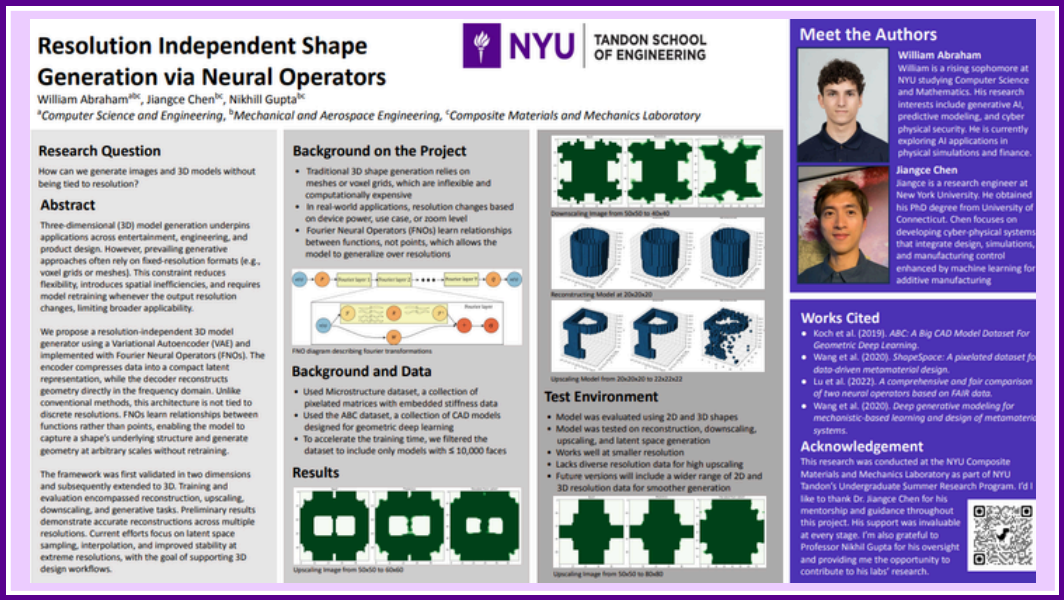
Web-based Platform for Dynamic Mechanical Analysis Data Acquirement and Machine Learning Model Design

3D model generation is used in everything from video games and animation to engineering and product design. However, many current methods rely on fixed-resolution representations, like voxel grids or meshes, which makes them less flexible and often inefficient. These models typically need to be retrained if the output resolution changes, which limits their usefulness in real-world applications. To solve this problem, we're developing a new kind of 3D model generator that can work at any resolution. Our approach combines a Variational Autoencoder (VAE), which encodes a compact representation of a shape, a 1d vector, with a Fourier Neural Operator (FNO), a neural network that can decode smooth 3D models from 2d images using frequency information instead of pixels or grid points. This lets us create detailed shapes without being tied to a specific resolution. During training, we test the model on multiple resolutions to see how well it can generalize. Early results from a 2d structured encoder and decoder show that a VAE integrated with FNO models can accurately reconstruct 2d images at both lower and higher resolution shapes without needing to be retrained. Current efforts to restructure the encoder and decoder for 3d model generation are promising. The system also supports shape interpolation and sampling, which could be useful for design and creative tasks.

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Research Staff	*Caleb Beckwith & Jiangce Chen*



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Developing an AI-Enabled Digital Twin to Enhance Situational Awareness for Urban Mobility and Safety

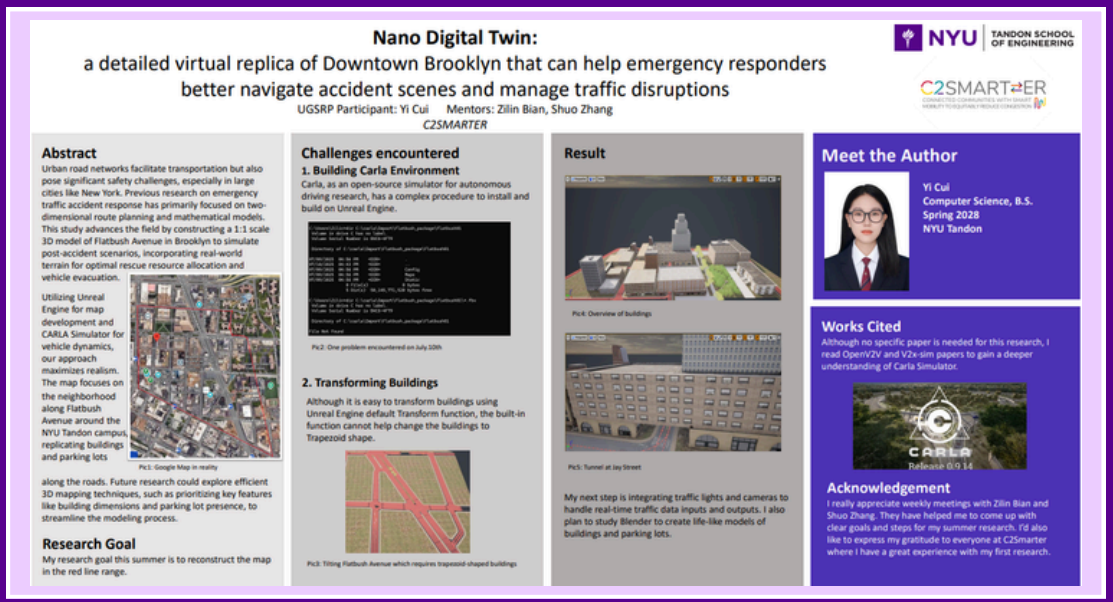
Urban road networks facilitate transportation but also pose significant safety challenges, especially in large cities like New York. Previous research on emergency traffic accident response has primarily focused on two-dimensional route planning and mathematical models. This study advances the field by constructing a 1:1 scale 3D model of Flatbush Avenue in Brooklyn to simulate post-accident scenarios, incorporating real-world terrain for optimal rescue resource allocation and vehicle evacuation. Utilizing Unreal Engine for map development and CARLA Simulator for vehicle dynamics, our approach maximizes realism. The map focuses on the neighborhood around the intersection of Flatbush Avenue and Kings Highway, replicating buildings and parking lots along the roads. Future research could explore efficient 3D mapping techniques, such as prioritizing key features like building dimensions and parking lot presence, to streamline the modeling process.

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Emerging Media



The next immersive VR experiences, killer apps, and new gaming platforms are made here. We're creating and adapting new modes of communication that impact the worlds of art, entertainment, education, business, and healthcare.

Metaverse for Education

The shift to virtual learning environments, accelerated by the COVID-19 pandemic, has prompted new approaches to education that bridge physical and digital spaces. This research explores the development of a cross-platform metaverse designed for the NYU community, centered around a virtual recreation of the NYU Tandon MakerSpace. Built using the Unity engine, the environment enables real-time collaboration between on-site and remote users through support for devices such as Oculus, HoloLens, and Apple Vision Pro. Using CAD software, we were able to produce almost identical models of the MakerSpace tools, equipment, and layout. Combining this with Unity's interactive capabilities, we aim to replicate the full hands-on experience of 3D printing, laser cutting, woodworking, and all other machines and equipment, to create a virtual experience that is as close to the real world as possible. Additionally, with the use of depth-sensing cameras that utilize AI and machine learning technologies, we are also able to monitor in-person users in real time. This creates a sense of presence and connection between the physical and virtual environments. The platform incorporates features like user authentication, session-based lobbies, and multiplayer networking using Unity services including Authentication, Lobby, and Relay, creating a more interactive experience.The project aims to demonstrate how immersive technologies can enhance accessibility, communication, and engagement in academic settings.

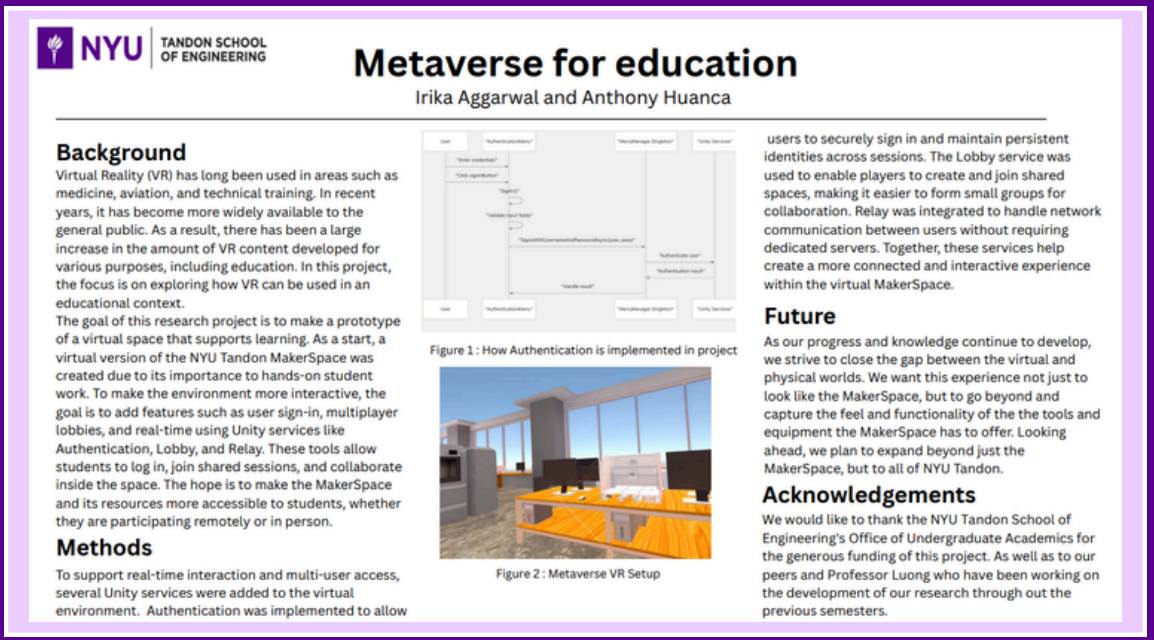
Project Supervisor	*Dzung Luong*
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NYU TANDON SCHOOL OF ENGINEERING

Metaverse for education

Irika Aggarwal and Anthony Huanca

Background

Virtual Reality (VR) has long been used in areas such as medicine, aviation, and technical training. In recent years, it has become more widely available to the general public. As a result, there has been a large increase in the amount of VR content developed for various purposes, including education. In this project, the focus is on exploring how VR can be used in an educational context.

The goal of this research project is to make a prototype of a virtual space that supports learning. As a start, a virtual version of the NYU Tandon MakerSpace was created due to its importance to hands-on student work. To make the environment more interactive, the goal is to add features such as user sign-in, multiplayer lobbies, and real-time using Unity services like Authentication, Lobby, and Relay. These tools allow students to log in, join shared sessions, and collaborate inside the space. The hope is to make the MakerSpace and its resources more accessible to students, whether they are participating remotely or in person.

Methods

To support real-time interaction and multi-user access, several Unity services were added to the virtual environment. Authentication was implemented to allow users to securely sign in and maintain persistent identities across sessions. The Lobby service was used to enable players to create and join shared spaces, making it easier to form small groups for collaboration. Relay was integrated to handle network communication between users without requiring dedicated servers. Together, these services help create a more connected and interactive experience within the virtual MakerSpace.

Figure 1 : How Authentication is implemented in project

Figure 2 : Metaverse VR Setup

Future

As our progress and knowledge continue to develop, we strive to close the gap between the virtual and physical worlds. We want this experience not just to look like the MakerSpace, but to go beyond and capture the feel and functionality of the the tools and equipment the MakerSpace has to offer. Looking ahead, we plan to expand beyond just the MakerSpace, but to all of NYU Tandon.

Acknowledgements

We would like to thank the NYU Tandon School of Engineering's Office of Undergraduate Academics for the generous funding of this project. As well as to our peers and Professor Luong who have been working on the development of our research through out the previous semesters.

Wearable Electronics for Learning

Creative computing learning environments play a crucial role in sparking young learners' interest in STEM fields while fostering inclusivity in historically underrepresented groups within STEM. However, bridging the gap between STEM and creative expression can be difficult given lack of interdisciplinary tools and curriculum. Our research involves the making of a website, the "Creative Computing Cookbook", that includes "recipes" of detailed examples students can follow for computing arts projects like wearable dance performances and interactive storytelling props. We also create electronics toolkits that use a plug-and-play solderless system for fast prototyping and ease of use distributed to students in 2 educational non-profits, STEM from Dance and the Community Word Project. By working closely with instructors and students over the course of these programs, we sought to understand how students use and iterate upon our digital and physical designs through the Cookbook and toolkits.

Project Supervisor *Kathleen McDermott*

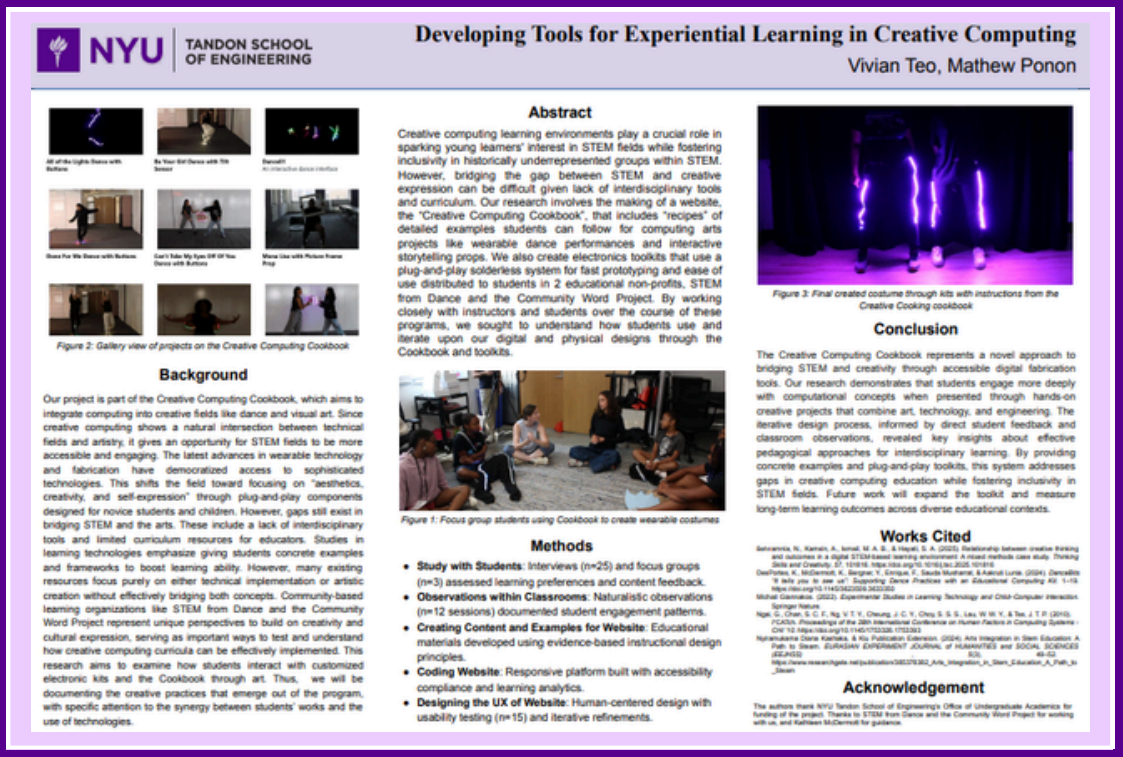
Research Areas *Emerging Media*



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NYU TANDON SCHOOL OF ENGINEERING

Developing Tools for Experiential Learning in Creative Computing

Vivian Teo, Mathew Ponon

Figure 2: Gallery view of projects on the Creative Computing Cookbook

Background

Our project is part of the Creative Computing Cookbook, which aims to integrate computing into creative fields like dance and visual art. Since creative computing shows a natural intersection between technical fields and artistry, it gives an opportunity for STEM fields to be more accessible and engaging. The latest advances in wearable technology and fabrication have democratized access to sophisticated technologies. This shifts the field toward focusing on "aesthetics, creativity, and self-expression" through plug-and-play components designed for novice students and children. However, gaps still exist in bridging STEM and the arts. These include a lack of interdisciplinary tools and limited curriculum resources for educators. Studies in learning technologies emphasize giving students concrete examples and frameworks to boost learning ability. However, many existing resources focus purely on either technical implementation or artistic creation without effectively bridging both concepts. Community-based learning organizations like STEM from Dance and the Community Word Project represent unique perspectives to build on creativity and cultural expression, serving as important ways to test and understand how creative computing curricula can be effectively implemented. This research aims to examine how students interact with customized electronic kits and the Cookbook through art. Thus, we will be documenting the creative practices that emerge out of the program, with specific attention to the synergy between students' works and the use of technologies.

Abstract

Creative computing learning environments play a crucial role in sparking young learners' interest in STEM fields while fostering inclusivity in historically underrepresented groups within STEM. However, bridging the gap between STEM and creative expression can be difficult given lack of interdisciplinary tools and curriculum. Our research involves the making of a website, the "Creative Computing Cookbook", that includes "recipes" of detailed examples students can follow for computing arts projects like wearable dance performances and interactive storytelling props. We also create electronics toolkits that use a plug-and-play solderless system for fast prototyping and ease of use distributed to students in 2 educational non-profits, STEM from Dance and the Community Word Project. By working closely with instructors and students over the course of these programs, we sought to understand how students use and iterate upon our digital and physical designs through the Cookbook and toolkits.

Figure 1: Focus group students using Cookbook to create wearable costumes

Methods

- **Study with Students**: Interviews (n=25) and focus groups (n=3) assessed learning preferences and content feedback.
- **Observations within Classrooms**: Naturalistic observations (n=12 sessions) documented student engagement patterns.
- **Creating Content and Examples for Website**: Educational materials developed using evidence-based instructional design principles.
- **Coding Website**: Responsive platform built with accessibility compliance and learning analytics.
- **Designing the UX of Website**: Human-centered design with usability testing (n=15) and iterative refinements.

Figure 3: Final created costume through kits with instructions from the Creative Cooking cookbook

Conclusion

The Creative Computing Cookbook represents a novel approach to bridging STEM and creativity through accessible digital fabrication tools. Our research demonstrates that students engage more deeply with computational concepts when presented through hands-on creative projects that combine art, technology, and engineering. The iterative design process, informed by direct student feedback and classroom observations, revealed key insights about effective pedagogical approaches for interdisciplinary learning. By providing concrete examples and plug-and-play toolkits, this system addresses gaps in creative computing education while fostering inclusivity in STEM fields. Future work will expand the toolkit and measure long-term learning outcomes across diverse educational contexts.

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Acknowledgement

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for funding of the project. Thanks to STEM from Dance and the Community Word Project for working with us, and Kathleen McDermott for guidance.

Point cloud video processing

This work focuses on processing multi-view video to generate high-fidelity 3D video content suitable for immersive virtual reality (VR) and standard 2D displays. Our methodology begins with the precise calibration of a 26-camera capture system to determine both the intrinsic and extrinsic parameters for each camera. Following calibration, a foreground segmentation algorithm is applied to isolate the human subject from the background in each video stream. We then explore two distinct approaches for creating the final 3D representation. The first approach utilizes 4D Gaussian Splatting to train a dynamic, animatable model, from which individual 3D Gaussian Splatting frames are extracted to form a volumetric video. The second approach employs the MeshAvatar method to reconstruct a detailed mesh-based representation of the subject for each frame. These parallel pipelines yield two different formats of 3D video—one volumetric and one mesh-based—enabling flexible use across various rendering platforms.

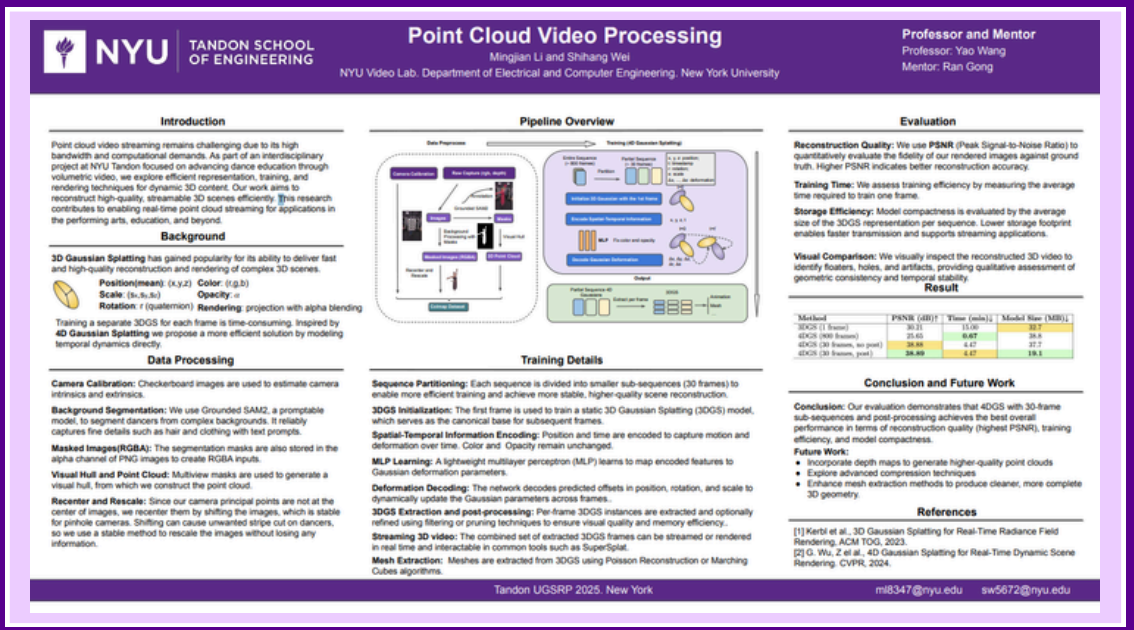
Project Supervisor *Yao Wang*
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C.A.S.S.A.N.D.R.A. (Compassionate and Altruistic Semi-Sentient Assistant and Negotiator of Dreams, Rationality, and Aspiration)

This research explores speculative design as a method to prototype new semiotic systems that emerge under ecological and technological constraints. Inspired by the myth of Cassandra, our project centers on a fictional Large Language Model named C.A.S.S.A.N.D.R.A. (Compassionate and Altruistic Semi-Sentient Assistant and Negotiator of Dreams, Rationality, and Aspiration), designed to generate visions of alternate realities and ecosystems. The work explores how nonhuman and artificial intelligences might convey meaning in contexts where conventional language is inadequate; where signals must adapt, evolve, or be reimagined entirely. My contributions focus on two interconnected research threads. The first is the NVV (Nonverbal Vocalization) Lexicon, a speculative font system developed at the intersection of language theory, sound design, and AI ethics. It encodes five primary nonverbal vocalizations (sigh, cry, moan, laugh, and scream) into modular glyphs. Two sets of context markers (emotional tone and social setting) enable these base units to recombine into composite forms, providing a typology for machine-generated emotional expression. The second thread involves a speculative data visualization of whale song, specifically examining how endangered marine species, such as baleen whales, might adapt their mating calls in response to acoustic interference from ship traffic. Worked with spectrogram data from Google's Pattern Radio to isolate individual "phrases" of whale song and compare them with ship noise patterns. These notes are then pitched up and re-compiled into a whale synth.These findings are translated into a speculative sound sequencer. The visualisation reflects the possibility of sonic adaptation and the emergence of a new whale vocal ecology. The outcomes include a functioning NVV glyph system, a prototype whale-song synthesizer with spectrogram-based visualizations, and a broader conceptual framework that links these speculative semiotics within a shared narrative about communication beyond anthropocentrism. This project positions language as a living system; responsive, fragmented, and reforming. It invites reflection on how expression might continue when existing forms are not viable.

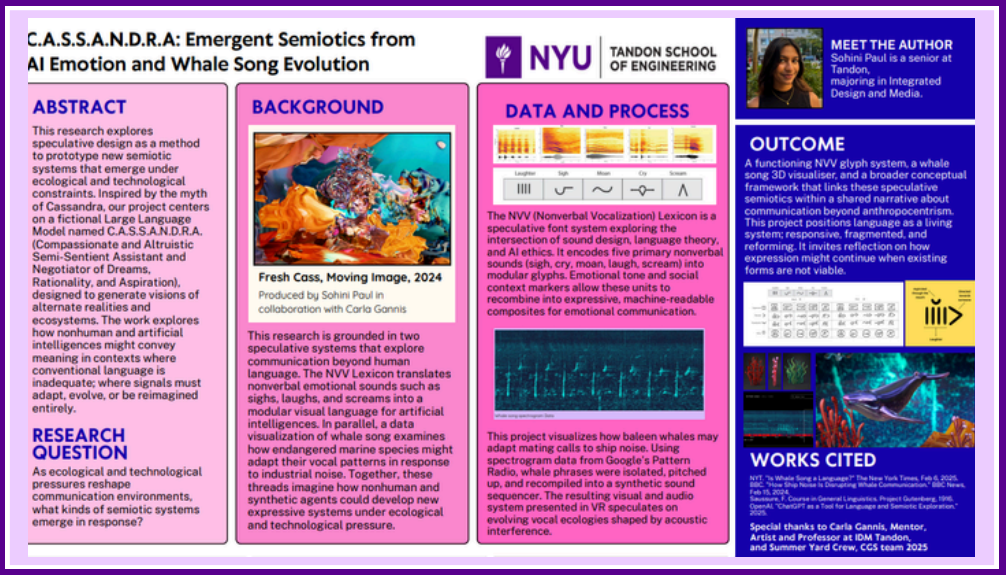
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Urban



The world is changing, and it’s clear we need to help drive that change. With more than half of the world’s population now residing in urban areas and that figure expected to rise to more than 70% by mid- century, NYU Tandon is innovating ways to make the cities of the future smart and resilient.

VR-based co-simulation to improve work zone safety

The growing complexity of urban traffic systems combined with rising concerns around road safety has prompted the need for better tools to study how drivers respond to infrastructural cues in dynamic environments. Traditional traffic simulations often fail to capture the sensory realism needed to evaluate driver behavior with accuracy, especially under variable, real-world conditions. This project presents a VR-based research tool, built in Unreal Engine and CARLA, that simulates immersive driving environments for behavioral analysis. The system incorporates spatialized audio and immersive driving environments, utilizing MetaQuest 3 Virtual reality technology and LogiTech G920 Driving Simulator, allowing for analysis of both driver and worker behavior in workzone traffic areas. By observing behaviors that could potentially pose risks for drivers and construction worker safety in these environments, this tool aims to improve experimental control and data collection in driving studies, ultimately informing safe infrastructure design and smarter urban planning.

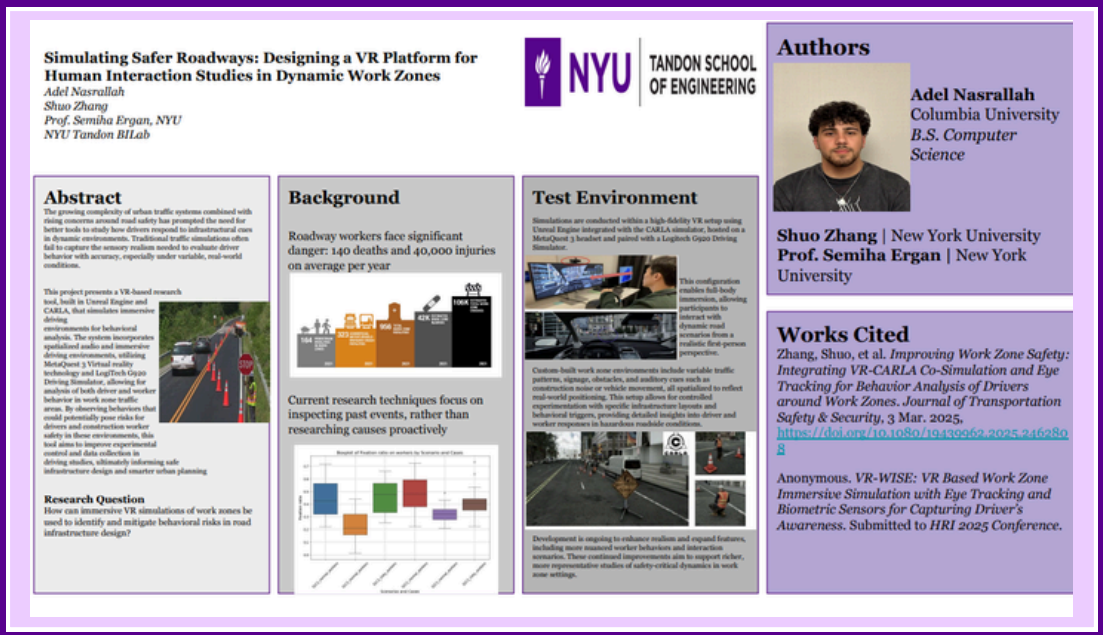
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Research Areas *Urban*



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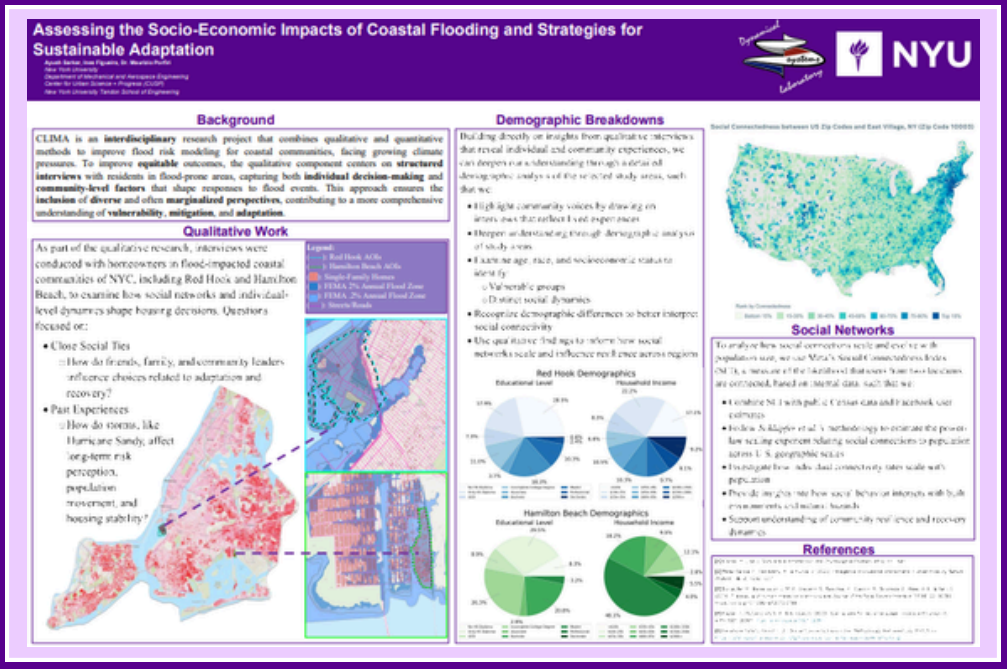
Assessing the Socio-Economic Impacts of Coastal Flooding and Strategies for Sustainable Adaptation

Coastal flooding presents an increasingly persistent challenge for many communities, with impacts that go beyond physical damage to affect social and economic well-being. This research examines how such impacts are experienced differently across coastal areas, depending on factors like income, education, and social connectedness. While the study takes a broad view of coastal vulnerability, qualitative interviews conducted in New York City neighborhoods such as, Red Hook and Hamilton Beach, offer specific insight into how these issues unfold at the community level. Through the use of spatial data, demographic analysis, and national social network metrics, the project investigates how structural inequalities can intensify flood risk, while strong local ties can support resilience. These findings help understand to the importance of developing adaptation strategies that are both environmentally sustainable and socially equitable, especially for communities that face the greatest risks and fewest resources.

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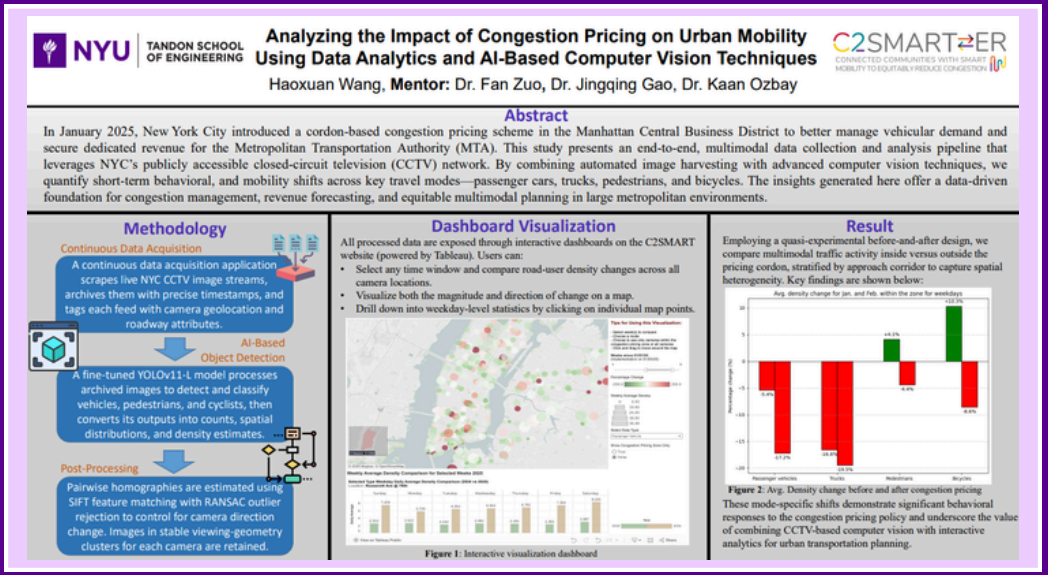
Analyzing the Impact of Congestion Pricing on Urban Mobility Using Data Analytics and AI-Based Computer Vision Techniques

New York City implemented a cordon-based congestion pricing program in January 2025 to manage vehicular demand within the Manhattan central business district and generate dedicated revenue for the Metropolitan Transportation Authority (MTA). This study develops and applies an automated, multi-modal data collection and analytics pipeline that exploits the City's publicly available closed-circuit television (CCTV) traffic camera network to evaluate short-run behavioral and mobility responses to the policy across key urban travel modes—passenger cars, trucks, pedestrians, and bicycles. We built a continuous data acquisition application that scrapes live NYC CCTV image streams, archives them with precise timestamps, and tags each feed with camera geolocation and roadway attributes. A computer vision workflow adapted from pandemic-era crowd monitoring research employs a pre-trained YOLO object detector fine-tuned for urban street scenes to identify and classify roadway users. To control for variable camera pitch and roll, as well as view obstruction over time, we estimate pairwise homographies using SIFT feature matching with RANSAC outlier rejection. We then retain image sets that fall within stable viewing-geometry clusters for each camera. Mode-specific counts are aggregated to consistent temporal bins (e.g., 5-minute, hourly, and peak-period windows) and normalized by camera field-of-view characteristics. Using a quasi-experimental before–and–after design anchored on the congestion pricing go-live date, we compare multi-modal traffic activity detected inside and outside the pricing cordon and examine spatial heterogeneity by approach corridors. Trend analyses, difference-in-differences style contrasts with control cameras outside the tolled zone, and exploratory elasticity estimates will be used to quantify policy impacts on passenger vehicle re-routing, freight displacement, and potential shifts toward walking and cycling exposure. The findings will provide data-driven evidence to inform congestion management, revenue forecasting, and equitable multimodal planning in large metropolitan areas.

Project Supervisor	*Kaan Ozbay*
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Understanding how opportunities for in-person encounters could lead to social interactions in NYC public spaces

Natural areas within urban parks play a critical role in supporting ecological health and enhancing community well-being. In densely built environments like New York City, ensuring equitable access to these spaces is a growing priority. The Forever Wild Program, initiated in 2001, protects over 12,400 acres of high-value natural habitat across 135 city parks. Despite these efforts, disparities in park access and usage persist across demographic lines. Prior research has highlighted differences in park visitation based on race, gender, and socioeconomic status, particularly with regard to preferences for developed versus natural park settings. This research utilizes large-scale mobile phone location data spanning five years to analyze visitation patterns to nature-based areas in NYC parks. By connecting observed visits to their corresponding Census Block Groups (CBGs), we assess which communities are most and least represented among visitors. In doing so, we investigate how patterns of use vary by demographic and spatial factors. We examine the role of spatial proximity in shaping visitation behavior and seek to determine whether the distance to parks with nature areas is equitably distributed across demographic groups. Our ongoing analysis also compares visitation to nature-based areas with visitation to more developed park areas, to assess differences in access and use across park types. These findings aim to inform urban planning and park management strategies by providing data-driven insights into how nature access operates in a diverse urban context and how it can be made more equitable in the future.

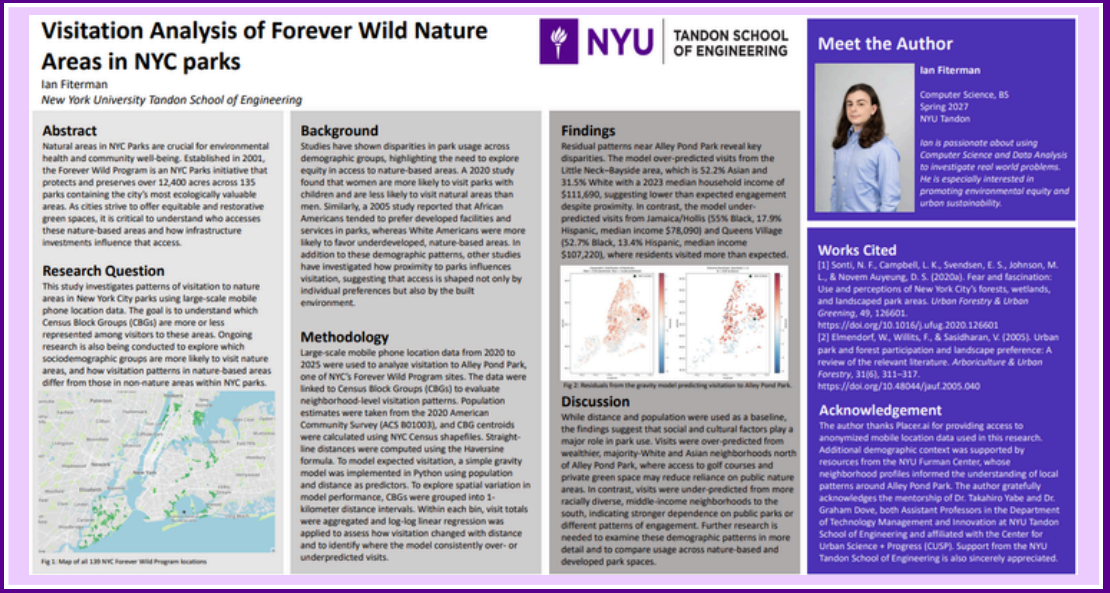
Project Supervisors *Graham Dove, Takahiro Yabe*

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Visitation Analysis of Forever Wild Nature Areas in NYC parks

Ian Fiterman
New York University Tandon School of Engineering

NYU TANDON SCHOOL OF ENGINEERING

Abstract

Natural areas in NYC Parks are crucial for environmental health and community well-being. Established in 2001, the Forever Wild Program is an NYC Parks initiative that protects and preserves over 12,400 acres across 135 parks containing the city's most ecologically valuable areas. As cities strive to offer equitable and restorative green spaces, it is critical to understand who accesses these nature-based areas and how infrastructure investments influence that access.

Research Question

This study investigates patterns of visitation to nature areas in New York City parks using large-scale mobile phone location data. The goal is to understand which Census Block Groups (CBGs) are more or less represented among visitors to these areas. Ongoing research is also being conducted to explore which sociodemographic groups are more likely to visit nature areas, and how visitation patterns in nature-based areas differ from those in non-nature areas within NYC parks.

Fig 1: Map of all 139 NYC Forever Wild Program locations

Background

Studies have shown disparities in park usage across demographic groups, highlighting the need to explore equity in access to nature-based areas. A 2020 study found that women are more likely to visit parks with children and are less likely to visit natural areas than men. Similarly, a 2005 study reported that African Americans tended to prefer developed facilities and services in parks, whereas White Americans were more likely to favor underdeveloped, nature-based areas. In addition to these demographic patterns, other studies have investigated how proximity to parks influences visitation, suggesting that access is shaped not only by individual preferences but also by the built environment.

Methodology

Large-scale mobile phone location data from 2020 to 2025 were used to analyze visitation to Alley Pond Park, one of NYC's Forever Wild Program sites. The data were linked to Census Block Groups (CBGs) to evaluate neighborhood-level visitation patterns. Population estimates were taken from the 2020 American Community Survey (ACS B01003), and CBG centroids were calculated using NYC Census shapefiles. Straight-line distances were computed using the Haversine formula. To model expected visitation, a simple gravity model was implemented in Python using population and distance as predictors. To explore spatial variation in model performance, CBGs were grouped into 1-kilometer distance intervals. Within each bin, visit totals were aggregated and log-log linear regression was applied to assess how visitation changed with distance and to identify where the model consistently over- or underpredicted visits.

Findings

Residual patterns near Alley Pond Park reveal key disparities. The model over-predicted visits from the Little Neck–Bayside area, which is 52.2% Asian and 31.5% White with a 2023 median household income of $111,690, suggesting lower than expected engagement despite proximity. In contrast, the model under-predicted visits from Jamaica/Hollis (55% Black, 17.9% Hispanic, median income $78,090) and Queens Village (52.7% Black, 13.4% Hispanic, median income $107,220), where residents visited more than expected.

Fig 2: Residuals from the gravity model predicting visitation to Alley Pond Park.

Discussion

While distance and population were used as a baseline, the findings suggest that social and cultural factors play a major role in park use. Visits were over-predicted from wealthier, majority-White and Asian neighborhoods north of Alley Pond Park, where access to golf courses and private green space may reduce reliance on public nature areas. In contrast, visits were under-predicted from more racially diverse, middle-income neighborhoods to the south, indicating stronger dependence on public parks or different patterns of engagement. Further research is needed to examine these demographic patterns in more detail and to compare usage across nature-based and developed park spaces.

Meet the Author

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Ian is passionate about using Computer Science and Data Analysis to investigate real world problems. He is especially interested in promoting environmental equity and urban sustainability.

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Acknowledgement

The author thanks Placer.ai for providing access to anonymized mobile location data used in this research. Additional demographic context was supported by resources from the NYU Furman Center, whose neighborhood profiles informed the understanding of local patterns around Alley Pond Park. The author gratefully acknowledges the mentorship of Dr. Takahiro Yabe and Dr. Graham Dove, both Assistant Professors in the Department of Technology Management and Innovation at NYU Tandon School of Engineering and affiliated with the Center for Urban Science + Progress (CUSP). Support from the NYU Tandon School of Engineering is also sincerely appreciated.

Measuring the disaster resilience of local businesses

As climate change and urbanization accelerate, local businesses—essential to community livelihoods—face growing vulnerability to disruptive events. This study focuses on Downtown Brooklyn, an urban core where the closure of major anchor institutions—most notably the seasonal closure of NYU Tandon—has created measurable ripple effects on surrounding commercial activity. Using large-scale mobile phone location data, we analyze foot traffic patterns, visitor origins, and shifts in clientele composition across businesses before and after these disruptions. With techniques such as cosine similarity and synthetic control analysis, we assess the overlap in visitor segments at NYU Tandon and evaluate which businesses are most dependent on specific populations. These insights feed into predictive models that estimate the impact of seasonal breaks or business closures, as well as tools for identifying strategies to strengthen resilience—such as locating businesses with similar clientele bases or targeting underrepresented customer groups. While grounded in Downtown Brooklyn, the methodology is transferable to other urban neighborhoods facing climate, infrastructural, or economic disruptions. Our results reveal patterns of vulnerability and resilience, highlighting both businesses highly dependent on Tandon traffic and those drawing from more diverse or non-overlapping visitor bases. These insights inform strategies to mitigate the impact of future disruptions, strengthen business resilience, and support the development of more adaptable local economies.

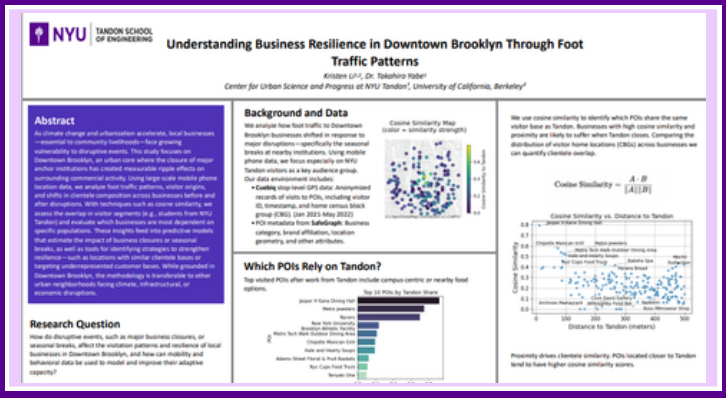
Project Supervisor *Takahiro Yabe*

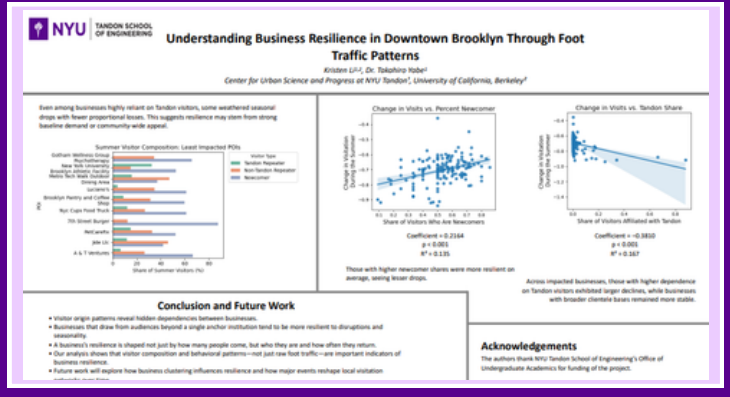
Research Areas *Urban*

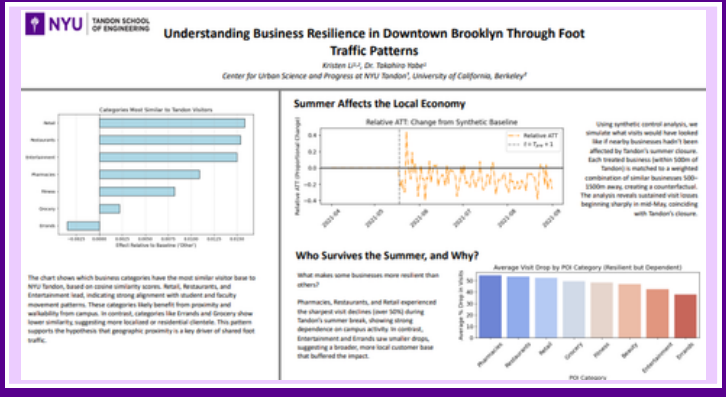


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Deep Learning based Urban Building Façade Inspections

Modern approaches to building façade inspections are manually intensive and time consuming. Developments in drone and image recognition technology has fronted the idea of using them to automate the inspection process. However, image recognition models require a vast and diverse dataset to train on, and current façade image datasets are lacking in both. We have turned towards generating synthetic images using Generative Adversarial Networks (GANs) to bolster an existing image dataset. We trained and tested three different GAN architectures (DCGAN, Big-GAN, Lightweight GAN) with the goal of choosing the best performing to enhance the existing façade image dataset. For training, an existing façade image dataset was randomly split into a 21500-image training set and a 1000-image test set. The models were given an initial arbitrary stopping point of 300 epochs, and depending on whether performance showed signs of continued increase, more training time would have been allotted. After training, 1000 images every fifth epoch version of the models were generated. After training, the Fréchet Inception Distance (FID) scores were calculated between the generated images and the test dataset.The model version with the lowest FID score was chosen as the best performing model. Lightweight GAN, DCGAN, and Big-GAN resulted in FID scores of 55.55, 92.7, 205.98 respectively. These results indicate that Lightweight GAN produced the most realistic synthetic façade images, significantly outperforming the other models. This demonstrates its potential for enhancing existing datasets and supporting more effective automated façade inspection systems.

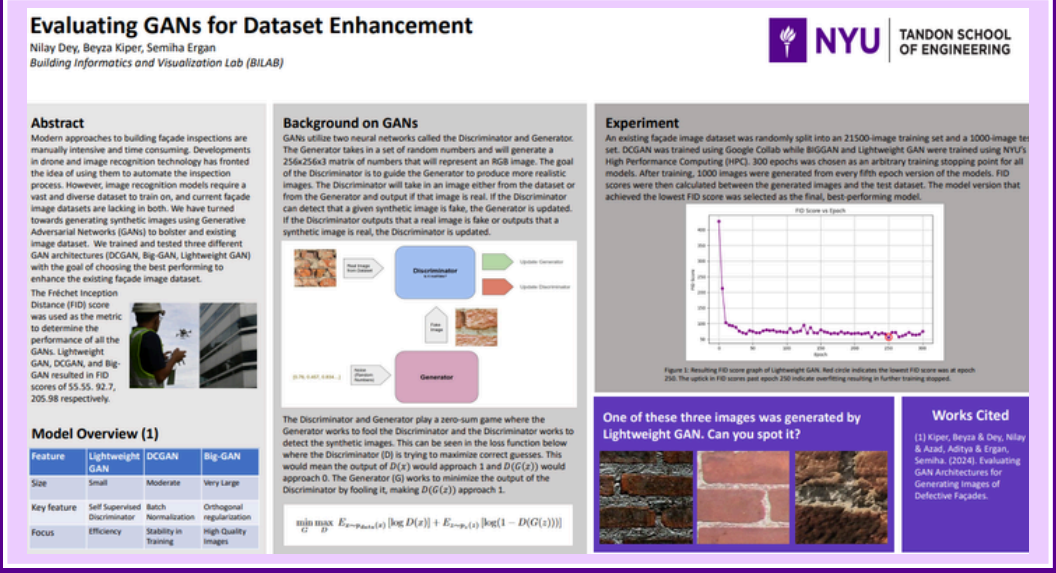
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Research Areas *Urban*



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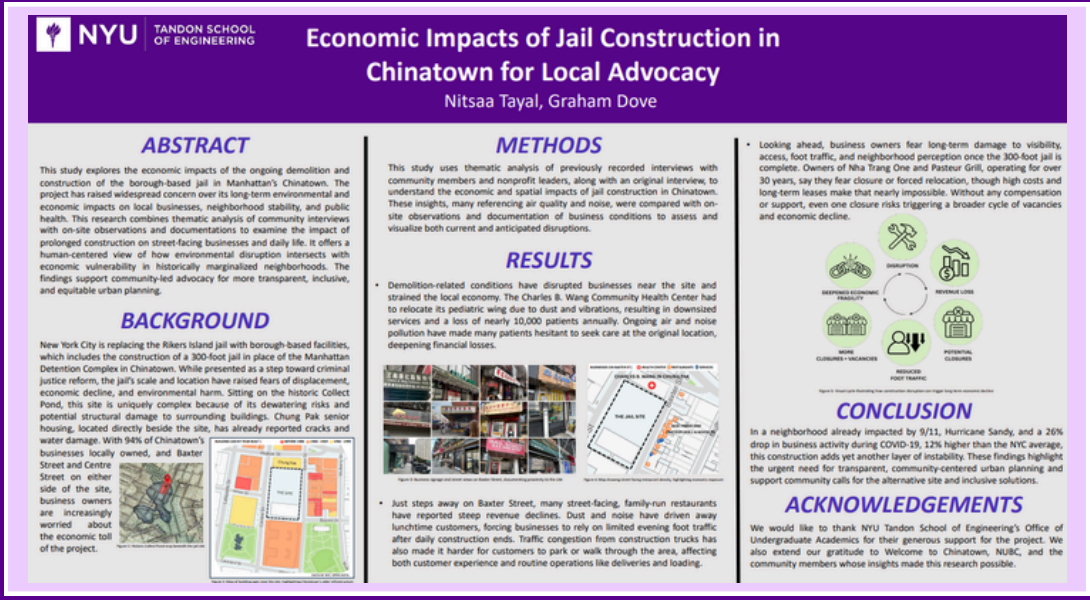
Visualize noise and air quality data for environmental justice advocacy

This study explores the economic impacts of the ongoing demolition and construction of the borough-based jail in Manhattan's Chinatown. The project has raised widespread concern over its long-term environmental and economic impacts on local businesses, neighborhood stability, and public health. This research combines thematic analysis of community interviews with on-site observations and documentations to examine the impact of prolonged construction on street-facing businesses and daily life. It offers a human-centered view of how environmental disruption intersects with economic vulnerability in historically marginalized neighborhoods. The findings support community-led advocacy for more transparent, inclusive, and equitable urban planning.

Project Supervisor *Graham Dove*
Research Areas *Urban*



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NYU TANDON SCHOOL OF ENGINEERING

Economic Impacts of Jail Construction in Chinatown for Local Advocacy

Nitsaa Tayal, Graham Dove

ABSTRACT

This study explores the economic impacts of the ongoing demolition and construction of the borough-based jail in Manhattan's Chinatown. The project has raised widespread concern over its long-term environmental and economic impacts on local businesses, neighborhood stability, and public health. This research combines thematic analysis of community interviews with on-site observations and documentations to examine the impact of prolonged construction on street-facing businesses and daily life. It offers a human-centered view of how environmental disruption intersects with economic vulnerability in historically marginalized neighborhoods. The findings support community-led advocacy for more transparent, inclusive, and equitable urban planning.

BACKGROUND

New York City is replacing the Rikers Island jail with borough-based facilities, which includes the construction of a 300-foot jail in place of the Manhattan Detention Complex in Chinatown. While presented as a step toward criminal justice reform, the jail's scale and location have raised fears of displacement, economic decline, and environmental harm. Sitting on the historic Collect Pond, this site is uniquely complex because of its dewatering risks and potential structural damage to surrounding buildings. Chung Pak senior housing, located directly beside the site, has already reported cracks and water damage. With 94% of Chinatown's businesses locally owned, and Baxter Street and Centre Street on either side of the site, business owners are increasingly worried about the economic toll of the project.

METHODS

This study uses thematic analysis of previously recorded interviews with community members and nonprofit leaders, along with an original interview, to understand the economic and spatial impacts of jail construction in Chinatown. These insights, many referencing air quality and noise, were compared with on-site observations and documentation of business conditions to assess and visualize both current and anticipated disruptions.

RESULTS

- Demolition-related conditions have disrupted businesses near the site and strained the local economy. The Charles B. Wang Community Health Center had to relocate its pediatric wing due to dust and vibrations, resulting in downsized services and a loss of nearly 10,000 patients annually. Ongoing air and noise pollution have made many patients hesitant to seek care at the original location, deepening financial losses.
- Just steps away on Baxter Street, many street-facing, family-run restaurants have reported steep revenue declines. Dust and noise have driven away lunchtime customers, forcing businesses to rely on limited evening foot traffic after daily construction ends. Traffic congestion from construction trucks has also made it harder for customers to park or walk through the area, affecting both customer experience and routine operations like deliveries and loading.
- Looking ahead, business owners fear long-term damage to visibility, access, foot traffic, and neighborhood perception once the 300-foot jail is complete. Owners of Nha Trang One and Pasteur Grill, operating for over 30 years, say they fear closure or forced relocation, though high costs and long-term leases make that nearly impossible. Without any compensation or support, even one closure risks triggering a broader cycle of vacancies and economic decline.

CONCLUSION

In a neighborhood already impacted by 9/11, Hurricane Sandy, and a 26% drop in business activity during COVID-19, 12% higher than the NYC average, this construction adds yet another layer of instability. These findings highlight the urgent need for transparent, community-centered urban planning and support community calls for the alternative site and inclusive solutions.

ACKNOWLEDGEMENTS

We would like to thank NYU Tandon School of Engineering's Office of Undergraduate Academics for their generous support for the project. We also extend our gratitude to Welcome to Chinatown, NUBC, and the community members whose insights made this research possible.

Wireless



In a wireless world, fast, secure and reliable communications are paramount. We're doing research that will make the next era of communications and connection possible.

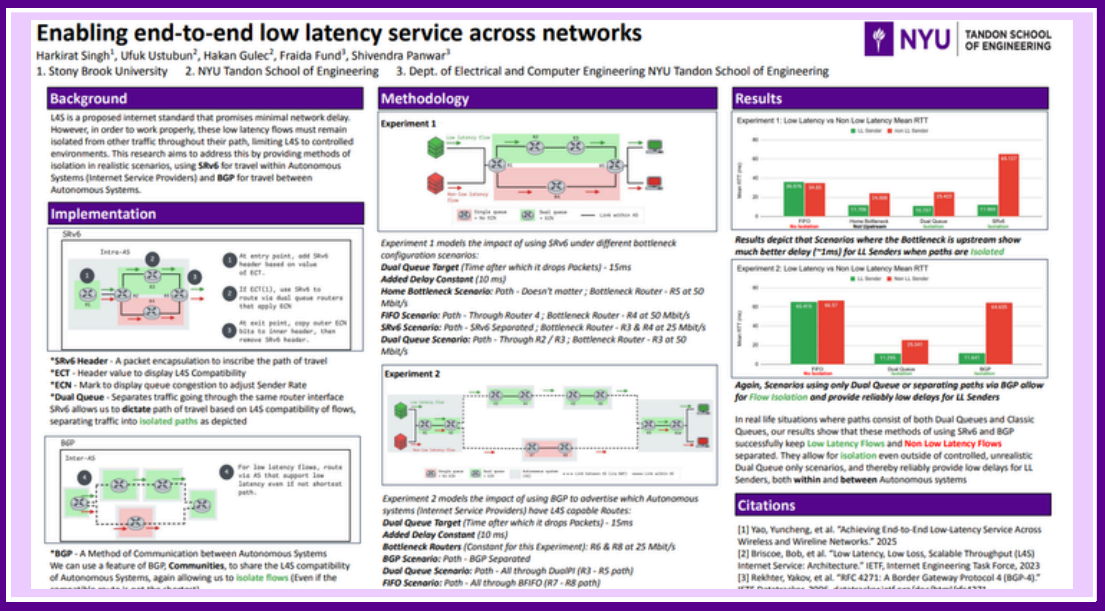
Pushing the limits of ultra low latency communications

L4S (Low Latency, Low Loss, Scalable Throughput) is a proposed Internet standard that promises to deliver network traffic with extremely low latency (delay) in controlled settings. However, a major limitation of L4S is that outside of a tightly controlled "L4S-compatible" environment, it does not have any mechanism to protect low latency flows from the delay caused by non-L4S flows. This means that if you try to use L4S for latency sensitive applications like live gaming, you may lose out on its benefits because your network traffic passes through "non-L4S-compatible" parts of the Internet along the way. To address this, we propose an approach using existing well-supported protocols, SRv6 within a service provider's network and BGP between different providers' networks, to steer L4S traffic along "L4S-compatible" paths. With this solution, L4S can be more widely implemented, delivering its low latency benefits across a wide range of networked services and applications.

Project Supervisor *Shivendra Panwar, Fraida Fund*
Research Areas *Wireless*



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Design and Fabrication of Undersea Meta-Antenna

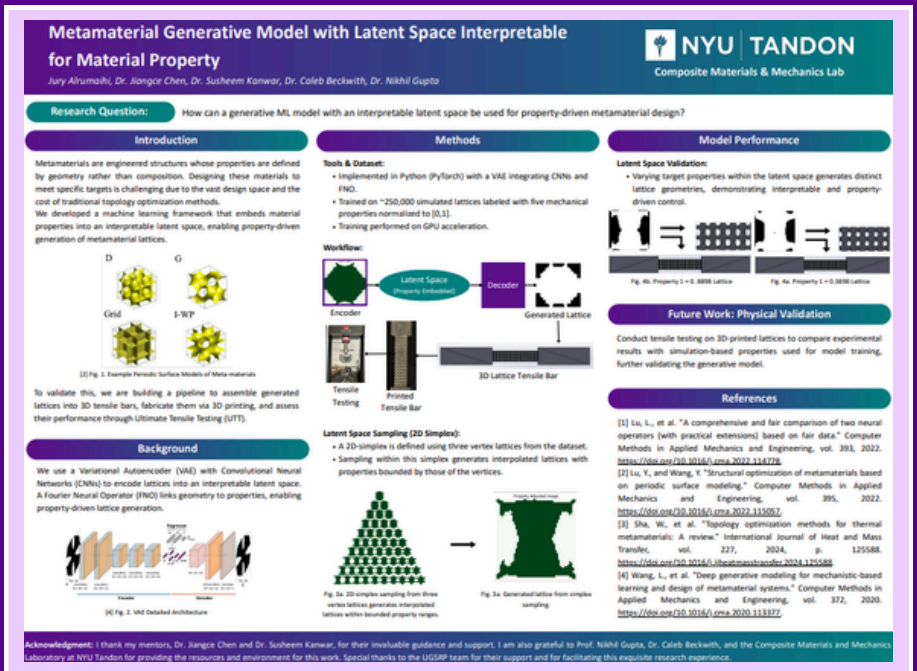
Metamaterials are artificial structures engineered to exhibit customized mechanical properties based on their geometry rather than their composition. These materials can be designed to bend, stretch, or respond to forces in controlled ways, making them useful in a wide range of engineering applications. Designing such structures in reverse, starting from desired properties and figuring the right geometry, is a significant challenge due to the large number of possible designs and the difficulty in predicting how each will behave. Traditional topology optimization methods can generate designs that satisfy target properties, but they're often computationally expensive and time-consuming. On the other hand, machine learning-based generative models offer faster generation but typically have uninterpretable latent spaces, making it difficult to control or fine-tune the resulting structures for specific material properties. To address this, we are developing a Variational Autoencoder (VAE) model that combines Convolutional Neural Networks (CNNs) and Fourier Neural Operators (FNOs). The goal is to generate lattice structures based on specified mechanical properties. By jointly training the model with a regressor that learns the relationship between a design and its properties, we aim to embed material properties directly into the model's latent space. This makes it easier to explore and adjust designs by moving through the latent space in meaningful ways. We are also building a code pipeline to assemble the generated lattice microstructures into a 3D tensile testing bar. The bar will be fabricated using 3D printing and evaluated through Ultimate Tensile Testing (UTT) to assess how well the generated structures match the target properties and to validate the effectiveness of the model.

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Research Areas	*Wireless*
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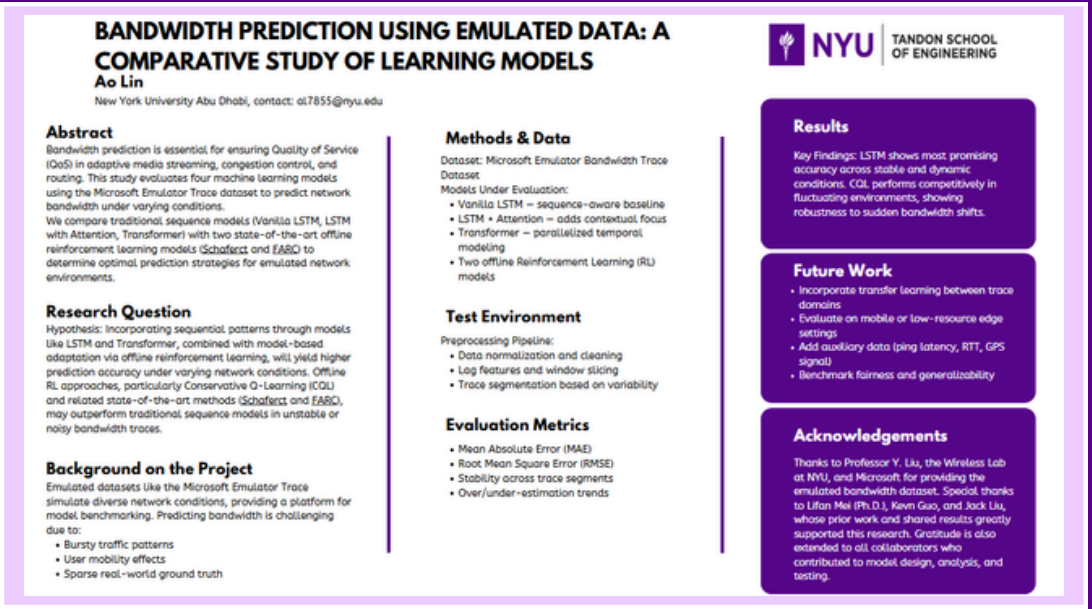
Realtime Network Quality-of-Service (QoS) Measurement and Prediction

Bandwidth prediction is essential for ensuring Quality of Service (QoS) in adaptive media streaming, congestion control, and routing. This study evaluates four machine learning models using the Microsoft Emulator Trace dataset to predict network bandwidth under varying conditions.
We compare traditional sequence models (Vanilla LSTM, LSTM with Attention, Transformer) with two state-of-the-art offline reinforcement learning models (Schaferct and FARC) to determine optimal prediction strategies for emulated network environments.

Project Supervisor *Yong Liu*
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Health



Today more than ever, it’s clear that everything depends on our health. Collaborating across all disciplines, NYU Tandon has been working at the intersection of engineering, healthcare, and life sciences for decades, and our researchers have the expertise to create next- generation solutions at every scale.

Bio-inspired Capsular Robot for Medical Applications

Large Language Models (LLMs) demonstrate strong performance on straightforward and structured tasks; however, they often lack creativity, the ability to handle open-ended queries, and effectiveness in educational settings. Recent advances, such as AutoDAN, have made significant strides in the exploration of self-improving multi-agent prompting. This project aims to increase the creativity of LLM responses through a multi-agent system in tandem with human-in-the-loop feedback. Our system utilized a four-agent framework composed of a Prompt Generator Agent (PGA), Critic Agent (CA), Refiner Agent (RA), and Output Evaluator Agent (OEA). The PGA enriches raw prompts. The CA critiques them, then the RA refines them based on AI and human feedback, and finally, the output of the refined prompt is evaluated by the OEA on multiple metrics. These metrics include coherence, creativity, and engagement, and a human rates these outputs with reasoning to influence later further rounds of refinement. Over 200 prompt iterations have been evaluated so far. In one 100-prompt batch, enriched prompts performed equal to the baseline prompt 99% of the time with no outperformance rounds. The refined prompts outperformed the baseline 44% of the time and matched the baseline score 56% of the time. This highlights the impact of layered feedback and refinement. Although research is still ongoing, this suggests that enrichment alone is insufficient and that deeper, layered, feedback-driven refinement has a positive impact on creative quality. Overall, our results indicate that combining multi-agent prompt iteration with human feedback yields higher-quality and more creative responses than baseline LLM responses with no iterative refinement. This framework may hold future promise for higher-quality educational tools focused on peer feedback and assisting in creative writing tasks.

Project Supervisor *Rui Li*

Research Areas *Health*



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Miki Guo

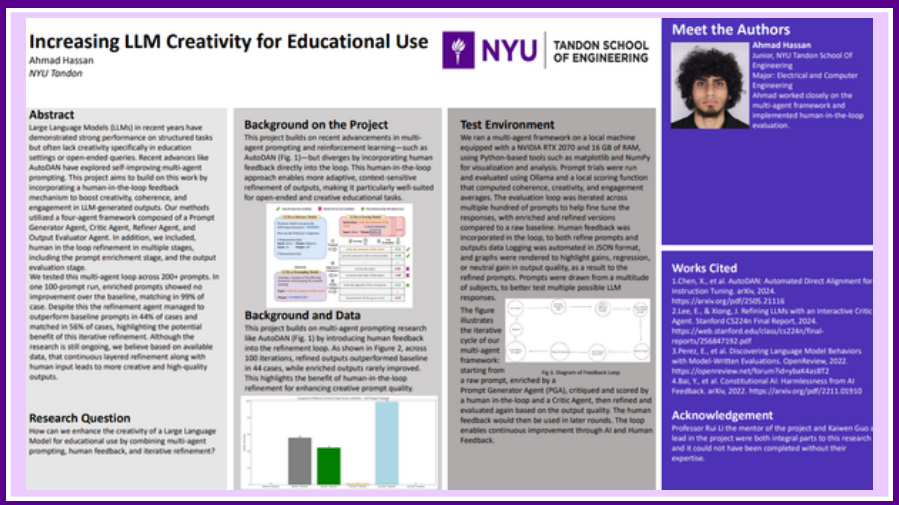
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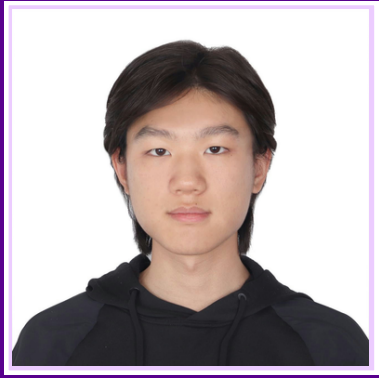




Studying light-induced crystallization using microfluidic devices

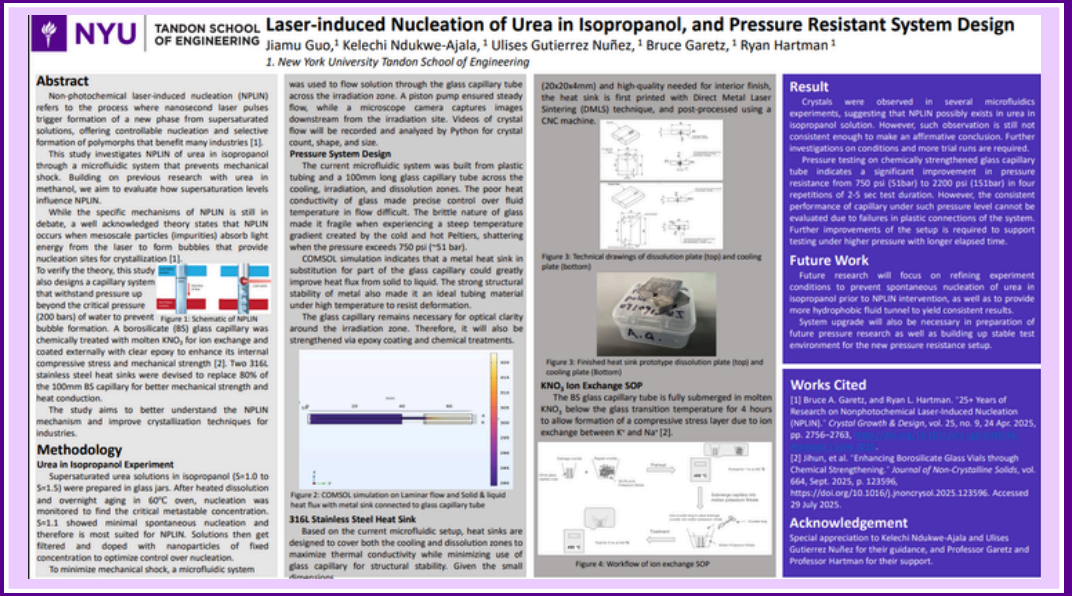
Non-photochemical laser-induced nucleation (NPLIN) refers to the process where nanosecond laser pulses trigger formation of a new phase from supersaturated solutions, offering controllable nucleation and selective formation of polymorphs that benefit many industries. This study investigates NPLIN of urea in isopropanol through a microfluidic system that prevents mechanical shock. Building on previous research with urea in methanol, we aim to evaluate how supersaturation levels influence NPLIN. While the specific mechanisms of NPLIN is still in debate, a well acknowledged theory states that NPLIN occurs when mesoscale particles (impurities) absorb light energy from the laser to form bubbles that provide nucleation sites for crystallization. To verify the theory, this study also designs a capillary system that withstand pressure up beyond the critical pressure (200 bars) of water to prevent bubble formation. A borosilicate (BS) glass capillary was chemically treated with molten KNO3 for ion exchange and coated externally with clear epoxy to enhance its internal compressive stress and mechanical strength. Two 316L stainless steel heat sinks were devised to replace 80% of the 100mm BS capillary for better mechanical strength and heat conduction. The study aims to better understand the NPLIN mechanism and improve crystallization techniques for industries.

Project Supervisor	*Bruce Garetz, Ryan Hartman*
Research Areas	*Health*
Research Staff	*Kelechi Ndukwe-Ajala*



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NYU TANDON SCHOOL OF ENGINEERING

Laser-induced Nucleation of Urea in Isopropanol, and Pressure Resistant System Design

Jiamu Guo,[1] Kelechi Ndukwe-Ajala, [1] Ulises Gutierrez Nuñez, [1] Bruce Garetz, [1] Ryan Hartman [1]

1. New York University Tandon School of Engineering

Abstract

Non-photochemical laser-induced nucleation (NPLIN) refers to the process where nanosecond laser pulses trigger formation of a new phase from supersaturated solutions, offering controllable nucleation and selective formation of polymorphs that benefit many industries [1].

This study investigates NPLIN of urea in isopropanol through a microfluidic system that prevents mechanical shock. Building on previous research with urea in methanol, we aim to evaluate how supersaturation levels influence NPLIN.

While the specific mechanisms of NPLIN is still in debate, a well acknowledged theory states that NPLIN occurs when mesoscale particles (impurities) absorb light energy from the laser to form bubbles that provide nucleation sites for crystallization [1].

To verify the theory, this study also designs a capillary system that withstand pressure up beyond the critical pressure (200 bars) of water to prevent bubble formation. A borosilicate (BS) glass capillary was chemically treated with molten KNO_3 for ion exchange and coated externally with clear epoxy to enhance its internal compressive stress and mechanical strength [2]. Two 316L stainless steel heat sinks were devised to replace 80% of the 100mm BS capillary for better mechanical strength and heat conduction.

The study aims to better understand the NPLIN mechanism and improve crystallization techniques for industries.

Figure 1: Schematic of NPLIN

Methodology

Urea in Isopropanol Experiment

Supersaturated urea solutions in isopropanol (S=1.0 to S=1.5) were prepared in glass jars. After heated dissolution and overnight aging in 60°C oven, nucleation was monitored to find the critical metastable concentration. S=1.1 showed minimal spontaneous nucleation and therefore is most suited for NPLIN. Solutions then get filtered and doped with nanoparticles of fixed concentration to optimize control over nucleation.

To minimize mechanical shock, a microfluidic system was used to flow solution through the glass capillary tube across the irradiation zone. A piston pump ensured steady flow, while a microscope camera captures images downstream from the irradiation site. Videos of crystal flow will be recorded and analyzed by Python for crystal count, shape, and size.

Pressure System Design

The current microfluidic system was built from plastic tubing and a 100mm long glass capillary tube across the cooling, irradiation, and dissolution zones. The poor heat conductivity of glass made precise control over fluid temperature in flow difficult. The brittle nature of glass made it fragile when experiencing a steep temperature gradient created by the cold and hot Peltiers, shattering when the pressure exceeds 750 psi (~51 bar).

COMSOL simulation indicates that a metal heat sink in substitution for part of the glass capillary could greatly improve heat flux from solid to liquid. The strong structural stability of metal also made it an ideal tubing material under high temperature to resist deformation.

The glass capillary remains necessary for optical clarity around the irradiation zone. Therefore, it will also be strengthened via epoxy coating and chemical treatments.

Figure 2: COMSOL simulation on Laminar flow and Solid & liquid heat flux with metal sink connected to glass capillary tube

316L Stainless Steel Heat Sink

Based on the current microfluidic setup, heat sinks are designed to cover both the cooling and dissolution zones to maximize thermal conductivity while minimizing use of glass capillary for structural stability. Given the small dimensions (20x20x4mm) and high-quality needed for interior finish, the heat sink is first printed with Direct Metal Laser Sintering (DMLS) technique, and post-processed using a CNC machine.

Figure 3: Technical drawings of dissolution plate (top) and cooling plate (bottom)

Figure 3: Finished heat sink prototype dissolution plate (top) and cooling plate (bottom)

KNO_3 Ion Exchange SOP

The BS glass capillary tube is fully submerged in molten KNO_3 below the glass transition temperature for 4 hours to allow formation of a compressive stress layer due to ion exchange between K^+ and Na^+ [2].

Figure 4: Workflow of ion exchange SOP

Result

Crystals were observed in several microfluidics experiments, suggesting that NPLIN possibly exists in urea in isopropanol solution. However, such observation is still not consistent enough to make an affirmative conclusion. Further investigations on conditions and more trial runs are required.

Pressure testing on chemically strengthened glass capillary tube indicates a significant improvement in pressure resistance from 750 psi (51bar) to 2200 psi (151bar) in four repetitions of 2-5 sec test duration. However, the consistent performance of capillary under such pressure level cannot be evaluated due to failures in plastic connections of the system. Further improvements of the setup is required to support testing under higher pressure with longer elapsed time.

Future Work

Future research will focus on refining experiment conditions to prevent spontaneous nucleation of urea in isopropanol prior to NPLIN intervention, as well as to provide more hydrophobic fluid tunnel to yield consistent results.

System upgrade will also be necessary in preparation of future pressure research as well as building up stable test environment for the new pressure resistance setup.

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[2] Jihun, et al. "Enhancing Borosilicate Glass Vials through Chemical Strengthening." *Journal of Non-Crystalline Solids*, vol. 664, Sept. 2025, p. 123596, https://doi.org/10.1016/j.jnoncrysol.2025.123596. Accessed 29 July 2025.

Acknowledgement

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Novel photonic materials for X-ray detection and cancer imaging

Dip-coating is a widely utilized, industrially scalable technique for depositing uniform thin films onto substrates of nearly any geometry, offering a compelling combination of simplicity, reproducibility, and suitability for high-throughput production. Unlike spin-coating, dip-coating involves the gradual withdrawal of a substrate from a solution bath, allowing excess solution to drain back and resulting in dramatically higher material efficiency. This is especially critical when working with costly or precious materials, as up to 80–90% of solution is typically lost during spin-coating. This advantage is particularly pronounced for colloidal quantum dots (cQDs), which combine solution-processability, tunable bandgaps, and low-temperature synthesis, making them attractive candidates for low-cost, large-area optoelectronics. Automation of dip-coating, through programmable, multi-stage instruments, further expands this technique by enabling precise control over reproducibility, withdrawal speeds, and the implementation of custom protocols. However, commercial systems that offer this level of control remain expensive and inflexible, restricting widespread access to high-precision dip-coating in many academic settings. Recent advances in low-cost motors, open-source microcontrollers, and 3D printing have facilitated the emergence of do-it-yourself scientific hardware platforms that match commercial performance at a fraction of the cost. This project introduces biphasic dip-coating of cQDs, where the substrate is withdrawn through two immiscible liquids. Here, the top phase contains the desired film material, and the bottom acts as an inert solution. Since film formation occurs exclusively at this solvent-substrate interface, the dip-coating process remains virtually unchanged, drastically minimizing solvent and material waste while maintaining the same control over film morphology and assembly. This approach is especially beneficial for sensitive or expensive materials, maximizing material recovery and enabling film structures unattainable by single-phase methods. We implement both easy automation and biphasic dip-coating, representing a powerful approach for fabricating quantum dot thin films with minimal waste and high reproducibility for optoelectronic and photovoltaic applications.

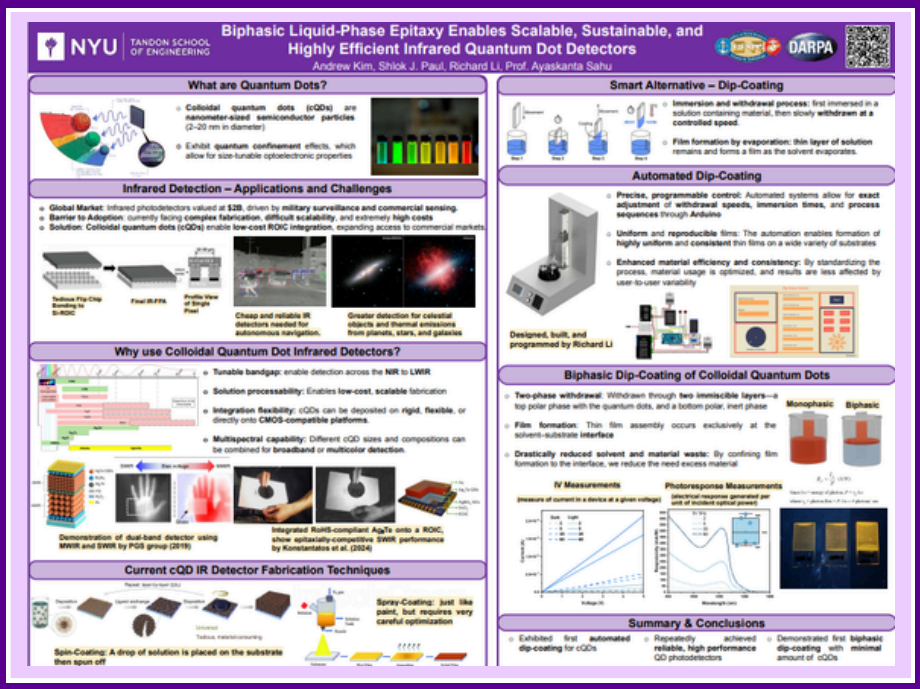
Project Supervisor *Ayaskanta Sahu*

Research Areas *Health*



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Magnetic-Polymer-Ceramic Smart Scaffolds for Enhanced Bone Regeneration, Controlled Drug Delivery and Magnetic Hyperthermia

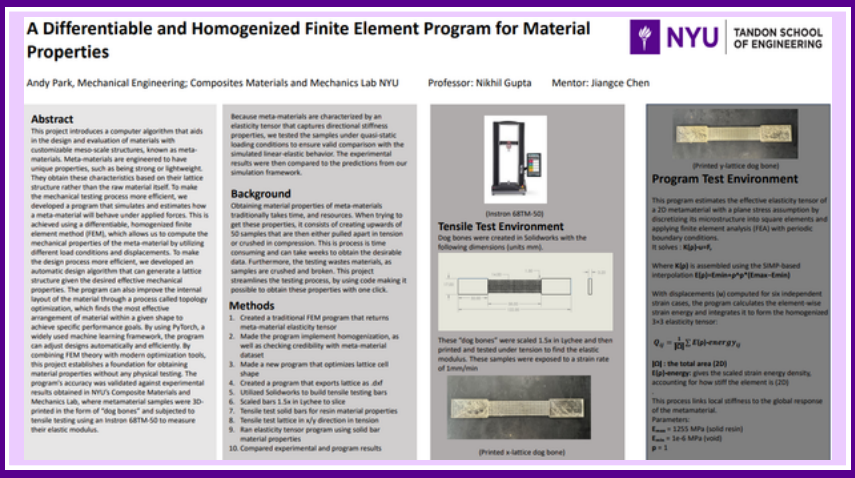
This project introduces a computer algorithm that aids in the design and evaluation of materials with customizable microstructures, known as meta-materials. Meta-materials are engineered to have unique properties, such as being strong or lightweight. They obtain these characteristics based on their internal structure rather than the raw material itself. To make the mechanical testing process more efficient, we developed a program that simulates and estimates how a meta-material will behave under applied forces. This is achieved using a differentiable, homogeneous finite element method (FEM), which allows us to compute the mechanical properties of the meta-material by utilizing different load conditions and displacements. The program can also improve the internal layout of the material through a process called topology optimization, which finds the most effective arrangement of material within a given shape to achieve specific performance goals. By using PyTorch, a widely used machine learning framework, the program is capable of adjusting designs automatically and efficiently. By combining FEM theory with modern optimization tools, this project establishes a foundation for obtaining material properties without any physical testing. The program's accuracy was tested against experimental results obtained in NYU's C114 Lab, where we 3D-printed meta-material samples as ASTM D628 dogbones and measured their elastic modulus in tension using an Instron UTM 6800. Because meta-materials are characterized by an elasticity tensor that captures directional stiffness properties, we tested the samples under quasi-static loading conditions to ensure valid comparison with the simulated linear-elastic behavior. The experimental results were then compared to the predictions from our simulation framework.

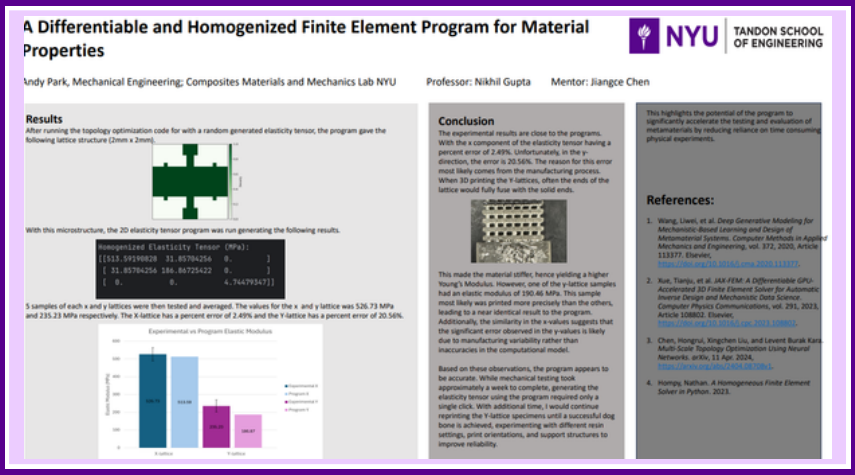
Project Supervisor	*Nikhil Gupta*
Research Areas	*Health*
Research Staff	*Caleb Beckwith, Jiangce Chen*



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Biosensor project

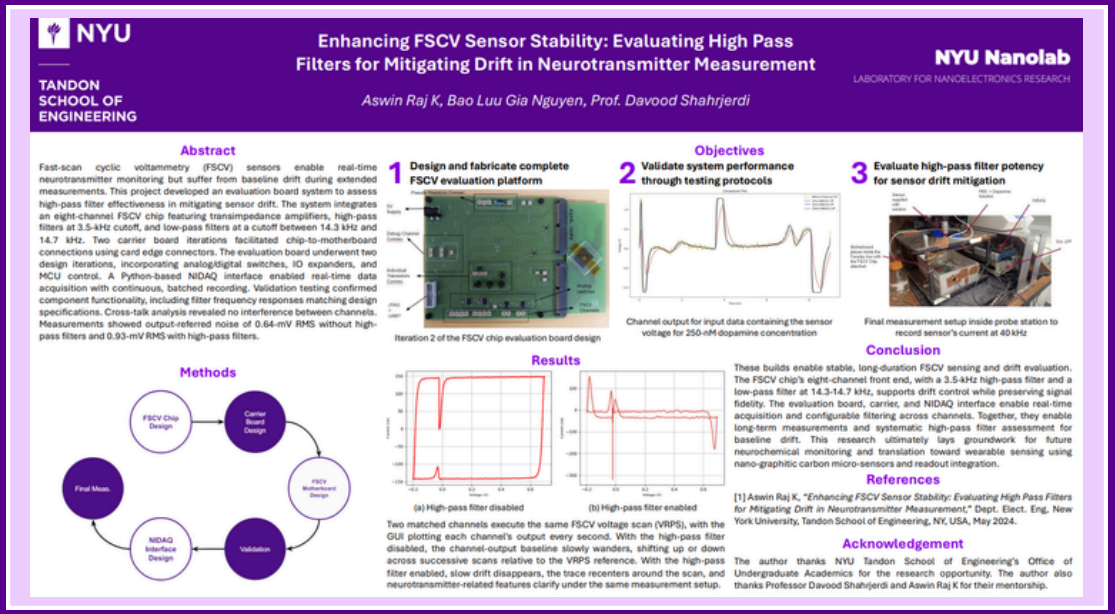
Fast-scan cyclic sensors (FSCV) enable real-time neurotransmitter monitoring but suffer from baseline drift during extended measurements. This project developed an evaluation board system to assess high-pass filter effectiveness in mitigating sensor drift. The system integrates an eight-channel FSCV chip featuring transimpedance amplifiers, high-pass filters at 3.5kHz cutoff, and low-pass filters at 14.3kHz cutoff. Two carrier board iterations facilitated chip-to-motherboard connections using card edge connectors. The evaluation board underwent two design iterations, incorporating analog/digital switches, IO expanders, and MCU control. A Python-based NIDAQ interface enabled real-time data acquisition at 40kHz sampling rate with continuous recording capabilities. Validation testing confirmed individual component functionality, including filter frequency responses matching design specifications. Cross-talk analysis revealed no interference between channels. Noise measurements showed output-referred noise of 0.64mV RMS without high-pass filters and 0.93mV RMS with high-pass filters enabled. The system successfully measured dopamine concentrations using capacitor-based functionality tests. The integrated system provides a reliable platform for assessing high-pass filters effectiveness in drift mitigation during long-term neurochemical monitoring.

Project Supervisor	*Davood Shahrjerdi*
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NYU TANDON SCHOOL OF ENGINEERING

Enhancing FSCV Sensor Stability: Evaluating High Pass Filters for Mitigating Drift in Neurotransmitter Measurement

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Abstract

Fast-scan cyclic voltammetry (FSCV) sensors enable real-time neurotransmitter monitoring but suffer from baseline drift during extended measurements. This project developed an evaluation board system to assess high-pass filter effectiveness in mitigating sensor drift. The system integrates an eight-channel FSCV chip featuring transimpedance amplifiers, high-pass filters at 3.5-kHz cutoff, and low-pass filters at a cutoff between 14.3 kHz and 14.7 kHz. Two carrier board iterations facilitated chip-to-motherboard connections using card edge connectors. The evaluation board underwent two design iterations, incorporating analog/digital switches, IO expanders, and MCU control. A Python-based NIDAQ interface enabled real-time data acquisition with continuous, batched recording. Validation testing confirmed component functionality, including filter frequency responses matching design specifications. Cross-talk analysis revealed no interference between channels. Measurements showed output-referred noise of 0.64-mV RMS without high-pass filters and 0.93-mV RMS with high-pass filters.

Objectives

1 Design and fabricate complete FSCV evaluation platform

Iteration 2 of the FSCV chip evaluation board design

2 Validate system performance through testing protocols

Channel output for input data containing the sensor voltage for 250-nM dopamine concentration

3 Evaluate high-pass filter potency for sensor drift mitigation

Final measurement setup inside probe station to record sensor's current at 40 kHz

Methods

FSCV Chip Design
Carrier Board Design
FSCV Motherboard Design
Validation
NIDAQ Interface Design
Final Meas.

Results

(a) High-pass filter disabled

(b) High-pass filter enabled

Two matched channels execute the same FSCV voltage scan (VRPS), with the GUI plotting each channel's output every second. With the high-pass filter disabled, the channel-output baseline slowly wanders, shifting up or down across successive scans relative to the VRPS reference. With the high-pass filter enabled, slow drift disappears, the trace recenters around the scan, and neurotransmitter-related features clarify under the same measurement setup.

Conclusion

These builds enable stable, long-duration FSCV sensing and drift evaluation. The FSCV chip's eight-channel front end, with a 3.5-kHz high-pass filter and a low-pass filter at 14.3-14.7 kHz, supports drift control while preserving signal fidelity. The evaluation board, carrier, and NIDAQ interface enable real-time acquisition and configurable filtering across channels. Together, they enable long-term measurements and systematic high-pass filter assessment for baseline drift. This research ultimately lays groundwork for future neurochemical monitoring and translation toward wearable sensing using nano-graphitic carbon micro-sensors and readout integration.

References

[1] Aswin Raj K, *"Enhancing FSCV Sensor Stability: Evaluating High Pass Filters for Mitigating Drift in Neurotransmitter Measurement,"* Dept. Elect. Eng, New York University, Tandon School of Engineering, NY, USA, May 2024.

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16S Metagenomics sequencing studies

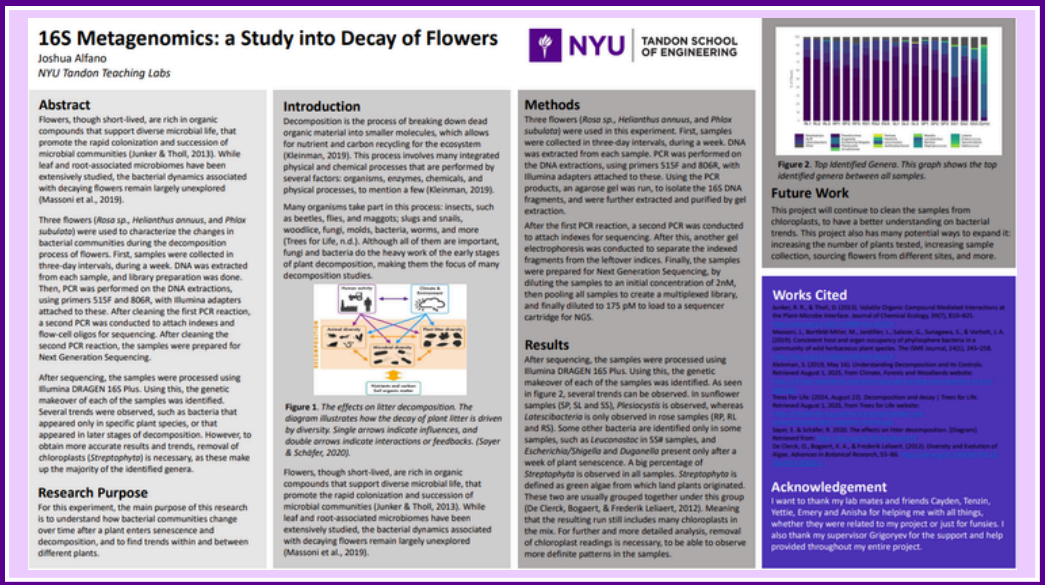
Flowers, though short-lived, are rich in organic compounds that support diverse microbial life, that promote the rapid colonization and succession of microbial communities (Junker & Tholl, 2013). While leaf and root-associated microbiomes have been extensively studied, the bacterial dynamics associated with decaying flowers remain largely unexplored (Massoni et al., 2019). Three flowers (Rosa sp., Helianthus annuus, and Phlox subulata) were used to characterize the changes in bacterial communities during the decomposition process of flowers. First, samples were collected in three-day intervals, during a week. DNA was extracted from each sample, and library preparation was done. Then, PCR was performed on the DNA extractions, using primers 515F and 806R, with Illumina adapters attached to these. After cleaning the first PCR reaction, a second PCR was conducted to attach indexes for sequencing. After cleaning the second PCR reaction, the samples were prepared for Next Generation Sequencing. The obtained results were average, but can be improved, with a %Q30 score of 69.46%, and a %PF score of 31.2%. The obtained data was filtered, and the amount of significant data used in the analysis was calculated. Finally the filtered data was organized into tables per sample type, and finally plotted in graphs. The sample analysis contained many interesting genera present in the collected data, such as marine genus Plesiocystis, to fermentation genus Leuconostoc. The samples were compared within the same sample types and within the flower sample. A comparison between the flower samples was not possible due to the flower samples being from different genetic families. Further research is needed to understand the bacterial succession patterns within the same plant genera and/or families.

Project Supervisor *Nikita Grigoryev*

Research Areas *Health*



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16S Metagenomics: a Study into Decay of Flowers

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Abstract

Flowers, though short-lived, are rich in organic compounds that support diverse microbial life, that promote the rapid colonization and succession of microbial communities (Junker & Tholl, 2013). While leaf and root-associated microbiomes have been extensively studied, the bacterial dynamics associated with decaying flowers remain largely unexplored (Massoni et al., 2019).

Three flowers (*Rosa sp., Helianthus annuus,* and *Phlox subulata*) were used to characterize the changes in bacterial communities during the decomposition process of flowers. First, samples were collected in three-day intervals, during a week. DNA was extracted from each sample, and library preparation was done. Then, PCR was performed on the DNA extractions, using primers 515F and 806R, with Illumina adapters attached to these. After cleaning the first PCR reaction, a second PCR was conducted to attach indexes and flow-cell oligos for sequencing. After cleaning the second PCR reaction, the samples were prepared for Next Generation Sequencing.

After sequencing, the samples were processed using Illumina DRAGEN 16S Plus. Using this, the genetic makeover of each of the samples was identified. Several trends were observed, such as bacteria that appeared only in specific plant species, or that appeared in later stages of decomposition. However, to obtain more accurate results and trends, removal of chloroplasts (*Streptophyta*) is necessary, as these make up the majority of the identified genera.

Research Purpose

For this experiment, the main purpose of this research is to understand how bacterial communities change over time after a plant enters senescence and decomposition, and to find trends within and between different plants.

Introduction

Decomposition is the process of breaking down dead organic material into smaller molecules, which allows for nutrient and carbon recycling for the ecosystem (Kleinman, 2019). This process involves many integrated physical and chemical processes that are performed by several factors: organisms, enzymes, chemicals, and physical processes, to mention a few (Kleinman, 2019).

Many organisms take part in this process: insects, such as beetles, flies, and maggots; slugs and snails, woodlice, fungi, molds, bacteria, worms, and more (Trees for Life, n.d.). Although all of them are important, fungi and bacteria do the heavy work of the early stages of plant decomposition, making them the focus of many decomposition studies.

Figure 1. *The effects on litter decomposition. The diagram illustrates how the decay of plant litter is driven by diversity. Single arrows indicate influences, and double arrows indicate interactions or feedbacks. (Sayer & Schäfer, 2020).*

Flowers, though short-lived, are rich in organic compounds that support diverse microbial life, that promote the rapid colonization and succession of microbial communities (Junker & Tholl, 2013). While leaf and root-associated microbiomes have been extensively studied, the bacterial dynamics associated with decaying flowers remain largely unexplored (Massoni et al., 2019).

Methods

Three flowers (*Rosa sp., Helianthus annuus,* and *Phlox subulata*) were used in this experiment. First, samples were collected in three-day intervals, during a week. DNA was extracted from each sample. PCR was performed on the DNA extractions, using primers 515F and 806R, with Illumina adapters attached to these. Using the PCR products, an agarose gel was run, to isolate the 16S DNA fragments, and were further extracted and purified by gel extraction.

After the first PCR reaction, a second PCR was conducted to attach indexes for sequencing. After this, another gel electrophoresis was conducted to separate the indexed fragments from the leftover indices. Finally, the samples were prepared for Next Generation Sequencing, by diluting the samples to an initial concentration of 2nM, then pooling all samples to create a multiplexed library, and finally diluted to 175 pM to load to a sequencer cartridge for NGS.

Results

After sequencing, the samples were processed using Illumina DRAGEN 16S Plus. Using this, the genetic makeover of each of the samples was identified. As seen in figure 2, several trends can be observed. In sunflower samples (SP, SL and SS), *Plesiocystis* is observed, whereas *Lutescibacteria* is only observed in rose samples (RP, RL and RS). Some other bacteria are identified only in some samples, such as *Leuconostoc* in SSR samples, and *Escherichia/Shigella* and *Duganella* present only after a week of plant senescence. A big percentage of *Streptophyta* is observed in all samples. *Streptophyta* is defined as green algae from which land plants originated. These two are usually grouped together under this group (De Clerck, Bogaert, & Frederik Leliaert, 2012). Meaning that the resulting run still includes many chloroplasts in the mix. For further and more detailed analysis, removal of chloroplast readings is necessary, to be able to observe more definite patterns in the samples.

Figure 2. *Top Identified Genera. This graph shows the top identified genera between all samples.*

Future Work

This project will continue to clean the samples from chloroplasts, to have a better understanding on bacterial trends. This project also has many potential ways to expand it: increasing the number of plants tested, increasing sample collection, sourcing flowers from different sites, and more.

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Acknowledgement

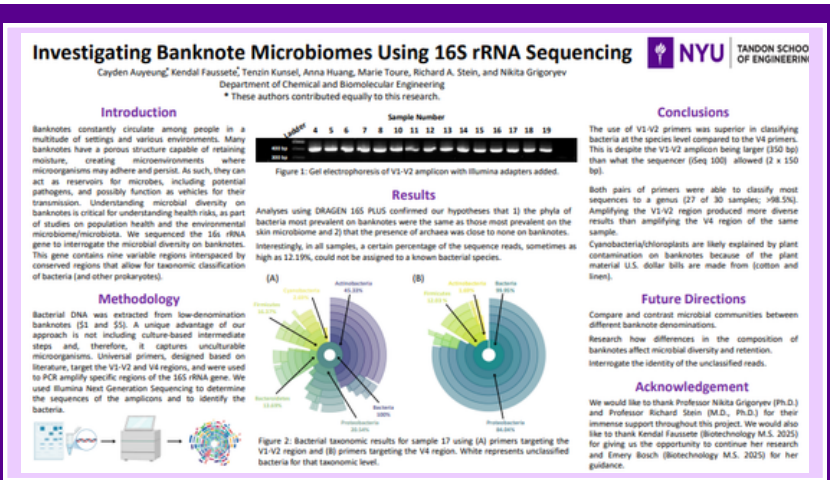
I want to thank my lab mates and friends Cayden, Tenzin, Yettie, Emery and Anisha for helping me with all things, whether they were related to my project or just for funsies. I also thank my supervisor Grigoryev for the support and help provided throughout my entire project.

16S Metagenomics sequencing studies

Banknotes, frequently used in daily transactions in countries all over the world, are potential carriers of different bacterias. Studies have shown that banknotes contain different bacterias, fungal and viruses that can be transmitted by individuals handling them. It has been found that bacterias such as MRSA: Methicillin-resistant Staphylococcus aureus, VRE: Vancomycin-resistant Enterococcus and ESBL–E. coli: Extended-Spectrum Beta-Lactamase-producing Escherichia coli can last on banknotes for up to 12 hours depending on their material. In some cases, this can result in infections, or even some serious illnesses, especially in individuals with weakened immune systems. In this study, Next Generation Sequencing (NGS) has been used to characterize the types of bacteria found on banknotes. The procedure involves non culture based DNA extraction from the surface of banknotes that have been circulated. The samples are run through illumina sequencing platforms and analyzed utilizing DRAGEN metagenomics software. This well thought out approach allowed the identification of microbial DNA at both the genus and species level, allowing for an in-depth picture of the type of bacteria that is present on banknotes. Through this, accurate identification and classification of the type of bacteria that can survive on banknotes has been possible. The use of sequencing offers a wider and more well-rounded understanding of microbial presence on money and highlights the vast array of bacteria that we are prone to come in contact with in our daily lives. These findings show how molecular tools can be used to better assess the public health risks and help inform future decisions about the material used to manufacture banknotes in order to prevent bacterial infections.

Project Supervisor *Nikita Grigoryev, Richard A Stein*

Research Areas *Health*





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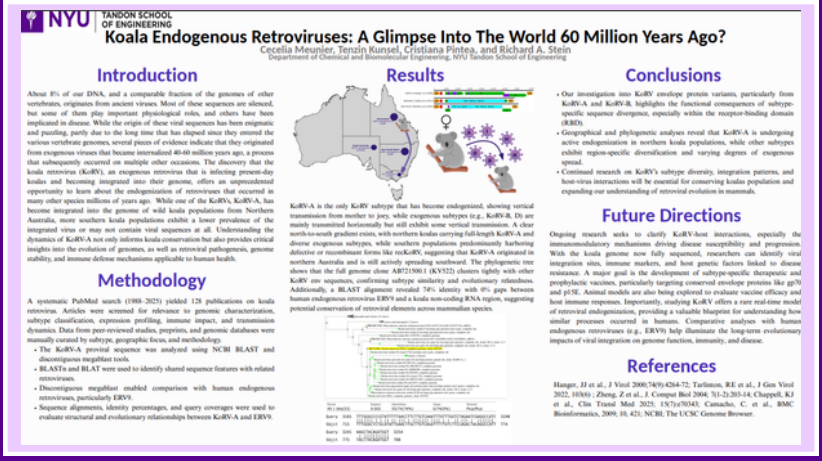


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Koala Endogenous Retroviruses: A Glimpse Into The World 60 Million Years Ago?

About 8% of our DNA, and a comparable fraction of the genome of other vertebrates, originates from ancient viruses. Most these sequences are silenced, but some of them play important physiological roles and others were implicated in disease. While the origin of these viral sequences has been enigmatic and intriguing, partly due to the long time that has elapsed since then, several pieces of evidence indicate that they originated from exogenous viruses that became internalized 40-60 million years ago, a process that subsequently occurred on multiple other occasions. The discovery that the koala retrovirus (KoRV), an exogenous retrovirus that is infecting present-day koalas, is currently becoming integrated into the genomes of some wild koalas, offers an unprecedented opportunity to learn about the endogenization of retroviruses that occurred in many other species millions of years ago. KoRV infection is associated with immune suppression, a higher risk to develop malignancies, most notably lymphoma and leukemia, and increased susceptibility to microbial co-infections. KoRVs are the only retroviruses that currently exist both in an exogenous, infectious and an endogenous, integrated form. While one of the KoRVs, KoRV-A has become integrated into the genome of wild koala populations from Northern Australia, more southern koala populations exhibit a lower prevalence of the integrated virus or may not contain viral sequences at all. Using platforms such as BLAST and Integrated Genomics Viewer, we performed bioinformatics analyses to explore the relatedness among different endogenous viral sequences from koala genomes and their relationship with viral sequences from the genome of other species, including humans, as a way to better understand the dynamics of viral integration into vertebrate genomes over evolutionary time. Understanding the dynamics of KoRV-A not only informs koala conservation, but also provides critical insights into retroviral pathogenesis, genome stability, and immune defense mechanisms applicable to human health.

Project Supervisor	*Richard A Stein, Nikita Grigoryev*
Research Areas	*Health*


NYU TANDON SCHOOL OF ENGINEERING

Koala Endogenous Retroviruses: A Glimpse Into The World 60 Million Years Ago?

Cecelia Meunier, Tenzin Kunsel, Cristiana Pintea, and Richard A. Stein

Department of Chemical and Biomolecular Engineering, NYU Tandon School of Engineering

Introduction

About 8% of our DNA, and a comparable fraction of the genomes of other vertebrates, originates from ancient viruses. Most of these sequences are silenced, but some of them play important physiological roles, and others have been implicated in disease. While the origin of these viral sequences has been enigmatic and puzzling, partly due to the long time that has elapsed since they entered the various vertebrate genomes, several pieces of evidence indicate that they originated from exogenous viruses that became internalized 40-60 million years ago, a process that subsequently occurred on multiple other occasions. The discovery that the koala retrovirus (KoRV), an exogenous retrovirus that is infecting present-day koalas and becoming integrated into their genome, offers an unprecedented opportunity to learn about the endogenization of retroviruses that occurred in many other species millions of years ago. While one of the KoRVs, KoRV-A, has become integrated into the genome of wild koala populations from Northern Australia, more southern koala populations exhibit a lower prevalence of the integrated virus or may not contain viral sequences at all. Understanding the dynamics of KoRV-A not only informs koala conservation but also provides critical insights into the evolution of genomes, as well as retroviral pathogenesis, genome stability, and immune defense mechanisms applicable to human health.

Methodology

A systematic PubMed search (1988–2025) yielded 128 publications on koala retrovirus. Articles were screened for relevance to genomic characterization, subtype classification, expression profiling, immune impact, and transmission dynamics. Data from peer-reviewed studies, preprints, and genomic databases were manually curated by subtype, geographic focus, and methodology.

- The KoRV-A proviral sequence was analyzed using NCBI BLAST and discontiguous megablast tools.
- BLASTn and BLAT were used to identify shared sequence features with related retroviruses.
- Discontiguous megablast enabled comparison with human endogenous retroviruses, particularly ERV9.
- Sequence alignments, identity percentages, and query coverages were used to evaluate structural and evolutionary relationships between KoRV-A and ERV9.

Results

KoRV-A is the only KoRV subtype that has become endogenized, showing vertical transmission from mother to joey, while exogenous subtypes (e.g., KoRV-B, D) are mainly transmitted horizontally but still exhibit some vertical transmission. A clear north-to-south gradient exists, with northern koalas carrying full-length KoRV-A and diverse exogenous subtypes, while southern populations predominantly harboring defective or recombinant forms like recKoRV, suggesting that KoRV-A originated in northern Australia and is still actively spreading southward. The phylogenetic tree shows that the full genome clone AB721500.1 (KV522) clusters tightly with other KoRV env sequences, confirming subtype similarity and evolutionary relatedness. Additionally, a BLAST alignment revealed 74% identity with 0% gaps between human endogenous retrovirus ERV9 and a koala non-coding RNA region, suggesting potential conservation of retroviral elements across mammalian species.

Conclusions

- Our investigation into KoRV envelope protein variants, particularly from KoRV-A and KoRV-B, highlights the functional consequences of subtype-specific sequence divergence, especially within the receptor-binding domain (RBD).
- Geographical and phylogenetic analyses reveal that KoRV-A is undergoing active endogenization in northern koala populations, while other subtypes exhibit region-specific diversification and varying degrees of exogenous spread.
- Continued research on KoRV's subtype diversity, integration patterns, and host-virus interactions will be essential for conserving koalas population and expanding our understanding of retroviral evolution in mammals.

Future Directions

Ongoing research seeks to clarify KoRV-host interactions, especially the immunomodulatory mechanisms driving disease susceptibility and progression. With the koala genome now fully sequenced, researchers can identify viral integration sites, immune markers, and host genetic factors linked to disease resistance. A major goal is the development of subtype-specific therapeutic and prophylactic vaccines, particularly targeting conserved envelope proteins like gp70 and p15E. Animal models are also being explored to evaluate vaccine efficacy and host immune responses. Importantly, studying KoRV offers a rare real-time model of retroviral endogenization, providing a valuable blueprint for understanding how similar processes occurred in humans. Comparative analyses with human endogenous retroviruses (e.g., ERV9) help illuminate the long-term evolutionary impacts of viral integration on genome function, immunity, and disease.

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Characterization of chemotherapy induced cardiotoxicity

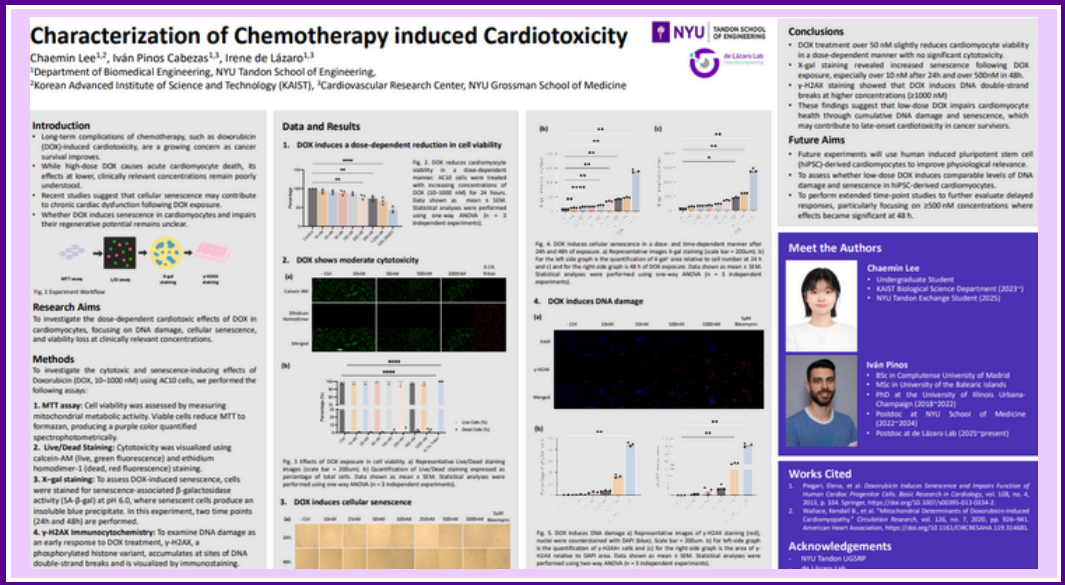
Cancer survival rates have increased in recent years, but the long-term side effects of certain chemotherapies have become a growing concern. Doxorubicin (DOX) is a widely used chemotherapeutic agent for the treatment of solid tumors, leukemia, and lymphoma. Although a dose-dependent cardiotoxic effect of DOX has been documented, the mechanisms behind this damage are not fully understood. Here, we hypothesize that submicromolar concentrations of DOX induce a senescent phenotype in cardiomyocytes, ultimately impairing their regenerative potential. To test this hypothesis, we exposed AC10 cells to DOX doses ranging from 10nM to 1,000nM and assessed: 1) cell viability using MTT assay and calcein AM/ethidium homodimer ("Live/Dead") staining at 24 hours postexposure , 2) DNA damage through γ-H2AX immunocytochemistry, and 3) senescenceassociated β-galactosidase activity using X-gal staining at 24 and 48 hours post-exposure. Our results showed a dose-dependent decrease in cell viability in MTT assays, although no significant cell death was observed by "Live/Dead" staining. Accordingly, DOX exposure resulted in higher γ-H2AX positive cells and elevated β-galactosidase activity compared to untreated controls. These results suggest that even at sub-micromolar concentrations, DOX induce cellular damage and senescence, providing insights into the cellular mechanisms underlying DOX-induced cardiotoxicity. Future research will evaluate these effects in human induced pluripotent stem cell-derived cardiac lineages to better recapitulate cardiomyocyte physiology and validate our findings in clinically relevant models.

Project Supervisor	*Irene de Lazaro*
Research Areas	*Health*
Research Staff	*Ivan Pinos*



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Bioengineering Lymph node-on a Chip for Modeling Human Adaptive Immune Responses and Vaccine Evaluation (AHA Fellowship Project)

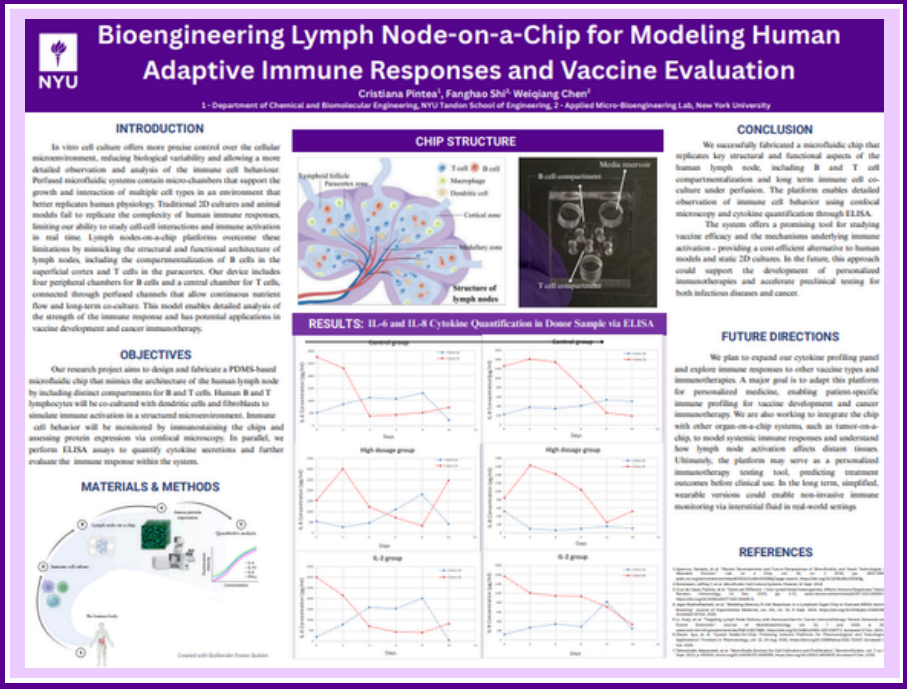
The lymphatic vascular is a major circulatory system that drains interstitial fluid from tissues and returns it to the bloodstream as lymph via lymphatic vessels. The lymph contains lymphocytes - B cells, T cells, and natural killer cells - that migrate to the blood system or lymph nodes (LNs). Due to differences in lymphatic connection, LNs are considered heterogeneous, which means that the immune cell population and, thus, the immune response in each lymph node varies. Animal models can shed light on the mechanism of the B cell response, but they do not fully represent the human physiology, which means that researchers cannot use them to accurately predict the immune response in humans. To overcome this challenge and be able to study the effectiveness of the flu vaccine in different age populations, we use a bioengineered LN-on-a-chip platform to mimic LN structure and model the interaction of immune cells. The chip, fabricated from a mix of polydimethylsiloxane (PDMS) and curing agent, is a cell culture device that allows multiple types of cells to grow in separate chambers and interact with each other through channels. The microfluidic device provides the perfect microenvironemt for antigen-specific lymphocytes to cooperate and initiate an effective and adaptive immune response. By immunostaining the chips and using confocal microscopy, we can assess the structure, activation, migration, and interaction of the lymphocytes. An optimal vaccine will induce a cellular immune response, and the strength and characteristics of this response help us understand which specific factors in cell interaction play the most important in vaccine effectiveness.

Project Supervisor *Weiqiang Chen*

Research Areas *Health*



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As plastic pollution continues to threaten ecosystems worldwide, innovative biological strategies are being developed to degrade synthetic polymers like PET at the molecular level. One approach involves engineering a bacterial consortium within a bioreactor system. This consortium consists of I. Sakaiensis and P. Putida. The primary focus is I. Sakaiensis, a bacterium known to degrade PET into MHET, and further into ethylene glycol and TPA. In this study, E.coli strains were used to carry plasmids encoding the native I. Sakaiensis PETase and MHETase genes. The goal of this is to optimize the efficiency of PET degradation using I. Sakaiensis, and later on, using P. Putida to further break down the ethylene glycol. To support this microbial system, a small-scale bioreactor was constructed to maintain a stable and controlled environment for enzymatic PET breakdown. The system uses a sealed Mason jar equipped with pH and temperature sensors, and a peristaltic pump for fluid control. An Arduino microcontroller collects real-time sensor data and uses relay logic to trigger environmental adjustments. A heating and cooling system is also being integrated to maintain optimal conditions for bacterial activity. This setup provides a practical, bench-top platform for studying plastic degradation and lays the groundwork for scaling enzymatic breakdown as a viable environmental solution.

Project Supervisor *Jin Ryoun Kim*

Research Areas *Health*



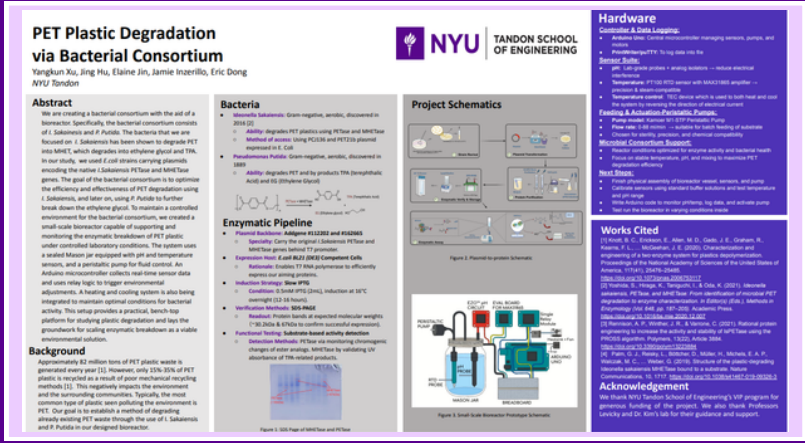
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Engineering Lymph Node Targeting Cytokines for the Treatment of Autoimmune Diseases

Interleukin-10 (IL-10) is a potent anti-inflammatory cytokine; however, its rapid clearance and limited accumulation in secondary lymphoid organs constrain its therapeutic utility in neuroinflammatory diseases such as multiple sclerosis. To address these limitations, the Hubbell laboratory has developed an engineered IL-10 (Eng-IL-10) protein with extended plasma half-life and improved lymph node retention. In this study, we will investigate the effects of Eng-IL-10 on T cell infiltration in the spinal cord of mice with experimental autoimmune encephalomyelitis (EAE), a preclinical model of multiple sclerosis. Spinal cord tissues from Eng-IL-10 treated EAE mice will be immuno-stained for T cell markers (CD45, CD4, and CD8). , and whole-section images will be analyzed using QuPath software to quantify total spinal cord area and marker-positive regions. We anticipate that Eng-IL-10 treatment will delay disease onset and reduce CD45⁺, CD4⁺, CD8⁺ areas, respectively indicating markedly attenuated leukocyte and T-cell infiltration into the spinal cord. These findings support the potential of Eng-IL-10 as a therapeutic strategy in neuroinflammatory disorders.

Project Supervisor	*Jeffrey Hubbell*
Research Areas	*Health*
Research Staff	*Erica Budina*



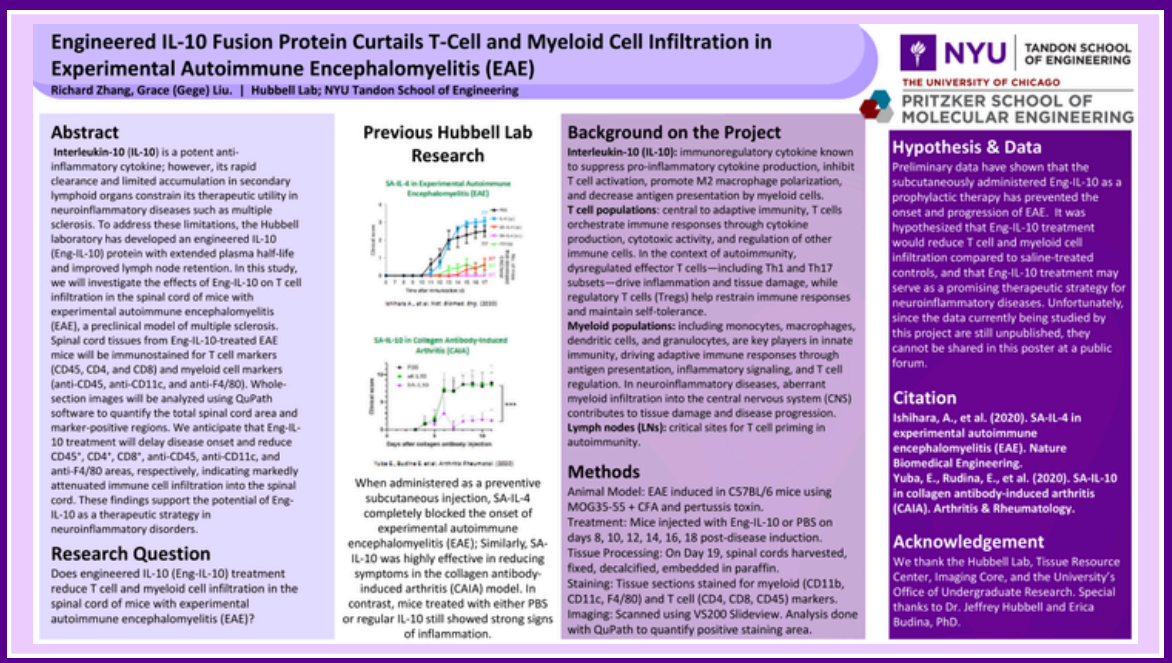
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Engineered IL-10 Fusion Protein Curtails T-Cell and Myeloid Cell Infiltration in Experimental Autoimmune Encephalomyelitis (EAE)

Richard Zhang, Grace (Gege) Liu. | Hubbell Lab; NYU Tandon School of Engineering

NYU TANDON SCHOOL OF ENGINEERING
THE UNIVERSITY OF CHICAGO PRITZKER SCHOOL OF MOLECULAR ENGINEERING

Abstract

Interleukin-10 (IL-10) is a potent anti-inflammatory cytokine; however, its rapid clearance and limited accumulation in secondary lymphoid organs constrain its therapeutic utility in neuroinflammatory diseases such as multiple sclerosis. To address these limitations, the Hubbell laboratory has developed an engineered IL-10 (Eng-IL-10) protein with extended plasma half-life and improved lymph node retention. In this study, we will investigate the effects of Eng-IL-10 on T cell infiltration in the spinal cord of mice with experimental autoimmune encephalomyelitis (EAE), a preclinical model of multiple sclerosis. Spinal cord tissues from Eng-IL-10-treated EAE mice will be immunostained for T cell markers (CD45, CD4, and CD8) and myeloid cell markers (anti-CD45, anti-CD11c, and anti-F4/80). Whole-section images will be analyzed using QuPath software to quantify the total spinal cord area and marker-positive regions. We anticipate that Eng-IL-10 treatment will delay disease onset and reduce CD45⁺, CD4⁺, CD8⁺, anti-CD45, anti-CD11c, and anti-F4/80 areas, respectively, indicating markedly attenuated immune cell infiltration into the spinal cord. These findings support the potential of Eng-IL-10 as a therapeutic strategy in neuroinflammatory disorders.

Research Question

Does engineered IL-10 (Eng-IL-10) treatment reduce T cell and myeloid cell infiltration in the spinal cord of mice with experimental autoimmune encephalomyelitis (EAE)?

Previous Hubbell Lab Research

SA-IL-4 in Experimental Autoimmune Encephalomyelitis (EAE)

SA-IL-10 in Collagen Antibody-Induced Arthritis (CAIA)

When administered as a preventive subcutaneous injection, SA-IL-4 completely blocked the onset of experimental autoimmune encephalomyelitis (EAE); Similarly, SA-IL-10 was highly effective in reducing symptoms in the collagen antibody-induced arthritis (CAIA) model. In contrast, mice treated with either PBS or regular IL-10 still showed strong signs of inflammation.

Background on the Project

Interleukin-10 (IL-10): immunoregulatory cytokine known to suppress pro-inflammatory cytokine production, inhibit T cell activation, promote M2 macrophage polarization, and decrease antigen presentation by myeloid cells.
T cell populations: central to adaptive immunity, T cells orchestrate immune responses through cytokine production, cytotoxic activity, and regulation of other immune cells. In the context of autoimmunity, dysregulated effector T cells—including Th1 and Th17 subsets—drive inflammation and tissue damage, while regulatory T cells (Tregs) help restrain immune responses and maintain self-tolerance.
Myeloid populations: including monocytes, macrophages, dendritic cells, and granulocytes, are key players in innate immunity, driving adaptive immune responses through antigen presentation, inflammatory signaling, and T cell regulation. In neuroinflammatory diseases, aberrant myeloid infiltration into the central nervous system (CNS) contributes to tissue damage and disease progression.
Lymph nodes (LNs): critical sites for T cell priming in autoimmunity.

Methods

Animal Model: EAE induced in C57BL/6 mice using MOG35-55 + CFA and pertussis toxin.
Treatment: Mice injected with Eng-IL-10 or PBS on days 8, 10, 12, 14, 16, 18 post-disease induction.
Tissue Processing: On Day 19, spinal cords harvested, fixed, decalcified, embedded in paraffin.
Staining: Tissue sections stained for myeloid (CD11b, CD11c, F4/80) and T cell (CD4, CD8, CD45) markers.
Imaging: Scanned using VS200 Slideview. Analysis done with QuPath to quantify positive staining area.

Hypothesis & Data

Preliminary data have shown that the subcutaneously administered Eng-IL-10 as a prophylactic therapy has prevented the onset and progression of EAE. It was hypothesized that Eng-IL-10 treatment would reduce T cell and myeloid cell infiltration compared to saline-treated controls, and that Eng-IL-10 treatment may serve as a promising therapeutic strategy for neuroinflammatory diseases. Unfortunately, since the data currently being studied by this project are still unpublished, they cannot be shared in this poster at a public forum.

Citation

Ishihara, A., et al. (2020). SA-IL-4 in experimental autoimmune encephalomyelitis (EAE). Nature Biomedical Engineering.
Yuba, E., Rudina, E., et al. (2020). SA-IL-10 in collagen antibody-induced arthritis (CAIA). Arthritis & Rheumatology.

Acknowledgement

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Nanomedicines for Pain

Nanotechnology has emerged as a promising approach in treating conditions that require controlled and precise administration of medicines. Polymer nanoparticles (NPs) are a particularly effective nanoscale drug delivery system, as they can encapsulate naked active pharmaceutical ingredients (APIs) while enhancing their safety, adsorption, and circulation time in the body. NP properties are tunable and can be functionalized to enable more site-specific and controlled release of APIs, thereby reducing toxic off-target effects. However, while substantial research has been conducted on the manufacturing and biocompatibility of these NPs, there is limited knowledge about NP interactions with more complex physiological systems, including the nervous system and its relationship with pain.

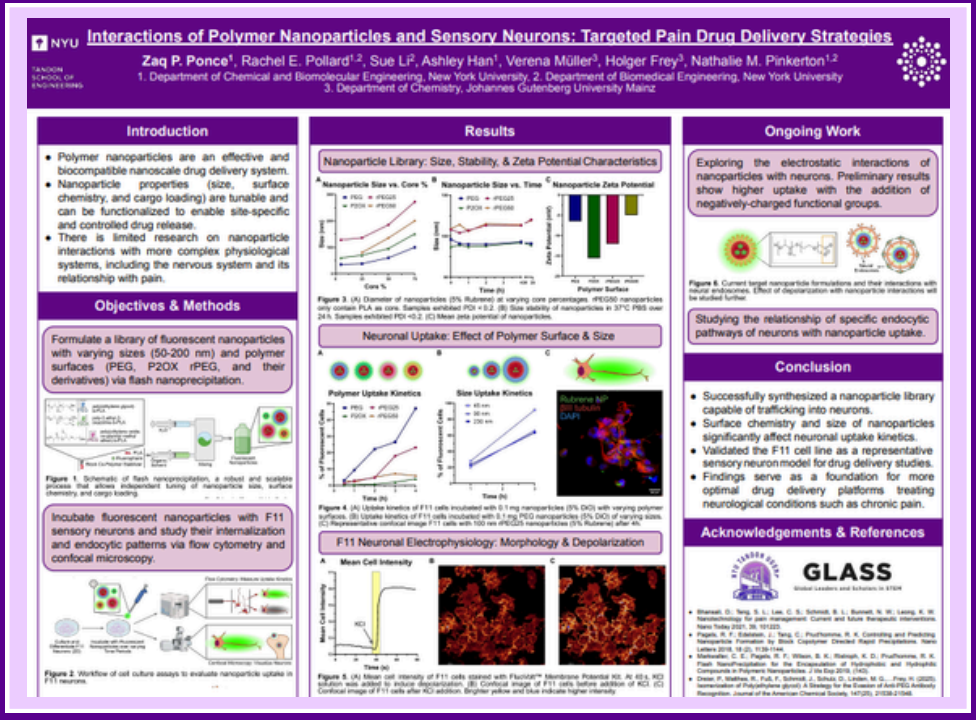
In this work, we formulate a library of core-shell NPs with various physicochemical characteristics and investigate their internalization and endocytic patterns in sensory neurons. NPs were assembled via Flash Nanoprecipitation, a robust and scalable process that allows independent modification of NP size, surface chemistry, and cargo loading. Specifically, we studied three different polymer surfaces: polyethylene glycol (PEG), poly(ethylene oxide-co-glycidyl methyl ether) (rPEG), and poly-2-ethyl-2-oxazoline (P2OX), as well as some of their derivatives. NPs were loaded with fluorescent small molecules, ranged in size from 50 nm to 200 nm, and were incubated with dorsal root ganglion neurons (F11). Current results demonstrate the successful trafficking of NPs into neural endosomes, as visualized with confocal microscopy. Furthermore, compelling flow cytometry data show that the surface chemistry and size of NPs significantly affect uptake kinetics within these neurons. This project validates the F11 cell line as a representative model of sensory neurons through cell membrane potential assays. Ongoing work involves further internalization testing of the NP library, while also examining the specific endocytic receptors involved in nano-neuro interactions. These findings serve as a comprehensive foundation for more optimal drug delivery platforms treating chronic pain.

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Spatial-temporal digital ELISA for cytokine detection (AHA Fellowship Project)

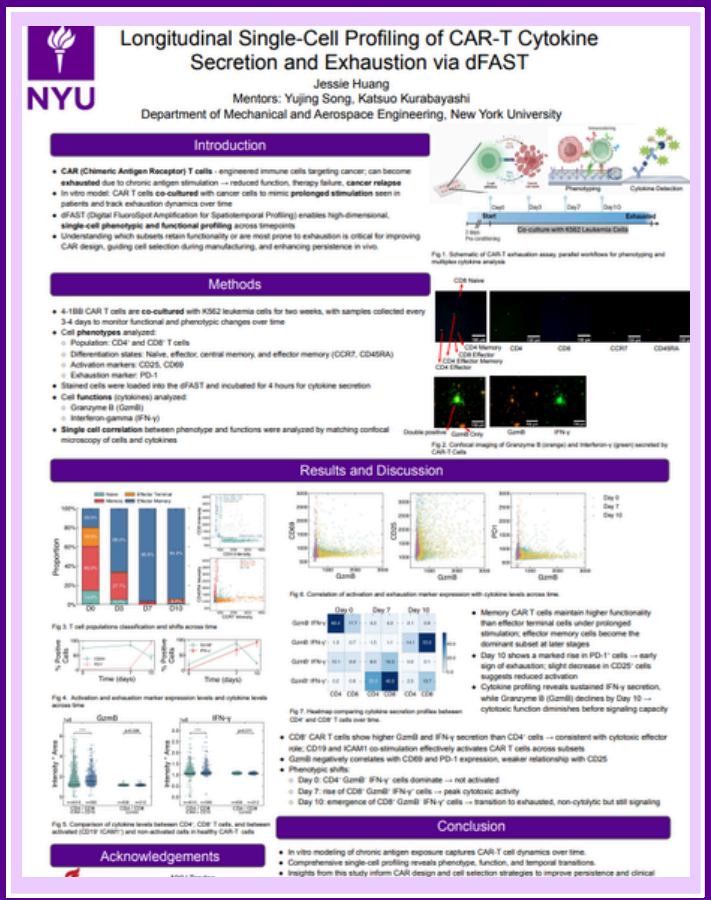
Chimeric Antigen Receptor (CAR) T cell therapy has emerged as a powerful approach for treating hematologic malignancies, yet its long-term efficacy is often limited by T cell exhaustion and functional heterogeneity. This study investigates how CAR-T cells engineered with 4-1BB, an FDA-approved co-stimulatory domain used in clinical CAR-T therapy, respond to sustained antigen exposure. CAR-T cells are co-cultured with cancer cells over two weeks to model chronic stimulation. Using dFAST (Digital FluoroSpot Amplification for Spatiotemporal Profiling), our lab's recently developed platform for multidimensional single-cell phenotypic and functional analysis, we performed multiplexed measurements of key effector cytokines granzyme B (GzmB) and interferon-gamma (IFN-γ) to assess cytotoxicity and inflammation. In parallel, cells are classified by CD4/CD8 lineage and differentiation state (naïve, effector terminal, central memory, effector memory), and expression of CD25 and CD69 (activation) and PD-1 (exhaustion) is tracked over time. All parameters are captured simultaneously at single-cell resolution, enabling one-to-one correlation of phenotype, function, and temporal dynamics within the same individual cell. This unified approach allowed us to resolve functional and phenotypic dynamics at single-cell resolution across time. Understanding which subsets retain functionality or are most prone to exhaustion is critical for improving CAR design, guiding cell selection during manufacturing, and enhancing persistence in vivo. These insights are especially relevant as CAR-T therapies expand beyond hematologic cancers into solid tumors, where persistent antigen exposure and immune suppression are more pronounced. Ultimately, identifying markers of potency and durability will help translate CAR-T therapy into more reliable and lasting clinical responses.

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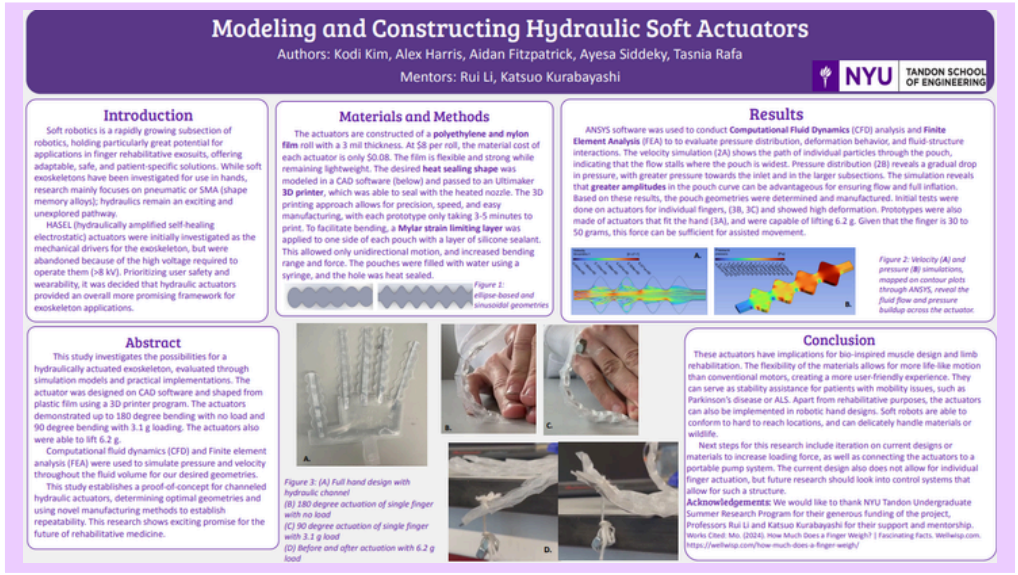


Soft actuators for Rehabilitation

This study investigates the possibilities for a hydraulically actuated exoskeleton, evaluated through simulation models and practical implementations. The actuator was designed on CAD software and shaped from plastic film using a 3D printer program. The actuators demonstrated up to 180 degree bending with no load and 90 degree bending with 3.1 g loading. The actuators also were able to lift 6.2 g. Computational fluid dynamics (CFD) and Finite element analysis (FEA) were used to simulate pressure and velocity throughout the fluid volume for our desired geometries. This study establishes a proof-of-concept for channeled hydraulic actuators, determining optimal geometries and using novel manufacturing methods to establish repeatability. This research shows exciting promise for the future of rehabilitative medicine.

Project Supervisor *Rui Li*

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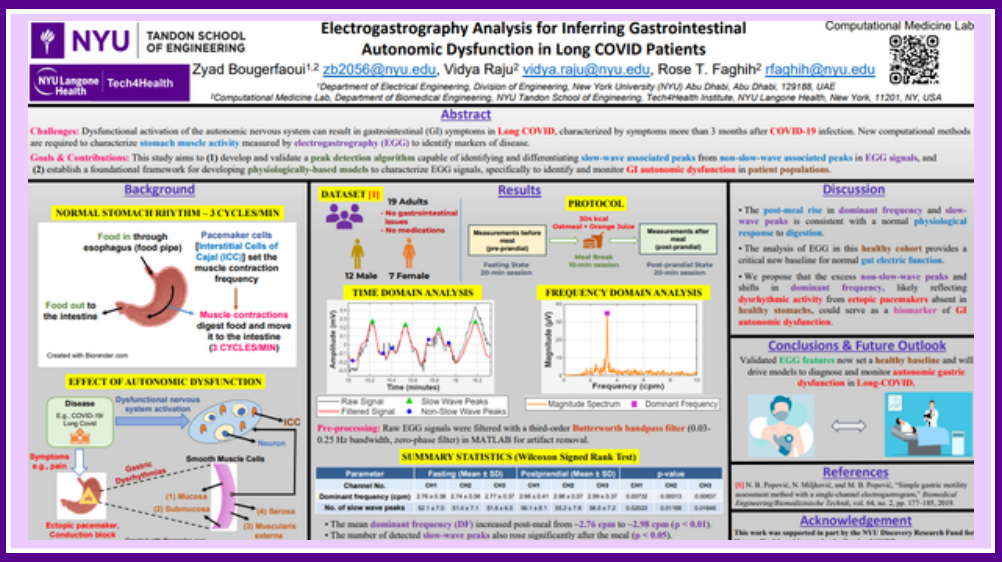
Analysis of health data to infer long COVID outcomes

Dysfunctional activation of the autonomic nervous system (ANS) has been identified as an underlying cause of many Long COVID symptoms, i.e., post-acute sequelae of COVID-19 infection that last beyond three months. Of these, gastrointestinal (GI) symptoms include pain, constipation and impaired bowel movement. New computational methods are required to characterize stomach muscle activity (peristaltic activity) measured by electrogastrography (EGG) to identify and track markers of disease in relation to ANS activation. This study developed and validated a peak detection algorithm capable of identifying and differentiating slow-wave associated peaks from non-slow-wave associated peaks in EGG signals to characterize peristaltic activity in healthy individuals before and after meal intake and established a foundational framework for developing physiologically-based models to characterize EGG signals, specifically to identify and monitor GI autonomic dysfunction in patient populations. The analysis of EGG in this healthy cohort provided a critical new baseline for normal gut electric function. We identified that the excess non-slow-wave peaks and shifts in dominant frequency, likely reflecting dysrhythmic activity from ectopic pacemakers absent in healthy stomachs, could serve as plausible biomarkers of GI autonomic dysfunction. The identified EGG features enable an understanding of a healthy baseline and will drive future mathematical models to diagnose and monitor autonomic gastric dysfunction in Long COVID, which can be scalably extended to other chronic GI disorders in a disease-specific manner.

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Monoallelic HLA cell lines for downstream PC-CAR T cell assaying

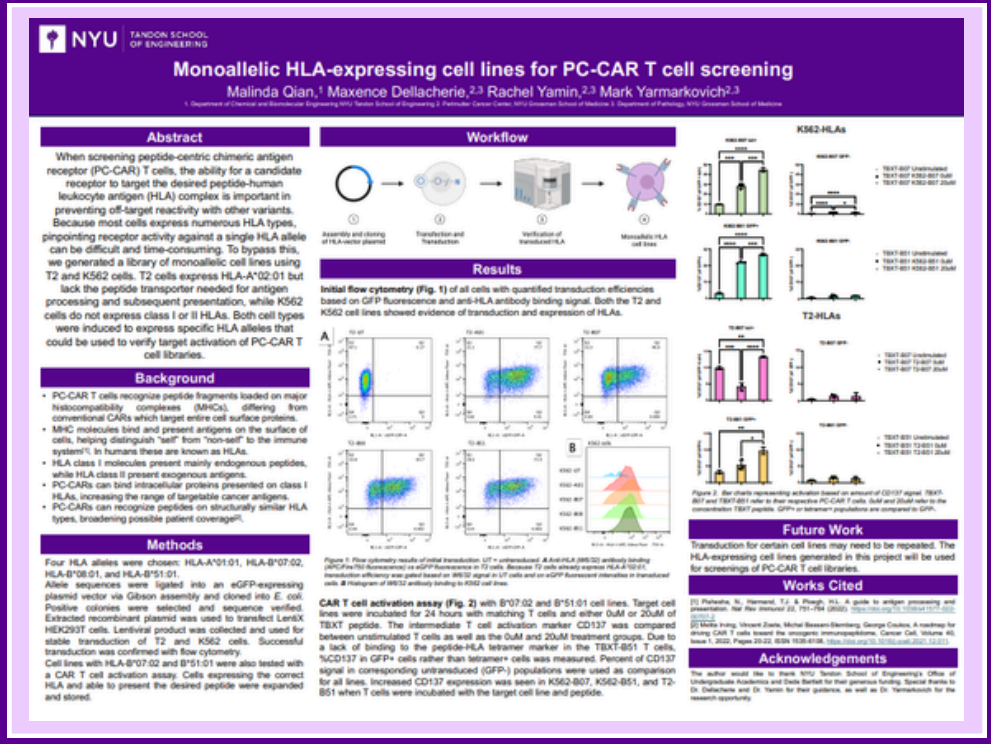
Peptide-centric chimeric antigen receptor (PC-CAR) T cells are T cells with specially engineered receptors aimed at recognizing peptide fragments presented by the major histocompatibility complex (MHC). MHC molecules, in humans known as human leukocyte antigens (HLAs), are glycoproteins that present peptides on the surface of cells, helping distinguish “self” from “non-self” antigens to the immune system. Compared to conventional CAR T cells which target entire cell-surface antigens, PC-CAR T cells have the advantage of being able to target intracellular proteins that become presented on the surface of cells. In the screening of PC-CARs, the ability for a candidate receptor to target the desired peptide-HLA complex is important in preventing off-target reactivity with other HLA variants. Because most cells express numerous HLA types, pinpointing receptor activity against a single HLA allele can be difficult and time-consuming. To bypass this, we generated a library of monoallelic cell lines using T2 and K562 cells. T2 cells express HLA-A*02:01 but lack the peptide transporter needed for antigen processing and subsequent presentation. K562 cells do not express class I or II HLAs. Both cell lines can be induced to express specific HLA class I types and present antigens on said types. Stable transduction of cell lines was verified with flow cytometry, along with an activation assay using MHC-specific PC-CAR T cells and target peptides.

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Monoallelic HLA-expressing cell lines for PC-CAR T cell screening

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Abstract

When screening peptide-centric chimeric antigen receptor (PC-CAR) T cells, the ability for a candidate receptor to target the desired peptide-human leukocyte antigen (HLA) complex is important in preventing off-target reactivity with other variants. Because most cells express numerous HLA types, pinpointing receptor activity against a single HLA allele can be difficult and time-consuming. To bypass this, we generated a library of monoallelic cell lines using T2 and K562 cells. T2 cells express HLA-A*02:01 but lack the peptide transporter needed for antigen processing and subsequent presentation, while K562 cells do not express class I or II HLAs. Both cell types were induced to express specific HLA alleles that could be used to verify target activation of PC-CAR T cell libraries.

Background

- PC-CAR T cells recognize peptide fragments loaded on major histocompatibility complexes (MHCs), differing from conventional CARs which target entire cell surface proteins.
- MHC molecules bind and present antigens on the surface of cells, helping distinguish “self” from “non-self” to the immune system[1]. In humans these are known as HLAs.
- HLA class I molecules present mainly endogenous peptides, while HLA class II present exogenous antigens.
- PC-CARs can bind intracellular proteins presented on class I HLAs, increasing the range of targetable cancer antigens.
- PC-CARs can recognize peptides on structurally similar HLA types, broadening possible patient coverage[2].

Methods

Four HLA alleles were chosen: HLA-A*01:01, HLA-B*07:02, HLA-B*08:01, and HLA-B*51:01. Allele sequences were ligated into an eGFP-expressing plasmid vector via Gibson assembly and cloned into *E. coli*. Positive colonies were selected and sequence verified. Extracted recombinant plasmid was used to transfect LentiX HEK293T cells. Lentiviral product was collected and used for stable transduction of T2 and K562 cells. Successful transduction was confirmed with flow cytometry.
Cell lines with HLA-B*07:02 and B*51:01 were also tested with a CAR T cell activation assay. Cells expressing the correct HLA and able to present the desired peptide were expanded and stored.

Workflow

Results

Initial flow cytometry (Fig. 1) of all cells with quantified transduction efficiencies based on GFP fluorescence and anti-HLA antibody binding signal. Both the T2 and K562 cell lines showed evidence of transduction and expression of HLAs.

CAR T cell activation assay (Fig. 2) with B*07:02 and B*51:01 cell lines. Target cell lines were incubated for 24 hours with matching T cells and either 0uM or 20uM of TBXT peptide. The intermediate T cell activation marker CD137 was compared between unstimulated T cells as well as the 0uM and 20uM treatment groups. Due to a lack of binding to the peptide-HLA tetramer marker in the TBXT-B51 T cells, %CD137 in GFP+ cells rather than tetramer+ cells was measured. Percent of CD137 signal in corresponding untransduced (GFP-) populations were used as comparison for all lines. Increased CD137 expression was seen in K562-B07, K562-B51, and T2-B51 when T cells were incubated with the target cell line and peptide.

Future Work

Transduction for certain cell lines may need to be repeated. The HLA-expressing cell lines generated in this project will be used for screenings of PC-CAR T cell libraries.

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[2] Media Irving, Vincent Zoete, Michel Bassani-Sternberg, George Coukos, A roadmap for driving CAR T cells toward the oncogenic immunopeptidome, Cancer Cell, Volume 40, Issue 1, 2022, Pages 20-22, ISSN 1535-6108, https://doi.org/10.1016/j.ccell.2021.12.011.

Acknowledgements

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Developing a Novel Phage Platform to Target Solid Tumors

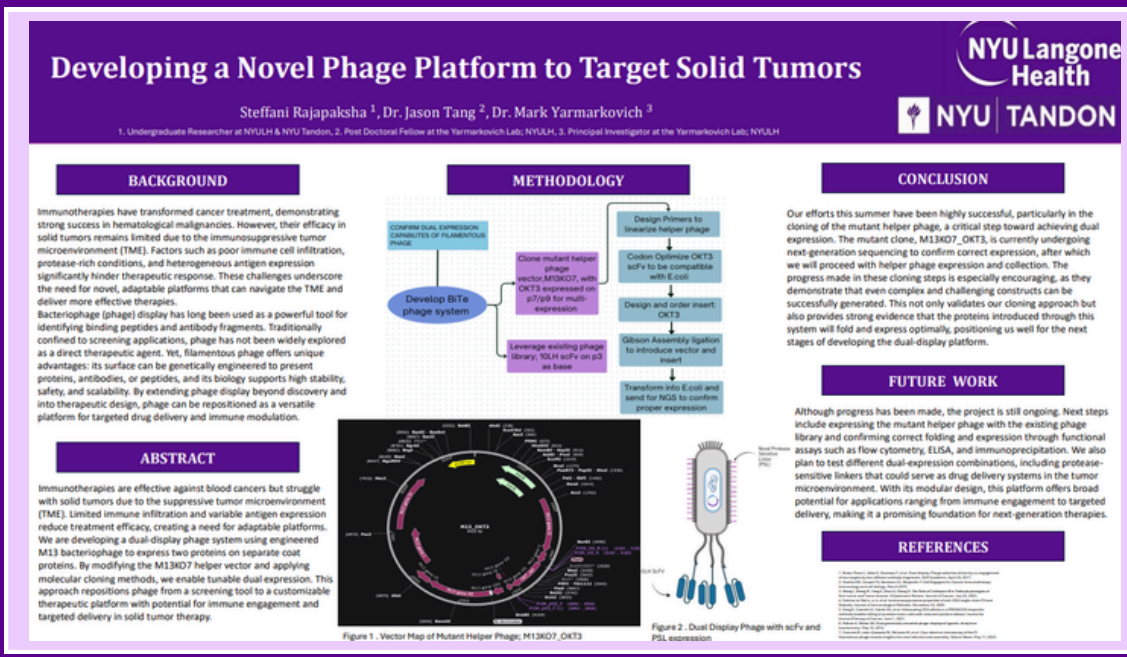
Current immunotherapies have shown success in treating hematological cancers, however, solid tumors remain resistant due to the complex and immunosuppressive nature of the tumor microenvironment (TME). The TME presents numerous challenges, including limited immune cell infiltration and heterogeneous tumor antigen expression, which hinder the efficacy of current treatments. Innovative platforms are needed to overcome these barriers and deliver more targeted, adaptable therapies. The current strategy explores the development of a dual display phage platform, an engineered bacteriophage system, designed to express two distinct proteins on separate coat proteins of M13 filamentous phage. Traditionally used in phage display to identify binding sequences, phage has served primarily as a screening tool. However, by enhancing its functional capacity to simultaneously express multiple proteins, we can begin to reposition phage as a customizable therapeutic platform with applications ranging from immune engagement to targeted delivery. Our strategy involves modifying the helper phage vector, M13KO7, to introduce a second gene of interest while maintaining the original display on the phagemid. Through molecular cloning techniques such as PCR, Gibson Assembly, and bacterial transformation, we aim to enable dual expression and control protein display levels on the phage surface. Our cloning efforts are proving to be fruitful, and the project is ongoing. Multiple verification assays are currently underway to confirm proper folding and expression of the displayed proteins and to test the system's efficacy in simulated TME conditions.

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Augmenting Stem Cells with Synthetic Gene Circuitry

Alzheimer's disease (AD) is a progressive neurodegenerative disorder characterized by memory impairment, cognitive decline, and behavioral changes. Contemporarily, pharmaceutical interventions remain limited, and traditional animal models fail to fully capture the complexity of human AD pathology. To address these challenges, we propose a synthetic biology-driven "brain-in-a-dish" platform leveraging induced pluripotent stem cells (iPSCs) and genetic circuit engineering. iPSCs, derived from reprogrammed adult cells, are able to differentiate into any cell type, relevant within the disease modelling framework. Our approach employs programmable genetic circuits—biological systems analogous to electronic circuits—to precisely regulate iPSC differentiation into oligodendrocytes, responsible for axonal myelination, which is disrupted in light of AD. To enhance iPSC differentiation into oligodendrocytes, we integrated microRNAs (miRNA) with transcription factors into synthetic circuits. miRNAs are small, naturally occurring regulators of gene expression that help fine-tune differentiation pathways and better mimic disease-specific cellular behavior. Based on literature, we chose several miRNAs (miR-219, miR-338, miR-7a, miR-184, miR-297-5p, miR-23a, miR-204, miR-146a, miR-138) that control different steps of oligodendrocyte cell development. Transcription factors regulate gene expression by binding to specific DNA sequences. Preliminary data from the Truong Lab demonstrates doxycycline-inducible expression of NGN2, a neuronal transcription factor, promotes ectodermal lineage maturation. Building upon this foundation, our miRNA-augmented circuits aim to improve differentiation efficiency and yield of oligodendrocytes from iPSCs. In the future, we hope to hone this technology to differentiate iPSCs into additional neural cell types, such as microglia, astrocytes, and neurons, to assemble a multicellular 2D "brain-in-a-dish" model. This model will guide high-resolution studies of AD mechanisms and accelerate the development and testing of next-generation therapeutics within a controlled synthetic biology framework. By bridging stem cell engineering and programmable gene circuits, our work seeks to establish a scalable and precise in-vitro model, paving the way toward universal cell-based interventions for neurodegenerative diseases.

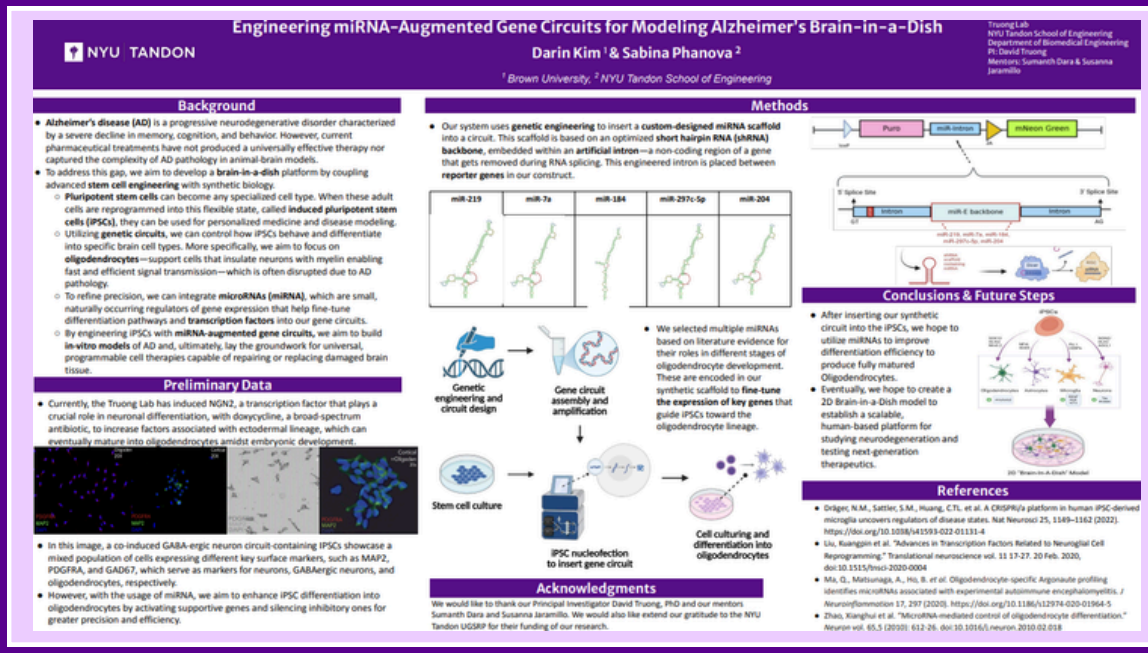
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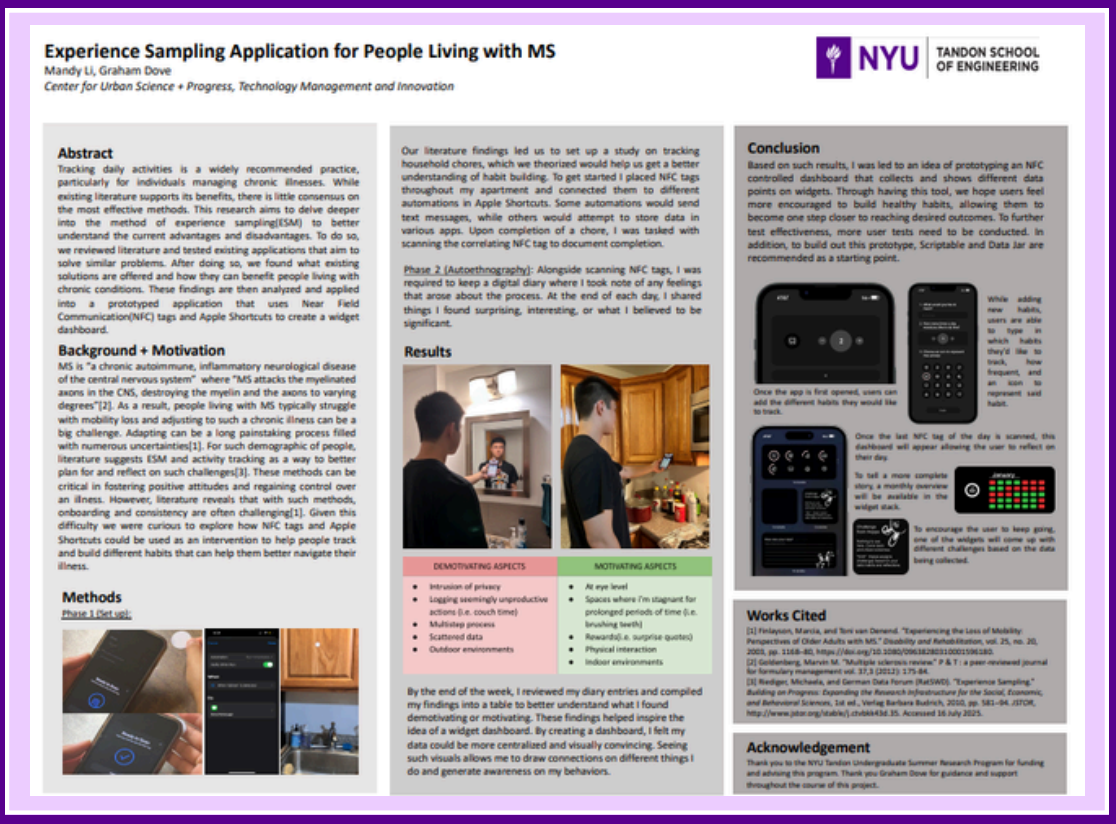
Develop an experience sampling app for healthcare research

Tracking daily activities is a widely recommended practice, particularly for individuals managing chronic illnesses. While existing literature supports its benefits, there is little consensus on the most effective methods. This research aims to delve deeper into the method of experience sampling(ESM) to better understand the current advantages and disadvantages. To do so, we reviewed literature and tested existing applications that aim to solve similar problems. After doing so, we found what existing solutions are offered and how they can benefit people living with chronic conditions. These findings are then analyzed and applied into a prototyped application that uses Near Field Communication(NFC) tags and Apple Shortcuts to create a widget dashboard.

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Experience Sampling Application for People Living with MS

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Abstract

Tracking daily activities is a widely recommended practice, particularly for individuals managing chronic illnesses. While existing literature supports its benefits, there is little consensus on the most effective methods. This research aims to delve deeper into the method of experience sampling(ESM) to better understand the current advantages and disadvantages. To do so, we reviewed literature and tested existing applications that aim to solve similar problems. After doing so, we found what existing solutions are offered and how they can benefit people living with chronic conditions. These findings are then analyzed and applied into a prototyped application that uses Near Field Communication(NFC) tags and Apple Shortcuts to create a widget dashboard.

Background + Motivation

MS is "a chronic autoimmune, inflammatory neurological disease of the central nervous system" where "MS attacks the myelinated axons in the CNS, destroying the myelin and the axons to varying degrees"[2]. As a result, people living with MS typically struggle with mobility loss and adjusting to such a chronic illness can be a big challenge. Adapting can be a long painstaking process filled with numerous uncertainties[1]. For such demographic of people, literature suggests ESM and activity tracking as a way to better plan for and reflect on such challenges[3]. These methods can be critical in fostering positive attitudes and regaining control over an illness. However, literature reveals that with such methods, onboarding and consistency are often challenging[1]. Given this difficulty we were curious to explore how NFC tags and Apple Shortcuts could be used as an intervention to help people track and build different habits that can help them better navigate their illness.

Methods

Phase 1 (Set up):

Our literature findings led us to set up a study on tracking household chores, which we theorized would help us get a better understanding of habit building. To get started I placed NFC tags throughout my apartment and connected them to different automations in Apple Shortcuts. Some automations would send text messages, while others would attempt to store data in various apps. Upon completion of a chore, I was tasked with scanning the correlating NFC tag to document completion.

Phase 2 (Autoethnography): Alongside scanning NFC tags, I was required to keep a digital diary where I took note of any feelings that arose about the process. At the end of each day, I shared things I found surprising, interesting, or what I believed to be significant.

Results

DEMOTIVATING ASPECTS	MOTIVATING ASPECTS
• Intrusion of privacy • Logging seemingly unproductive actions (i.e. couch time) • Multistep process • Scattered data • Outdoor environments	• At eye level • Spaces where I'm stagnant for prolonged periods of time (i.e. brushing teeth) • Rewards(i.e. surprise quotes) • Physical interaction • Indoor environments

By the end of the week, I reviewed my diary entries and compiled my findings into a table to better understand what I found demotivating or motivating. These findings helped inspire the idea of a widget dashboard. By creating a dashboard, I felt my data could be more centralized and visually convincing. Seeing such visuals allows me to draw connections on different things I do and generate awareness on my behaviors.

Conclusion

Based on such results, I was led to an idea of prototyping an NFC controlled dashboard that collects and shows different data points on widgets. Through having this tool, we hope users feel more encouraged to build healthy habits, allowing them to become one step closer to reaching desired outcomes. To further test effectiveness, more user tests need to be conducted. In addition, to build out this prototype, Scriptable and Data Jar are recommended as a starting point.

While adding new habits, users are able to type in which habits they'd like to track, how frequent, and an icon to represent said habit.

Once the app is first opened, users can add the different habits they would like to track.

Once the last NFC tag of the day is scanned, this dashboard will appear allowing the user to reflect on their day.

To tell a more complete story, a monthly overview will be available in the widget stack.

To encourage the user to keep going, one of the widgets will come up with different challenges based on the data being collected.

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Acknowledgement

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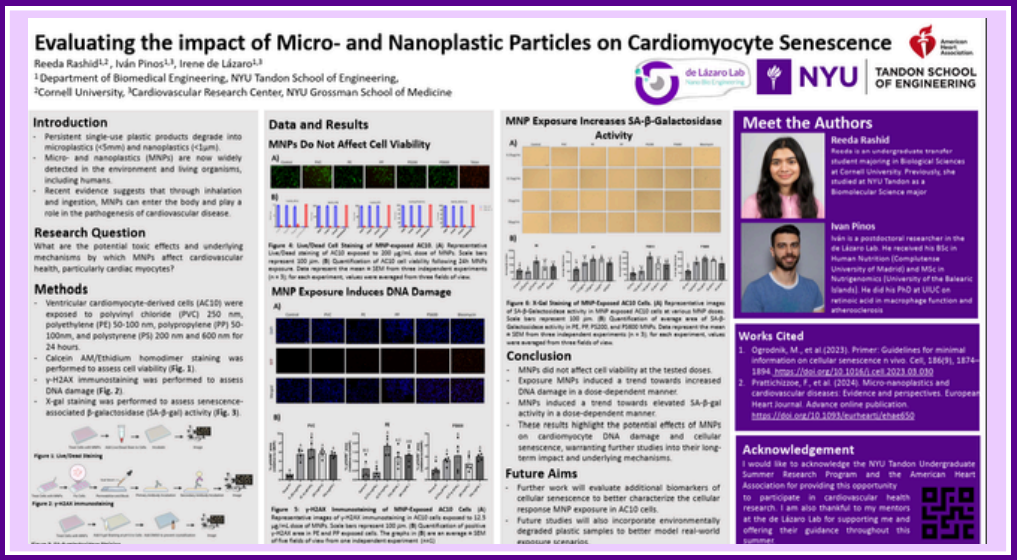
Cardiomyocyte Reprogramming (AHA Fellowship Project)

Emerging evidence on plastic pollution has revealed the widespread presence of micro- and nanoplastics (MNPs), which pose significant environmental and public health concerns. With the continuous increase of single-use plastic products and packaging in modern day, the durability and persistence of plastics have become environmental liabilities. As plastic waste accumulates in the environment, it undergoes weathering and fragmentation into microplastics (<5 mm) and nanoplastics (<1 μm) that are now found in air, soil, water, and food. More importantly, these plastic particles have been found in several living organisms, including humans. Although the exact pathways by which MNPs enter the human body remain unclear, inhalation and ingestion are considered the most likely routes. Notably, emerging experimental and epidemiological evidence has implicated MNPs in cardiotoxicity, suggesting their potential role as novel environmental risk factors contributing to the pathogenesis of cardiovascular disease. This study aims to investigate the potential toxic effects and mechanisms of MNPs on cardiac health. To this end, we exposed ventricular cardiomyocyte-derived cells (AC10) to different doses) of commonly encountered nanoplastics—polyvinyl chloride (PVC), polypropylene (PP), polyethylene (PE), and polystyrene (PS)—for 24 hours. We assessed cytotoxicity by Calcein AM/Ethidium homodimer (Live/Dead) staining, DNA damage via γ-H2AX immunostaining for DNA Damage Response (DDR), and cellular senescence using senescence-associated β-galactosidase (SA-β-gal) activity by X-gal staining. Live/Dead staining demonstrated that cardiomyocyte viability remained unaffected by exposure to 25 μg/mL and 200 μg/mL MNPs, indicating a lack of cytotoxicity at these concentrations. γ-H2AX staining revealed a trend of increased nuclear foci formation at 12 μg/mL, 25 μg/mL, and 50 μg/mL doses, indicating elevated DDR signaling. Accordingly, preliminary X-gal stainings suggest a dose-dependent increase in cardiomyocyte senescence, indicating that MNPs may be inducers of cellular aging. In conclusion, these early findings suggest that MNPs can induce DNA damage and senescence in cardiomyocytes, underscoring the need for further investigation into their underlying toxicological mechanisms and implications for cardiovascular health.

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Biomimetic hydrogels for in vitro melanoma models

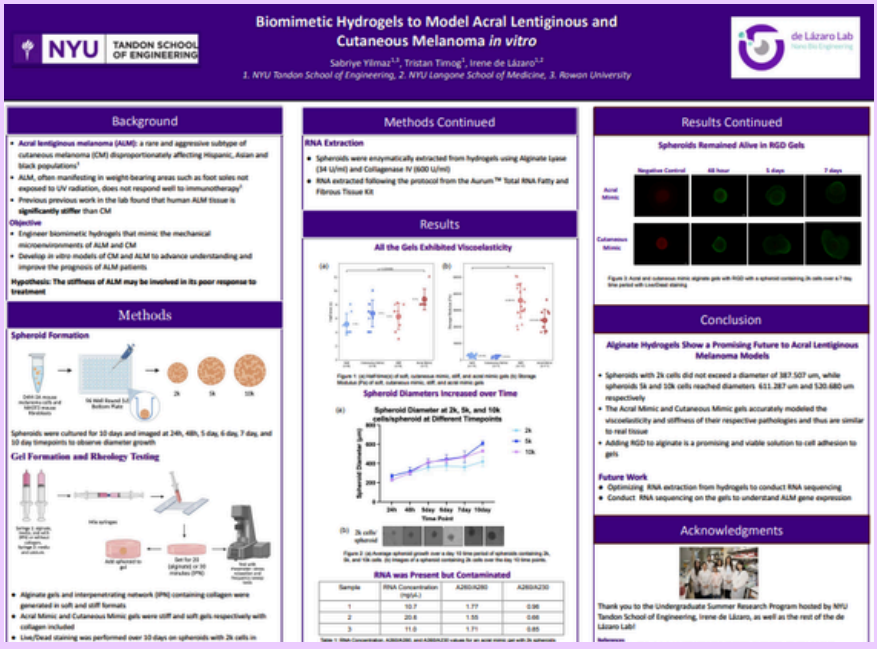
Acral lentiginous melanoma (ALM) is a rare and aggressive subtype of cutaneous melanoma (CM) disproportionately affecting Hispanic and black populations. The primary risk factor for CM is exposure to ultraviolet (UV) radiation, causing genetic mutations and oncogenesis in melanocytes that can be targeted with traditional immunotherapy. However, ALM, which often manifests in weight-bearing areas such as foot soles not exposed to UV radiation, does not respond well to immunotherapy. It is currently unknown how oncogenesis occurs in ALM, but previous work in the lab found that human ALM tissue is significantly stiffer than CM. We hypothesize that the stiffness of ALM may be involved in its poor response to treatment. We propose to engineer biomimetic hydrogels that mimic the mechanical microenvironments of ALM and CM to test this. Alginate is a biocompatible polymer that crosslinks with calcium to form three-dimensional hydrogel constructs mimicking the ECM. Type I collagen is an abundant ECM protein, which, when combined with alginate, results in an interpenetrating network (IPN) hydrogel that improves the physiological relevance of the system. Three-dimensional multicellular tumor spheroids (MCTS) were cultured using D4M-3A mouse melanoma cells and NIH3T3 mouse fibroblasts to mimic physiological tumors. Soft (CM-mimicking) and stiff (ALM-mimicking) hydrogel formulations were generated by tuning crosslinker concentration, and MCTS were embedded, to form in vitro models. MCTS diameter was optimized by testing different cell seeding densities of 2k, 5k, and 10k cells. Rheological mechanical characterization of the gels was performed to measure the storage modulus (G′), loss modulus (G′′), and half-time (t1/2) to understand stiffness and viscoelasticity. Additionally, optimization of RNA extraction from MTCS was performed in preparation for RNA-sequencing experiments studying differences in gene expression between hydrogel models. This research aims to develop models of CM and ALM to advance understanding and improve the prognosis of ALM patients.

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Enzymatic Synthesis of Furan-Based Polymers

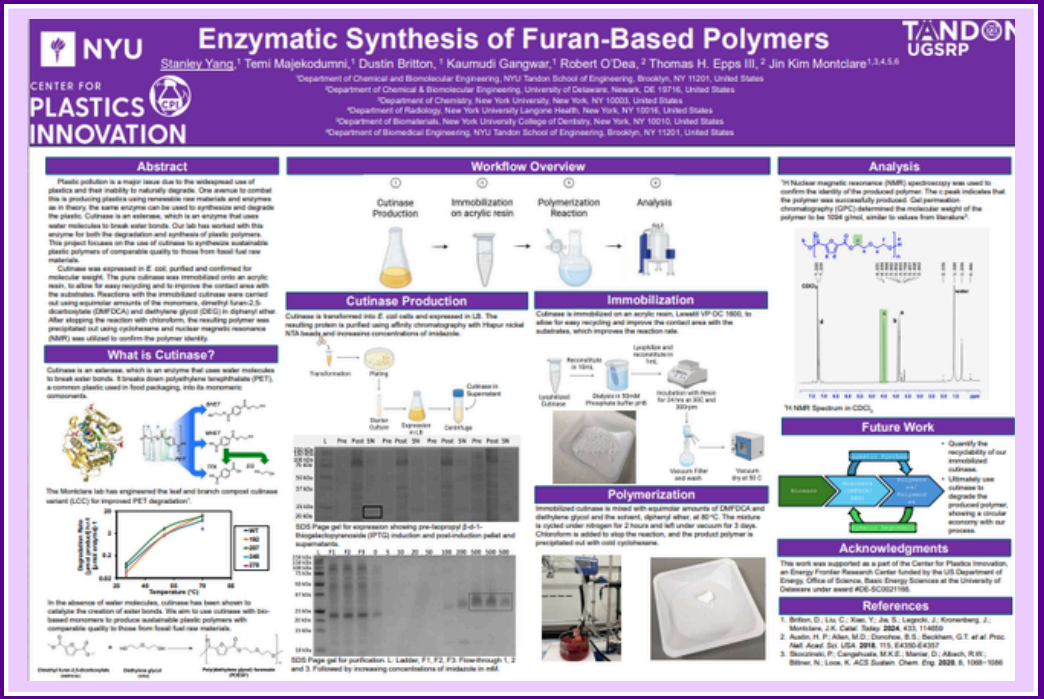
Plastic pollution is a major issue due to the widespread use of plastics and their inability to naturally degrade. One avenue to combat this is producing plastics using renewable raw materials and enzymes as in theory, the same enzyme can be used to synthesize and degrade the plastic. Cutinase is an esterase, which is an enzyme that uses water molecules to break ester bonds. Our lab has worked with this enzyme for both the degradation and synthesis of plastic polymers. This project focuses on the use of cutinase to synthesize sustainable plastic polymers of comparable quality to those from fossil fuel raw materials. Cutinase was expressed in E. coli, purified and confirmed for molecular weight. The pure cutinase was immobilized onto an acrylic resin, to allow for easy recycling and to improve the contact area with the substrates. Reactions with the immobilized cutinase were carried out using equimolar amounts of the monomers, dimethyl furan-2,5-dicarboxylate (DMFDCA) and diethylene glycol in diphenyl ether. After stopping the reaction with chloroform, the resulting polymer was precipitated out using methanol and nuclear magnetic resonance (NMR) was utilized to confirm the polymer identity.

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Engineered Proteins for Targeted Drug Delivery in HER2+ Breast Cancer

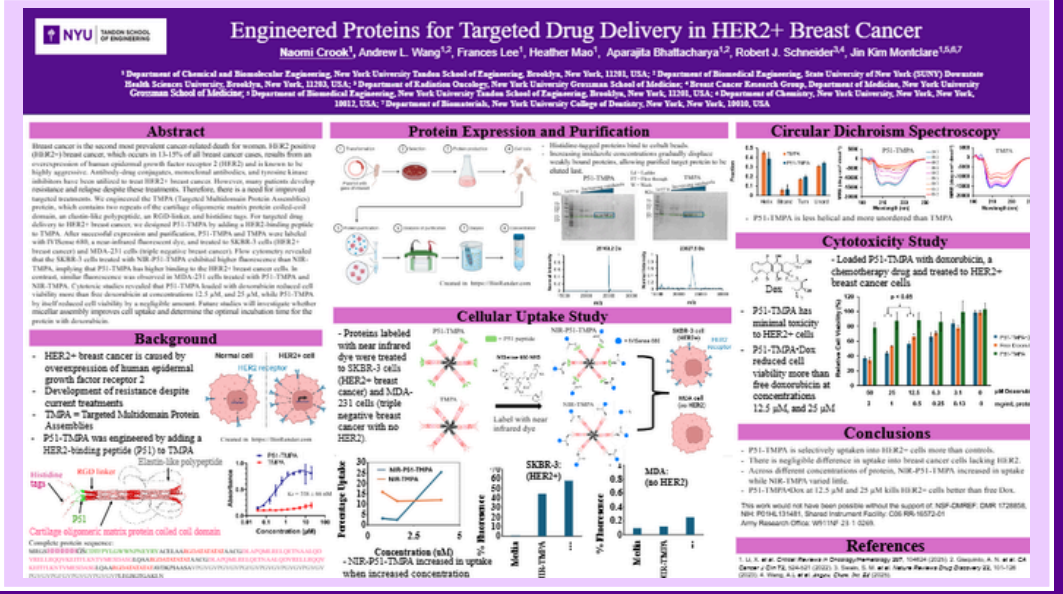
Breast cancer is the second most prevalent cancer-related death for women. HER2 positive (HER2+) breast cancer, which occurs in 13-15% of all breast cancer cases, results from an overexpression of human epidermal growth factor receptor 2 (HER2) and is known to be highly aggressive. Antibody-drug conjugates, monoclonal antibodies, and tyrosine kinase inhibitors have been utilized to treat HER+ breast cancer. However, more efficient antibody binding is needed, and some patients develop resistance and relapse despite these treatments. Therefore, there is a need for improved targeted treatments. We engineered the TMPA (Targeted Multidomain Protein Assemblies) protein, which contains two repeats of the cartilage oligomeric matrix protein coiled-coil domain, an elastin-like polypeptide, an RGD-linker, and histidine tags. For targeted drug delivery to HER2+ breast cancer, we designed P51-TMPA by adding a HER2-binding peptide to TMPA. After successful expression and purification, P51-TMPA and TMPA were labeled with IVISense 680, a near-infrared fluorescent dye, and treated to SKBR-3 cells (HER2+ breast cancer) and MDA-231 cells (triple negative breast cancer). Flow cytometry revealed that the SKBR-3 cells treated with NIR-P51-TMPA exhibited higher fluorescence than NIR-TMPA, implying that P51-TMPA has higher uptake into the HER2+ breast cancer cells. In contrast, similar fluorescence was observed in MDA-231 cells treated with NIR-P51-TMPA and NIR-TMPA. Cytotoxic studies revealed that P51-TMPA loaded with doxorubicin reduced cell viability more than free doxorubicin at concentrations 12.5 μM, and 25 μM, while P51-TMPA by itself reduced cell viability by a negligible amount. Future studies will investigate whether micellar assembly improves cell uptake and determine the optimal incubation time for the protein with doxorubicin.

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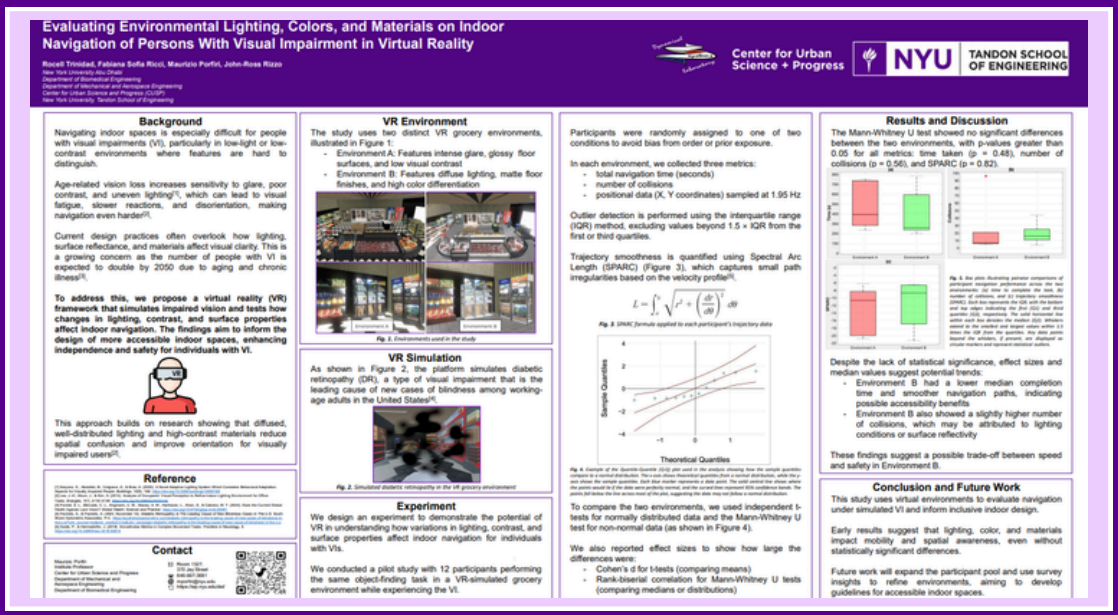
Effects of environmental lighting, colors and materials on indoor navigation of persons with visual impairment in virtual reality

Navigating indoor environments poses ongoing challenges for individuals with visual impairments (VI), particularly in low contrast settings where environmental features become ambiguous. While inclusive design seeks to address accessibility, it often fails to account for how subtle environmental variables such as lighting, color contrast, and material texture affect spatial perception. This study introduces a virtual reality-based framework to systematically examine the impact of these design elements on navigation performance under simulated diabetic retinopathy. Through controlled manipulations of visual features in a virtual grocery environment, and by measuring task efficiency, movement patterns, and collision rates alongside user-reported legibility, we aim to surface insights into how environmental features shape navigational experience. The findings are intended to inform more responsive, evidence-based approaches to designing inclusive indoor spaces.

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Evaluating Environmental Lighting, Colors, and Materials on Indoor Navigation of Persons With Visual Impairment in Virtual Reality

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Center for Urban Science + Progress · NYU TANDON SCHOOL OF ENGINEERING

Background

Navigating indoor spaces is especially difficult for people with visual impairments (VI), particularly in low-light or low-contrast environments where features are hard to distinguish.

Age-related vision loss increases sensitivity to glare, poor contrast, and uneven lighting[1], which can lead to visual fatigue, slower reactions, and disorientation, making navigation even harder[2].

Current design practices often overlook how lighting, surface reflectance, and materials affect visual clarity. This is a growing concern as the number of people with VI is expected to double by 2050 due to aging and chronic illness[3].

To address this, we propose a virtual reality (VR) framework that simulates impaired vision and tests how changes in lighting, contrast, and surface properties affect indoor navigation. The findings aim to inform the design of more accessible indoor spaces, enhancing independence and safety for individuals with VI.

This approach builds on research showing that diffused, well-distributed lighting and high-contrast materials reduce spatial confusion and improve orientation for visually impaired users[4].

Reference

Contact

VR Environment

The study uses two distinct VR grocery environments, illustrated in Figure 1:

- Environment A: Features intense glare, glossy floor surfaces, and low visual contrast
- Environment B: Features diffuse lighting, matte floor finishes, and high color differentiation

Fig. 1. Environments used in the study

VR Simulation

As shown in Figure 2, the platform simulates diabetic retinopathy (DR), a type of visual impairment that is the leading cause of new cases of blindness among working-age adults in the United States[5].

Fig. 2. Simulated diabetic retinopathy in the VR grocery environment

Experiment

We design an experiment to demonstrate the potential of VR in understanding how variations in lighting, contrast, and surface properties affect indoor navigation for individuals with VIs.

We conducted a pilot study with 12 participants performing the same object-finding task in a VR-simulated grocery environment while experiencing the VI.

Participants were randomly assigned to one of two conditions to avoid bias from order or prior exposure.

In each environment, we collected three metrics:

- total navigation time (seconds)
- number of collisions
- positional data (X, Y coordinates) sampled at 1.95 Hz

Outlier detection is performed using the interquartile range (IQR) method, excluding values beyond 1.5 × IQR from the first or third quartiles.

Trajectory smoothness is quantified using Spectral Arc Length (SPARC) (Figure 3), which captures small path irregularities based on the velocity profile[6].

$$L = \int_0^{t_f} \sqrt{\dot{r}^2 + \left(\frac{d\dot{r}}{d\theta}\right)^2}\, d\theta$$

Fig. 3. SPARC formula applied to each participant's trajectory data

Fig. 4. Example of the Quantile-Quantile (Q-Q) plot used in the analysis showing how the sample quantiles compare to a normal distribution. The x-axis shows theoretical quantiles from a normal distribution, while the y-axis shows the sample quantiles. Each blue marker represents a data point. The solid central line shows where the points would lie if the data were perfectly normal, and the curved lines represent 95% confidence bands. The points fall below the line across most of the plot, suggesting the data may not follow a normal distribution.

To compare the two environments, we used independent t-tests for normally distributed data and the Mann-Whitney U test for non-normal data (as shown in Figure 4).

We also reported effect sizes to show how large the differences were:

- Cohen's d for t-tests (comparing means)
- Rank-biserial correlation for Mann-Whitney U tests (comparing medians or distributions)

Results and Discussion

The Mann-Whitney U test showed no significant differences between the two environments, with p-values greater than 0.05 for all metrics: time taken ($p = 0.48$), number of collisions ($p = 0.56$), and SPARC ($p = 0.82$).

Fig. 5. The plots illustrating pairwise comparisons of (a) time taken, (b) number of collisions, and (c) trajectory smoothness (SPARC). Each box represents the IQR, with the bottom and top edges indicating the first (Q1) and third quartiles (Q3), respectively. The solid horizontal line within each box denotes the median (Q2). Whiskers extend to the most extreme data points within 1.5 times the IQR from the quartiles. Any data points beyond the whiskers, if present, are displayed as circular markers and represent statistical outliers.

Despite the lack of statistical significance, effect sizes and median values suggest potential trends:

- Environment B had a lower median completion time and smoother navigation paths, indicating possible accessibility benefits
- Environment B also showed a slightly higher number of collisions, which may be attributed to lighting conditions or surface reflectivity

These findings suggest a possible trade-off between speed and safety in Environment B.

Conclusion and Future Work

This study uses virtual environments to evaluate navigation under simulated VI and inform inclusive indoor design.

Early results suggest that lighting, color, and materials impact mobility and spatial awareness, even without statistically significant differences.

Future work will expand the participant pool and use survey insights to refine environments, aiming to develop guidelines for accessible indoor spaces.

Light-Responsive Nanomedicines for Precise Immunoncology

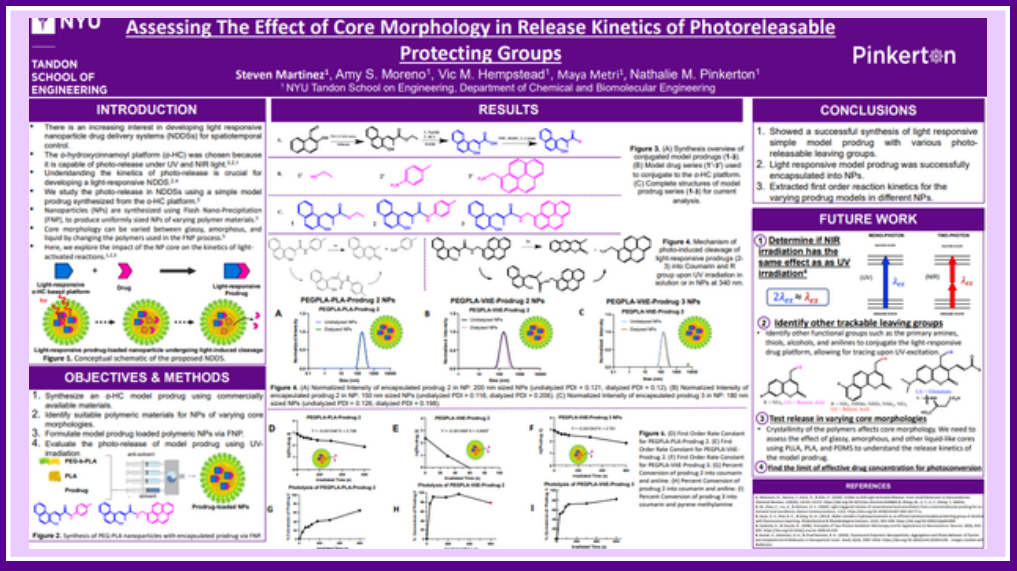
There is growing interest in developing nanoparticle drug delivery systems (NDDS) to achieve controlled release for localized spatial and temporal control. These nanocarriers have unique properties due to their morphology, which allows them to release their contents in response to different stimuli. Utilizing light as one such modality is advantageous due to the manipulation of light and its various parameters that make it suitable for various biomedical applications. Spatiotemporal control is accomplished by using a photoreleasable protecting group (PPG) to regulate the release kinetics of drugs using near-infrared (NIR) light. The PPG of interest is the ortho-hydroxycinnamoyl (o-HA) platform, which can act as a PPG with both ultraviolet (UV) and NIR irradiation. This work utilizes a model prodrug system that has been translated into biological applications, specifically as a conjugatable handle for immune agonist drugs. Light-responsive prodrugs can be created by conjugating the PPG (such as the o-HA) to the desired drug, enabling straightforward encapsulation into polymeric nanoparticles. The synthesized prodrug platform, (E)-3-(2-hydroxynaphthalen-1-yl)-2-methyl-N-(p-tolyl)acrylamide, was encapsulated into nanoparticles via Flash NanoPrecipitation (FNP), which produces uniformly sized nanoparticles by rapid mixing using a multi-inlet vortex mixer (MIVM). Rapid photoconversion of o-HC-based chemistries has been observed within the solid matrix of a polymeric nanoparticle core. Thus, nanoparticles with different core morphologies were constructed to observe the photoconversion in the o-HC prodrug platform, with the goal of achieving 200-nanometer-sized particles. The morphology of the core influences various properties, such as the release kinetics (conversion) of the PPG upon irradiation. The different morphologies include: polyethylene glycol-polylactic acid-tocopherol (PEG-PLA-vitE, liquid-like core), polylactic acid (PLA, amorphous core), and PDLLA (poly-D,L-lactic acid, glassy core). Ultimately, the project hopes to assess the impact of the environment of nanoparticles on light-responsive reactions to achieve favorable photorelease kinetics during light-triggered reactions.

Project Supervisor *Nathalie Pinkerton*

Research Areas *Health*



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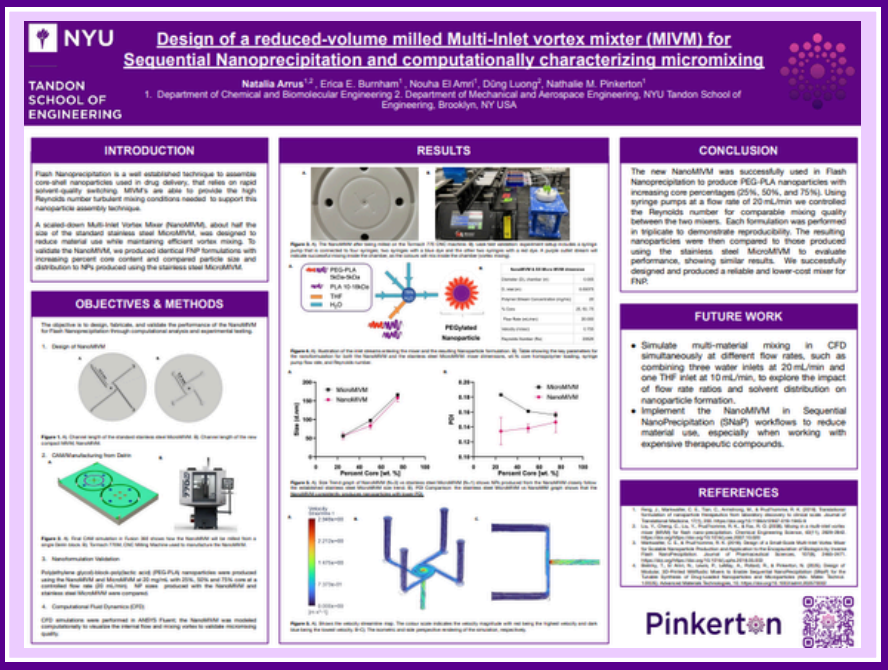
Fundamentals of the Sequential NanoPrecipitation (SNaP) Process

Flash nanoprecipitation (FNP) enables rapid formation of core-shell nanoparticles (NPs) by solvent switching, requiring precise micromixing to ensure uniformity. To reduce material consumption, especially with expensive therapeutic compounds, we designed a low-volume Multi-Inlet Vortex Mixer (nanoMIVM), about half the size of the stainless steel standardized microMIVM, and fabricated it entirely from Delrin using CNC milling in the MakerSpace. The entire mixer was modeled in Computer-Aided Design (CAD) and Computer aided manufacture (CAM) software, with toolpaths generated for precise CNC fabrication. Each part was milled from a single solid block of Delrin to ensure a perfect seal and alignment between the top and bottom sections. Any misalignment would disrupt the internal flow inside the vortex mixing compromising nanoparticle formation. Poly(ethylene glycol)-block-poly(lactic acid) (PEG-PLA) nanoparticles at increasing core percentages were assembled using the nanoMIVM to validate NP reproducibility and mixer performance. Comparing the sizes of the nanoparticles from the nanoMIVM to the microMIVM at identical formulations, where each formulation will be performed in triplicate to show reproducibility. Reynolds number calculations were used to define flow regimes (Re > 1600), and CFD simulations were performed to evaluate the micromixing of our validated formulations in the nanoMIVM. CFD results were used to identify regions of optimal mixing and were compared to experimental nanoparticle size data to ensure correlation between simulation and outcome.

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Magnetic-Polymer-Ceramic Smart Scaffolds for Enhanced Bone Regeneration, Controlled Drug Delivery and Magnetic Hyperthermia

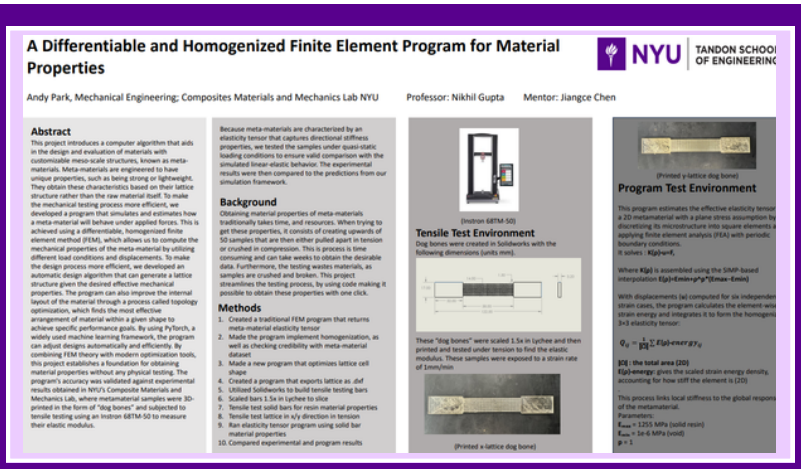
This project introduces a computer algorithm that aids in the design and evaluation of materials with customizable microstructures, known as meta-materials. Meta-materials are engineered to have unique properties, such as being strong or lightweight. They obtain these characteristics based on their internal structure rather than the raw material itself. To make the mechanical testing process more efficient, we developed a program that simulates and estimates how a meta-material will behave under applied forces. This is achieved using a differentiable, homogeneous finite element method (FEM), which allows us to compute the mechanical properties of the meta-material by utilizing different load conditions and displacements. The program can also improve the internal layout of the material through a process called topology optimization, which finds the most effective arrangement of material within a given shape to achieve specific performance goals. By using PyTorch, a widely used machine learning framework, the program is capable of adjusting designs automatically and efficiently. By combining FEM theory with modern optimization tools, this project establishes a foundation for obtaining material properties without any physical testing. The program's accuracy was tested against experimental results obtained in NYU's C114 Lab, where we 3D-printed meta-material samples as ASTM D628 dogbones and measured their elastic modulus in tension using an Instron UTM 6800. Because meta-materials are characterized by an elasticity tensor that captures directional stiffness properties, we tested the samples under quasi-static loading conditions to ensure valid comparison with the simulated linear-elastic behavior. The experimental results were then compared to the predictions from our simulation framework.

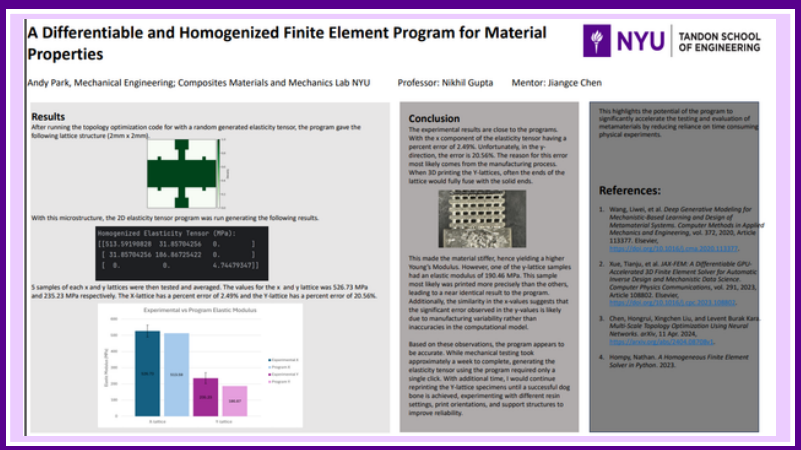
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Research Areas	*Health*
Research Staff	*Caleb Beckwith, Jiangce Chen*



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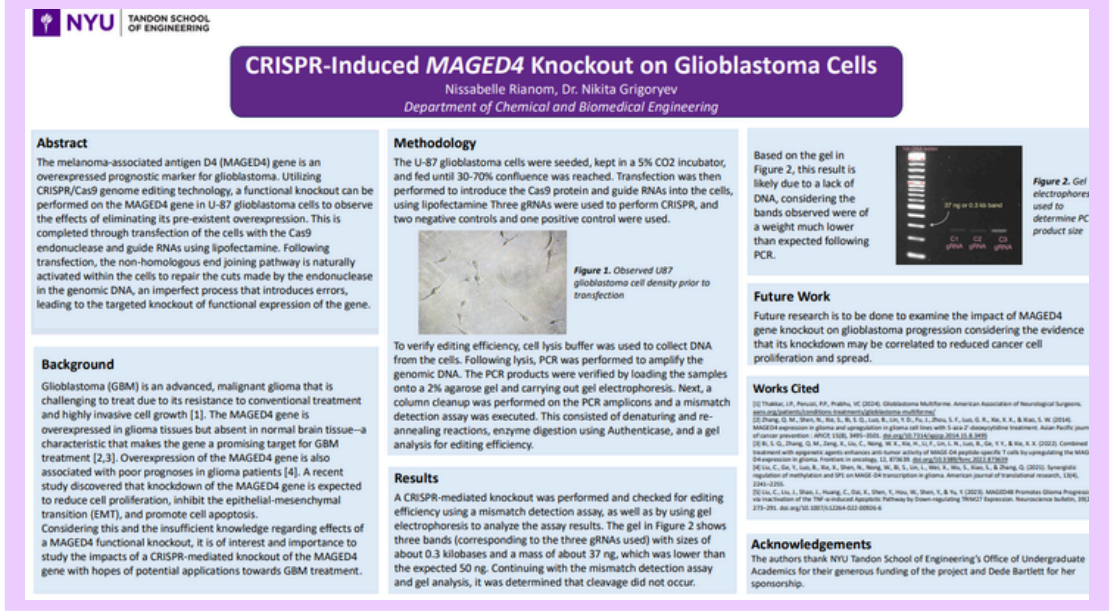
CRISPR for disease modeling

The melanoma-associated antigen D4 (MAGED4) gene is an overexpressed prognostic marker for glioblastoma. Utilizing CRISPR/Cas9 genome editing technology, a functional knockout can be performed on the MAGED4 gene in U-87 glioblastoma cells to observe the effects of eliminating its pre-existent overexpression. This is completed through transfection of the cells with the Cas9 endonuclease and guide RNAs using lipofectamine. Following transfection, the non-homologous end joining pathway is naturally activated within the cells to repair the cuts made by the endonuclease in the genomic DNA, an imperfect process that introduces errors, leading to the targeted knockout of functional expression of the gene.

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NYU TANDON SCHOOL OF ENGINEERING

CRISPR-Induced *MAGED4* Knockout on Glioblastoma Cells

Nissabelle Rianom, Dr. Nikita Grigoryev
Department of Chemical and Biomedical Engineering

Abstract

The melanoma-associated antigen D4 (MAGED4) gene is an overexpressed prognostic marker for glioblastoma. Utilizing CRISPR/Cas9 genome editing technology, a functional knockout can be performed on the MAGED4 gene in U-87 glioblastoma cells to observe the effects of eliminating its pre-existent overexpression. This is completed through transfection of the cells with the Cas9 endonuclease and guide RNAs using lipofectamine. Following transfection, the non-homologous end joining pathway is naturally activated within the cells to repair the cuts made by the endonuclease in the genomic DNA, an imperfect process that introduces errors, leading to the targeted knockout of functional expression of the gene.

Background

Glioblastoma (GBM) is an advanced, malignant glioma that is challenging to treat due to its resistance to conventional treatment and highly invasive cell growth [1]. The MAGED4 gene is overexpressed in glioma tissues but absent in normal brain tissue--a characteristic that makes the gene a promising target for GBM treatment [2,3]. Overexpression of the MAGED4 gene is also associated with poor prognoses in glioma patients [4]. A recent study discovered that knockdown of the MAGED4 gene is expected to reduce cell proliferation, inhibit the epithelial-mesenchymal transition (EMT), and promote cell apoptosis.
Considering this and the insufficient knowledge regarding effects of a MAGED4 functional knockout, it is of interest and importance to study the impacts of a CRISPR-mediated knockout of the MAGED4 gene with hopes of potential applications towards GBM treatment.

Methodology

The U-87 glioblastoma cells were seeded, kept in a 5% CO2 incubator, and fed until 30-70% confluence was reached. Transfection was then performed to introduce the Cas9 protein and guide RNAs into the cells, using lipofectamine Three gRNAs were used to perform CRISPR, and two negative controls and one positive control were used.

Figure 1. *Observed U87 glioblastoma cell density prior to transfection*

To verify editing efficiency, cell lysis buffer was used to collect DNA from the cells. Following lysis, PCR was performed to amplify the genomic DNA. The PCR products were verified by loading the samples onto a 2% agarose gel and carrying out gel electrophoresis. Next, a column cleanup was performed on the PCR amplicons and a mismatch detection assay was executed. This consisted of denaturing and re-annealing reactions, enzyme digestion using Authenticase, and a gel analysis for editing efficiency.

Results

A CRISPR-mediated knockout was performed and checked for editing efficiency using a mismatch detection assay, as well as by using gel electrophoresis to analyze the assay results. The gel in Figure 2 shows three bands (corresponding to the three gRNAs used) with sizes of about 0.3 kilobases and a mass of about 37 ng, which was lower than the expected 50 ng. Continuing with the mismatch detection assay and gel analysis, it was determined that cleavage did not occur.

Based on the gel in Figure 2, this result is likely due to a lack of DNA, considering the bands observed were of a weight much lower than expected following PCR.

Figure 2. *Gel electrophores used to determine PC product size*

Future Work

Future research is to be done to examine the impact of MAGED4 gene knockout on glioblastoma progression considering the evidence that its knockdown may be correlated to reduced cancer cell proliferation and spread.

Works Cited

Acknowledgements

The authors thank NYU Tandon School of Engineering's Office of Undergraduate Academics for their generous funding of the project and Dede Bartlett for her sponsorship.

Regulation of shape and growth in microorganisms

Cells depend on the membrane potential to grow and divide. Bacillus subtilis is a gram-positive bacterium that stops growing when exposed to an uncoupler, 2,4-dinitrophenol (DNP) (Guffanti et al., 1987), which collapses the membrane potential. However, the molecular and physical mechanisms underlying this response are unknown. To address this question, we applied high selective pressure by growing B. subtilis in the minimum inhibitory concentration of DNP. This evolutionary approach was conducted to discover spontaneous mutations that tolerate membrane potential stress. We also tested for bacterial growth in the presence of CCCP, another uncoupler, alongside a control sample of just lysogeny broth (LB), a nutrient-rich culture medium. Cells were passed daily in fresh media, and colony spot assays were performed weekly. We monitored changes in growth for a total of 4 weeks through the spot assays and growth curves. We aim to identify any mutations in adapted bacterial cells that are involved in cell elongation under membrane potential stress through DNA sequencing.

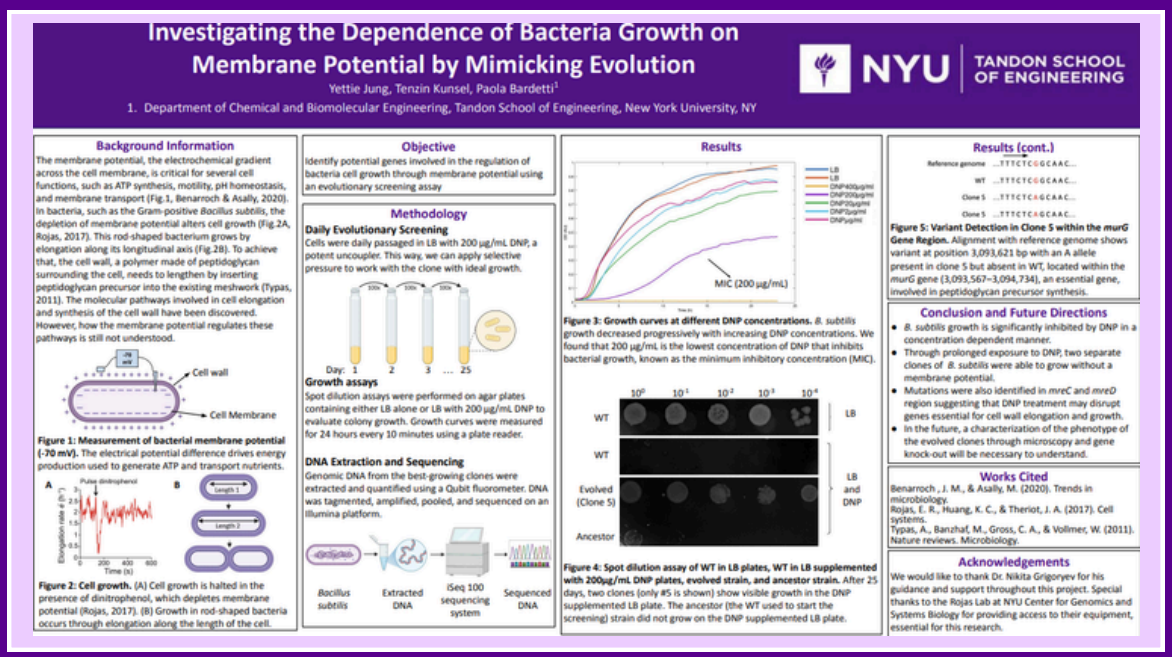
Project Supervisor *Paola Bardetti*
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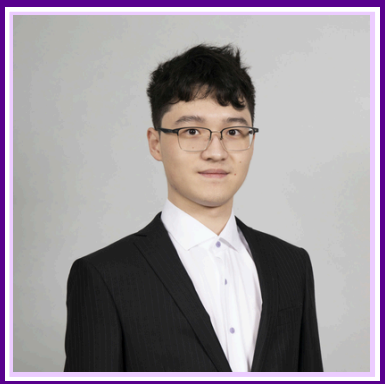
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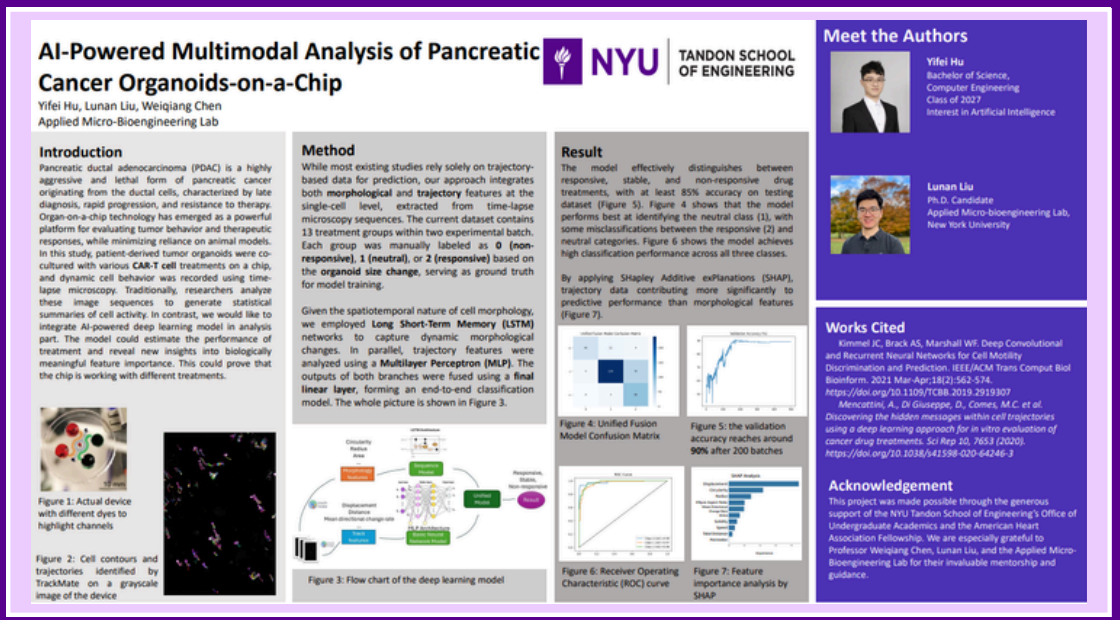
Microengineering 3D vascularized Cancer-on-a-Chip models for cancer immunotherapy study (AHA Fellowship Project)

Organ-on-a-chip technology has emerged as a powerful platform for modeling pancreatic ductal adenocarcinoma (PDAC), enabling precise recreation of the tumor microenvironment and facilitating physiologically relevant studies of cancer progression and drug response. In this project, we developed an AI-driven model to classify treatment responses based on features extracted from PDAC organoid-on-a-chip experiments. While most existing studies rely solely on trajectory-based data for prediction, our approach integrates both morphological and trajectory data at the single-cell level, extracted from time-lapsed microscopy sequences. Given the spatiotemporal nature of morphological features, we employed a hybrid model combining convolutional and long short-term memory (LSTM) networks to capture dynamic cell morphology, while trajectory-level data were analyzed using a multilayer perceptron (MLP). The outputs were fused through a final linear regression layer. Our results demonstrate that the model effectively distinguishes between responsive, stable, and non-responsive drug treatments, with trajectory data contributing more significantly to predictive performance than morphological features.

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2025 Weiqiang Chen 3 - Exploring the CAR T-cell Mechanoimmunology with Novel Engineered Micromechanical Tools

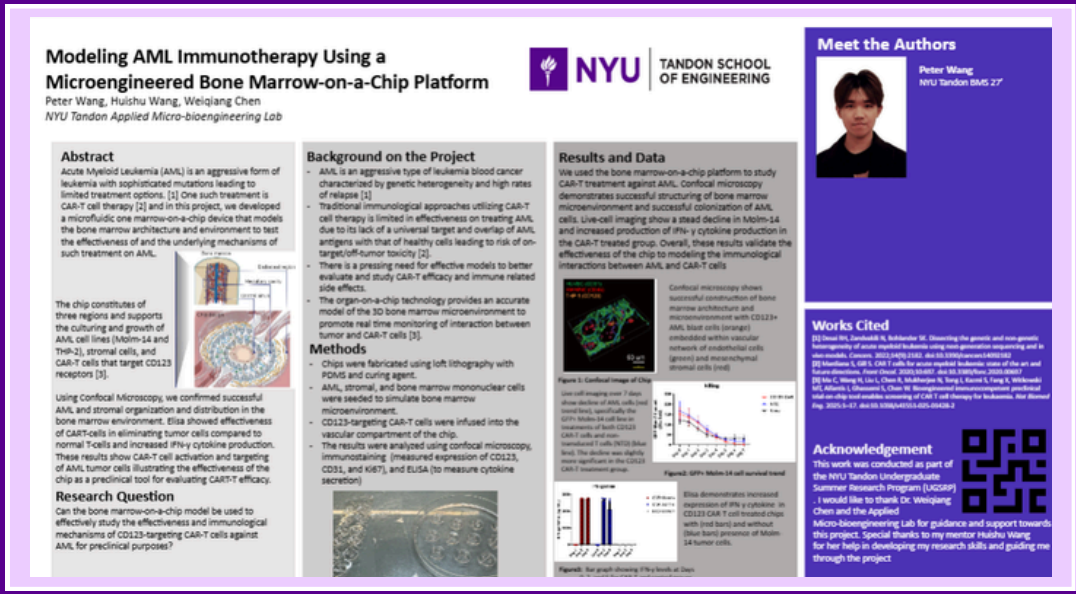
Acute Myeloid Leukemia (AML) is an aggressive type of cancer of the myeloid lineage. AML's inherent heterogeneic nature leads to frequent mutations and relapse after treatment. AML cells' diverse antigens present a major obstacle for traditional CAR-T cell treatments with specific targets such as the CD19 receptor of B-cell Leukemia. It also causes on-target/off-tumor toxicity due to shared receptors with healthy cells. There is a need for new approaches to study AML and test CAR-T cell treatments by developing clinical models that effectively mimic the human marrow environment. In our research, we engineered microfluidic chips that closely replicates the architecture of the human bone marrow to allow AML cell growth and evaluate CAR-T cell dynamics. The chips were constructed using a mixture of PDMS and curing agent to form the scaffold for the cells and contained three zones, a central sinus, a medullary cavity, and an endosteal region. AML cell lines, either Molm-14 or THP-1, along with stromal cells and immune cells were cultured in the chips. CAR-T cells targeting the CD123 AML antigens were infused into the bloodstream. Effectiveness of the CAR-T cells and cancer cell development alone with gene expressions were observed using immunostaining, confocal microscopy, and Elisa. Confocal imaging confirmed the presence and spatial arrangement of CD123+ AML blasts embedded within a vascularized stromal network of CD31+ endothelial cells and Mesenchymal stem cells (MSCs) showing success modeling of the bone marrow microenvironment. After injection of CD123 CAR-T cells, the results show a slight enhancement of AML cell death and a significant increase in IFN-γ production, indicating activation after recognition. These measurements support the device's usage in effectively studying both therapeutic efficacy and immune-related side effects in a preclinical setting.

Project Supervisor *Weiqiang Chen*

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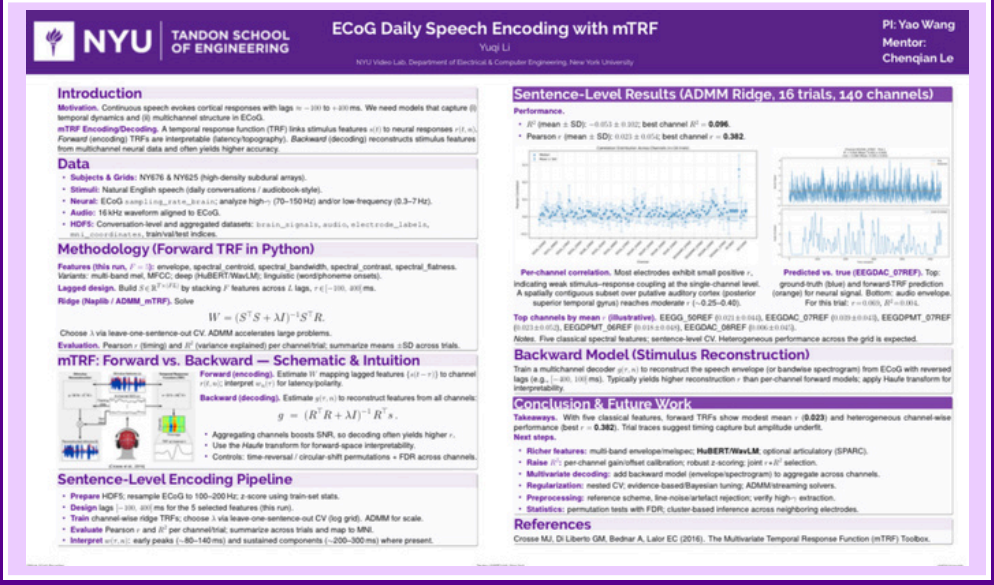
ECoG Daily Speech Encoding with mTRF: A Pipeline for Sentence-Level Modeling of Natural Conversation

We present a fully reproducible, Python-based encoding framework that relates continuous speech to electrocorticography (ECoG) during natural daily conversations. Using HDF5 datasets from two patients (NY676, NY625) with high-density subdural grids, we analyze high-gamma (70–150 Hz) and low-frequency (0.3–7 Hz) neural activity aligned to 16 kHz audio. The stimulus is represented by five classical acoustic features—amplitude envelope, spectral centroid, bandwidth, contrast, and flatness—and embedded in a lagged design matrix spanning -100 to +400 ms to capture physiologically plausible latencies. Channel-wise multivariate temporal response functions (mTRFs) are estimated via ridge regression with leave-one-sentence-out cross-validation; we implement both NapLib-TRF solvers and an ADMM-optimized ridge variant for scalability. On NY676 (140 channels, 16 trials), sentence-level performance is heterogeneous across the grid: mean Pearson correlation r=0.023±0.054 with a best channel r=0.382. The framework yields interpretable latency profiles (often peaking ~80–140 ms with sustained components to ~300 ms) and supports extensibility to multichannel backward (stimulus-reconstruction) models, deep self-supervised features (HuBERT/WavLM), articulatory representations (SPARC), and permutation-based significance testing. This work provides a clear, modular pipeline—data preparation, lagged feature construction, regularized TRF estimation, and brain-surface visualization—for benchmarking speech-to-ECoG encoding in ecologically valid settings.

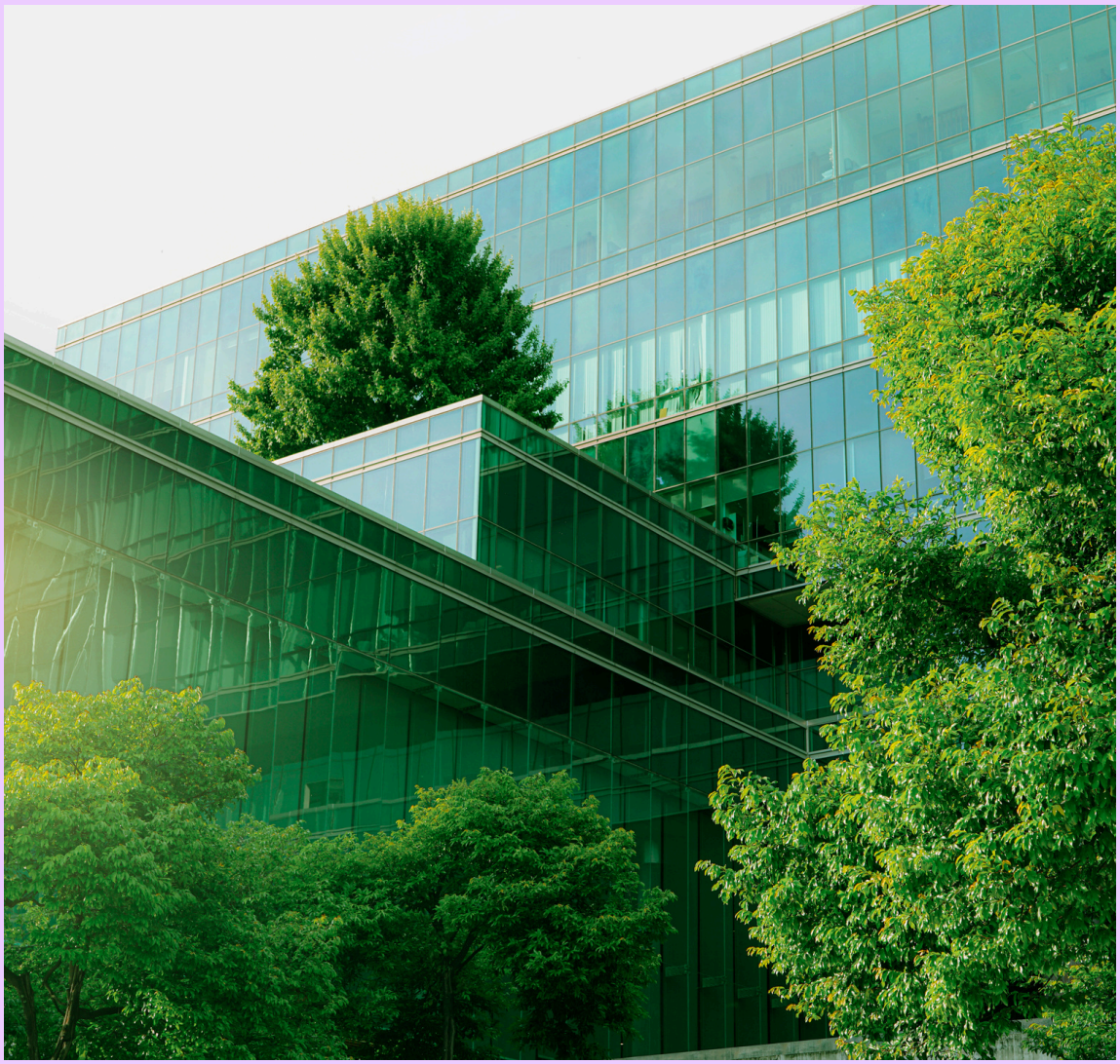
Project Supervisor	*Yao Wang*
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Sustainability

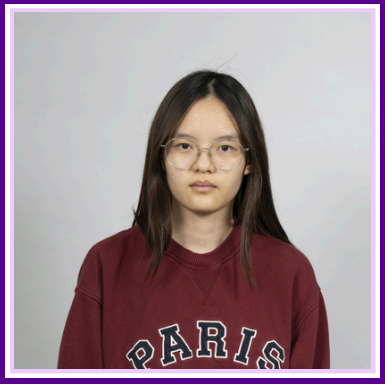


In a world threatened by pollution and climate change, we believe that engineering holds the key to a greener, healthier future. We focus on developing solutions that can help the world thrive technologically and economically without compromising the well-being of future generations.

Nanoparticle Catalysts for CO 2 Electrolysis using Flash Joule Heating

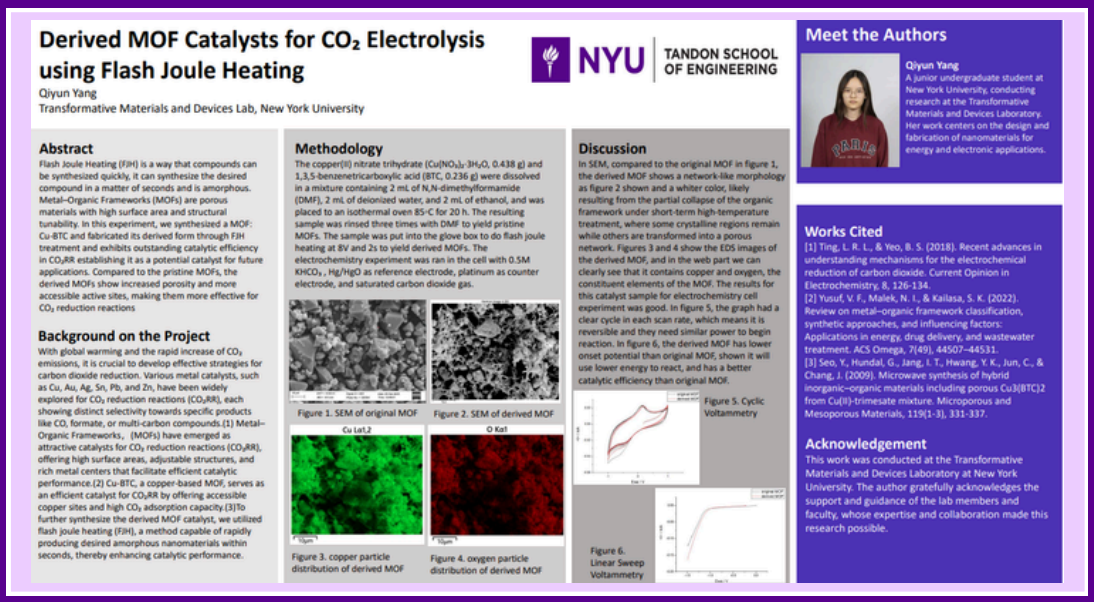
Flash Joule Heating (FJH) is a way that compounds can be synthesized quickly, it can synthesize the desired compound in a matter of seconds and is amorphous. Metal–Organic Frameworks (MOFs) are porous materials with high surface area and structural tunability. In this experiment, we synthesized a MOF: Cu-BTC and fabricated its derived form through FJH treatment and exhibits outstanding catalytic efficiency in CO_2RR establishing it as a potential catalyst for future applications. Compared to the pristine MOFs, the derived MOFs show increased porosity and more accessible active sites, making them more effective for CO_2 reduction reactions.

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Research Areas	*Sustainability*
Research Staff	*Nathan Makowski*



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Derived MOF Catalysts for CO_2 Electrolysis using Flash Joule Heating

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NYU TANDON SCHOOL OF ENGINEERING

Abstract

Flash Joule Heating (FJH) is a way that compounds can be synthesized quickly, it can synthesize the desired compound in a matter of seconds and is amorphous. Metal–Organic Frameworks (MOFs) are porous materials with high surface area and structural tunability. In this experiment, we synthesized a MOF: Cu-BTC and fabricated its derived form through FJH treatment and exhibits outstanding catalytic efficiency in CO_2RR establishing it as a potential catalyst for future applications. Compared to the pristine MOFs, the derived MOFs show increased porosity and more accessible active sites, making them more effective for CO_2 reduction reactions

Background on the Project

With global warming and the rapid increase of CO_2 emissions, it is crucial to develop effective strategies for carbon dioxide reduction. Various metal catalysts, such as Cu, Au, Ag, Sn, Pb, and Zn, have been widely explored for CO_2 reduction reactions (CO_2RR), each showing distinct selectivity towards specific products like CO, formate, or multi-carbon compounds.(1) Metal–Organic Frameworks, (MOFs) have emerged as attractive catalysts for CO_2 reduction reactions (CO_2RR), offering high surface areas, adjustable structures, and rich metal centers that facilitate efficient catalytic performance.(2) Cu-BTC, a copper-based MOF, serves as an efficient catalyst for CO_2RR by offering accessible copper sites and high CO_2 adsorption capacity.(3)To further synthesize the derived MOF catalyst, we utilized flash joule heating (FJH), a method capable of rapidly producing desired amorphous nanomaterials within seconds, thereby enhancing catalytic performance.

Methodology

The copper(II) nitrate trihydrate ($Cu(NO_3)_2 \cdot 3H_2O$, 0.438 g) and 1,3,5-benzenetricarboxylic acid (BTC, 0.236 g) were dissolved in a mixture containing 2 mL of N,N-dimethylformamide (DMF), 2 mL of deionized water, and 2 mL of ethanol, and was placed to an isothermal oven 85◦C for 20 h. The resulting sample was rinsed three times with DMF to yield pristine MOFs. The sample was put into the glove box to do flash joule heating at 8V and 2s to yield derived MOFs. The electrochemistry experiment was ran in the cell with 0.5M $KHCO_3$, Hg/HgO as reference electrode, platinum as counter electrode, and saturated carbon dioxide gas.

Figure 1. SEM of original MOF

Figure 2. SEM of derived MOF

Figure 3. copper particle distribution of derived MOF

Figure 4. oxygen particle distribution of derived MOF

Discussion

In SEM, compared to the original MOF in figure 1, the derived MOF shows a network-like morphology as figure 2 shown and a whiter color, likely resulting from the partial collapse of the organic framework under short-term high-temperature treatment, where some crystalline regions remain while others are transformed into a porous network. Figures 3 and 4 show the EDS images of the derived MOF, and in the web part we can clearly see that it contains copper and oxygen, the constituent elements of the MOF. The results for this catalyst sample for electrochemistry cell experiment was good. In figure 5, the graph had a clear cycle in each scan rate, which means it is reversible and they need similar power to begin reaction. In figure 6, the derived MOF has lower onset potential than original MOF, shown it will use lower energy to react, and has a better catalytic efficiency than original MOF.

Figure 5. Cyclic Voltammetry

Figure 6. Linear Sweep Voltammetry

Meet the Authors

Qiyun Yang
A junior undergraduate student at New York University, conducting research at the Transformative Materials and Devices Laboratory. Her work centers on the design and fabrication of nanomaterials for energy and electronic applications.

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Acknowledgement

This work was conducted at the Transformative Materials and Devices Laboratory at New York University. The author gratefully acknowledges the support and guidance of the lab members and faculty, whose expertise and collaboration made this research possible.

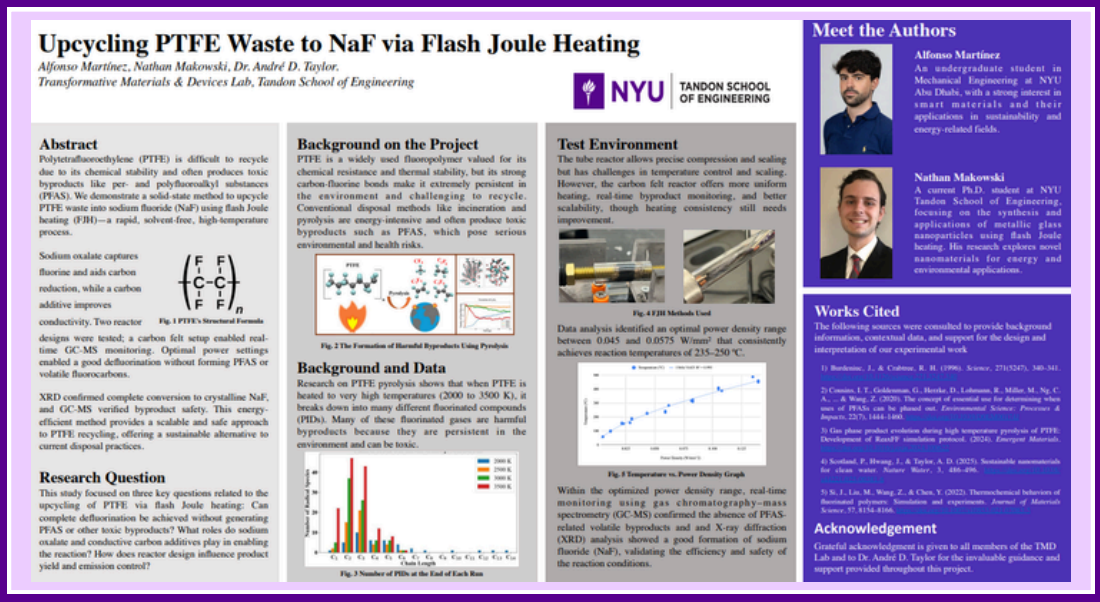
Cathode Design for Enhanced Battery Performance

Polytetrafluoroethylene (PTFE) is difficult to recycle due to its chemical stability and often produces toxic byproducts like per- and polyfluoroalkyl substances (PFAS). We demonstrate a solid-state method to upcycle PTFE waste into sodium fluoride (NaF) using flash Joule heating (FJH)—a rapid, solvent-free, high-temperature process. Sodium oxalate captures fluorine and aids carbon reduction, while a carbon additive improves conductivity. Two reactor designs were tested; a carbon felt setup enabled realtime GC-MS monitoring. Optimal power settings enabled a good defluorination without forming PFAS or volatile fluorocarbons. XRD confirmed complete conversion to crystalline NaF, and GC-MS verified byproduct safety. This energyefficient method provides a scalable and safe approach to PTFE recycling, offering a sustainable alternative to current disposal practices.

Project Supervisor	*André D. Taylor*
Research Areas	*Sustainability*
Research Staff	*Yaxin Shen*



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Upcycling PTFE Waste to NaF via Flash Joule Heating

Alfonso Martínez, Nathan Makowski, Dr. André D. Taylor.
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NYU TANDON SCHOOL OF ENGINEERING

Abstract

Polytetrafluoroethylene (PTFE) is difficult to recycle due to its chemical stability and often produces toxic byproducts like per- and polyfluoroalkyl substances (PFAS). We demonstrate a solid-state method to upcycle PTFE waste into sodium fluoride (NaF) using flash Joule heating (FJH)—a rapid, solvent-free, high-temperature process.

Sodium oxalate captures fluorine and aids carbon reduction, while a carbon additive improves conductivity. Two reactor designs were tested; a carbon felt setup enabled real-time GC-MS monitoring. Optimal power settings enabled a good defluorination without forming PFAS or volatile fluorocarbons.

XRD confirmed complete conversion to crystalline NaF, and GC-MS verified byproduct safety. This energy-efficient method provides a scalable and safe approach to PTFE recycling, offering a sustainable alternative to current disposal practices.

Research Question

This study focused on three key questions related to the upcycling of PTFE via flash Joule heating: Can complete defluorination be achieved without generating PFAS or other toxic byproducts? What roles do sodium oxalate and conductive carbon additives play in enabling the reaction? How does reactor design influence product yield and emission control?

Fig. 1 PTFE's Structural Formula

Background on the Project

PTFE is a widely used fluoropolymer valued for its chemical resistance and thermal stability, but its strong carbon-fluorine bonds make it extremely persistent in the environment and challenging to recycle. Conventional disposal methods like incineration and pyrolysis are energy-intensive and often produce toxic byproducts such as PFAS, which pose serious environmental and health risks.

Fig. 2 The Formation of Harmful Byproducts Using Pyrolysis

Background and Data

Research on PTFE pyrolysis shows that when PTFE is heated to very high temperatures (2000 to 3500 K), it breaks down into many different fluorinated compounds (PIDs). Many of these fluorinated gases are harmful byproducts because they are persistent in the environment and can be toxic.

Fig. 3 Number of PIDs at the End of Each Run

Test Environment

The tube reactor allows precise compression and sealing but has challenges in temperature control and scaling. However, the carbon felt reactor offers more uniform heating, real-time byproduct monitoring, and better scalability, though heating consistency still needs improvement.

Fig. 4 FJH Methods Used

Data analysis identified an optimal power density range between 0.045 and 0.0575 W/mm² that consistently achieves reaction temperatures of 235–250 °C.

Fig. 5 Temperature vs. Power Density Graph

Within the optimized power density range, real-time monitoring using gas chromatography–mass spectrometry (GC-MS) confirmed the absence of PFAS-related volatile byproducts and and X-ray diffraction (XRD) analysis showed a good formation of sodium fluoride (NaF), validating the efficiency and safety of the reaction conditions.

Meet the Authors

Alfonso Martínez
An undergraduate student in Mechanical Engineering at NYU Abu Dhabi, with a strong interest in smart materials and their applications in sustainability and energy-related fields.

Nathan Makowski
A current Ph.D. student at NYU Tandon School of Engineering, focusing on the synthesis and applications of metallic glass nanoparticles using flash Joule heating. His research explores novel nanomaterials for energy and environmental applications.

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Acknowledgement

Grateful acknowledgment is given to all members of the TMD Lab and to Dr. André D. Taylor for the invaluable guidance and support provided throughout this project.

Decay of microbial contaminants in water treatment and in the environment - environmental engineering

Enterococci in surface waters indicate potential fecal contamination. Previous lab work revealed that measured Enterococci concentrations in chlorine-treated wastewater effluent vary based on analytical methods applied (i.e., IDEXX Enterolert versus Membrane Filtration (MF)), with IDEXX showing higher bacterial concentrations. We hypothesized that IDEXX detects injured bacteria capable of repairing and reproducing in wells, while MF fails to capture sublethally damaged cells on agar plates. This study investigated variations in Enterococcus concentrations measured in wastewater. Duplicate sampling was conducted at a treatment plant, 20 minutes apart, for both secondary and final effluent, separately, and further divided into two subgroups based on sodium thiosulfate (ST) addition, the chlorine-quenching agent. Samples were stored at room temperature in the lab and analyzed at 3, 7, and 27 hours post-collection using IDEXX (51-Well Quanti-Tray and substrate-based indicator) and MF (0.45 µm filters and mEI agar). Percent differences between methods remained consistent across holding times, averaging 188.01%. Enterococcus concentrations of final effluent samples with ST measured by IDEXX were significantly different (p-value < 0.013) from those measured by MF. Samples without ST showed no significant difference between methods after 7 and 27 hours (p-value = 0.205, 0.065, respectively) likely because of lower bacterial concentrations approaching detection limits faster than samples with ST, at which point the difference between methods was no longer assessable. We anticipated sublethally damaged Enterococcus to die during extended room-temperature storage, decreasing IDEXX concentrations over time to reflect MF. Instead, IDEXX consistently reported higher concentrations, suggesting a systematic bias between methods independent of holding time. An absence of a consistent pattern in bacterial counts from samples without ST reveals the importance of dechlorinating samples upon collection. Results remain inconclusive about whether injured bacteria are responsible for the overestimation of Enterococcus concentration when enumerated by IDEXX.

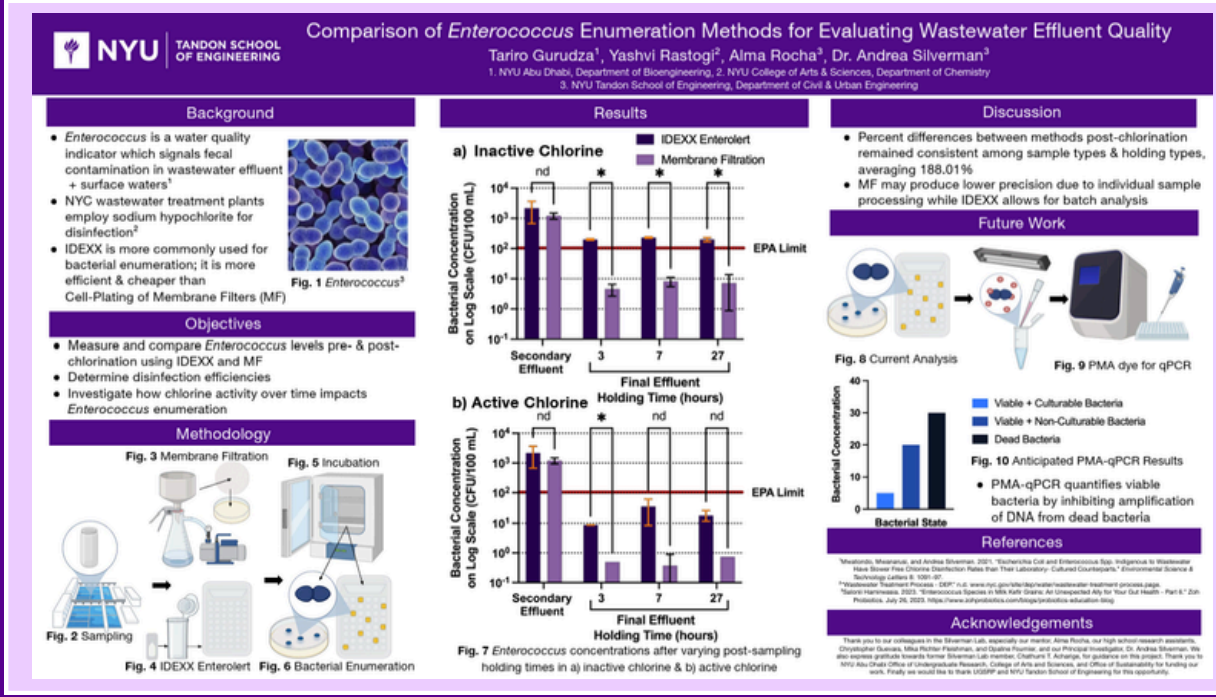
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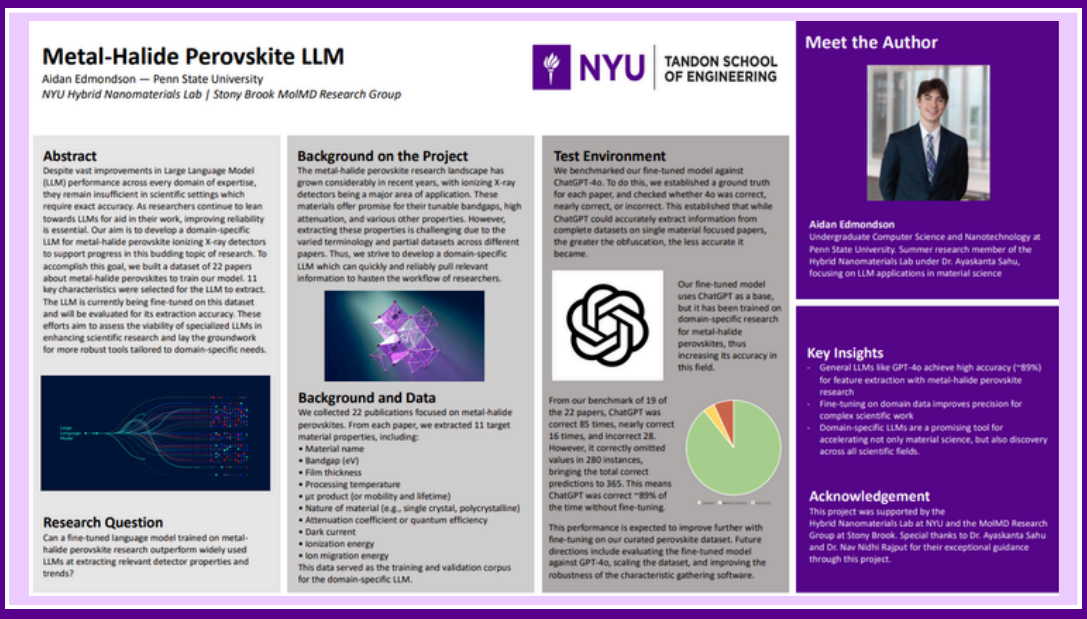
Infrared quantum dots to enable night vision

Despite vast improvements in Large Language Model (LLM) performance across every domain of expertise, they remain insufficient in scientific settings which require exact accuracy. As researchers continue to lean towards LLMs for aid in their work, improving reliability is essential. Our aim is to develop a domain-specific LLM for metal-halide perovskite ionizing X-ray detectors to support progress in this budding topic of research. To accomplish this goal, we built a dataset of 24 papers pertaining to metal-halide perovskites to train our model. Additionally, 11 key characteristics were selected for the LLM to extract. The LLM is currently being fine-tuned on this dataset and will be evaluated for its extraction accuracy. These efforts aim to engineer a tool that will expedite scientific discovery in the emerging sub-field of metal-halide perovskites, as well as demonstrate a method by which to improve LLM accuracy.

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Quantum and Optical Experimental Projects

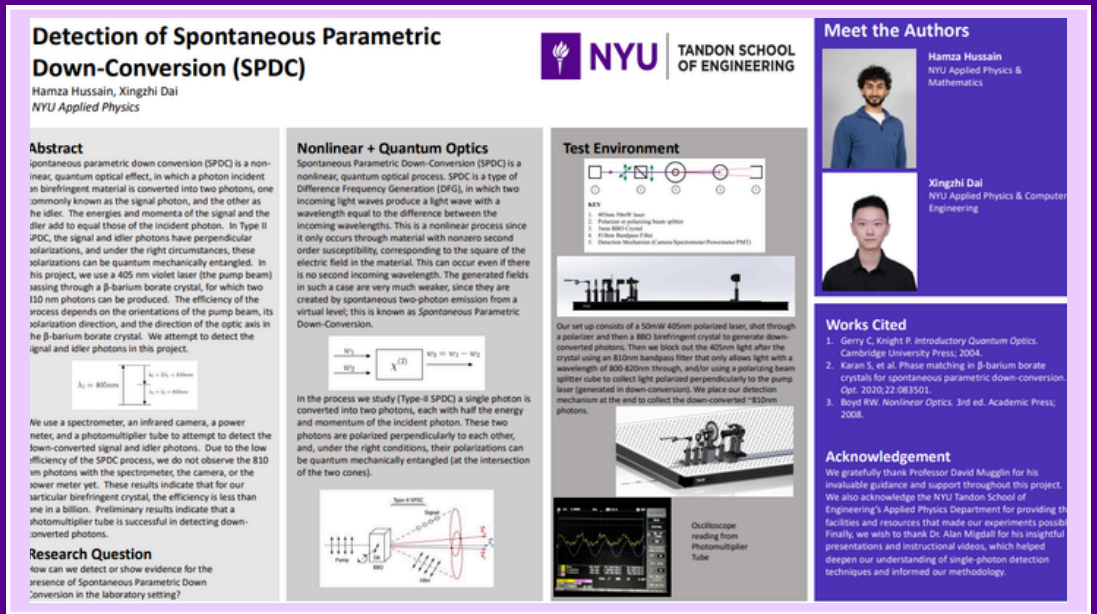
Spontaneous parametric down conversion (SPDC) is a non-linear, quantum optical effect, in which a photon incident on birefringent material is converted into two photons, one commonly known as the signal photon, and the other as the idler. The energies and momenta of the signal and the idler add to equal those of the incident photon. In Type II SPDC, the signal and idler photons have perpendicular polarizations, and under the right circumstances, these polarizations can be quantum mechanically entangled. In this project, we use a 405 nm violet laser (the pump beam) passing through a β-barium borate crystal, for which two 810 nm photons can be produced. The efficiency of the process depends on the orientations of the pump beam, its polarization direction, and the direction of the optic axis in the β-barium borate crystal. We attempt to detect the signal and idler photons in this project. We use a spectrometer, an infrared camera, a power meter, and a photomultiplier tube to attempt to detect the down-converted signal and idler photons. Due to the low efficiency of the SPDC process, we do not observe the 810 nm photons with the spectrometer, the camera, or the power meter yet. These results indicate that for our particular birefringent crystal, the efficiency is less than one in a billion. Preliminary results indicate that a photomultiplier tube is successful in detecting down-converted photons. By measuring on either side of the setup with the photomultiplier tube, we observe one signal polarized parallel to the pump, another polarized perpendicular to the pump, and an intermediate signal that exhibits both polarizations under certain conditions. These observations are consistent with the predictions of SPDC theory.

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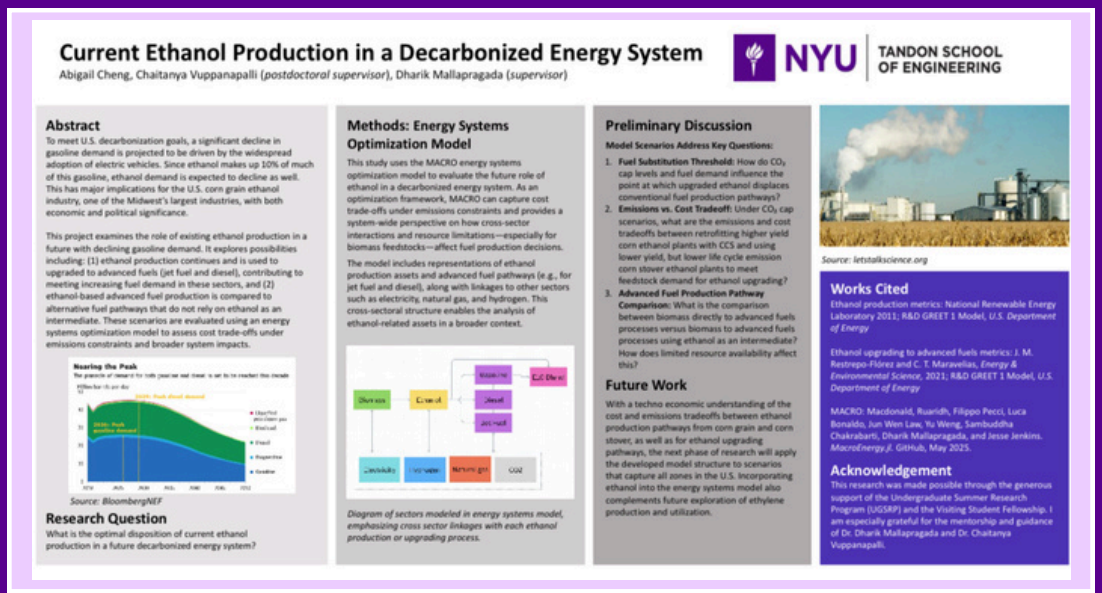
Systematic assessment of fuel production and chemical industry decarbonization in the context of net-zero energy systems

The U.S. currently produces over 16 billion gallons of ethanol from corn grain annually, primarily for blending into gasoline (E10) for reasons including domestic policy and sustainability. However, as one part of the transportation sector decarbonizes through electrification of light duty vehicles, gasoline—and thus ethanol—demand is expected to decline. This raises a critical question: what is the optimal disposition of existing corn ethanol in a decarbonized future? This study uses a multi-sector energy systems model to evaluate the roles of ethanol production, either via current methods or newer, lower-emissions processes, and ethanol upgrading processes into middle distillate fuels. We assess system-wide cost and emissions tradeoffs, such as those between retrofitting current ethanol production assets with carbon capture and choosing between ethanol upgrading pathways. By investigating the impacts of limited biomass and cross-sector impacts, we provide a systems level view relevant to making decisions about ethanol's evolving role in the broader U.S. energy transition.

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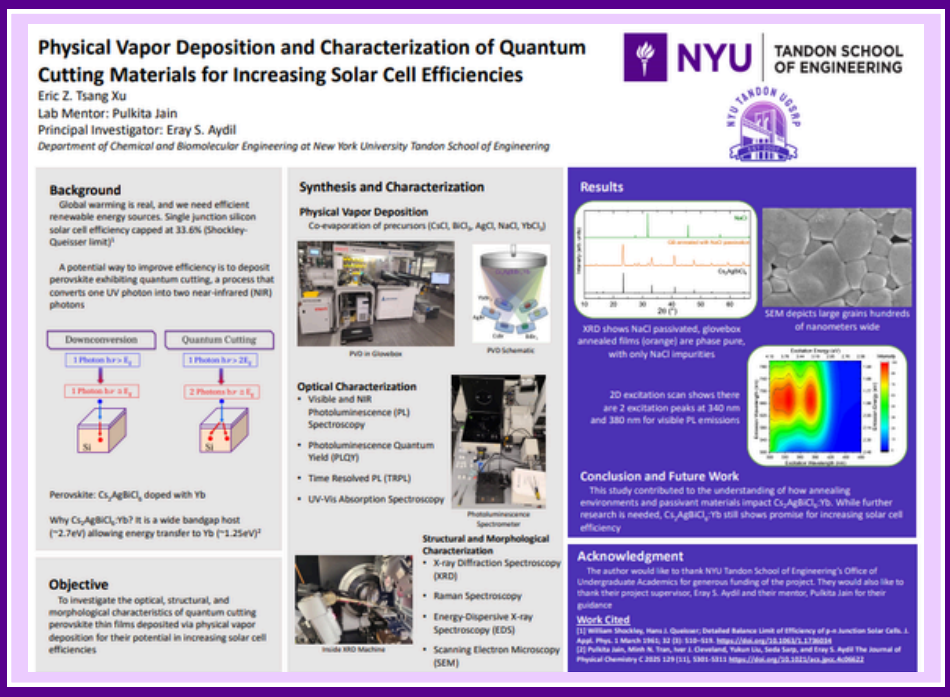
Physical Vapor Deposition and Optical Characterization of Quantum Cutting materials for increasing solar cell efficiencies

Solar cells serve a critical role in renewable energies as a sustainable alternative to burning fossil fuels for electricity. However, their inability to absorb UV light efficiently have contributed to capping silicon solar cell efficiency at 33.6%, the Shockley-Queisser limit. A potential option to improve efficiency beyond the Shockley-Queisser limit is to deposit perovskites that exhibit quantum cutting, a process that converts one UV photon into two near-infrared (NIR) photons, onto the solar cells. In this study Cs2AgBiCl6 perovskites doped with Yb (Cs2AgBiCl6 :Yb) were deposited onto glass substrates via physical vapor deposition. The effects of NaCl passivation and different annealing environments, such as glovebox, air, and petri dish covering, on Cs2AgBiCl6 :Yb were studied. The samples were optically characterized using photoluminescence quantum yield (PLQY), visible and NIR photoluminescence (PL), time resolved PL (TRPL), and absorption (UV-Vis). PLQY quantifies the ratio of emitted to absorbed photons, UV-Vis measures Cs2AgBiCl6 :Yb's absorption spectrum, and PL spectroscopy reveals its emission and excitation spectra, as well as the decay time of emitted photons. Additionally, X-ray diffraction spectroscopy, Raman spectroscopy, energy-dispersive X-ray spectroscopy, and scanning electron microscopy were used to characterize crystal structure and the morphology of the films to determine phase purity, crystallinity, elemental composition, and grain formation. Cs2AgBiCl6 :Yb films passivated with NaCl had lower PLQY, large grains, and blue shifted absorption. Annealing Cs2AgBiCl6 :Yb in glovebox (nitrogen environment) led to phase pure films compared to air annealing which had an impurity of BiOCl. This study contributed to the understanding of how annealing environments and passivant materials impact Cs2AgBiCl6 :Yb. While further research is needed to explore these and other factors, Cs2AgBiCl6 :Yb still shows promise for increasing solar cell efficiency.

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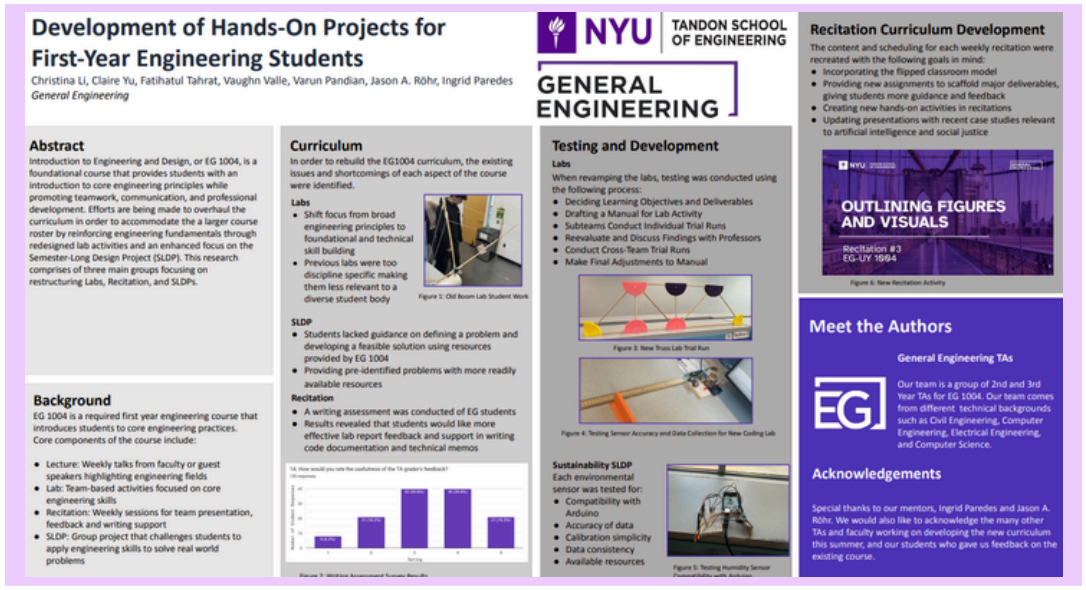
Development of Hands-On Projects for First-Year Engineering Sudents

Introduction to Engineering and Design, or EG 1004, is a foundational course that most freshmen at NYU Tandon School of Engineering take. This course provides students with an introduction to core engineering principles while promoting teamwork, communication, and professional development. However, as the course is taking in a larger number of students from different engineering backgrounds and interests, efforts are being made to overhaul the curriculum in order to accommodate the wider roster by reinforcing engineering fundamentals through redesigned lab activities and an enhanced focus on the Semester-Long Design Project (SLDP). A key goal of this effort is to support hands-on learning while standardizing instructional support across a large team of Teaching Assistants (TAs). The methods that are being utilized for curriculum development include updating lab and recitation modules to emphasize essential skills such as circuit design and programming, as well as developing detailed documentation and training materials for TAs. As part of the SLDP revitalization, a new sustainability-focused project was introduced, aligned with NYU's sustainability goals and LEED (Leadership in Energy and Environmental Design) principles. This project focused on testing whether the sensors were compatible with Arduinos, usability, accuracy, and consistency. As for the lab and recitation components, lab activities were designed by meeting with professors to discuss learning objectives, developing activities, and running test groups among TAs. Additionally, work is being done to promote better research practices for students, particularly in learning how to investigate sources without leaning too much on AI, and developing hands-on workshops for students to have more in-depth knowledge of specific sensors before they get far into their projects. The curriculum development in its current state is proceeding smoothly, with most deadlines being met on the lab front. This curriculum overhaul strengthens the foundation of EG 1004 by combining structured support with real-world, interdisciplinary applications. Through both improved instructional systems and the integration of sustainability-focused design work, the course better equips students to tackle complex engineering challenges from the start of their academic careers.

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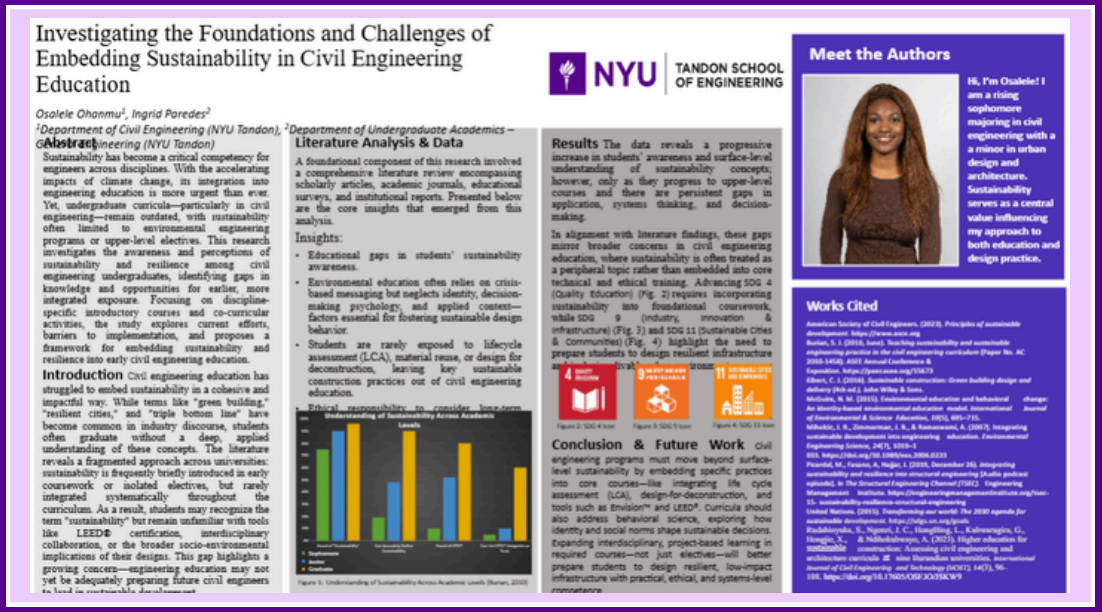
Investigating the Foundations and Challenges of Embedding Sustainability in Civil Engineering Education

Sustainability has become a critical competency for engineers across disciplines. With the accelerating impacts of climate change, its integration into engineering education is more urgent than ever. Yet, undergraduate curricula—particularly in civil engineering—remain outdated, with sustainability often limited to environmental engineering programs or upper-level electives. This research investigates the awareness and perceptions of sustainability and resilience among civil engineering undergraduates, identifying gaps in knowledge and opportunities for earlier, more integrated exposure. Focusing on discipline-specific introductory courses and co-curricular activities, the study explores current efforts, barriers to implementation, and proposes a framework for embedding sustainability and resilience into early civil engineering education.

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Research Areas *Sustainability*



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Investigating the Foundations and Challenges of Embedding Sustainability in Civil Engineering Education

NYU TANDON SCHOOL OF ENGINEERING

Osalele Ohanmu[1], Ingrid Paredes[2]
[1]Department of Civil Engineering (NYU Tandon), [2]Department of Undergraduate Academics – Civil Engineering (NYU Tandon)

Abstract
Sustainability has become a critical competency for engineers across disciplines. With the accelerating impacts of climate change, its integration into engineering education is more urgent than ever. Yet, undergraduate curricula—particularly in civil engineering—remain outdated, with sustainability often limited to environmental engineering programs or upper-level electives. This research investigates the awareness and perceptions of sustainability and resilience among civil engineering undergraduates, identifying gaps in knowledge and opportunities for earlier, more integrated exposure. Focusing on discipline-specific introductory courses and co-curricular activities, the study explores current efforts, barriers to implementation, and proposes a framework for embedding sustainability and resilience into early civil engineering education.

Introduction Civil engineering education has struggled to embed sustainability in a cohesive and impactful way. While terms like "green building," "resilient cities," and "triple bottom line" have become common in industry discourse, students often graduate without a deep, applied understanding of these concepts. The literature reveals a fragmented approach across universities: sustainability is frequently briefly introduced in early coursework or isolated electives, but rarely integrated systematically throughout the curriculum. As a result, students may recognize the term "sustainability" but remain unfamiliar with tools like LEED® certification, interdisciplinary collaboration, or the broader socio-environmental implications of their designs. This gap highlights a growing concern—engineering education may not yet be adequately preparing future civil engineers

Literature Analysis & Data
A foundational component of this research involved a comprehensive literature review encompassing scholarly articles, academic journals, educational surveys, and institutional reports. Presented below are the core insights that emerged from this analysis.

Insights:
- Educational gaps in students' sustainability awareness.
- Environmental education often relies on crisis-based messaging but neglects identity, decision-making psychology, and applied context—factors essential for fostering sustainable design behavior.
- Students are rarely exposed to lifecycle assessment (LCA), material reuse, or design for deconstruction, leaving key sustainable construction practices out of civil engineering education.
- Ethical responsibility to consider long-term

Understanding of Sustainability Across Academic Levels

Results The data reveals a progressive increase in students' awareness and surface-level understanding of sustainability concepts; however, only as they progress to upper-level courses and there are persistent gaps in application, systems thinking, and decision-making.

In alignment with literature findings, these gaps mirror broader concerns in civil engineering education, where sustainability is often treated as a peripheral topic rather than embedded into core technical and ethical training. Advancing SDG 4 (Quality Education) (Fig. 2) requires incorporating sustainability into foundational coursework, while SDG 9 (Industry, Innovation & Infrastructure) (Fig. 3) and SDG 11 (Sustainable Cities & Communities) (Fig. 4) highlight the need to prepare students to design resilient infrastructure

Conclusion & Future Work Civil engineering programs must move beyond surface-level sustainability by embedding specific practices into core courses—like integrating life cycle assessment (LCA), design-for-deconstruction, and tools such as Envision™ and LEED®. Curricula should also address behavioral science, exploring how identity and social norms shape sustainable decisions. Expanding interdisciplinary, project-based learning in required courses—not just electives—will better prepare students to design resilient, low-impact infrastructure with practical, ethical, and systems-level

Meet the Authors

Hi, I'm Osalele! I am a rising sophomore majoring in civil engineering with a minor in urban design and architecture. Sustainability serves as a central value influencing my approach to both education and design practice.

Works Cited

Integrating ESG into Engineering and Business Technology Curricula

This study investigates how Environmental, Social, and Governance (ESG) principles are integrated into the undergraduate engineering and Business Technology Management (BTM) curricula at New York University's Tandon School of Engineering. As industries increasingly prioritize ESG considerations and ethical leadership, there is growing pressure on academic institutions to prepare students with the knowledge and skills necessary to navigate these evolving expectations. The research uses a mixed-methods approach to assess current ESG coverage and identify opportunities for curricular improvement. We conducted a detailed syllabus review of core BTM courses to map ESG-relevant content, focusing on themes such as climate responsibility, diversity, equity, and inclusion (DEI), and corporate ethics. Simultaneously, a survey was developed and distributed to undergraduate students at Tandon to measure their awareness of ESG topics, perceived relevance to their careers, and preferred learning formats. To strengthen our methodology and provide a basis for comparison, we adapted survey instruments from the NYU Stern Center for Sustainable Business. This allowed us to contrast student perceptions and learning outcomes between business and engineering disciplines. Additionally, we plan to conduct follow-up interviews and focus groups with students and faculty to collect qualitative insights on ESG education and its implementation challenges. Quantitative analysis will include statistical methods such as t-tests to evaluate differences in student engagement and satisfaction between ESGintegrated and non-ESG courses. The findings aim to inform actionable recommendations for enhancing ESG education across the Tandon curriculum, ultimately fostering a new generation of sustainability-minded professionals equipped to lead in diverse sectors.

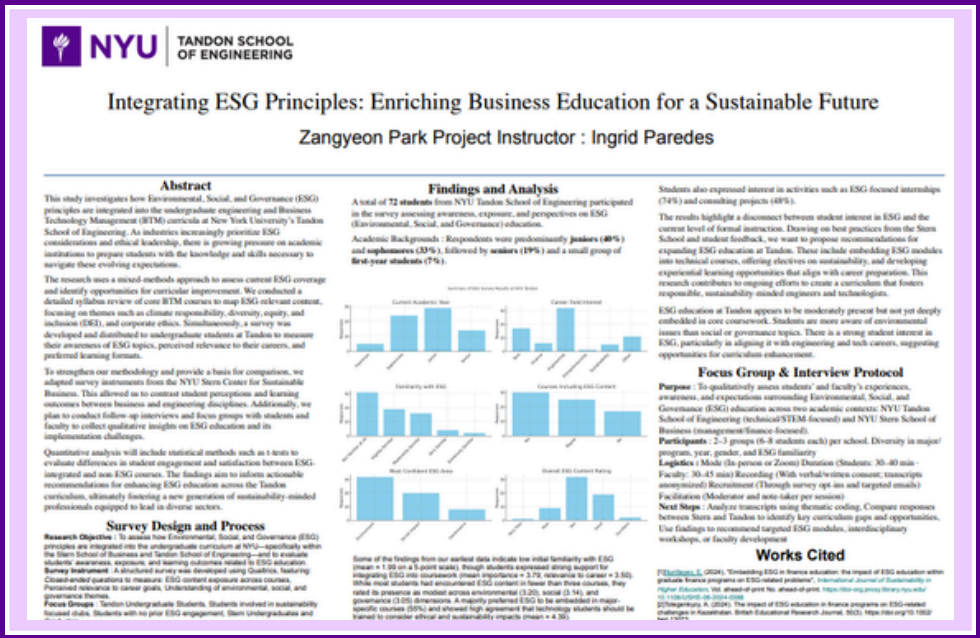
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Integrating ESG Principles: Enriching Business Education for a Sustainable Future

Zangyeon Park Project Instructor : Ingrid Paredes

Abstract

This study investigates how Environmental, Social, and Governance (ESG) principles are integrated into the undergraduate engineering and Business Technology Management (BTM) curricula at New York University's Tandon School of Engineering. As industries increasingly prioritize ESG considerations and ethical leadership, there is growing pressure on academic institutions to prepare students with the knowledge and skills necessary to navigate these evolving expectations.

The research uses a mixed-methods approach to assess current ESG coverage and identify opportunities for curricular improvement. We conducted a detailed syllabus review of core BTM courses to map ESG-relevant content, focusing on themes such as climate responsibility, diversity, equity, and inclusion (DEI), and corporate ethics. Simultaneously, a survey was developed and distributed to undergraduate students at Tandon to measure their awareness of ESG topics, perceived relevance to their careers, and preferred learning formats.

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Quantitative analysis will include statistical methods such as t-tests to evaluate differences in student engagement and satisfaction between ESG-integrated and non-ESG courses. The findings aim to inform actionable recommendations for enhancing ESG education across the Tandon curriculum, ultimately fostering a new generation of sustainability-minded professionals equipped to lead in diverse sectors.

Survey Design and Process

Research Objective : To assess how Environmental, Social, and Governance (ESG) principles are integrated into the undergraduate curriculum at NYU—specifically within the Stern School of Business and Tandon School of Engineering—and to evaluate students' awareness, exposure, and learning outcomes related to ESG education.

Survey Instrument : A structured survey was developed using Qualtrics, featuring Closed-ended questions to measure: ESG content exposure across courses, Perceived relevance to career goals, Understanding of environmental, social, and governance themes.

Focus Groups : Tandon Undergraduate Students. Students involved in sustainability focused clubs. Students with no prior ESG engagement. Stern Undergraduates and

Findings and Analysis

A total of **72 students** from NYU Tandon School of Engineering participated in the survey assessing awareness, exposure, and perspectives on ESG (Environmental, Social, and Governance) education.

Academic Backgrounds : Respondents were predominantly **juniors (40%)** and **sophomores (33%)**, followed by **seniors (19%)** and a small group of **first-year students (7%)**.

Some of the findings from our earliest data indicate low initial familiarity with ESG (mean = 1.99 on a 5-point scale), though students expressed strong support for integrating ESG into coursework (mean importance = 3.79, relevance to career = 3.50). While most students had encountered ESG content in fewer than three courses, they rated its presence as modest across environmental (3.20), social (3.14), and governance (3.05) dimensions. A majority preferred ESG to be embedded in major-specific courses (50%) and showed high agreement that technology students should be trained to consider ethical and sustainability impacts (mean = 4.36).

Students also expressed interest in activities such as ESG focused internships (74%) and consulting projects (48%).

The results highlight a disconnect between student interest in ESG and the current level of formal instruction. Drawing on best practices from the Stern School and student feedback, we want to propose recommendations for expanding ESG education at Tandon. These include embedding ESG modules into technical courses, offering electives on sustainability, and developing experiential learning opportunities that align with career preparation. This research contributes to ongoing efforts to create a curriculum that fosters responsible, sustainability-minded engineers and technologists.

ESG education at Tandon appears to be moderately present but not yet deeply embedded in core coursework. Students are more aware of environmental issues than social or governance topics. There is a strong student interest in ESG, particularly in aligning it with engineering and tech careers, suggesting opportunities for curriculum enhancement.

Focus Group & Interview Protocol

Purpose : To qualitatively assess students' and faculty's experiences, awareness, and expectations surrounding Environmental, Social, and Governance (ESG) education across two academic contexts: NYU Tandon School of Engineering (technical/STEM-focused) and NYU Stern School of Business (management/finance-focused).

Participants : 2–3 groups (6–8 students each) per school. Diversity in major/program, year, gender, and ESG familiarity

Logistics : Mode (In person or Zoom) Duration (Students: 30–40 min - Faculty: 30–45 min) Recording (With verbal/written consent; transcripts anonymized) Recruitment (Through survey opt-ins and targeted emails) Facilitators (Moderator and note-taker per session)

Next Steps : Analyze transcripts using thematic coding, Compare responses between Stern and Tandon to identify key curriculum gaps and opportunities, Use findings to recommend targeted ESG modules, interdisciplinary workshops, or faculty development

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Upcycling of waste plastics into valuable lubricants using catalytic slurry reactor

Polyolefins (PO) are among the most used plastics and accounts for approximately 70% of plastic waste in the U.S. which mainly ends up in landfills or incinerated. To prevent further waste of this material, this research focuses on the use of Ru/TiO2 catalysts and a semi-batch Parr reactor for the hydroconversion of high-density polyethylene (HDPE) into high-value liquid products such as surfactants, lubricants, waxes, and fuels. The reactor employs a dynamic sweeping strategy in which methane is periodically purged and replaced with fresh hydrogen gas for 10 minutes hourly after the reaction start time, promoting increased hydrogen availability and improving selectivity toward desired liquid-phase products. Under optimized sweeping-specific experimental conditions of 250° C, 60 bar H2, 14 hours and 700 rpm agitation, we observed a significant increase in liquid product selectivity compared to conventional hydroconversion runs. As study progresses, further improvements in reactor design and catalyst synthesis are anticipated to enhance conversion efficiency and carbon utilization. These developments aim to improve the economic viability and sustainability of PO upcycling.

Project Supervisor *Pavel Kots*

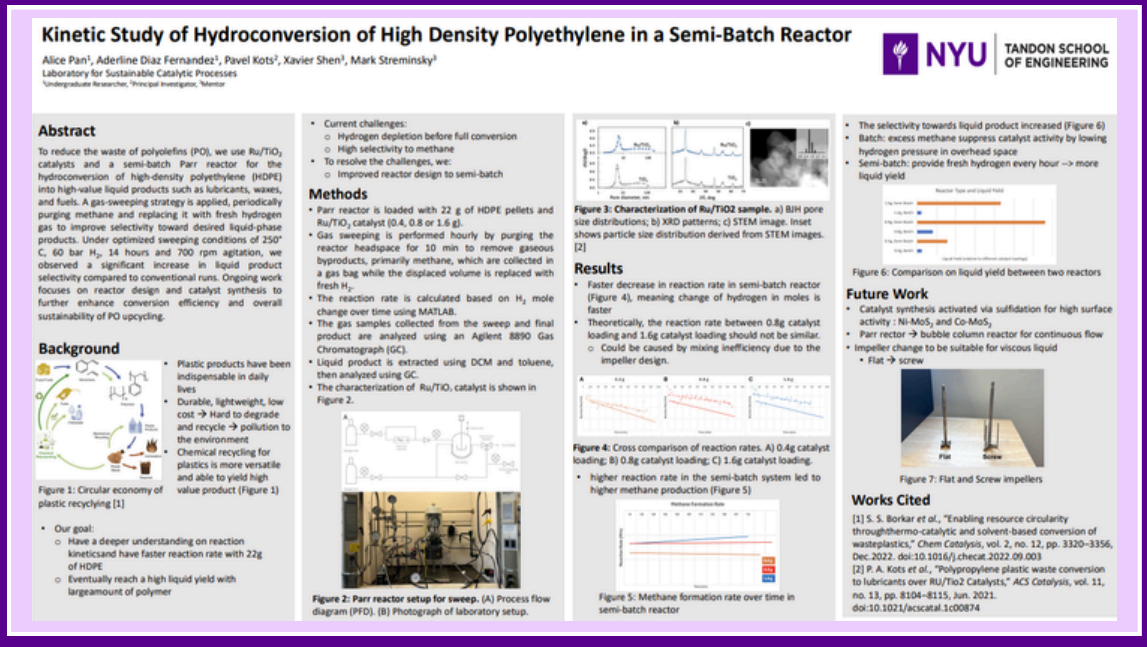
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Kinetic Study of Hydroconversion of High Density Polyethylene in a Semi-Batch Reactor

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[1]Undergraduate Researcher, [2]Principal Investigator, [3]Mentor

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Abstract

To reduce the waste of polyolefins (PO), we use Ru/TiO_2 catalysts and a semi-batch Parr reactor for the hydroconversion of high-density polyethylene (HDPE) into high-value liquid products such as lubricants, waxes, and fuels. A gas-sweeping strategy is applied, periodically purging methane and replacing it with fresh hydrogen gas to improve selectivity toward desired liquid-phase products. Under optimized sweeping conditions of 250° C, 60 bar H_2, 14 hours and 700 rpm agitation, we observed a significant increase in liquid product selectivity compared to conventional runs. Ongoing work focuses on reactor design and catalyst synthesis to further enhance conversion efficiency and overall sustainability of PO upcycling.

Background

- Plastic products have been indispensable in daily lives
- Durable, lightweight, low cost → Hard to degrade and recycle → pollution to the environment
- Chemical recycling for plastics is more versatile and able to yield high value product (Figure 1)

Figure 1: Circular economy of plastic recycling [1]

- Our goal:
  - Have a deeper understanding on reaction kineticsand have faster reaction rate with 22g of HDPE
  - Eventually reach a high liquid yield with largeamount of polymer

- Current challenges:
  - Hydrogen depletion before full conversion
  - High selectivity to methane
- To resolve the challenges, we:
  - Improved reactor design to semi-batch

Methods

- Parr reactor is loaded with 22 g of HDPE pellets and Ru/TiO_2 catalyst (0.4, 0.8 or 1.6 g).
- Gas sweeping is performed hourly by purging the reactor headspace for 10 min to remove gaseous byproducts, primarily methane, which are collected in a gas bag while the displaced volume is replaced with fresh H_2.
- The reaction rate is calculated based on H_2 mole change over time using MATLAB.
- The gas samples collected from the sweep and final product are analyzed using an Agilent 8890 Gas Chromatograph (GC).
- Liquid product is extracted using DCM and toluene, then analyzed using GC.
- The characterization of Ru/TiO_2 catalyst is shown in Figure 2.

Figure 2: Parr reactor setup for sweep. (A) Process flow diagram (PFD). (B) Photograph of laboratory setup.

Figure 3: Characterization of Ru/TiO_2 sample. a) BJH pore size distributions; b) XRD patterns; c) STEM image. Inset shows particle size distribution derived from STEM images. [2]

Results

- Faster decrease in reaction rate in semi-batch reactor (Figure 4), meaning change of hydrogen in moles is faster
- Theoretically, the reaction rate between 0.8g catalyst loading and 1.6g catalyst loading should not be similar.
  - Could be caused by mixing inefficiency due to the impeller design.

Figure 4: Cross comparison of reaction rates. A) 0.4g catalyst loading; B) 0.8g catalyst loading; C) 1.6g catalyst loading.

- higher reaction rate in the semi-batch system led to higher methane production (Figure 5)

Figure 5: Methane formation rate over time in semi-batch reactor

- The selectivity towards liquid product increased (Figure 6)
- Batch: excess methane suppress catalyst activity by lowing hydrogen pressure in overhead space
- Semi-batch: provide fresh hydrogen every hour –> more liquid yield

Figure 6: Comparison on liquid yield between two reactors

Future Work

- Catalyst synthesis activated via sulfidation for high surface activity : Ni-MoS_2 and Co-MoS_2
- Parr rector → bubble column reactor for continuous flow
- Impeller change to be suitable for viscous liquid
  - Flat → screw

Figure 7: Flat and Screw impellers

Works Cited

[1] S. S. Borkar *et al.*, "Enabling resource circularity throughthermo-catalytic and solvent-based conversion of wasteplastics," *Chem Catalysis*, vol. 2, no. 12, pp. 3320–3356, Dec. 2022. doi:10.1016/j.checat.2022.09.003
[2] P. A. Kots *et al.*, "Polypropylene plastic waste conversion to lubricants over RU/Tio2 Catalysts," *ACS Catalysis*, vol. 11, no. 13, pp. 8104–8115, Jun. 2021. doi:10.1021/acscatal.1c00874

Developing and Modeling the Instructional Pilot Plant for Chemical Engineering

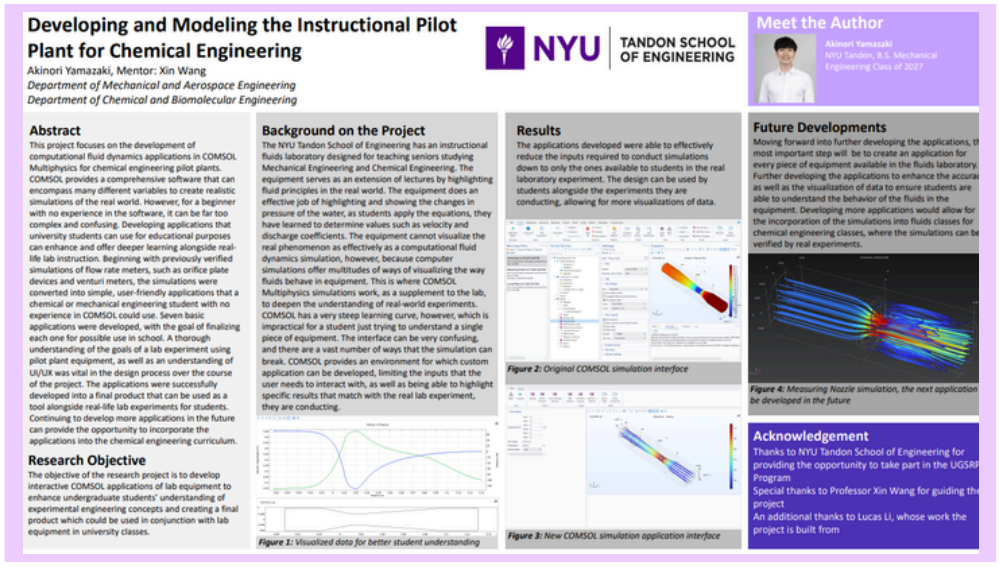
This project focuses on the development of computational fluid dynamics applications in COMSOL Multiphysics for chemical engineering pilot plants. COMSOL provides a comprehensive software that can encompass many different variables to create realistic simulations of the real world. The software allows for more visualization methods for fluid dynamics. However, for a beginner with no experience in the software, using the software can be far too complex and confusing. The goal of the applications developed in this project is that university students can use them for educational purposes, and that the applications can enhance and offer deeper learning alongside real-life lab instruction. Beginning with previously verified simulations of flow rate meters, such as orifice plate devices and venturi meters, the simulations were converted into simple, user-friendly applications that an engineering student with no experience in COMSOL could use. Seven basic applications were developed, aiming to finalize each one for possible use in school. A thorough understanding of the goals of a lab experiment using pilot plant equipment, as well as an understanding of UI/UX, was vital in the design process over the course of the project. The applications were successfully developed into a final product that can be used as a tool alongside real-life lab experiments for students. The simulations worked within a 2% error of the equipment manufacturer's specifications. Continuing to develop more applications in the future can provide the opportunity to incorporate modern simulation software into the engineering curriculum.

Project Supervisor *Xin Wang*

Research Areas *Sustainability*



Akinori Yamazaki
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Spring 2027
NYU Tandon



Developing and Modeling the Instructional Pilot Plant for Chemical Engineering

Akinori Yamazaki, Mentor: Xin Wang
Department of Mechanical and Aerospace Engineering
Department of Chemical and Biomolecular Engineering

NYU TANDON SCHOOL OF ENGINEERING

Meet the Author

Abstract

Background on the Project

Results

Future Developments

Research Objective

Figure 1: Visualized data for better student understanding

Figure 2: Original COMSOL simulation interface

Figure 3: New COMSOL simulation application interface

Figure 4: Measuring Nozzle simulation, the next application be developed in the future

Acknowledgement

Developing Simulation Application for Instructional Heat Exchanger for Fluid Lab

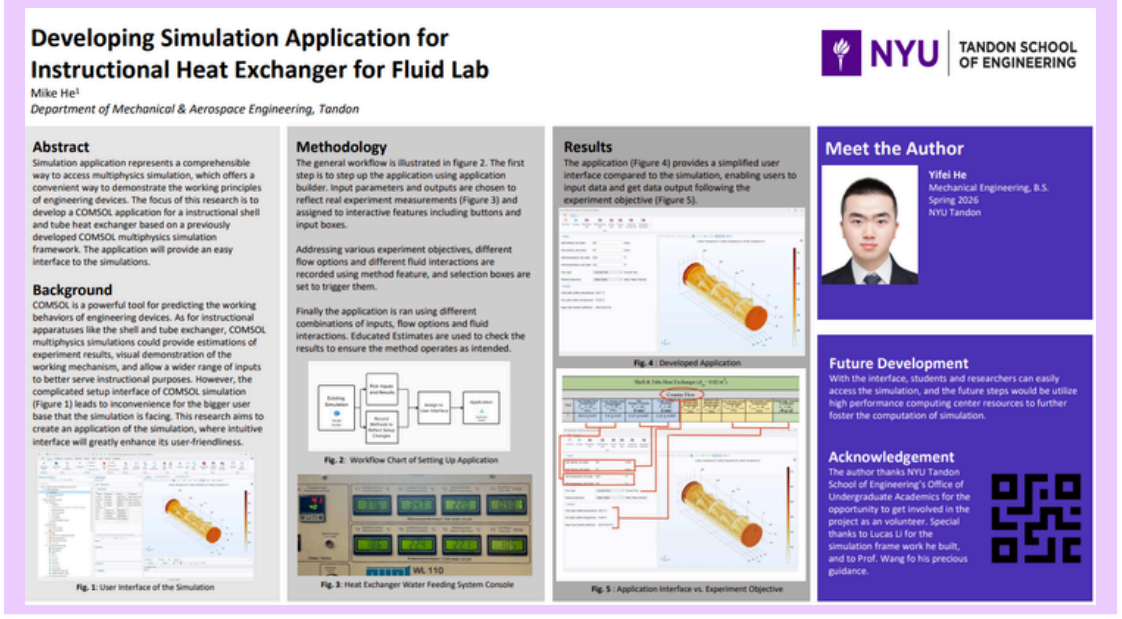
Simulation applications represent a convenient way to access multiphysics simulations, which comprehensively demonstrate the working principles of engineering devices. The focus of this research is to develop a COMSOL application for a shell-and-tube heat exchanger based on a previously developed COMSOL multiphysics simulation framework. The application will provide a straightforward simulation interface, making it easier for researchers and students to use and thereby fostering the learning process.

Project Supervisor *Xin Wang*
Research Areas *Sustainability*



Yifei He

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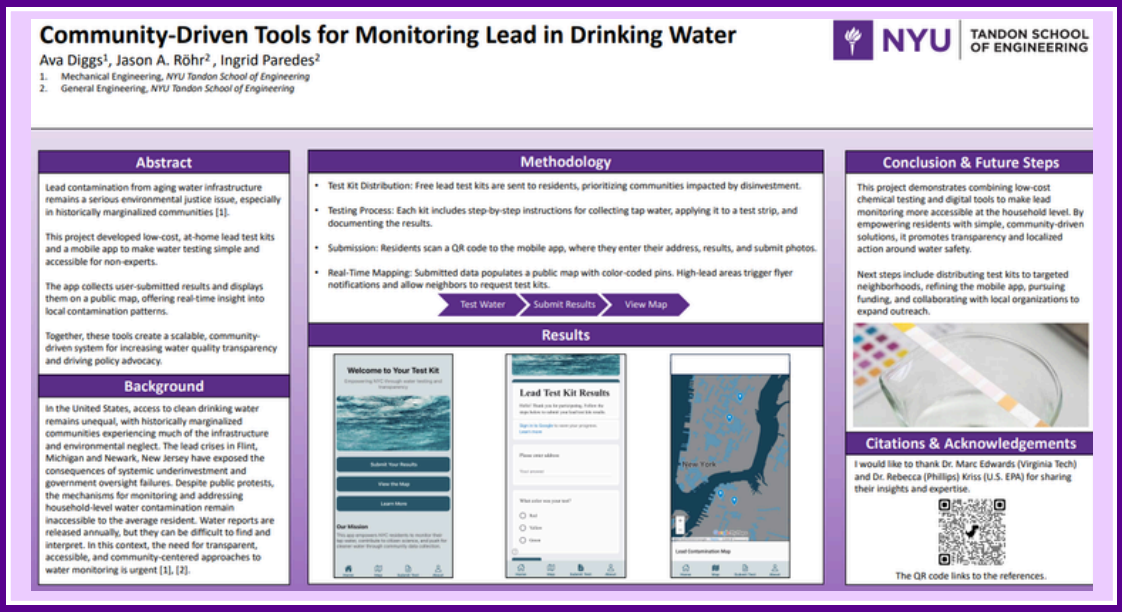
Development of Open-Source, Hands-On Tools for Climate Communication

Lead contamination from aging water infrastructure remains a serious environmental justice issue, especially in historically marginalized communities. This project developed low-cost, at-home lead test kits and a mobile app to make water testing simple and accessible for non-experts. The app collects user-submitted results and displays them on a public map, offering real-time insight into local contamination patterns. Together, these tools create a scalable, communitydriven system for increasing water quality transparency and driving policy advocacy.

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Community-Driven Tools for Monitoring Lead in Drinking Water

Ava Diggs[1], Jason A. Röhr[2], Ingrid Paredes[2]

1. Mechanical Engineering, *NYU Tandon School of Engineering*
2. General Engineering, *NYU Tandon School of Engineering*

NYU TANDON SCHOOL OF ENGINEERING

Abstract

Lead contamination from aging water infrastructure remains a serious environmental justice issue, especially in historically marginalized communities [1].

This project developed low-cost, at-home lead test kits and a mobile app to make water testing simple and accessible for non-experts.

The app collects user-submitted results and displays them on a public map, offering real-time insight into local contamination patterns.

Together, these tools create a scalable, community-driven system for increasing water quality transparency and driving policy advocacy.

Background

In the United States, access to clean drinking water remains unequal, with historically marginalized communities experiencing much of the infrastructure and environmental neglect. The lead crises in Flint, Michigan and Newark, New Jersey have exposed the consequences of systemic underinvestment and government oversight failures. Despite public protests, the mechanisms for monitoring and addressing household-level water contamination remain inaccessible to the average resident. Water reports are released annually, but they can be difficult to find and interpret. In this context, the need for transparent, accessible, and community-centered approaches to water monitoring is urgent [1], [2].

Methodology

- Test Kit Distribution: Free lead test kits are sent to residents, prioritizing communities impacted by disinvestment.
- Testing Process: Each kit includes step-by-step instructions for collecting tap water, applying it to a test strip, and documenting the results.
- Submission: Residents scan a QR code to the mobile app, where they enter their address, results, and submit photos.
- Real-Time Mapping: Submitted data populates a public map with color-coded pins. High-lead areas trigger flyer notifications and allow neighbors to request test kits.

Test Water → Submit Results → View Map

Results

Conclusion & Future Steps

This project demonstrates combining low-cost chemical testing and digital tools to make lead monitoring more accessible at the household level. By empowering residents with simple, community-driven solutions, it promotes transparency and localized action around water safety.

Next steps include distributing test kits to targeted neighborhoods, refining the mobile app, pursuing funding, and collaborating with local organizations to expand outreach.

Citations & Acknowledgements

I would like to thank Dr. Marc Edwards (Virginia Tech) and Dr. Rebecca (Phillips) Kriss (U.S. EPA) for sharing their insights and expertise.

The QR code links to the references.

On the Role of Shunt Resistance on the Performance of Underwater Solar

Underwater solar offers the opportunity to power submerged devices without the need to surface, and there are a plethora of modern solar cells with the potential to provide adequate efficiency when submerged. Shunt resistance is an important characteristic of all solar cells which describes the amount of current that travels through unwanted pathways. While traditional solar cells have been optimized to operate under typical outdoor irradiances, studies show that solar cells can suffer severe efficiency losses at lower irradiances if the shunt resistance is too low. Ensuring that the shunt resistance is large is therefore important for underwater solar. To investigate the role of shunt resistance in an organic solar cell, that has been identified as a potential candidate for underwater applications, we perform drift-diffusion simulations at different underwater depths with various shunt resistances to investigate the effects on efficiency. At shallow depths such as 2 meters, the efficiency at a shunt resistance of 1.14 Ω m−2 is close to the theoretical maximum, but as depth increases, the gap between the theoretical maximum increases. However, at depths up to 50 meters, a shunt resistance of 11.4 Ω m−2 (an order of magnitude higher than the original shunt resistance value) results in an efficiency that remains close to the theoretical maximum. Our results provide guidelines for engineers and manufacturers to optimize underwater solar cells for the depths they are deployed, offering the potential to accelerate the use of solar cells for underwater applications.

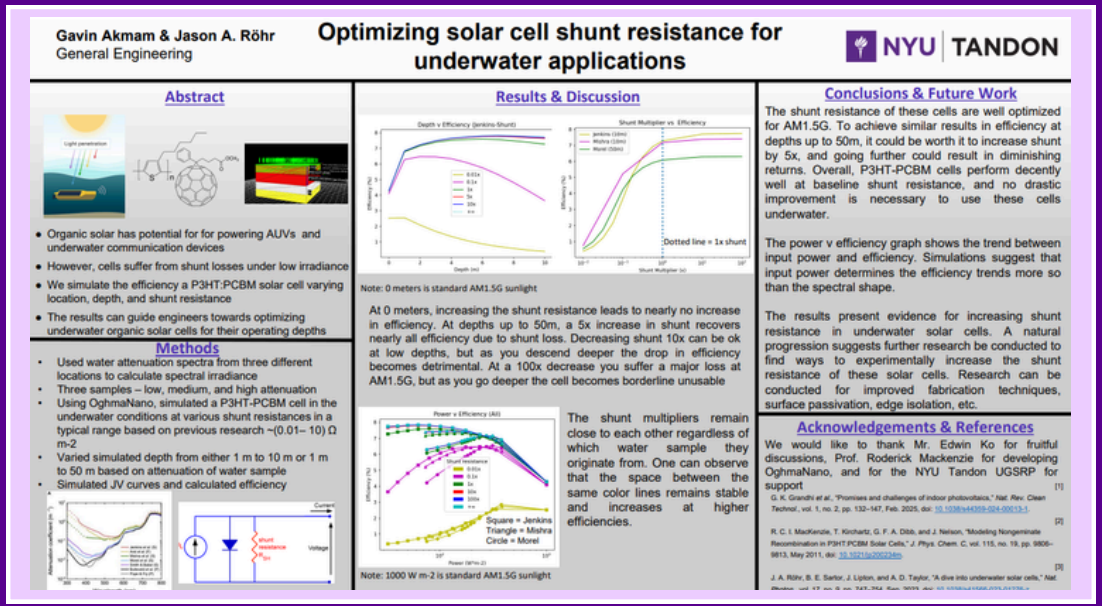
Project Supervisor *Jason Röhr*

Research Areas *Sustainability*



Gavin Akmam

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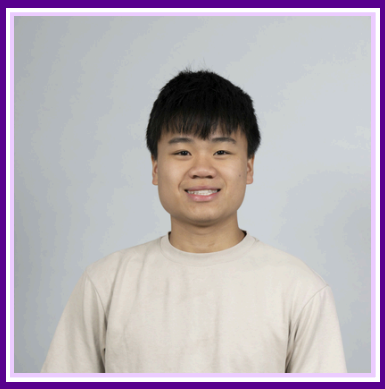


Electrical Probe of Defect States in Inorganic Perovskite Thin-Films

Space-charge-limited current (SCLC) measurements are crucial in understanding the optoelectronic properties and parameters, such as charge-carrier mobilities and trap characteristics, of metal-halide perovskites. At higher voltages, SCLC measurement-based current density (J) - voltage (V) curves follow a square-law dependence, and can be used to extract the above-mentioned parameters using the Mott-Gurney (MG) Law. The MG law depends on multiple assumptions, most importantly that it applies only to single-carrier devices, and therefore, traditional SCLC measurement methods fail to incorporate the dynamics of complex electronic-ionic conductivity in metal-halide perovskites. The presence of mobile ionic species greatly affects charge carrier injection, transport, and extraction, and therefore the shape of J-V curves, resulting in the origin of hysteresis in such materials. Without proper methodologies in place for how to conduct SCLC measurements to account for mobile ions, estimates for charge-carrier mobility and trap characteristics are not reliable. We therefore aim to provide a set benchmark for measuring and analyzing SCLC data, ensuring experimental reproducibility for similar devices and a unified approach to analysis. We analytically modeled the pulsed SCLC measurement to extract transient J-V curves from a set of CsPbBr3 devices, which is well known for Br-ion conduction. Pulsed SCLC is usually believed to pseudolocalize mobile ions during a sweep. Still, our measurement methodology demonstrates that the transient J-V curves, when fitted across multiple time scales, present a trend in the change of slope, depending on the time from the initial pulse our current values are extracted. These signify that reported current values can be misrepresented as a square-law regime in the SCLC fit, and parameters extracted using the MG law might not be reliable. The results suggest that the scientific community requires proper guidelines for performing and reporting SCLC data when considering these measurements on materials with ion-dependent hysteresis.

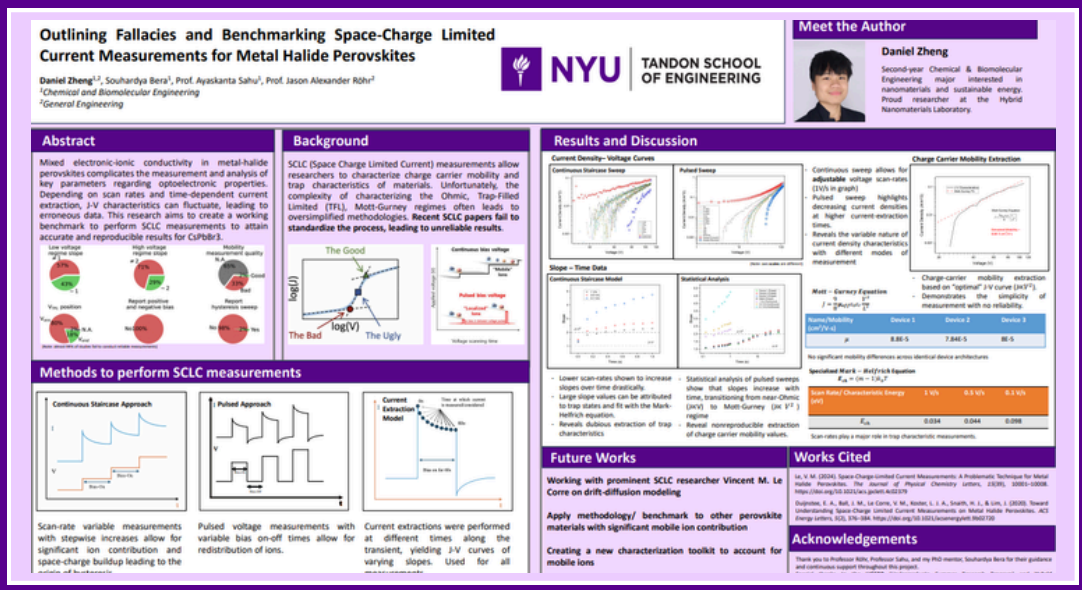
Project Supervisor *Jason Röhr*

Research Areas *Sustainability*



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Enzyme engineering

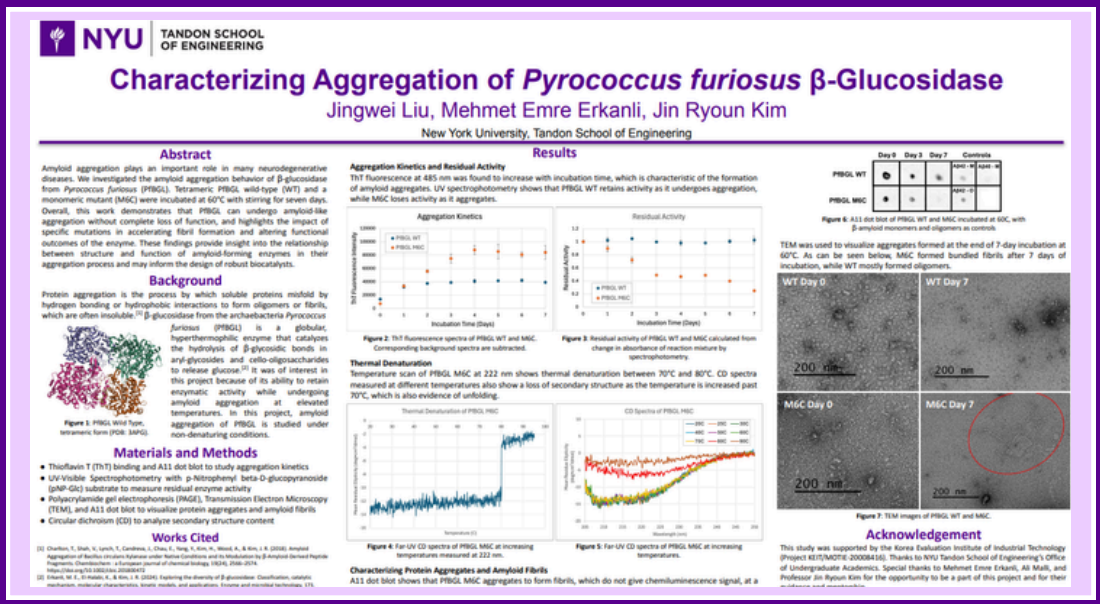
Amyloid aggregation plays an important role in many neurodegenerative diseases. We investigated the amyloid aggregation behavior of β-glucosidase from Pyrococcus furiosus (PfBGL). Tetrameric PfBGL wild-type (WT) and a monomeric mutant (M6C) were incubated at 60°C with stirring for seven days. Overall, this work demonstrates that PfBGL can undergo amyloid-like aggregation without complete loss of function, and highlights the impact of specific mutations in accelerating fibril formation and altering functional outcomes of the enzyme. These findings provide insight into the relationship between structure and function of amyloid-forming enzymes in their aggregation process and may inform the design of robust biocatalysts.

Project Supervisor *Jin Ryoun Kim*
Research Areas *Sustainability*



Jingwei Liu

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NYU TANDON SCHOOL OF ENGINEERING

Characterizing Aggregation of *Pyrococcus furiosus* β-Glucosidase

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New York University, Tandon School of Engineering

Abstract

Amyloid aggregation plays an important role in many neurodegenerative diseases. We investigated the amyloid aggregation behavior of β-glucosidase from *Pyrococcus furiosus* (PfBGL). Tetrameric PfBGL wild-type (WT) and a monomeric mutant (M6C) were incubated at 60°C with stirring for seven days. Overall, this work demonstrates that PfBGL can undergo amyloid-like aggregation without complete loss of function, and highlights the impact of specific mutations in accelerating fibril formation and altering functional outcomes of the enzyme. These findings provide insight into the relationship between structure and function of amyloid-forming enzymes in their aggregation process and may inform the design of robust biocatalysts.

Background

Protein aggregation is the process by which soluble proteins misfold by hydrogen bonding or hydrophobic interactions to form oligomers or fibrils, which are often insoluble.[1] β-glucosidase from the archaebacteria *Pyrococcus furiosus* (PfBGL) is a globular, hyperthermophilic enzyme that catalyses the hydrolysis of β-glycosidic bonds in aryl-glycosides and cello-oligosaccharides to release glucose.[2] It was of interest in this project because of its ability to retain enzymatic activity while undergoing amyloid aggregation at elevated temperatures. In this project, amyloid aggregation of PfBGL is studied under non-denaturing conditions.

Figure 1: PfBGL Wild Type, tetrameric form (PDB: 3APG).

Materials and Methods

- Thioflavin T (ThT) binding and A11 dot blot to study aggregation kinetics
- UV-Visible Spectrophotometry with p-Nitrophenyl beta-D-glucopyranoside (pNP-Glc) substrate to measure residual enzyme activity
- Polyacrylamide gel electrophoresis (PAGE), Transmission Electron Microscopy (TEM), and A11 dot blot to visualize protein aggregates and amyloid fibrils
- Circular dichroism (CD) to analyze secondary structure content

Works Cited

[1] Charlton, T., Shah, V., Lynch, T., Candreva, J., Chau, E., Yang, Y., Kim, H., Wood, A., & Kim, J. R. (2018). Amyloid Aggregation of Bacillus circulans Xylanase under Native Conditions and Its Modulation by β-Amyloid Derived Peptide Fragments. ChemBioChem : a European journal of chemical biology, 19(24), 2566–2574. https://doi.org/10.1002/cbic.201800472

[2] Erkanli, M. E., El-Kaddo, K., & Kim, J. R. (2024). Exploring the diversity of β-glucosidase: Classification, catalytic mechanism, molecular characteristics, kinetic models, and applications. Enzyme and microbial technology, 173,

Results

Aggregation Kinetics and Residual Activity

ThT fluorescence at 485 nm was found to increase with incubation time, which is characteristic of the formation of amyloid aggregates. UV spectrophotometry shows that PfBGL WT retains activity as it undergoes aggregation, while M6C loses activity as it aggregates.

Figure 2: ThT fluorescence spectra of PfBGL WT and M6C. Corresponding background spectra are subtracted.

Figure 3: Residual activity of PfBGL WT and M6C calculated from change in absorbance of reaction mixture by spectrophotometry.

Thermal Denaturation

Temperature scan of PfBGL M6C at 222 nm shows thermal denaturation between 70°C and 80°C. CD spectra measured at different temperatures also show a loss of secondary structure as the temperature is increased past 70°C, which is also evidence of unfolding.

Figure 4: Far-UV CD spectra of PfBGL M6C at increasing temperatures measured at 222 nm.

Figure 5: Far-UV CD spectra of PfBGL M6C at increasing temperatures.

Characterizing Protein Aggregates and Amyloid Fibrils

A11 dot blot shows that PfBGL M6C aggregates to form fibrils, which do not give chemiluminescence signal, at a

Figure 6: A11 dot blot of PfBGL WT and M6C incubated at 60C, with β-amyloid monomers and oligomers as controls

TEM was used to visualize aggregates formed at the end of 7-day incubation at 60°C. As can be seen below, M6C formed bundled fibrils after 7 days of incubation, while WT mostly formed oligomers.

Figure 7: TEM images of PfBGL WT and M6C.

Acknowledgement

This study was supported by the Korea Evaluation Institute of Industrial Technology (Project KEIT/MOTIE-20008416). Thanks to NYU Tandon School of Engineering's Office of Undergraduate Academics. Special thanks to Mehmet Emre Erkanli, Ali Malli, and Professor Jin Ryoun Kim for the opportunity to be a part of this project and for their

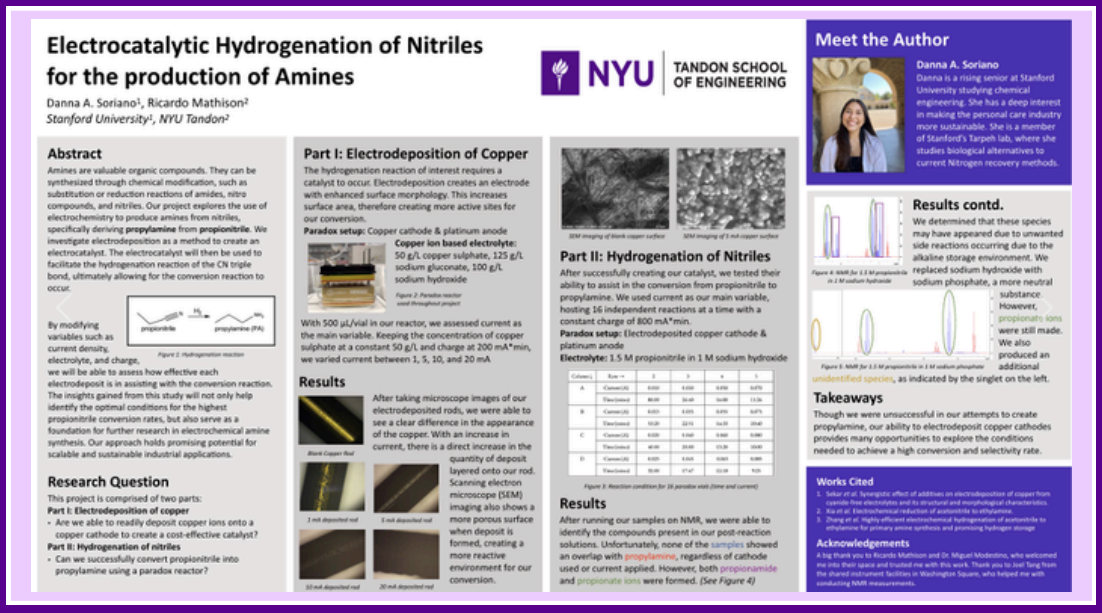
Electrocatalytic Hydrogenation of Nitriles for the production of Amines

Amines are valuable organic compounds. Their versatility and wide-spread application can be seen through their use in the pharmaceutical, agricultural, material science, and biochemical industries. Amines can be synthesized through chemical modification, such as substitution or reduction reactions of amides, nitro compounds, and nitriles. Our project explores the potential use of electrochemistry to produce these high value compounds from nitriles, specifically deriving propylamine from propionitrile. We begin by investigating electrodeposition as a method to create an effective electrocatalyst in an inexpensive manner. The electrocatalyst will then be used to facilitate the hydrogenation reaction of the CN triple bond, ultimately allowing for the conversion reaction to occur. By modifying variables such as current density, electrolyte composition, and charge, we will have the opportunity to assess how effective each individual electrodeposit is in assisting with the conversion reaction. The insights gained from this study will not only help identify the optimal conditions for the highest propionitrile conversion rates, but also serve as a foundation for further research in electrochemical amine synthesis. Our approach holds promising potential for scalable and sustainable industrial applications.

Project Supervisor	*Miguel Modestino*
Research Areas	*Sustainability*
Research Staff	*Ricardo Mathison*



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Harnessing Lightning in a Bottle: Engineering Plasma-Water Interfaces for Green Chemistry

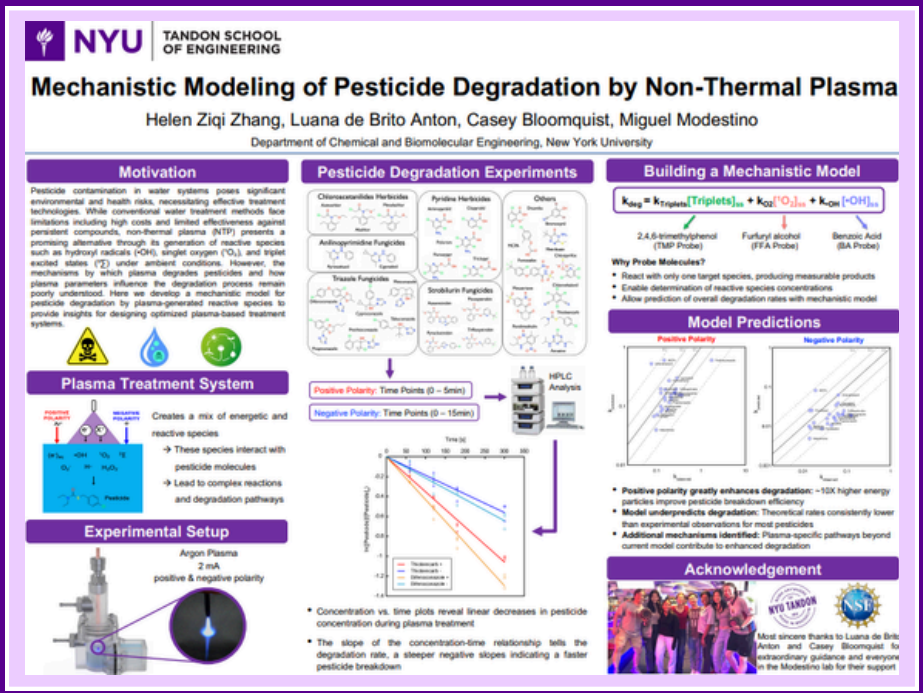
Pesticide contamination in water systems poses significant environmental and health risks, necessitating effective treatment technologies. While conventional water treatment methods face limitations including high costs and limited effectiveness against persistent compounds, non-thermal plasma (NTP) presents a promising alternative through its generation of reactive species such as hydroxyl radicals (•OH), singlet oxygen ($^1O_2$), and triplet excited states ($^3\Sigma$) under ambient conditions. Our study investigates plasma-induced pesticide degradation mechanisms by developing a mechanistic model based on reactive species quantification across 28 different pesticides. Using probe molecules—furfuryl alcohol for triplet excited states, 2,4,6-trimethylphenol for singlet oxygen, and benzoic acid for hydroxyl radicals—we quantified steady-state concentrations of key reactive species under different plasma conditions. Results reveal discrepancies between theoretical predictions and experimental degradation rates, indicating that the simple mechanistic model does not fully capture the complex plasma degradation process. Plasma parameter substantially influence degradation efficiency: positive polarity generated significantly higher H_2O_2 concentrations compared to negative polarity, while current was maintained at 2 mA. Additionally, solution pH was found to vary with polarity, decreasing under positive polarity and increasing under negative polarity. These findings highlight the complex interactions between plasma parameters and pesticide degradation mechanisms, suggesting that plasma-specific pathways contribute significantly beyond conventional photodegradation processes. These poorly understood pathways caused by plasma systems likely account for the discrepancies observed in our experiments. The limitations of the current model underscore the need for more comprehensive approaches incorporating additional reactive species and plasma-specific mechanisms. This research provides foundational insights for designing optimized plasma-based pesticide treatment systems and establishes a framework for future mechanistic model development.

Project Supervisor	*Miguel Modestino*
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REnewthanol: Precision-Pulsed CO2 Conversion for Tomorrow's Green Ethanol

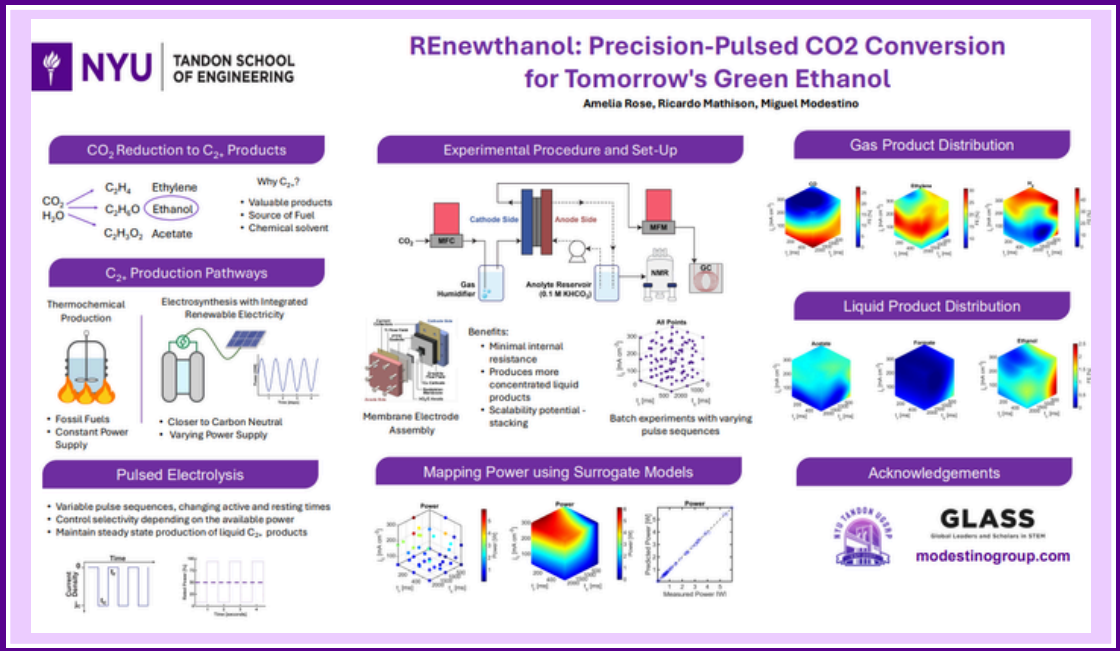
Renewable energy technologies such as solar and wind present effective pathways for generating green electricity that can drive the electrochemical conversion of CO_2 into ethanol and other C_2+ products. However, the integration of such electricity into chemical manufacturing is challenging due to the variable and intermittent nature of renewable power. This research aims to mitigate this challenge by employing pulsed electrolysis to enable steady-state production of ethanol and related C_2+ products. A membrane electrode assembly with a copper electrocatalyst was used to apply pulsed current sequences to hydrated CO_2, alternating between active and resting periods. The resulting products were analyzed to identify the pulsing conditions and current densities that maximize the faradaic efficiency toward ethanol, ethylene, and acetate. These findings establish a relationship between power input and product selectivity, providing a framework for dynamically controlling electrochemical reactions based on power availability. This approach can be used for scaling renewable-powered chemical processes, where consistent and reliable product output is required for industrial implementation.

Project Supervisor	*Miguel Modestino*
Research Areas	*Sustainability*
Research Staff	*Ricardo Mathison*



Amelia Rose

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Investigation of Materials using Density Functional Theory

Organic donor–acceptor (D–A) cocrystals have emerged as suitable candidates for electronic materials because of their low cost, ease of processing, and excellent electronic properties. Yet the performance of organic cocrystals is far from optimized. Synthesizing a new and effective D–A combination is faced by the countless possible D–A pairings, structural mismatches between constituent compounds, and unpredictable changes in properties. To help close this gap, we analyzed the electronic structures of a series of novel organic cocrystals built from 7,7,8,8-tetracyanoquinodimethane (TCNQ) derivatives and benzimidazole-hydride (BIH) based donors. The objective is to identify combinations that deliver narrow band gaps suitable for organic semiconductors. First-principles density-functional theory (DFT) calculation on the molecular and crystalline scale was carried out on NYU's Greene HPC. The combined, neutral D–A molecular pairs—as the charge and multiplicity were ambiguous with the initial run on the isolated cation and anion—were treated with Gaussian 16 with three basis sets of the B3LYP functional. Across all three basis sets, the TCNQ–benzimidazole derivative "SS50" delivered a consistent HOMO–LUMO gap of ~0.5 eV, whereas the remaining candidates exceeded 1 eV. Visualisation in GaussView revealed that the frontier orbitals responsible for all gaps are confined to the acceptor core, suggesting that D–A charge transfer is limited in the isolated molecular scale. The results provide valuable insight into a novel cocrystal structure, suggesting further analysis in the crystalline scale.

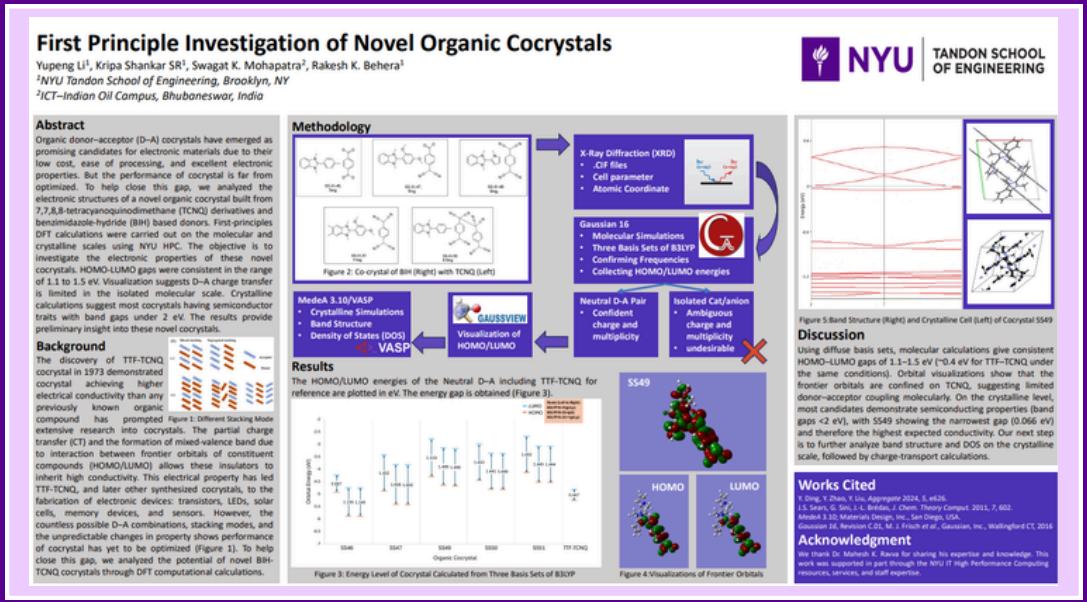
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Research Areas *Sustainability*



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NYU Tandon



Upgrading biomass to fuels and CO2 reduction using designer 2-D transition metal nanocatalysts

Quantum dots (QDs) are semiconductor nanocrystals with size-tunable optical and electronic properties. In this realm, silver telluride (Ag_2Te) has been studied intensively in recent years for its strong infrared absorption, narrow bandgap in the short-wave infrared region, and its composition of relatively less toxic and abundant elements, making it attractive for scalable photodetector and sensing applications. A key limitation of Ag_2Te QDs is their high ion migration, which leads to long-term degradation. To improve device stability, this project explores core-shell structures synthesized via hot injection, using silver sulfide (AgS) or zinc sulfide (ZnS) as protective shells. Following synthesis, the QDs undergo purification to maintain colloidal stability and enable smooth film formation during deposition. Thin films are fabricated through spin coating, and a solid-state ligand exchange process is implemented. Device performance is evaluated through current-voltage measurements, comparing response under illumination and dark conditions. Responsivity values were measured in mA/W under illumination and FTIR/absorbance was used to observe bonding changes throughout ligand exchange steps. Results showed that while core-shell designs improved stability, they also introduced potential carrier transport barriers. This work focuses on optimizing shell material and thickness to strike a balance between long-term durability and efficient carrier mobility for infrared optoelectronic applications.

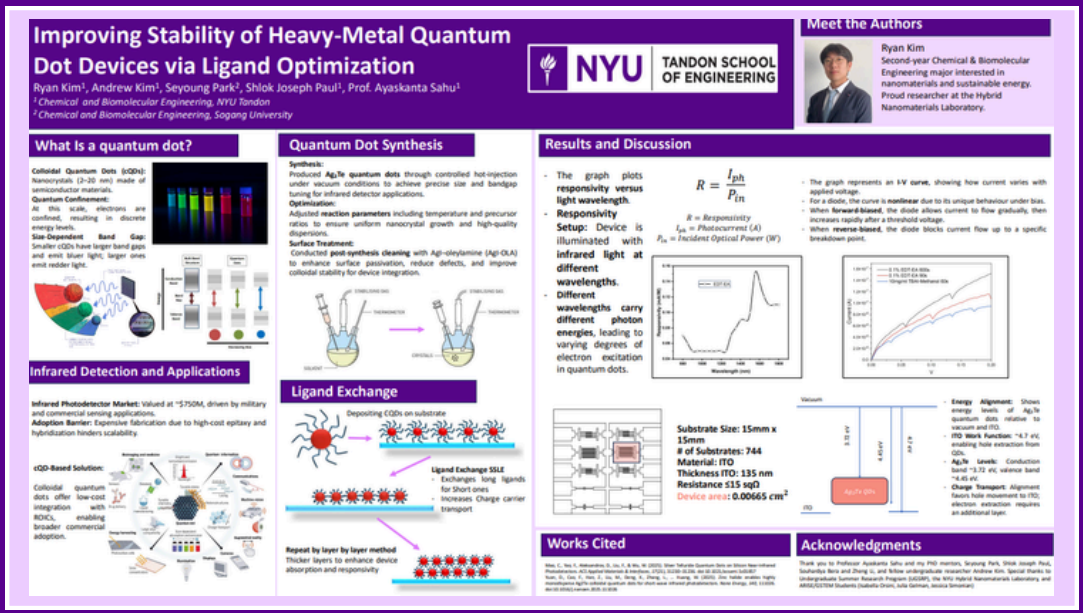
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Research Areas *Sustainability*



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PINKERTON LAB

Project Supervisor: Nathalie Pinkerton
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A SPECIAL MESSAGE FROM THE PROGRAM COORDINATORS

The Tandon Undergraduate Summer Research Program (UGSRP) was initiated at NYU Tandon in 2007. Since 2011, the Office of Undergraduate Academics (UGA) has coordinated the program, significantly expanding its reach and impact. We have grown from 60 student participants to over 100, with this year having 129 participants! Our program includes a diverse array of faculty and research projects from prestigious groups.

We have worked tirelessly to match students with the best-suited Project Supervisors and Research Staff members, ensuring a fruitful experience and strong mentorship. In addition to research, we have dedicated significant effort to providing academic, career, and personal development seminars, lectures, workshops, and events. These initiatives are designed to enhance students' knowledge in their research areas and to inform them about various professional opportunities and paths.

Our commitment to developing, maintaining, and continually enhancing this program remains unwavering. We are immensely grateful to all who have joined and supported this summer's program, ensuring its seamless execution from start to finish. We congratulate all student participants on a successful summer and hope everyone enjoyed the experience.



Sara-Lee Ramsawak
Assistant Dean of Undergraduate Academics & Global Engagement



Jen Piro
Director of Undergraduate Programs



Kat Arredondo
Manager of Undergraduate Programs



Mohamed Asran
Global Opportunities Administrator



Adelia Vavilchenkova
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